Old Higher PPQs by Topic
Version 1

Mr Finch

June 24, 2020

Introduction

This file contains past paper questions from 1992–1998 inclusive[1]. It is intended for teachers who want to quickly locate PPQs on an area of Higher Physics. In my experience, it works best when opened in Adobe with the zoom set to 100%.

It is likely that there are a great many mistakes in this PDF: broken links, incorrect answers — please let me know if you find any. An up-to-date version of this file is kept here; compare your filename with the most recent version to check you have the newest one.

It was my intention to keep splitting-up Higher past papers and stop where Mr Davie started; however, given that the uncompressed version of this file was over 80 MB, I have come to the conclusion that this resource would be better on a website which we can all access, perhaps using Google Sites or maybe hosted by the IoP or some other interested party. Figuring-out how best this might be done is one of those never-ending projects which I might get around to some day.

[1] I think this is correct, I can't quite remember how far I got. I last opened this file in November 2019.

	1992		1993		1994		1995	
	P1	P2	P1	P2	P1	P2	P1	P2
Graphs of Motion	2	1(a) 2(a)(i)	1	1(a) 1	2 31	4(d)(ii)	2 4	
suvat	1	3(a)	2	2(b)	3	1	3	2
Forces, Energy and Power	5,6-8	1(c,d)	3	1(b) 2(a) 3(b)(ii, iii)	4-6 9	2 3(b) 4(a)	5-7	3(a)(i) 4(a)(b)(i)(c)
Collisions and Explosions	9	3(b)(i-ii)	5	3(a)(b)(i)	8	4(b)		3(a)(ii)(b)
Impulse			7	1(c, d)	7	4(d)(i)	8	
Gravitation	4		4 31					
Special Relativity								
The Expanding Universe								
Forces On Charged Particles		7(a-b)					11	8(c)
The Standard Model								
Nuclear Reactions		11(a)(i-v)	30		29 37		28	11
Inverse Square Law		9(d)	23	10(c)	25		26	
Wave-Particle Duality			24, 25 26		26-28		27	8(a, b)
Interference		9(b)	20 36		24 35		24, 25	
Spectra			37	8(a, b, c) 9(b)		10	23	
Refraction of Light		10(a)(i)	21 22		21, 22 23	9	21 22	9
Monitoring and Measuring AC	14	8(a)(i)	34		18		15	
Current, Potential Difference, Power and Resistance		6(b)	12 13	6(b)(i-ii)(c)	12 13	5(a)	12-14	5
Electrical Sources and Internal Resistance		5(a)(i-iii) 5(b)	14	6(a)(b)(iii)	14	6(b)		6(a) 7(b, c)
Capacitors	13	6(a), 6(c)(i-ii)	15, 16, 17 18 35	5(a)(i)(b)	11 16 17	6(a) 8	17, 18 19	6(b)
Semiconductors and P-N Junctions			27	10(a)	36			10
Open Ended								
Unseen Formula								7(a)
Graph Plotting		1(b)		11(a)(i, ii)				
Uncertainties	3	3(c)	6	5(a)(ii, iii)		12		

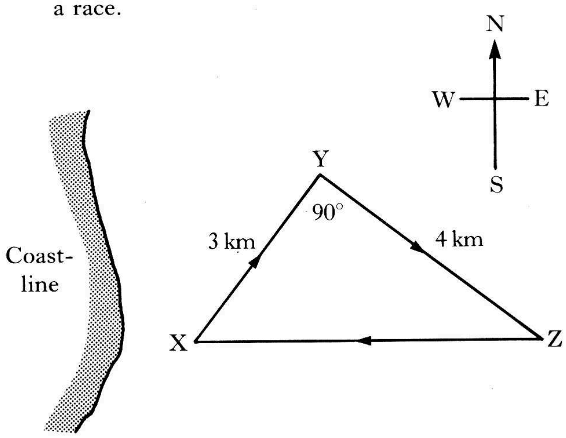
	1996		1997		1998		1999	
	P1	P2	P1	P2	P1	P2	P1	P2
Graphs of Motion	1 5	2	2	2(d)			1 3	
suvat	3		3-5	1(b)	3 31	1(a)(iii–iv)(b) 2(d)	1 4, 5	31
Forces, Energy and Power	4 6, 7	1(a) 2	6 7 31 32	10	5 6	1(a)(i, ii) 2(a–c)	6	
Collisions and Explosions	8	3(a)	33	3(a, b)	7 32			
Impulse	9	3(b)(i, iii)	8 9	3(c)		3(a)	7	
Gravitation (Projectiles)				2	4			
Special Relativity								
The Expanding Universe								
Forces On Charged Particles	11	6	12			7		33
The Standard Model								
Nuclear Reactions	28	11	29 30		27	11(a)	29	36
Inverse Square Law	27		23 24		25		25	35
Wave-Particle Duality			26	10	35		26 27	37
Interference	25, 26		21	8	24		23, 24	
Spectra	29		25 27 38		28 30 37	9	28	
Refraction of Light	21 22, 23		22	9	21 22	10(a)	21, 22	
Monitoring and Measuring AC	19	5(b)	18 19	6(a)(ii)	15 16		16 17	
Current, Potential Difference, Power and Resistance	12 16		13 14-16		11 33		11, 13	34
Electrical Sources and Internal Resistance	13, 14		35 36	5	12	5	12, 14	
Capacitors	17, 18 20	7	17	7	17 18 19 23	6	18, 19	
Semiconductors and P-N Junctions	24		37	26				
Open Ended								
Unseen Formula				1(a)				
Graph Plotting								
Uncertainties		1(b)				3(b)	30	

Back to Table Answers

SECTION A

Answer questions 1–30 on the answer sheet.

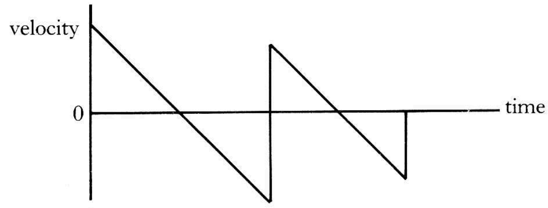
1. A yacht follows the course shown below during a race.

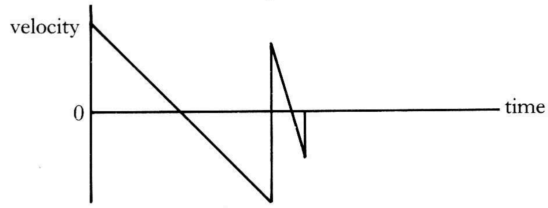


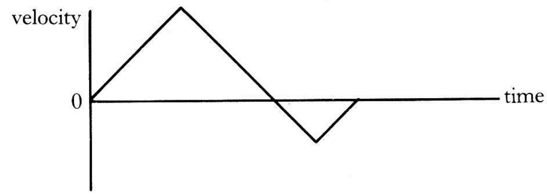
The race starts and finishes at X. Which entry in the table below gives the displacement of the yacht at position Z relative to the start; and the distance covered up to position Z?

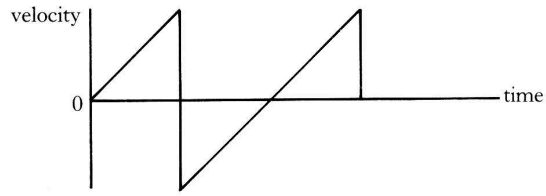
	Displacement	*Distance*
A	5 km due East	5 km
B	7 km due East	5 km due East
C	5 km	7 km due East
D	7 km due East	7 km
E	5 km due East	7 km

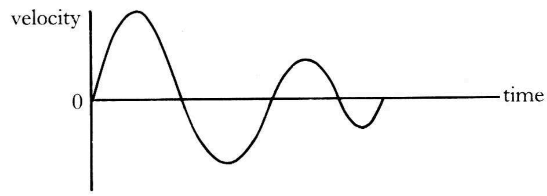
2. A ball is thrown vertically upwards from ground level. When it falls to the ground, it bounces several times before coming to rest. Which one of the following velocity–time graphs represents the motion of the ball from the instant it leaves the thrower's hand until it hits the ground for a second time?

A


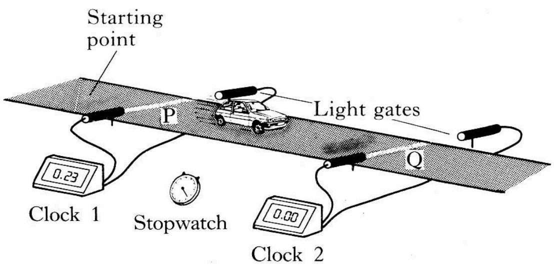
B


C


D


E


3. A student sets up the apparatus in the diagram to measure the average acceleration of a model car as it travels between P and Q.



For one run, the following measurements were recorded along with their estimated errors:

clock 1 reading $= 0{\cdot}23\,\text{s} \pm 0{\cdot}01\,\text{s}$

clock 2 reading $= 0{\cdot}12\,\text{s} \pm 0{\cdot}01\,\text{s}$

stopwatch reading $= 0{\cdot}95\,\text{s} \pm 0{\cdot}20\,\text{s}$

length of car $= 0{\cdot}050\,\text{m} \pm 0{\cdot}002\,\text{m}$

distance PQ $= 0{\cdot}30\,\text{m} \pm 0{\cdot}01\,\text{m}$

The measurement which gives the largest percentage error is the

A reading on clock 1

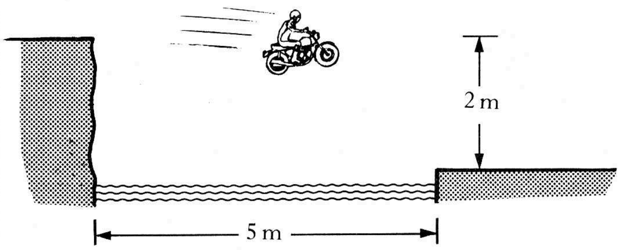
B reading on clock 2

C reading on the stopwatch

D length of car

E distance PQ.

4. A stunt motorcyclist attempts to jump a river which is 5 m wide. The bank from which he will take off is 2 m higher than the bank on which he will land as shown below.



What is the minimum horizontal speed he must achieve just before take-off to avoid landing in the river?

A $2{\cdot}0\,\text{m}\,\text{s}^{-1}$

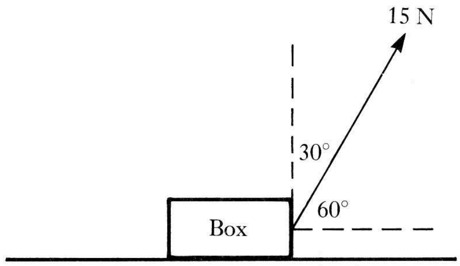
B $3{\cdot}2\,\text{m}\,\text{s}^{-1}$

C $7{\cdot}9\,\text{m}\,\text{s}^{-1}$

D $10{\cdot}0\,\text{m}\,\text{s}^{-1}$

E $12{\cdot}5\,\text{m}\,\text{s}^{-1}$

5. A force of 15 N acts on a box as shown below.



Which entry in the following table correctly shows the horizontal and vertical components of the force?

	Horizontal component/N	*Vertical component/N*
A	15 sin 60°	15 sin 30°
B	15 cos 60°	15 sin 30°
C	15 sin 60°	15 cos 60°
D	15 cos 30°	15 sin 30°
E	15 cos 60°	15 sin 60°

6. A hot air balloon of mass 300 kg has people with a total mass of 250 kg on board. It floats at a steady height.

The upthrust on the balloon is

A 0 N

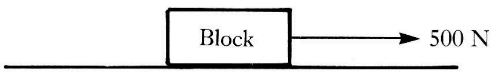
B 500 N

C 2500 N

D 3000 N

E 5500 N.

7. A block of weight 1500 N is dragged along a horizontal road at constant speed by a force of 500 N.



What is the force of friction between the block and the road?

A 3 N

B 500 N

C 1000 N

D 1500 N

E 2000 N

8. Two identical metal spheres X and Y are dropped onto a horizontal surface. The distance Y falls is double the distance X falls.

Which of the following is/are true if the effects of air resistance are negligible?

I Y takes twice as long to fall as X.

II The maximum speed of Y is double the maximum speed of X.

III The maximum kinetic energy of Y is double that of X.

A I only

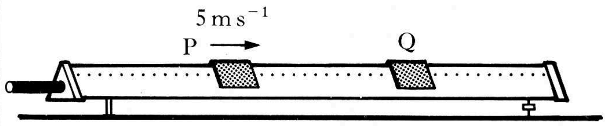
B II only

C III only

D I and II only

E I, II and III

9. The diagram below shows two vehicles, both of mass 0·2 kg, on a linear air track. Vehicle P is moving at 5 m s^{-1} towards vehicle Q, which is at rest before the collision.



Linear air track

After colliding, they move off **separately** to the right. Vehicle P moves with a speed of 2 m s^{-1} and vehicle Q moves with a speed of 3 m s^{-1}.

Which one of the following correctly describes this collision?

	Momentum	*Kinetic Energy*	*Type of Collision*
A	lost	conserved	elastic
B	conserved	lost	elastic
C	conserved	conserved	elastic
D	lost	conserved	inelastic
E	conserved	lost	inelastic

10. A rectangular block of wood of mass 200 kg has dimensions of 2 m by 1 m by 0·1 m.

The **greatest** pressure the block can exert when lying on a level surface is

A 1×10^2 Pa

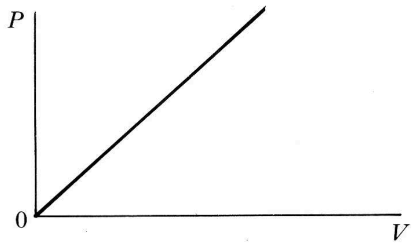
B 1×10^3 Pa

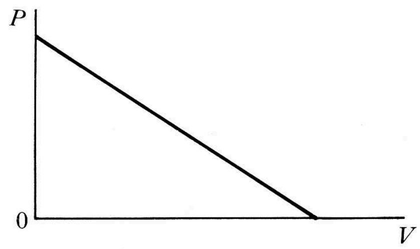
C 2×10^3 Pa

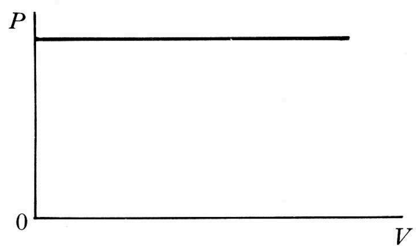
D 1×10^4 Pa

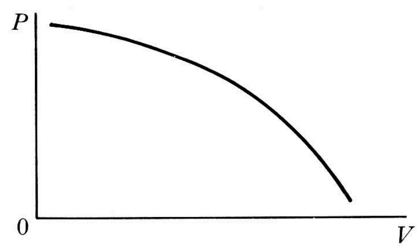
E 2×10^4 Pa.

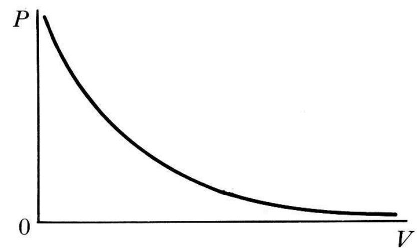
11. Which one of the following graphs illustrates the correct relationship between the pressure P and volume V of a fixed mass of gas at constant temperature?

A


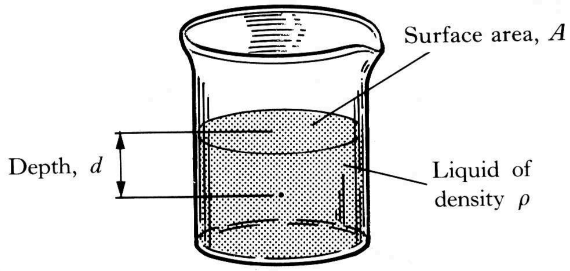
B


C


D


E


12. The glass beaker shown below contains a liquid of density ρ and surface area A.



Which of the following is/are true about the pressure, caused by the liquid, at depth d below the surface?

I The pressure varies directly as the surface area A.

II The pressure varies directly as the liquid density ρ.

III The pressure varies inversely as the depth d.

A I only

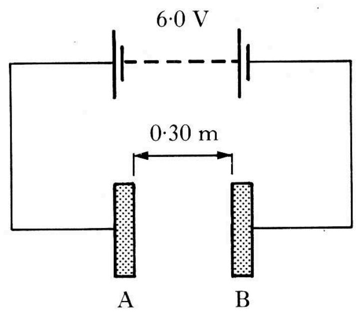
B II only

C III only

D I and II only

E II and III only

13. The diagram below shows a circuit with a 6·0 V battery connected to two parallel metal plates A and B which are 0·30 m apart.



The amount of work needed to move 2 coulombs of charge from plate A to plate B is

A 1·8 J

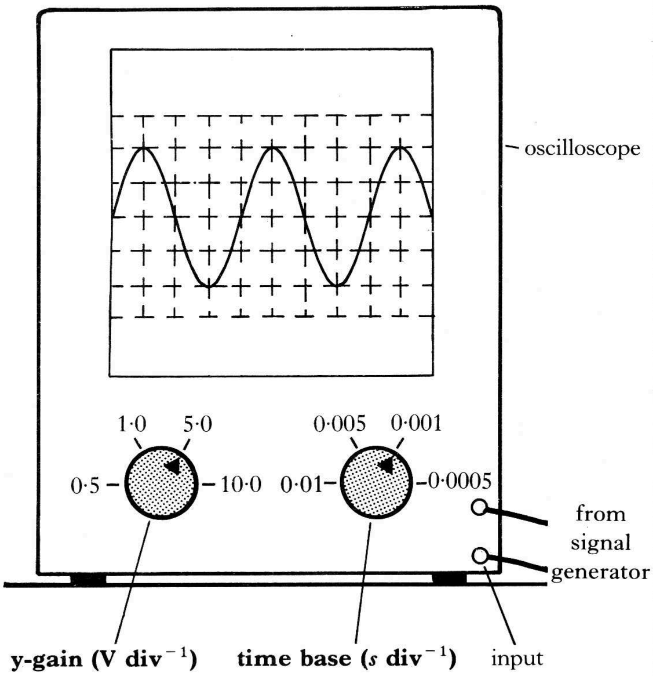
B 3·0 J

C 6·0 J

D 12·0 J

E 20·0 J.

14. The diagram below shows the screen and the settings of an oscilloscope, which is being used to measure the output frequency of a signal generator.



What is the frequency of the signal applied to the input of the oscilloscope?

A 2·5 Hz

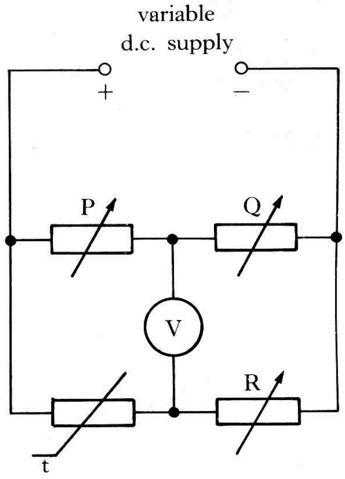
B 12·5 Hz

C 40 Hz

D 250 Hz

E 500 Hz

15. A Wheatstone bridge containing a thermistor is set up as shown below.



The resistance of the thermistor decreases as the temperature increases.

The variable resistor R is adjusted so that the bridge is balanced at a room temperature of 18 °C.

The thermistor is now placed in a beaker containing melting ice. Which adjustment could restore the bridge to its balanced condition?

A Increasing the resistance of R

B Decreasing the resistance of R

C Reducing the resistance of P

D Increasing the resistance of Q

E Increasing the supply voltage

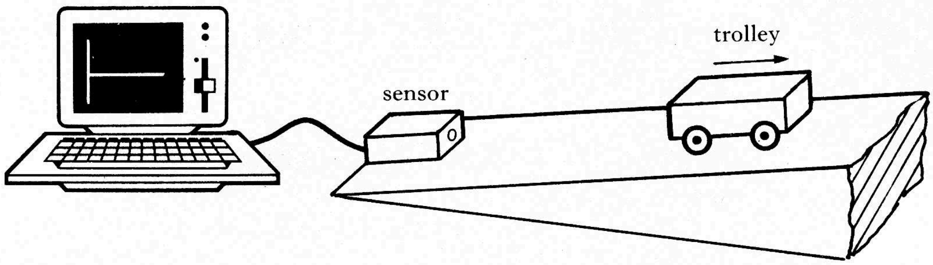
1992 Paper 1 (Multiple Choice)

Back to Table

1. E	11. E	21. B
2. A	12. B	22. C
3. C	13. D	23. C
4. C	14. D	24. B
5. E	15. A	25. A
6. E	16. B	26. B
7. B	17. B	27. D
8. C	18. A	28. C
9. E	19. B	29. C
10.E	20. E	30. C

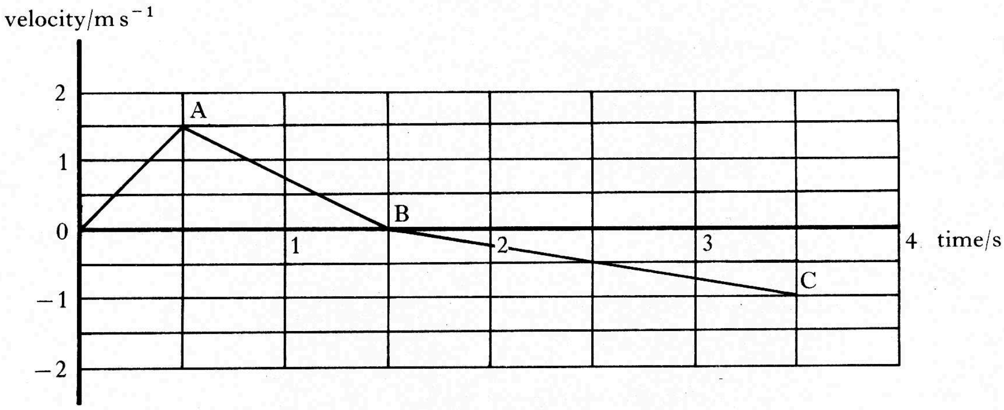
Marks

1. The velocity of a trolley on a slope can be investigated using a computer and a sensor as shown below.



The sensor emits ultrasound pulses which are reflected from the trolley. The computer measures the time between emitted and reflected pulses and uses this information to calculate the velocity at regular times.

In an investigation, the trolley is given a sharp push **up** the slope and then released. The graph below shows the resulting velocity-time graph as displayed on the screen.



Point A on the graph corresponds to the instant at which the trolley is released.

(*a*) At what time is the trolley at its maximum displacement from the sensor? You must justify your answer. **2**

(*b*) On the square-ruled paper provided, draw the corresponding acceleration-time graph of the motion. **3**

(*c*) Draw a diagram to show the forces acting on the trolley as it moves **up** the slope after the push is removed. Show only forces or components of forces acting parallel to the slope. **1**

(*d*) Explain, in terms of the forces acting on the trolley, why the magnitude of the acceleration from A to B differs from the magnitude of the acceleration from B to C. **2**

(8)

Past Paper Solutions

Solutions to SQA examination

1992 Higher Grade Physics

Paper II Solutions

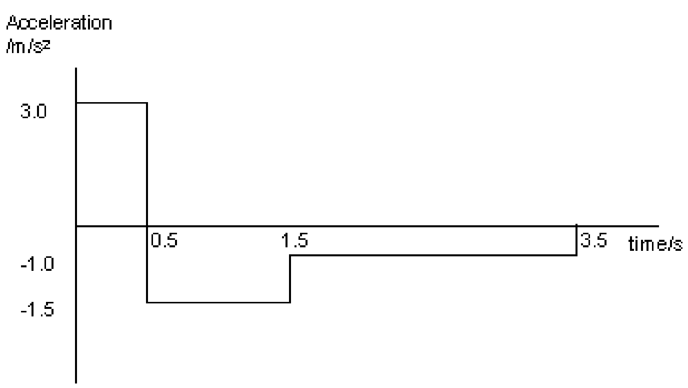
Return to past paper index page.

1.a. From 0s up to 1.5s(point B) the trolley is moving away from the sensor. At 1.5s the trolley stops, changes direction, and moves back towards the sensor for the next 2s.

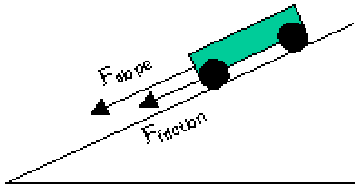
This means the trolley is at its greatest distance from the trolley after 1.5s.

b.

From OA	**From AB**	**From BC**
u = 0m/s	u = 1.5m/s	u = 0m/s
v = 1.5m/s	v = 0m/s	v = -1m/s
t = 0.5s	t = 1s	t = 2s
a = ?	a = ?	a = ?
a = (v-u)/t	a = (v-u)/t	a = (v-u)/t
a = (1.5-0)/0.5	a = (0-1.5)/1	a = (-1.0-0)/1
a_{0A} = 3m/s/s	a_{AB} = -1.5m/s/s	a_{BC} = -1m/s/s



c.



F_{slope} = component of gravitational force acting down the slope.

d. When moving up the slope: both F_{slope} and $F_{friction}$ are acting in the same direction. This means that the unbalanced force causing the acceleration between A and B is the sum of these two forces.

$F_{unbalanced} = F_{slope} + F_{friction}$

When moving down the slope: $F_{friction}$ acts up the slope, in the opposite direction to F_{slope}. This means that the unbalanced force causing the acceleration between B and C is the difference between these two forces.

$F_{unbalanced} = F_{slope} - F_{friction}$

The acceleration is therefore greater when the trolley is moving up the slope.

2.a.i. Step 1 : Calculate the energy available from 0.7kg of fuel.

$E_{increase}$ = mass of fuel x energy per kilogram

$E_{increase} = 0.7 \times 2.8\text{x}10^7$

$E_{increase} = 19.6\text{x}10^6\text{J}$

$E_k(\text{initial}) = 0\text{J}$

$E_k(\text{final}) = E_k(\text{initial}) + E_{increase}$

$E_k(\text{final}) = 19.6\text{x}10^6\text{J}$

$E_k(\text{final}) = mv^2/2$

$v^2 = 2E_k(\text{vehicle})/m$

$v = [2E_k(\text{vehicle})/m]^{1/2}$

$v = [2\text{x}19.6\text{x}10^6/500]^{1/2}$

$v = [78400]^{1/2}$

$v = 280\text{m/s}$

Note: It is not clear from the question whether the 500kg mass is that of the vehicle and dummy after, or before, burning the fuel. To get an answer exactly equal to 280m/s you seem to have to assume that the 500kg is the mass after burning the fuel.

a.ii. u = 0m/s
v= 280m/s
t = 8s
a = ?

a = (v-u)/t
a = (280 -0)/8
a = 35m/s/s

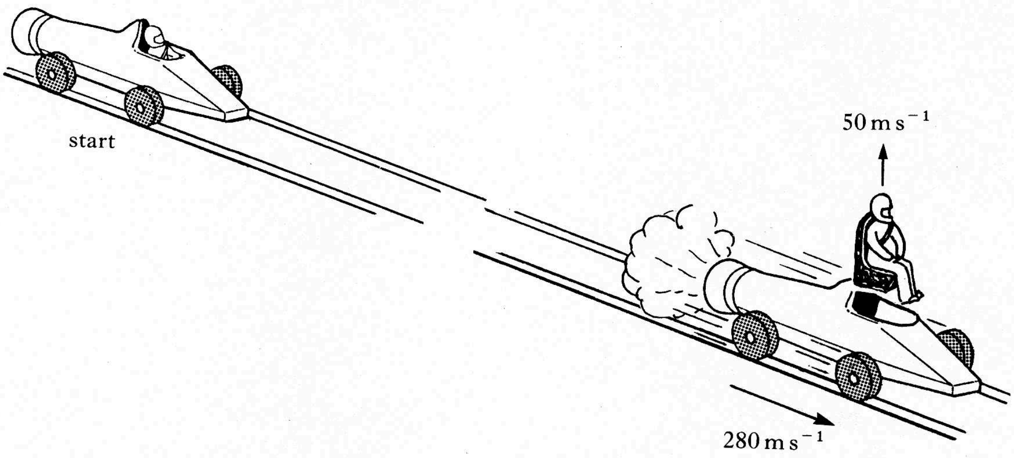
$s = ut + at^2/2$

$s = 0 + 35\text{x}8^2/2$

s = 1120m

Marks

2. A rocket-propelled vehicle carrying a dummy is used at a research centre to test the ejection seat for a jet aircraft as shown in the diagram.



The vehicle and dummy have a combined mass of 500 kg. The rocket engines increase the kinetic energy of the vehicle by $2{\cdot}80 \times 10^7$ J for each kilogram of fuel used.

In a test run, the vehicle accelerates **from rest** along the track until 0·70 kg of fuel is used up.

(*a*) (i) Show that the maximum possible speed reached by the vehicle is $280\,m\,s^{-1}$. You may ignore the effect of friction.

(ii) The dummy is ejected when the vehicle reaches a speed of $280\,m\,s^{-1}$ after 8·0 s.

Calculate how far the vehicle is from the start when the dummy is ejected. Assume that the acceleration of the vehicle is constant during the 8·0 s test run. **5**

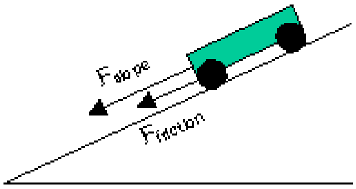
(*b*) The dummy is ejected at the instant the vehicle reaches a horizontal velocity of $280\,m\,s^{-1}$. The ejection seat being tested projects the dummy upwards with an initial vertical velocity of $50\,m\,s^{-1}$.

(i) Describe and explain the path taken by the dummy after its ejection from the vehicle.

(ii) Calculate the maximum height reached by the dummy. You may ignore the effect of friction. **4**

(9)

[Turn over



F_{slope} = component of gravitational force acting down the slope.

d. When moving up the slope: both F_{slope} and $F_{friction}$ are acting in the same direction. This means that the unbalanced force causing the acceleration between A and B is the sum of these two forces.

$F_{unbalanced} = F_{slope} + F_{friction}$

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$E_{increase}$ = mass of fuel x energy per kilogram

$E_{increase} = 0.7 \times 2.8\text{x}10^7$

$E_{increase} = 19.6\text{x}10^6\text{J}$

$E_k(\text{initial}) = 0\text{J}$

$E_k(\text{final}) = E_k(\text{initial}) + E_{increase}$

$E_k(\text{final}) = 19.6\text{x}10^6\text{J}$

$E_k(\text{final}) = mv^2/2$

$v^2 = 2E_k(\text{vehicle})/m$

$v = [2E_k(\text{vehicle})/m]^{1/2}$

$v = [2\text{x}19.6\text{x}10^6/500]^{1/2}$

$v = [78400]^{1/2}$

$v = 280\text{m/s}$

Note: It is not clear from the question whether the 500kg mass is that of the vehicle and dummy after, or before, burning the fuel. To get an answer exactly equal to 280m/s you seem to have to assume that the 500kg is the mass after burning the fuel.

a.ii. u = 0m/s
v= 280m/s
t = 8s
a = ?

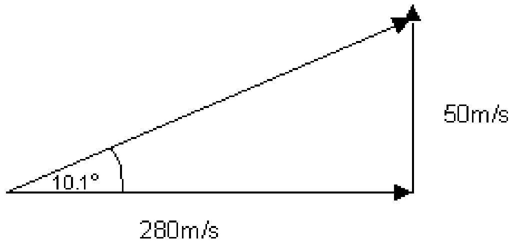
a = (v-u)/t
a = (280 -0)/8
a = 35m/s/s

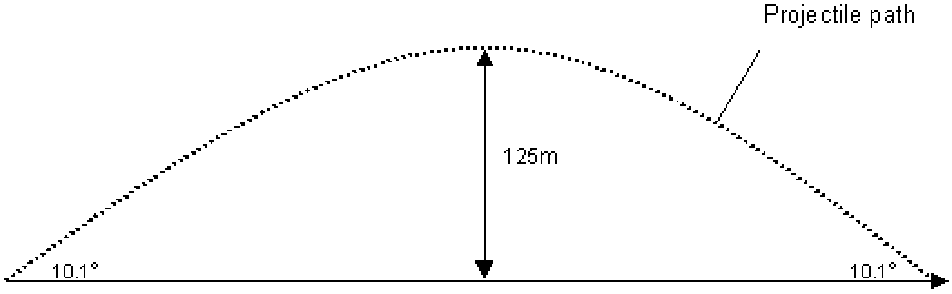
$s = ut + at^2/2$

$s = 0 + 35\text{x}8^2/2$

s = 1120m

b.i.





The horizontal velocity of the projectile is constant at 280m/s. The vertical component of the motion will be up to a maximum height and then fall back down to earth.

b.ii. The maximum height reached by the dummy will occur when the vertical component(v_{ver}) of the velocity is zero.

$v_{ver}^2 = u_{ver}^2 + 2as_{ver}$

$s_{ver} = (v_{ver}^2 - u_{ver}^2)/2a$

$s_{ver} = (0^2 - 50^2)/2x(-10)$

$s_{ver} = -2500/-20$

$\mathbf{s_{ver} = 125m}$

3.a. Step 1: calculate the time that the projectile takes to fall 0.8m.

$s_{ver} = -0.8m$

$u_{ver} = 0m/s$

$a_{ver} = -10m/s/s$

$t_{ver} = ?$

$s = ut + at^2/2$

$t^2 = 2(s - ut)/a$

$t^2 = 2(-0.8 - 0)/-10$

$t^2 = 0.16s$

$t = 0.4s$

$v_{hor} = s_{hor}/t$

$v_{hor} = 0.2/0.4$

$v_{hor} = 0.5m/s$

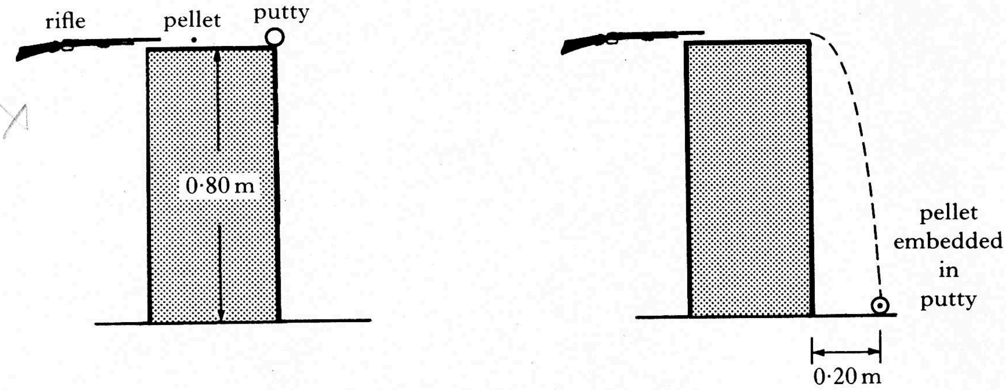
3.b.i. Momentum before(P_{before}) = Momentum after(P_{after})

b.ii. $m_{pellet}u_{pellet} + m_{putty}u_{putty} = (m_{pellet}+m_{putty})v$

$5.0x10^{-4}u_{pellet}+0.1x0 = (5.0x10^{-4}+0.1)0.5$

Marks

3. The diagrams below illustrate an experimental method which can be used to measure the speed of an air rifle pellet.



A lump of putty, of mass 0·10 kg, is resting on the edge of a bench of height 0·80 m. The pellet, of mass $5{\cdot}0 \times 10^{-4}$ kg, is fired at the lump of putty.

The putty, with the pellet embedded in it, lands 0·20 m from the foot of the bench as shown.

(*a*) Show that the horizontal velocity of the putty after the impact of the pellet is $0{\cdot}5\,\text{m}\,\text{s}^{-1}$. **3**

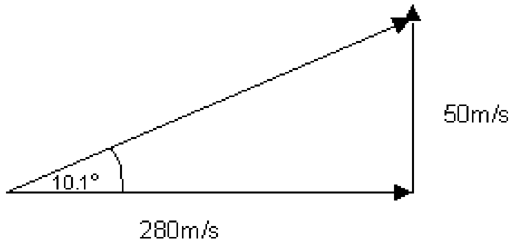
(*b*) (i) State the principle of conservation of momentum.

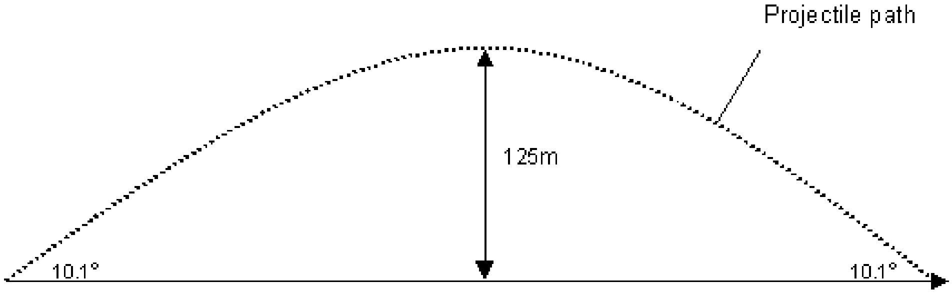
(ii) Using this principle, calculate the velocity of the pellet just before it strikes the putty. **3**

(*c*) Using only the apparatus above, suggest one way of improving the accuracy of this experiment. **1**

(7)

b.i.





The horizontal velocity of the projectile is constant at 280m/s. The vertical component of the motion will be up to a maximum height and then fall back down to earth.

b.ii. The maximum height reached by the dummy will occur when the vertical component(v_{ver}) of the velocity is zero.

$v_{ver}^2 = u_{ver}^2 + 2as_{ver}$

$s_{ver} = (v_{ver}^2 - u_{ver}^2)/2a$

$s_{ver} = (0^2 - 50^2)/2x(-10)$

$s_{ver} = -2500/-20$

$\mathbf{s_{ver} = 125m}$

3.a. Step 1: calculate the time that the projectile takes to fall 0.8m.

$s_{ver} = -0.8m$

$u_{ver} = 0m/s$

$a_{ver} = -10m/s/s$

$t_{ver} = ?$

$s = ut + at^2/2$

$t^2 = 2(s - ut)/a$

$t^2 = 2(-0.8 - 0)/-10$

$t^2 = 0.16s$

$t = 0.4s$

$v_{hor} = s_{hor}/t$

$v_{hor} = 0.2/0.4$

$v_{hor} = 0.5m/s$

3.b.i. Momentum before(P_{before}) = Momentum after(P_{after})

b.ii. $m_{pellet}u_{pellet} + m_{putty}u_{putty} = (m_{pellet}+m_{putty})v$

$5.0x10^{-4}u_{pellet}+0.1x0 = (5.0x10^{-4}+0.1)0.5$

Back to Table

$5.0\times10^{-4} u_{pellet} = 0.05025$

$u_{pellet} = 0.05025/5\times10^{-4}$

u_{pellet} = 100.5m/s

c. Reducing the mass of the lump of putty will mean that after the collision the pellet embedded in the putty will travel a greater horizontal displacement. This will give a more accurate horizontal velocity, which in turn will give a more accurate value of the pellets initial velocity.

4.a.i.

Pressure/kPa	89	96	103	110	117
Temperature/^{o}C	-20	0	20	40	60
Temperature/K	253	273	293	313	333

a.ii. Take each pair of pressure and temperature reading.
For each pair calculate P/T.

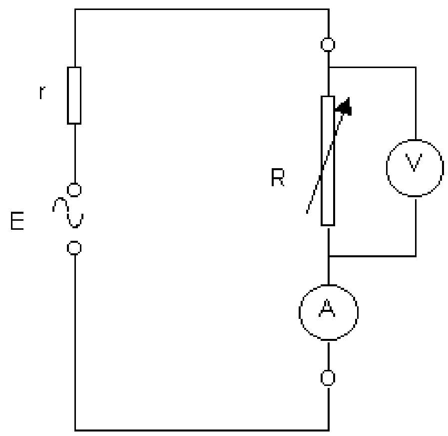
$89\times10^3/253 = 351.8$ Pa/K
$96\times10^3/273 = 351.6$ Pa/K
$103\times10^3/293 = 351.5$ Pa/K
$110\times10^3/313 = 351.4$ Pa/K
$117\times10^3/333 = 351.3$ Pa/K

From these calculations it is clear that : P/T = Constant

a.iii. As the temperature increases the helium atoms have more kinetic energy. With increased kinetic energy the atoms are moving faster and collide with the container walls, and the pressure probe, more frequently and forcefully. The pressure(force/area) therefore increases.

b.i. P/T = constant
T = P/constant
T = 24000Pa/(351.5Pa/K)
T = 68.3K

5.a.i.



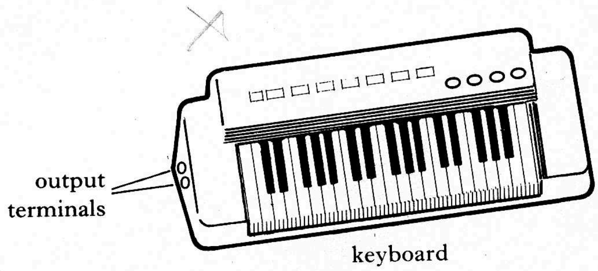
The variable resistor is connected across the audio output terminals. The voltmeter is connected across this resistor and the ammeter measures the current in the circuit.

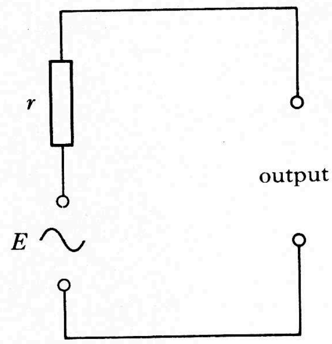
a.ii. The internal resistance has a value equal to the negative gradient of the graph.

Marks

5. (*a*) An electronic keyboard contains an audio amplifier with output terminals which can be connected to a loudspeaker.

When a key is pressed, the amplifier may be considered as a source of e.m.f. E and internal resistance r in series, as shown below.

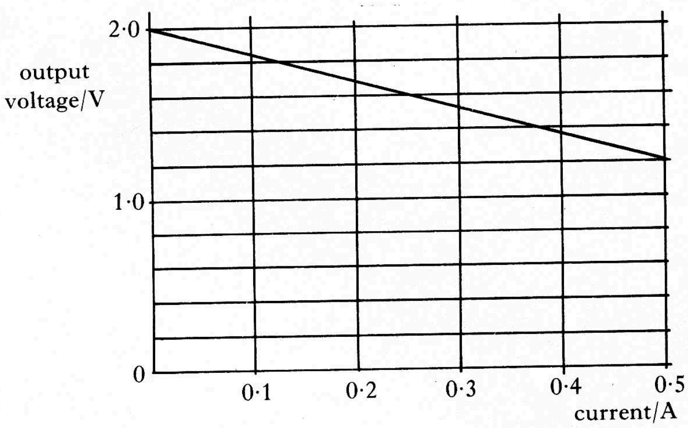




In an experiment to measure the internal resistance of the amplifier, the following equipment is used:

keyboard
a.c. ammeter
a.c. voltmeter
variable resistor.

The graph below displays the results of the experiment.



(i) Describe how the apparatus is used to obtain the data for this graph. Your answer must include a circuit diagram.

(ii) Calculate the value of the internal resistance of the amplifier.

(iii) A loudspeaker of resistance $4{\cdot}0\,\Omega$ is now connected across the output terminals of the amplifier and a key is pressed.

What is the output voltage across the loudspeaker? **7**

Marks

5. (continued)

(*b*) The internal resistance of a power supply can be measured with a voltmeter and a **calibrated** variable resistor.

First, the e.m.f. of the power supply is measured using the voltmeter as shown in Figure 1.

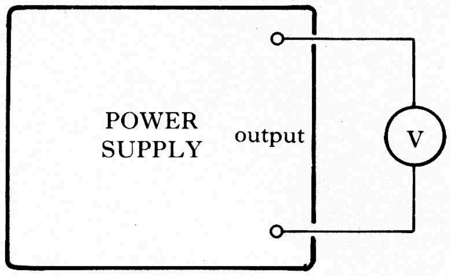


Figure 1

The variable resistor is then connected, as in Figure 2, and adjusted until the output p.d. is equal to half the e.m.f.

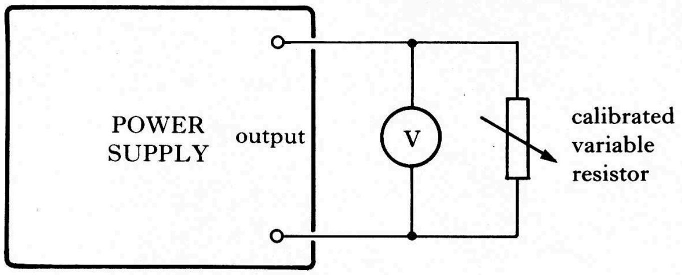


Figure 2

Explain how these measurements can be used to obtain the value of the internal resistance of the power supply. **2**

(9)

[Turn over

Back to Table

$5.0\times10^{-4}u_{pellet} = 0.05025$

$u_{pellet} = 0.05025/5\times10^{-4}$

$\mathbf{u_{pellet} = 100.5m/s}$

c. Reducing the mass of the lump of putty will mean that after the collision the pellet embedded in the putty will travel a greater horizontal displacement. This will give a more accurate horizontal velocity, which in turn will give a more accurate value of the pellets initial velocity.

4.a.i.

Pressure/kPa	89	96	103	110	117
Temperature/^{o}C	-20	0	20	40	60
Temperature/K	253	273	293	313	333

a.ii. Take each pair of pressure and temperature reading.
For each pair calculate P/T.

$89\times10^{3}/253 = 351.8$ Pa/K
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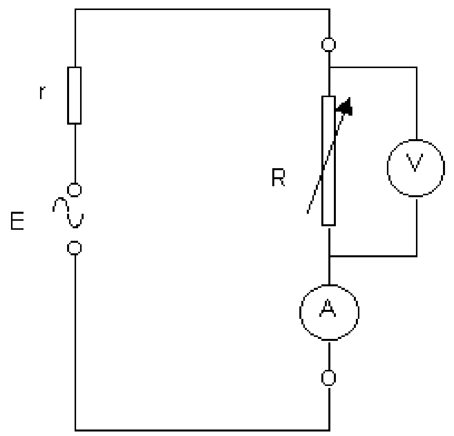
$117\times10^{3}/333 = 351.3$ Pa/K

From these calculations it is clear that : P/T = Constant

a.iii. As the temperature increases the helium atoms have more kinetic energy. With increased kinetic energy the atoms are moving faster and collide with the container walls, and the pressure probe, more frequently and forcefully. The pressure(force/area) therefore increases.

b.i. P/T = constant
T = P/constant
T = 24000Pa/(351.5Pa/K)
T = 68.3K

5.a.i.



The variable resistor is connected across the audio output terminals. The voltmeter is connected across this resistor and the ammeter measures the current in the circuit.

a.ii. The internal resistance has a value equal to the negative gradient of the graph.

Back to Table

r = -m

$m = (y_2 - y_1)/(x_2 - {}_1)$
m = (2-1.2)/(0-0.5)
m = -1.6Ω

=>**r=1.6Ω**

a.iii. The emf of the supply is equal to the output voltage when there is no current in the circuit.

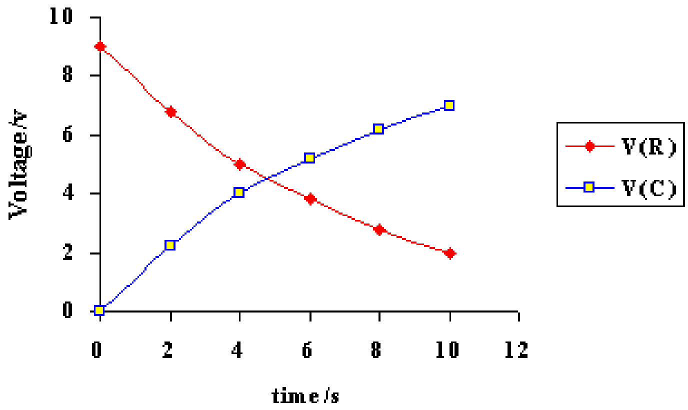
E = 2.0V

I = E/(R+r)
I = 2.0/(4+1.6)
I = 0.357A

$V_{loudspeaker}$ = IR
$V_{loudspeaker}$ = 0.357x4
$V_{loudspeaker}$ = 1.4V

b. When the voltage drop across the internal resistor and the calibrated variable resistor is the same, as will be the case when the voltage across the calibrated resistor is equal to half of the emf, the internal resistor and the calibrated resistor must have the same value.

6.a.



b. $V_s = V_R + V_c$
$V_R = V_s - V_c$
V_R = 9-6
V_R = 3V

I = V_R/R
I = 3/6800
I = 441.2μA

c.i. When fully charged: V_c = 9V

Energy stored in capacitor = Energy dissipated in resistor
$E = CV^2/2$
$E = 1000\times10^{-6}\times9^2/2$
E = 40.5mJ

c.ii. The energy dissipated in the 20Ω resistor will be the same as that dissipated in the 10Ω. This is because

$r = -m$

$m = (y_2 - y_1)/(x_2 - {}_1)$
$m = (2-1.2)/(0-0.5)$
$m = -1.6\Omega$

=>**$r=1.6\Omega$**

a.iii. The emf of the supply is equal to the output voltage when there is no current in the circuit.

$E = 2.0V$

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$I = 2.0/(4+1.6)$
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$V_{loudspeaker} = IR$
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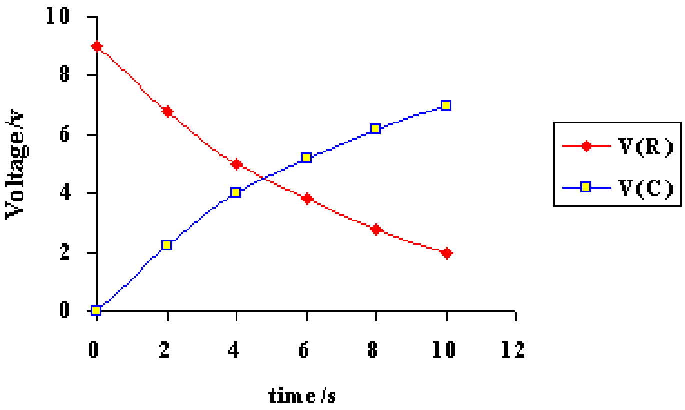
6.a.



b. $V_S = V_R + V_C$
$V_R = V_S - V_C$
$V_R = 9-6$
$V_R = 3V$

$I = V_R/R$
$I = 3/6800$
$I = 441.2\mu A$

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$E = CV^2/2$
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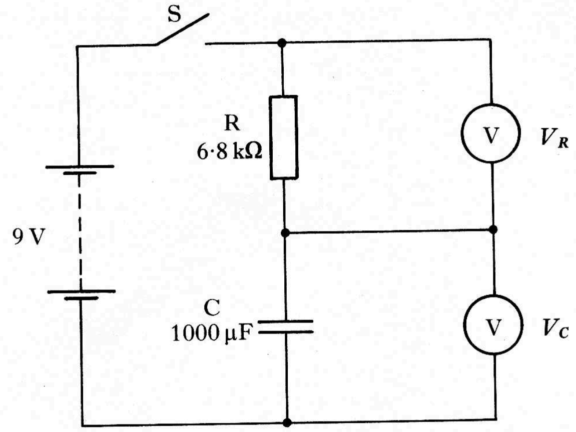
$E = 40.5mJ$

c.ii. The energy dissipated in the 20Ω resistor will be the same as that dissipated in the 10Ω. This is because

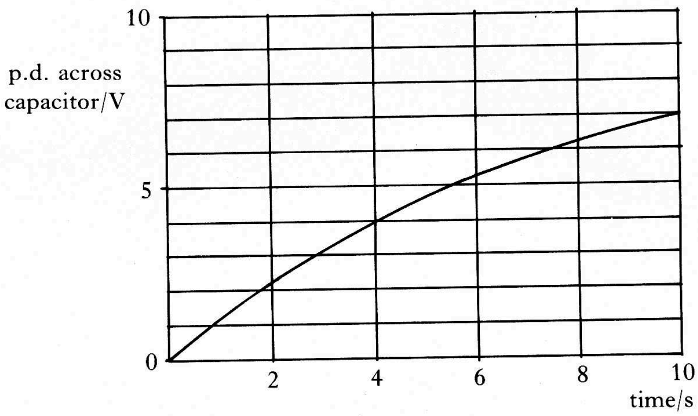
Marks

6. The following circuit is set up to investigate the charging of a capacitor.



At the start of the experiment the capacitor is uncharged.

(*a*) The graph below shows how the p.d. V_C across the capacitor varies with time from the instant the switch S is closed.



Sketch a graph showing how the p.d. V_R across the resistor varies with time during the first 10 s of charging. **2**

(*b*) Calculate the current in the circuit at the instant the p.d. across the capacitor is 6·0 V. **2**

(*c*) (i) When the capacitor is fully charged, it is removed from the circuit and connected across a 10 Ω resistor.

What is the total energy dissipated in the resistor?

(ii) In another experiment, the fully charged capacitor is connected across a 20 Ω resistor instead of the 10 Ω resistor.

How does the energy dissipated in this resistor compare with that calculated in part (i)? You must justify your answer. **3**

(7)

Back to Table

$r = -m$

$m = (y_2 - y_1)/(x_2 - {}_1)$
$m = (2-1.2)/(0-0.5)$
$m = -1.6\Omega$

$\Rightarrow r=1.6\Omega$

a.iii. The emf of the supply is equal to the output voltage when there is no current in the circuit.

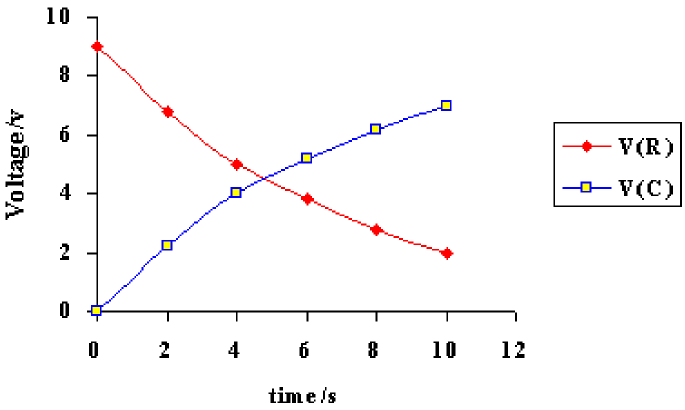
$E = 2.0V$

$I = E/(R+r)$
$I = 2.0/(4+1.6)$
$I = 0.357A$

$V_{loudspeaker} = IR$
$V_{loudspeaker} = 0.357x4$
$V_{loudspeaker} = 1.4V$

b. When the voltage drop across the internal resistor and the calibrated variable resistor is the same, as will be the case when the voltage across the calibrated resistor is equal to half of the emf, the internal resistor and the calibrated resistor must have the same value.

6.a.



b. $V_s = V_R + V_c$
$V_R = V_s - V_c$
$V_R = 9-6$
$V_R = 3V$

$I = V_R/R$
$I = 3/6800$
$I = 441.2\mu A$

c.i. When fully charged: $V_c = 9V$

Energy stored in capacitor = Energy dissipated in resistor
$E = CV^2/2$
$E = 1000x10^{-6}x9^2/2$
$E = 40.5mJ$

c.ii. The energy dissipated in the 20Ω resistor will be the same as that dissipated in the 10Ω. This is because

the energy stored in the capacitor is still the same. The only difference is that it will take longer for the capacitor to discharge when connected across the 20Ω resistor.

7.a.i. Equate the energy gained from the electric field(E_{elect}) to the final kinetic energy (E_k)of the electron.

$E_{elect} = E_k$

$qV = m_e v^2/2$

$v^2 = 2qV/m_e$

$v^2 = 2x1.6x10^{-19}x5000/9.11x10^{-31}$

$v^2 = 1.75x10^{15}$

$v = 41.9x10^6 m/s$

a.ii. $v_2 = (2qV/m_e)^{1/2}$

$v_2 = (2x1.6x10^{-19}x2500/9.11x10^{-31})^{1/2}$

$v_2 = 29.6x10^6 m/s$

$v_1 = const\ x\ V_1^{1/2}$

$v_2 = const\ x\ (V_1/2)^{1/2}$

$v_2/v_1 = const\ x\ (V_1/2)^{1/2}/const\ x\ (V_1)^{1/2}$

$v_2/v_1 = 1/sqrt2$

$v_2 = v_1/sqrt2$

b. Q = It (Q= total charge)

Nq = It (N = number of electrons & q = electronic charge)

N = It/q

$N = 15x10^{-3}x1/1.6x10^{-19}$

$N = 9.375x10^{16}$

8.a.i. $V_{pk} = 1.5x0.05$

$V_{pk} = 0.075V$

a.ii. $R_f/R_1 = - V_{out}/V_{in}$

$R_f = -R_1V_{out}/V_{in}$

$R_f = -10000x(0.9/-0.075)$

$R_f = 120000\Omega$

$R_f = 120k\Omega$

b.i. $V_{out} = (R_f/R_1)(V_2-V_1)$

$V_{out} = (5x10^6/10x10^3)(0.4x10^{-3})$

$V_{out} = 500x0.40x10^{-3}$

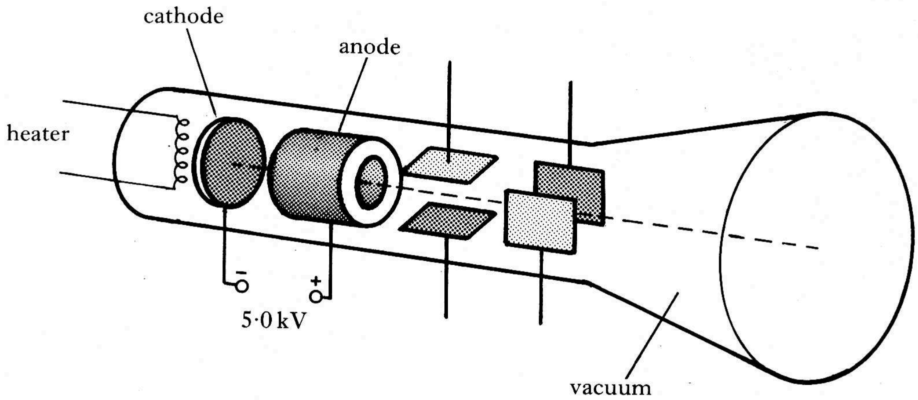
$V_{out} = 0.2V$

b.ii. The differential amplifier amplifies the difference between the inverting and non inverting input. The 50Hz mains signal will be input into both these inputs and will therefore be filtered out. This will leave only the amplified potential difference between the two pads.

9.a.i.

Marks

7. The diagram illustrates a cathode ray tube used in an oscilloscope.



Electrons released from the hot cathode are accelerated by a p.d. of 5·0 kV between the cathode and anode.

(*a*) (i) Assuming that an electron starts from rest at the cathode, calculate its speed just before it reaches the anode. (You may have to refer to the Science Data Booklet.)

(ii) What is the effect on the speed of the electron just before it reaches the anode if the p.d. between the cathode and anode is halved? Show your reasoning. **5**

(*b*) If the electron beam current is 15 mA, how many electrons leave the cathode each second? (You may have to refer to the Science Data Booklet.) **2**

(7)

[Turn over

the energy stored in the capacitor is still the same. The only difference is that it will take longer for the capacitor to discharge when connected across the 20Ω resistor.

7.a.i. Equate the energy gained from the electric field(E_{elect}) to the final kinetic energy (E_k)of the electron.

$E_{elect} = E_k$
$qV = m_e v^2/2$
$v^2 = 2qV/m_e$
$v^2 = 2x1.6x10^{-19}x5000/9.11x10^{-31}$
$v^2 = 1.75x10^{15}$
$v = 41.9x10^6$m/s

a.ii. $v_2 = (2qV/m_e)^{1/2}$
$v_2 = (2x1.6x10^{-19}x2500/9.11x10^{-31})^{1/2}$
$v_2 = 29.6x10^6$m/s

$v_1 = const\ x\ V_1^{1/2}$
$v_2 = const\ x\ (V_1/2)^{1/2}$

$v_2/v_1 = const\ x\ (V_1/2)^{1/2}/const\ x\ (V_1)^{1/2}$
$v_2/v_1 = 1/sqrt2$
$v_2 = v_1/sqrt2$

b. Q = It (Q= total charge)
Nq = It (N = number of electrons & q = electronic charge)
N = It/q
$N = 15x10^{-3}x1/1.6x10^{-19}$
$N = 9.375x10^{16}$

8.a.i. $V_{pk} = 1.5x0.05$
$V_{pk} = 0.075V$

a.ii. $R_f/R_1 = -\ V_{out}/V_{in}$
$R_f = -R_1V_{out}/V_{in}$
$R_f = -10000x(0.9/-0.075)$
$R_f = 120000\Omega$
$R_f = 120k\Omega$

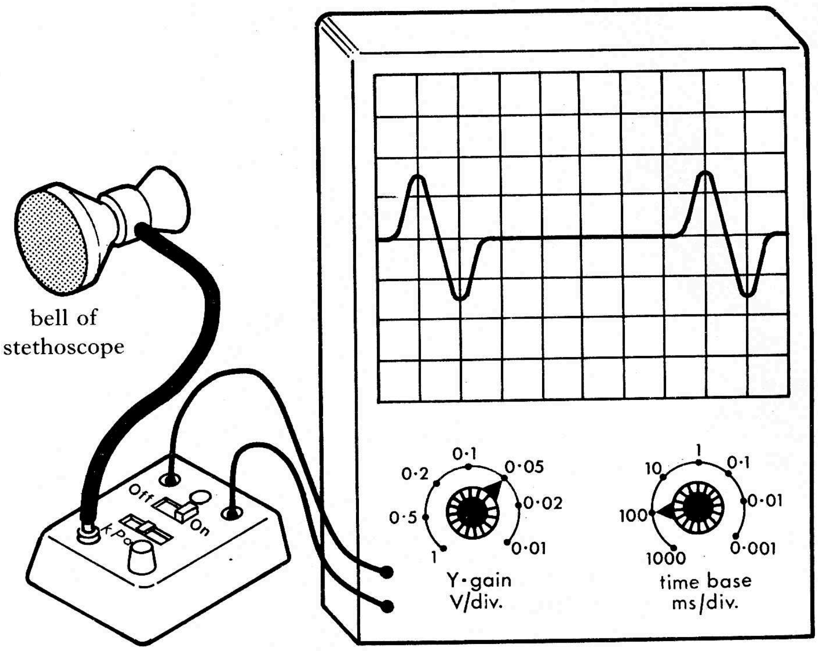
b.i. $V_{out} = (R_f/R_1)(V_2-V_1)$
$V_{out} = (5x10^6/10x10^3)(0.4x10^{-3})$
$V_{out} = 500x0.40x10^{-3}$
$V_{out} = 0.2V$

b.ii. The differential amplifier amplifies the difference between the inverting and non inverting input. The 50Hz mains signal will be input into both these inputs and will therefore be filtered out. This will leave only the amplified potential difference between the two pads.

9.a.i.

Marks

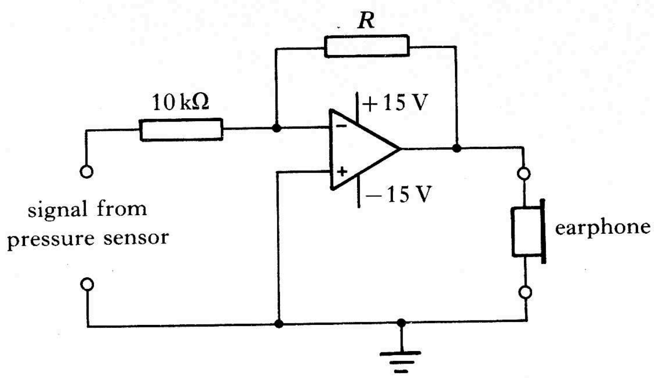
8. (*a*) A health physicist builds an electronic stethoscope system to monitor heart beats.



The trace shown is obtained when the oscilloscope has a Y-gain setting of 0·05 V/division.

(i) What is the peak voltage of the signal shown on the oscilloscope?

(ii) The following circuit is designed to amplify the signal from the electronic stethoscope to enable a doctor to hear the heart beats.



A peak output voltage of 0·90 V is required to operate the earphone.

What should be the value of the resistor R? **2**

the energy stored in the capacitor is still the same. The only difference is that it will take longer for the capacitor to discharge when connected across the 20Ω resistor.

7.a.i. Equate the energy gained from the electric field(E_{elect}) to the final kinetic energy (E_k)of the electron.

$E_{elect} = E_k$
$qV = m_e v^2/2$
$v^2 = 2qV/m_e$
$v^2 = 2x1.6x10^{-19}x5000/9.11x10^{-31}$
$v^2 = 1.75x10^{15}$
$v = 41.9x10^6 m/s$

a.ii. $v_2 = (2qV/m_e)^{1/2}$
$v_2 = (2x1.6x10^{-19}x2500/9.11x10^{-31})^{1/2}$
$v_2 = 29.6x10^6 m/s$

$v_1 = const\ x\ V_1^{1/2}$
$v_2 = const\ x\ (V_1/2)^{1/2}$

$v_2/v_1 = const\ x\ (V_1/2)^{1/2}/const\ x\ (V_1)^{1/2}$
$v_2/v_1 = 1/sqrt2$
$v_2 = v_1/sqrt2$

b. Q = It (Q= total charge)
Nq = It (N = number of electrons & q = electronic charge)
N = It/q
$N = 15x10^{-3}x1/1.6x10^{-19}$
$N = 9.375x10^{16}$

8.a.i. $V_{pk} = 1.5x0.05$
$V_{pk} = 0.075V$

a.ii. $R_f/R_1 = -V_{out}/V_{in}$
$R_f = -R_1 V_{out}/V_{in}$
$R_f = -10000x(0.9/-0.075)$
$R_f = 120000\Omega$
$R_f = 120k\Omega$

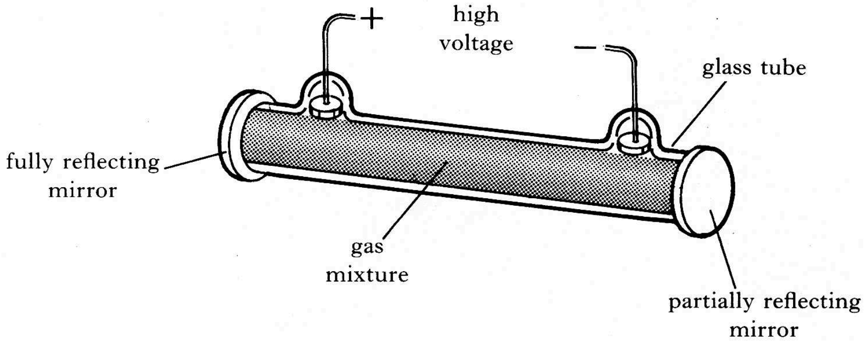
b.i. $V_{out} = (R_f/R_1)(V_2-V_1)$
$V_{out} = (5x10^6/10x10^3)(0.4x10^{-3})$
$V_{out} = 500x0.40x10^{-3}$
$V_{out} = 0.2V$

b.ii. The differential amplifier amplifies the difference between the inverting and non inverting input. The 50Hz mains signal will be input into both these inputs and will therefore be filtered out. This will leave only the amplified potential difference between the two pads.

9.a.i.

Marks

9. The diagram shows a simplified view of a laser tube used in a gas laser.

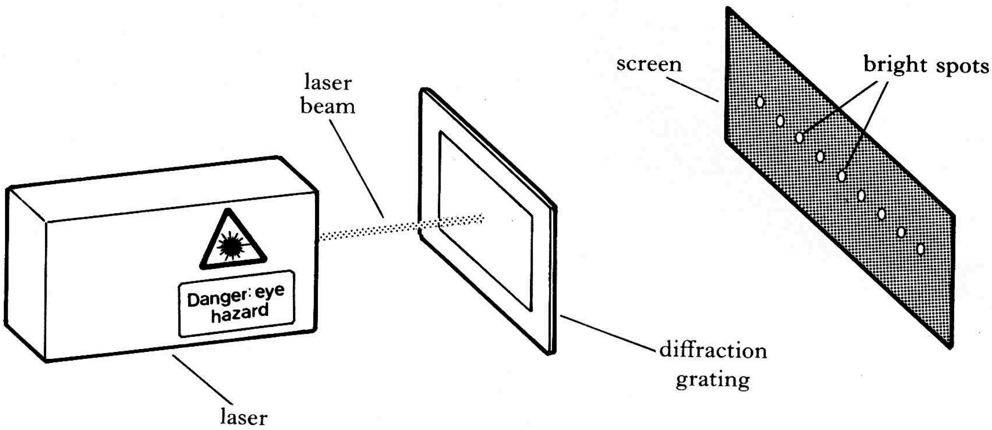


(*a*) The name LASER stands for Light Amplification by Stimulated Emission of Radiation.

(i) What is meant by "stimulated emission"?

(ii) Explain the purpose of each mirror in the laser tube. **4**

(*b*) In the experiment shown below, a laser beam is directed at a diffraction grating.



A pattern of bright spots is observed on the screen.

Explain, in terms of the wave nature of light, how this pattern is formed. **2**

Marks

9. (continued)

(*c*) The laser is marked with the warning "DANGER: EYE HAZARD".

Why does this laser, which has a power output of only 0·20 mW, present a greater potential eye hazard than a 100 W lamp? **2**

(*d*) In hospitals, pulsed lasers may be used to repair damage to the retina of the eye. The specification of a typical pulsed laser is given below:

gas used in laser	: argon
duration of pulse	: 0·50 ms
energy of one pulse	: 0·10 J
wavelengths of laser light emitted	: 488 and 514 nm.

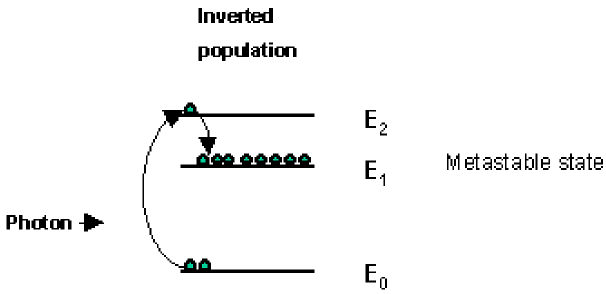
The cross-sectional area of the laser beam at the retina is $1{\cdot}5 \times 10^{-9}\,m^2$.

Calculate the light intensity produced at the retina during a pulse of light from this laser. **3**

(11)

[Turn over

Back to Table



The high voltage pumps electrons up into energy state(E_2) which then fall into the metastable state E_1 creating what is called an inverted population. A passing photon, having an energy equal to the energy gap E_1 to E_0 can encourage/stimulate an electron to drop from energy state E_1 to E_2. This is the basis for stimulated emission.

Note: This energy level diagram is only an illustration to help with the understanding of the concept of energy levels. Each different laser will have a different energy level diagram.

a.ii. The fully reflecting mirror keeps all the photons in the laser cavity to enable further stimulated emission. The partially reflecting mirror not only ensures some reflection to sustain the stimulated emission but also allows a narrow beam of laser light to leave the cavity.

b. Each bright spot occurs when the laser light interferes constructively. This happens when the path difference, from each adjacent slit in the diffraction grating to the screen, is a whole number of wavelengths.

In between the bright spots dark areas are produced when the laser light interferes destructively. The laser light will completely cancel when the path difference, from each adjacent slit in the diffraction grating to the screen, is an odd number of wavelengths/2.

c. The energy from any laser light entering the eye is concentrated into a very small area. This produces a very intense beam that will produce significant damage to the retina.(I = P/A)

The energy emitted from a 100W lamp is spread over a much larger area. This results in relatively low intensity light that will not result in any damage to the eye.

d. $I = P/A$
$P = E/t$

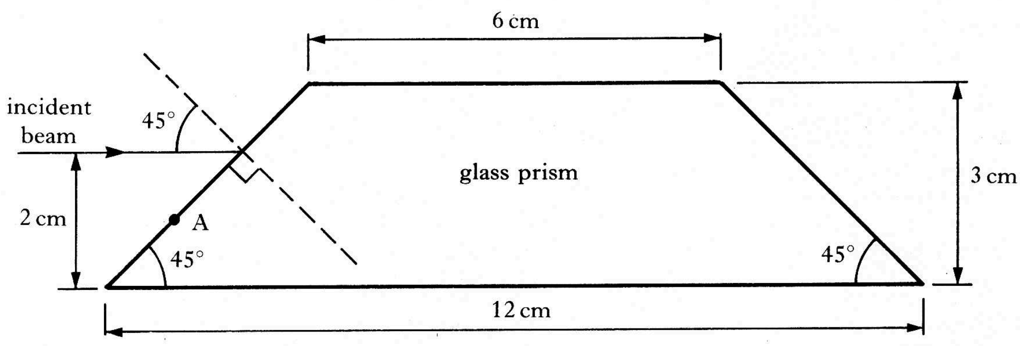
$\Rightarrow I = E/At$
$I = 0.1/1.5\times10^{-9}\times0.5\times10^{-3}$
$\mathbf{I = 133\times10^{9} W/m^{2}}$

10.a.i. $\theta_{critical} = \sin^{-1}(1/n)$
$\theta_{critical} = \sin^{-1}(1/1.52)$
$\theta_{critical} = \sin^{-1}(0.658)$
$\mathbf{\theta_{critical} = 41.1^{o}}$

a.ii.

Marks

10. A pupil finds a glass prism of the shape shown below when she dismantles an old optical instrument.



To investigate the optical properties of the prism, she directs a narrow beam of red light towards the prism as shown.

The glass prism has a refractive index of 1·52 for this red light.

(*a*) (i) Calculate the value of the critical angle for this light in the glass prism.

(ii) On the square-ruled paper provided, draw the prism with the dimensions stated in the diagram.

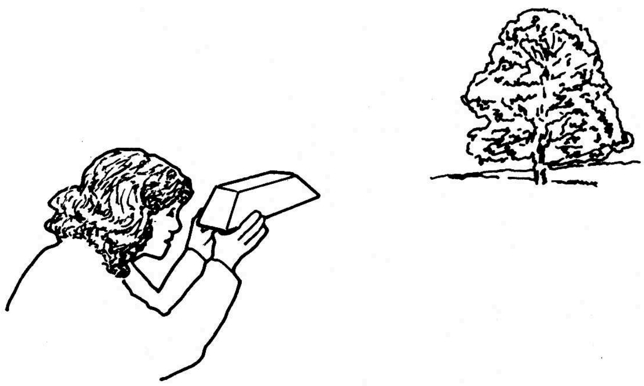
On your diagram, show the passage of the light beam until after it emerges from the prism.

Mark on your diagram the values of all relevant angles.

(iii) A second beam of light, parallel to the first and of the same wavelength, is now directed onto the prism at A.

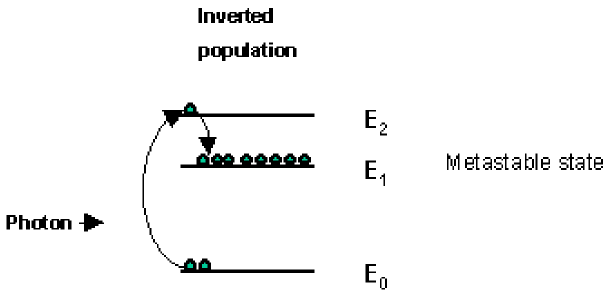
Add to your diagram the complete path of this beam through the prism. **7**

(*b*) How would a distant object appear when viewed through the prism when it is held as shown below?



1

(8)



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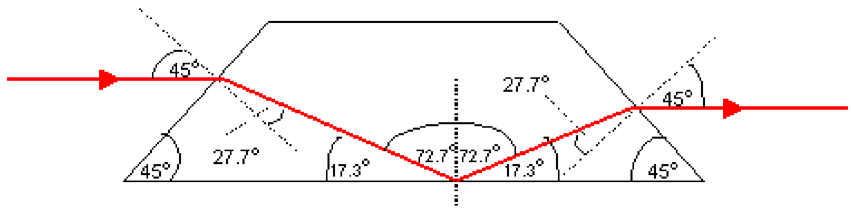
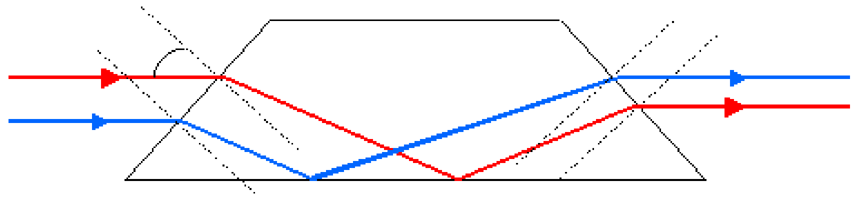
a.ii.



Note: This diagram has not been drawn to scale.

a.iii.



Angles have been omitted for clarity.

b. The image would be **inverted.**

11.a.i. Atomic number(Z) 95 = Number of protons in the nucleus.
Mass number(A) 241 = Number of protons + number of neutrons in the nucleus.

a.ii. 30kBq means that there are 30,000 nuclear disintegrations per second, or equivalently, 30000 nuclei decay every second.

a.iii. Radiation can cause atoms or molecules to lose electrons and become positive ions. These atoms, or molecules, have been ionised by the ionising radiation.

a.iv. Use conservation of atomic and mass number to find the type of radiation.

Mass Number
241 = 237 + A
A = 4

Atomic number
95 = 93 + Z
z = 2

Radiation = $^{4}_{2}He$ (alpha radiation)

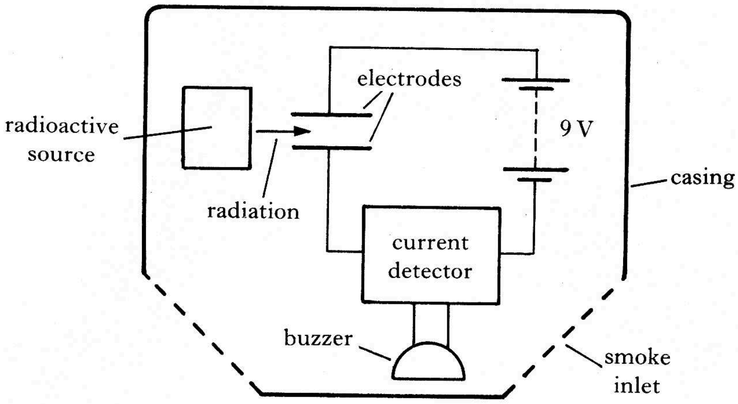
a.v. Smoke detectors are usually located on the roof of rooms. This means that any alpha radiation emitted will either be absorbed by the smoke detector construction or the surrounding air, making it impossible for the radiation to cause any biological damage.

b.i. Radioactive isotopes contained in natural rocks or soil contribute to background radiation.

Marks

11. Smoke detectors are important in giving early warning of fire starting in the home.

(*a*) The simplified layout of one type of smoke detector is illustrated below.



The following is an extract from the manufacturer's data sheet.

"The detector uses a low energy source of ionising radiation, 30 kBq Americium 241, which causes ionisation of the air molecules, and hence a small current between the electrodes. When smoke particles enter the space between the electrodes, they impede the flow of ions and the current is reduced. When the current falls below a certain value, the buzzer sounds."

(i) The symbol for the radioactive source used is $^{241}_{95}\text{Am}$.

What information is given by the numbers 95 and 241?

(ii) What is meant by "30 kBq"?

(iii) Explain what is meant by "ionising radiation".

(iv) The equation for the decay of this source is

$$^{241}_{95}\text{Am} \longrightarrow {}^{237}_{93}\text{Np} + \text{radiation}$$

Identify the type of radiation emitted in this decay and explain why this particular type of radiation is used in the smoke detector.

(v) The half-life of Americium 241 is 458 years.

Discuss the advantage of using this source compared to one with a half-life of 5 years. **7**

(*b*) The workers in the factory assembling this type of smoke detector will experience a higher radiation dose equivalent than that due to background radiation alone.

(i) State one factor contributing to background radiation.

(ii) It is recommended that the workers assembling the smoke detectors should not receive a dose equivalent rate greater than 5·0 mSv per year above the background level.

A worker in a factory making smoke detectors assembles 15 000 detectors in a year.

An absorbed dose of $1{\cdot}2 \times 10^{-8}$ Gy is received by the worker in assembling one detector and the quality factor of the radiation is 20.

Show, by calculation, whether the permissible level of 5·0 mSv per year will be exceeded for the worker. **4**

(11)

[*END OF QUESTION PAPER*]

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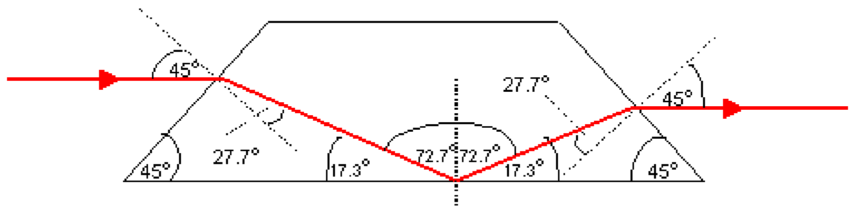

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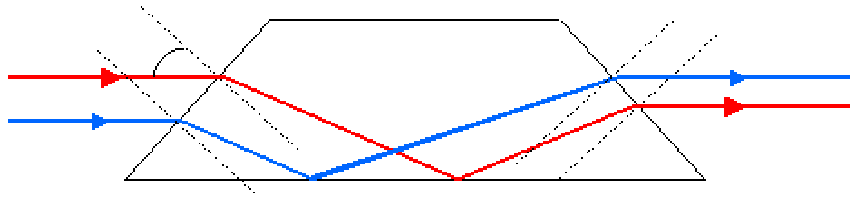
a.iii.



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a.iv. Use conservation of atomic and mass number to find the type of radiation.

Mass Number
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Radiation = $^{4}_{2}He$ (alpha radiation)

a.v. Smoke detectors are usually located on the roof of rooms. This means that any alpha radiation emitted will either be absorbed by the smoke detector construction or the surrounding air, making it impossible for the radiation to cause any biological damage.

b.i. Radioactive isotopes contained in natural rocks or soil contribute to background radiation.

b.ii. Total absorbed dose = dose per detector x number of detectors

Total absorbed dose = $1.2\times10^{-8}\times15000$

Total absorbed dose = 180µGy

Dose equivalent = Absorbed dose x Quality factor

H = DQ

H = $180\times10^{-6}\times20$

H = 3.6mSv

The permissible level of 5mSv per year is NOT exceeded.

END OF QUESTION PAPER

Return to past paper index page.

1993 Paper 1 (Multiple Choice)

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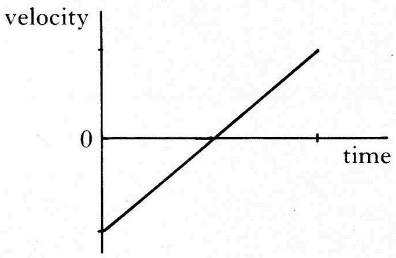
1. D	11. E	21. B
2. B	12. B	22. A
3. C	13. C	23. E
4. D	14. E	24. A
5. A	15. E	25. A
6. D	16. C	26. C
7. B	17. A	27. C
8. E	18. B	28. D
9. A	19. E	29. B
10.D	20. C	30. D

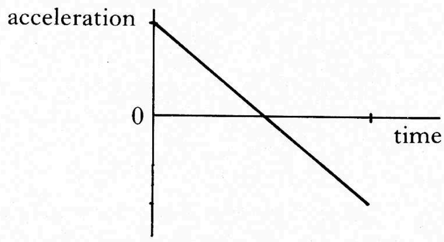
SECTION A

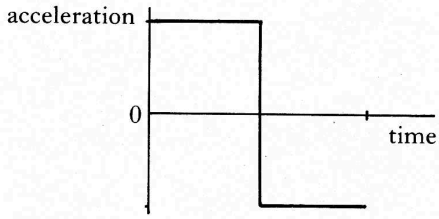
Answer questions 1–30 on the answer sheet.

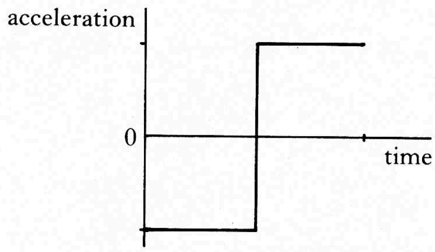
1. The following velocity-time graph represents the motion of a trolley.

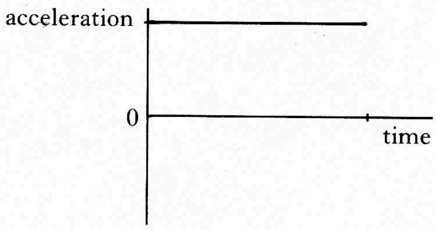


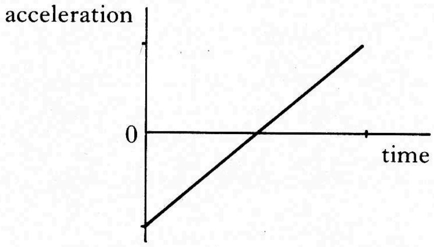
Which of the graphs below is the acceleration-time graph for the motion?

A


B


C


D


E


[Turn over

2. A car accelerates uniformly from rest and travels a distance of 60 m in 6·0 s. The acceleration of the car, in $m\,s^{-2}$, is

A 0·83

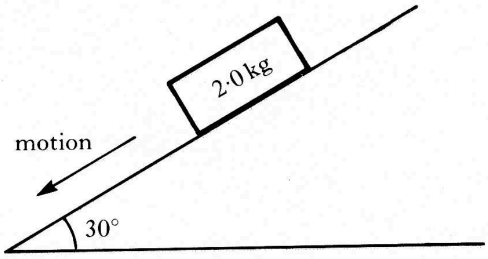
B 3·3

C 5·0

D 10

E 20.

3. A block of wood, of mass 2·0 kg, slides with a constant velocity down a slope. The slope makes an angle of 30° with the horizontal as shown in the diagram.



What is the value of the force of friction acting on the block?

A 1·0 N

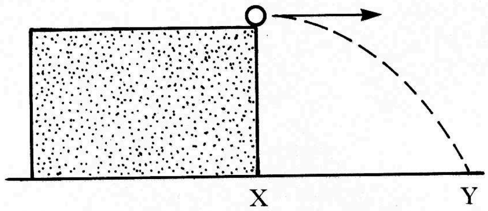
B 1·7 N

C 9·8 N

D 17·0 N

E 19·6 N

4. A ball is projected with a horizontal velocity from a bench. The ball travels a horizontal distance, XY, as shown.



Which of the following is/are used to calculate the distance XY?

I The mass of the ball

II The height of the table

III The horizontal velocity of the ball

A II only

B III only

C I and III only

D II and III only

E I, II and III

5. The unit of momentum is

A $kg\,m\,s^{-1}$

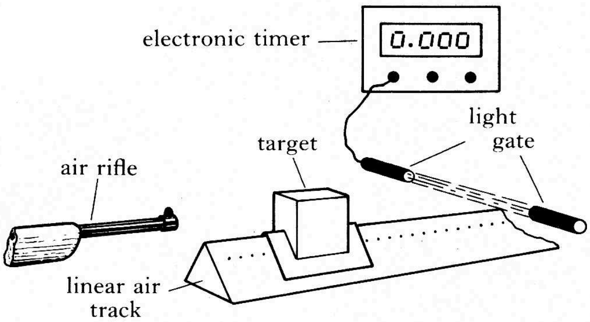
B $N\,m$

C $N\,m\,s^{-1}$

D $kg\,m\,s^{-2}$

E $N\,kg^{-1}$.

6. The experimental arrangement shown below is used to measure the speed of an air rifle pellet.



The speed of the pellet is calculated from the equation

$$\text{speed of pellet} = \frac{\text{final mass of target} \times \text{speed of target}}{\text{mass of pellet}}$$

The results from one experiment are

final mass of target $= (2{\cdot}00 \pm 0{\cdot}02)\,\text{kg}$

mass of pellet $= (10{\cdot}0 \pm 0{\cdot}5)\,\text{g}$

speed of target $= (0{\cdot}50 \pm 0{\cdot}01)\,\text{m s}^{-1}$

Which of the following gives a good estimate of the percentage error in the calculated speed of the pellet?

A 1%

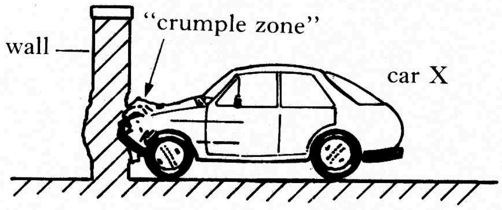
B 2%

C 3%

D 5%

E 8%

7. Car X is designed with a "crumple zone" so that the front of the car collapses during impact as shown in the diagram below.



A similar car, Y, of equal mass is built without a crumple zone. Both cars hit a wall at the same speed.

Comparing car X with car Y, which of the following statements is/are true during the collisions?

I The average force on car X is smaller.

II The time taken for car X to come to rest is greater.

III The change in momentum of car X is smaller.

A I only

B I and II only

C I and III only

D II and III only

E I, II and III

8. The pressure of a gas can be affected by factors such as its mass, its density, its volume and its temperature. Pressure is inversely proportional to volume if

A mass alone is constant

B density alone is constant

C temperature alone is constant

D mass and density are constant

E mass and temperature are constant.

9. A liquid is heated from 17 °C to 50 °C. The temperature **rise**, on the kelvin scale, is

A 33 K

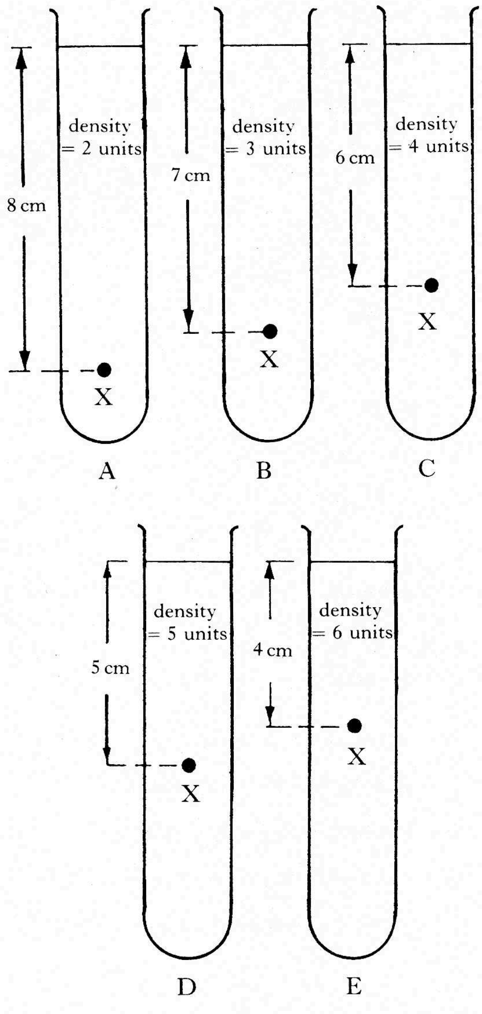
B 67 K

C 306 K

D 340 K

E 579 K.

10. Five liquids of different density are contained in separate, identical test tubes. The density of each liquid is given in the diagram. In which tube is the pressure greatest at point X?



11. A diver's air cylinder has a capacity of $0{\cdot}06\,m^3$. $4{\cdot}0\,m^3$ of air with a density of $1{\cdot}44\,kg\,m^{-3}$ is compressed into it. What is the density of the air in the cylinder?

A $0{\cdot}02\,kg\,m^{-3}$

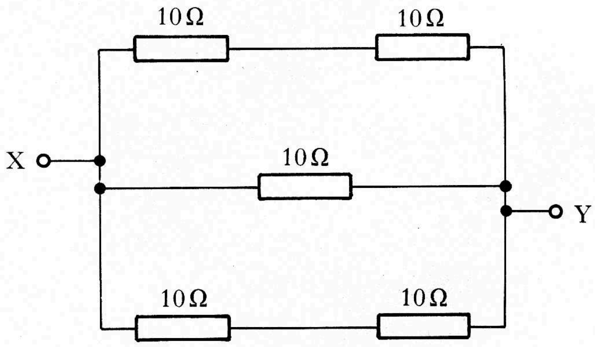
B $0{\cdot}17\,kg\,m^{-3}$

C $5{\cdot}76\,kg\,m^{-3}$

D $6{\cdot}00\,kg\,m^{-3}$

E $96{\cdot}0\,kg\,m^{-3}$

12. The diagram below shows part of an electrical circuit.



What is the resistance between X and Y?

A 0·2 Ω

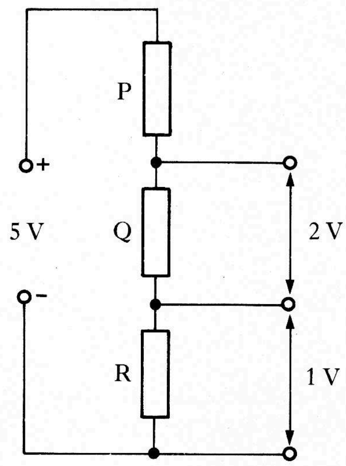
B 5 Ω

C 10 Ω

D 20 Ω

E 50 Ω

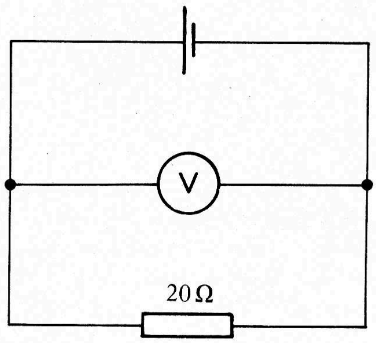
13. The circuit shown below is used to provide potential differences of 2 volts and 1 volt from a 5 volt supply with zero internal resistance.



Which of the following gives possible values, in kilohms, for resistors P, Q and R?

	P	Q	R
A	1	1	2
B	2	1	2
C	2	2	1
D	3	2	2
E	3	2	3

14. The reading on the high resistance voltmeter in the circuit shown below is 1·0 V.



The e.m.f. of the cell is 1·5 V.

The internal resistance of the cell is

A 0·1 Ω

B 0·5 Ω

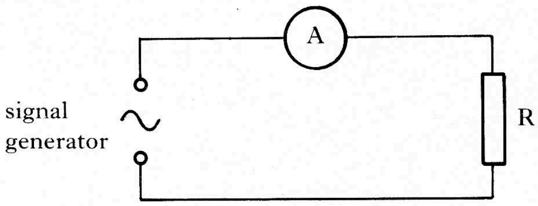
C 1·0 Ω

D 2·5 Ω

E 10 Ω.

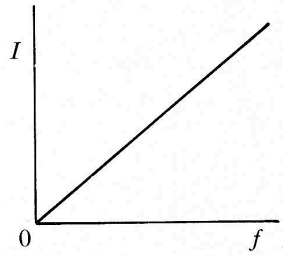
[Turn over

15. A resistor and an ammeter are connected to a signal generator having an output of constant amplitude and variable frequency.

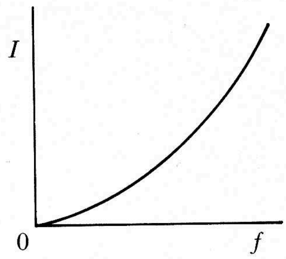


Which of the following graphs shows the correct relationship between the current I in the resistor and the output frequency f of the signal generator?

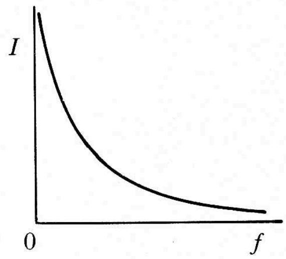
A



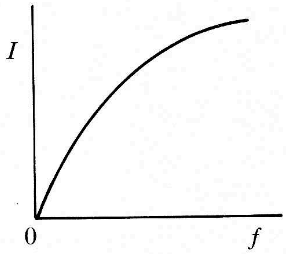
B



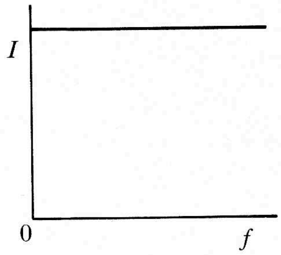
C



D



E



16. The energy stored in a capacitor, of capacitance C, when holding a charge Q is given by

A $\frac{1}{2}QC$

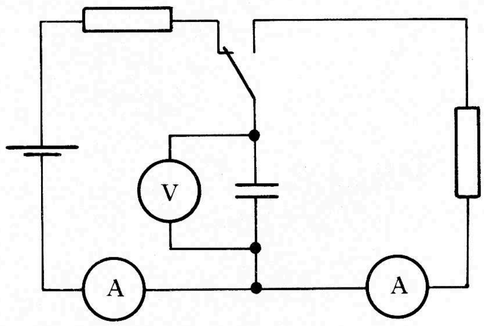
B $\frac{1}{2}\frac{Q}{C^2}$

C $\frac{1}{2}\frac{Q^2}{C}$

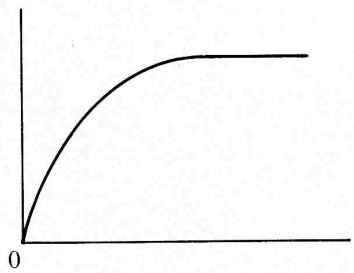
D $\frac{1}{2}QC^2$

E $\frac{1}{2}Q^2C$.

17. The circuit shown is used in an experiment to study the charging and discharging of a capacitor.



The unlabelled graph below is drawn using the results obtained during the experiment.



It is a graph of

A p.d. across the capacitor against time during charging

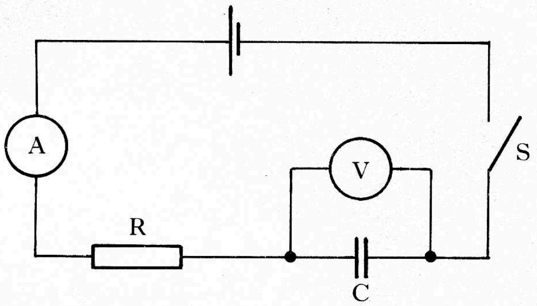
B current against time during charging

C current against p.d. across the capacitor during charging

D p.d. across the capacitor against time during discharging

E current against time during discharging.

18. In the following circuit, an uncharged capacitor, C, charges when switch S is closed.



This procedure is repeated with the resistor R replaced by one of **greater** resistance.

Which entry in the following table correctly shows the effect of this change on the initial charging current, the final p.d. across the capacitor and the final charge stored on the capacitor?

	Initial charging current	*Final p.d. across the capacitor*	*Final charge stored on the capacitor*
A	less	less	less
B	less	unchanged	unchanged
C	unchanged	less	less
D	unchanged	less	unchanged
E	unchanged	unchanged	unchanged

19. Which of the following statements is/are true for an ideal op-amp?

I It has infinite input resistance.

II Both input pins are at the same potential.

III The input current to the op-amp is zero.

A I only

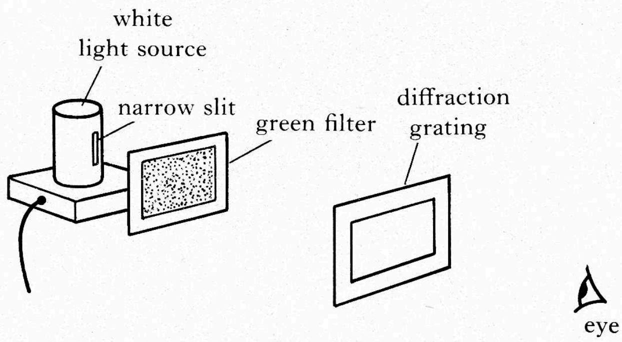
B II only

C I and II only

D II and III only

E I, II and III

20. A green filter is placed in front of a source of white light. The filtered light is viewed, as shown, through a diffraction grating with 100 lines per millimetre. A pattern of bright and dark bands is observed.



Which of the following changes would **decrease** the spacing between the bright bands?

I Use of a blue filter instead of the green filter

II Use of a grating with 50 lines per millimetre

III Use of a brighter lamp

A I only

B II only

C I and II only

D I and III only

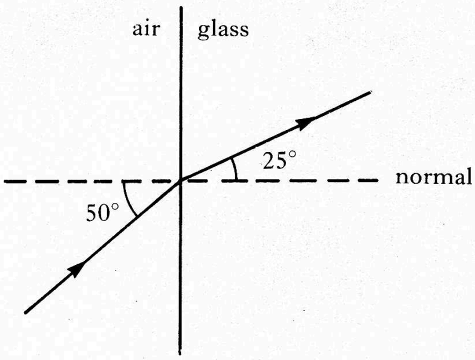
E II and III only

21. A ray of monochromatic light passes from air into perspex. What happens to the speed and frequency of the light on entering the perspex?

	Speed	*Frequency*
A	decreases	decreases
B	decreases	remains the same
C	remains the same	decreases
D	increases	remains the same
E	increases	increases

[Turn over

22. A ray of red light travels from air into glass as shown below.



The critical angle for the glass is

A 33·5°

B 41·1°

C 45·0°

D 45·2°

E 65·0°.

23. A space probe is positioned 3×10^{11} m from the Sun. It needs solar panels with an area of $4\,m^2$ to absorb sufficient energy from the Sun to keep it functioning correctly.

What area of solar panels would be needed to keep the probe functioning correctly if it is to be repositioned at a distance of 6×10^{11} m from the Sun?

A $1\,m^2$

B $2\,m^2$

C $4\,m^2$

D $8\,m^2$

E $16\,m^2$

24. Photons of energy $7{\cdot}0 \times 10^{-19}$ J are incident on a clean metal surface. The work function for the metal is $9{\cdot}0 \times 10^{-19}$ J.

Which one of the following is correct?

A No electrons are emitted from the metal.

B Electrons with a maximum kinetic energy of $2{\cdot}0 \times 10^{-19}$ J are emitted from the metal.

C Electrons with a maximum kinetic energy of $7{\cdot}0 \times 10^{-19}$ J are emitted from the metal.

D Electrons with a maximum kinetic energy of $9{\cdot}0 \times 10^{-19}$ J are emitted from the metal.

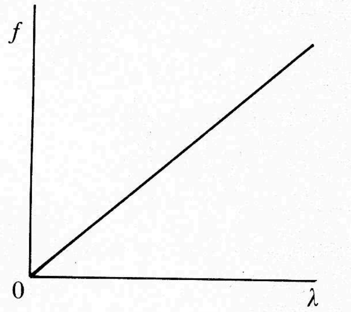
E Electrons with a maximum kinetic energy of $16{\cdot}0 \times 10^{-19}$ J are emitted from the metal.

25. Ultraviolet radiation is incident on a zinc plate. Photoelectrons with a certain maximum kinetic energy are released from the zinc. The intensity of the ultraviolet radiation is now increased. What happens to the maximum kinetic energy of the photoelectrons and the rate at which they are released?

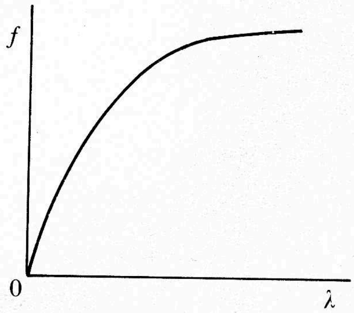
	Maximum kinetic energy of the photoelectrons	*Rate at which photoelectrons are released*
A	remains the same	increases
B	decreases	increases
C	increases	remains the same
D	increases	increases
E	remains the same	remains the same

26. Which of the following graphs correctly shows the relationship between the wavelength λ and the frequency f of photons of electromagnetic radiation?

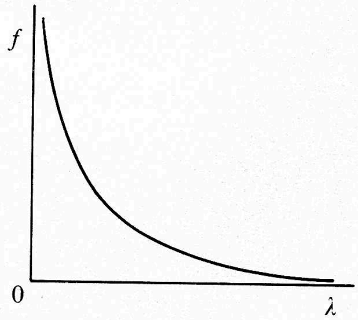
A



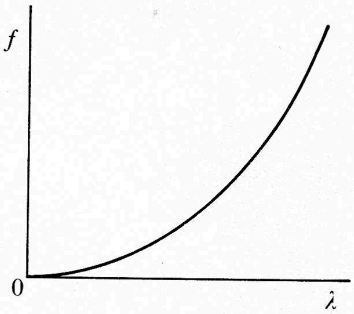
B



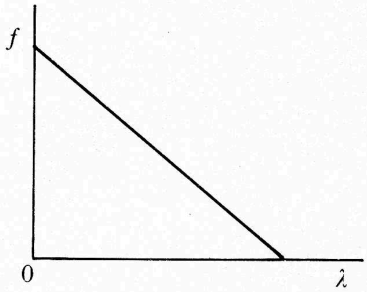
C



D

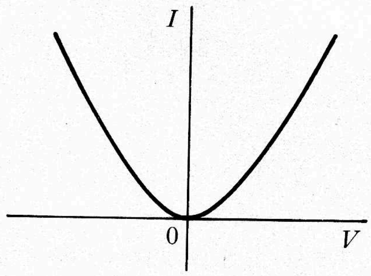


E

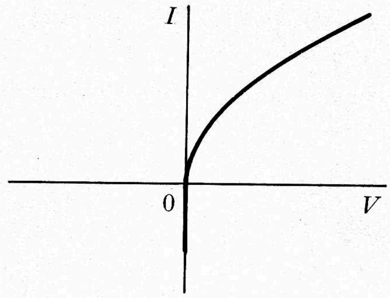


27. Which one of the following graphs shows the relationship between the current I in a p–n junction diode and the voltage V across the diode?

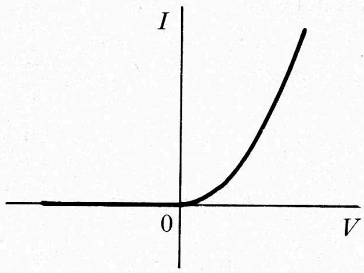
A



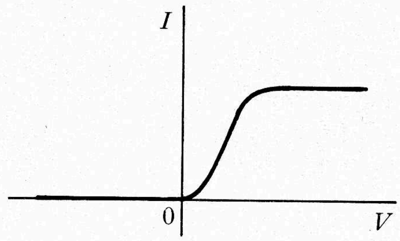
B



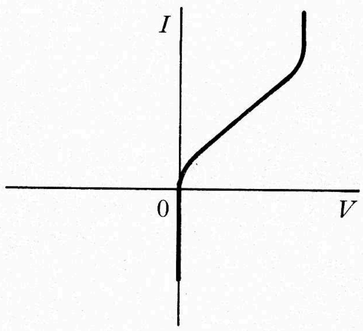
C



D



E



[Turn over

28. The typical dose equivalent rate, in millisieverts per year, due to background radiation is

A 0·002

B 0·02

C 0·2

D 2

E 20.

29. A radioactive isotope has a half-life of 20 minutes. A particular sample of this isotope gives a count rate of 3200 per second at 2 o'clock on a certain afternoon.

At what time on that day is the count rate 200 per second?

A 3.00 p.m.

B 3.20 p.m.

C 3.40 p.m.

D 4.40 p.m.

E 7.20 p.m.

30. The equation below represents a nuclear reaction.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{92}_{36}Kr + ^{141}_{56}Ba + ^{1}_{0}n + ^{1}_{0}n + ^{1}_{0}n$$

It is an example of

A nuclear fusion

B alpha particle emission

C beta particle emission

D induced nuclear fission

E spontaneous nuclear fission.

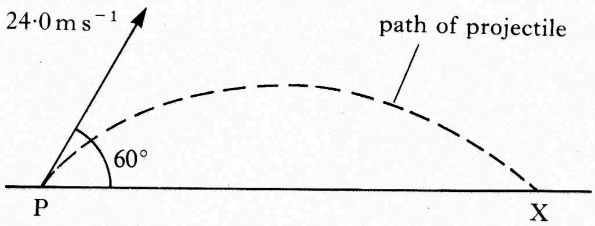
SECTION B

Write your answers to Questions 31 to 37 in the answer book.

Marks

31. During a visit to the Moon, an astronaut fires a small experimental projectile across a level surface. The projectile is launched, from point P, at a speed of 24·0 m s^{-1} and at an angle of 60° to the horizontal.

The projectile lands 26·0 s later at point X.



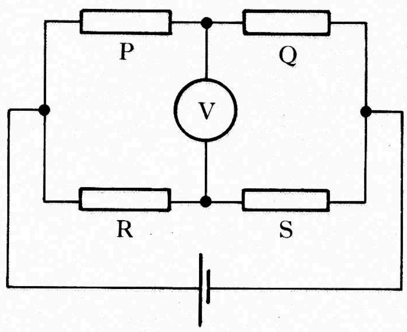
(*a*) Calculate the horizontal speed of the projectile at point P.

(*b*) Calculate the horizontal distance from P to X. **3**

32. The air pressure inside the passenger cabin of an airliner is 9×10^4 Pa when the airliner is at its cruising height. The pressure of the outside atmosphere at this height is 4×10^4 Pa.

Calculate the resultant force on the cabin door, of area 3 m^2, caused by this difference in air pressure. **3**

33. The diagram below shows a **balanced** Wheatstone bridge circuit with four resistors P, Q, R and S.



(*a*) Explain what is meant by a **balanced** Wheatstone bridge.

(*b*) After a period of use, the p.d. across the battery in the circuit decreases to half its original value.

What effect does this have on the reading on the voltmeter?

Justify your answer. **3**

[Turn over

Back to Table

Past Paper Solutions

Solutions to SQA examination

1993 Higher Grade Physics

Paper I Solutions

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1. **D**	11. **E**	21. **B**
2. **B**	12. **B**	22. **A**
3. **C**	13. **C**	23. **E**
4. **D**	14. **E**	24. **A**
5. **A**	15. **E**	25. **A**
6. **D**	16. **C**	26. **C**
7. **B**	17. **A**	27. **C**
8. **E**	18. **B**	28. **D**
9. **A**	19. **E**	29. **B**
10.**D**	20. **C**	30. **D**

31.a. $V_{Hor} = V\cos\theta$

$V_{Hor} = 24.0\cos60^{o}$

$\mathbf{V_{Hor} = 12m/s}$

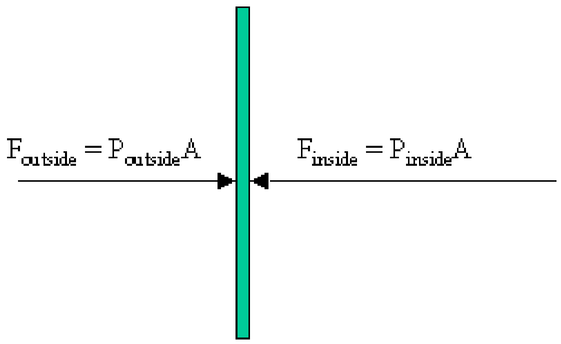
Note: the horizontal component of velocity is constant between P and X.

b. $S_{Hor} = V_{Hor}t$

$S_{Hor} = 12x26$

$\mathbf{S_{Hor} = 312m}$

32.

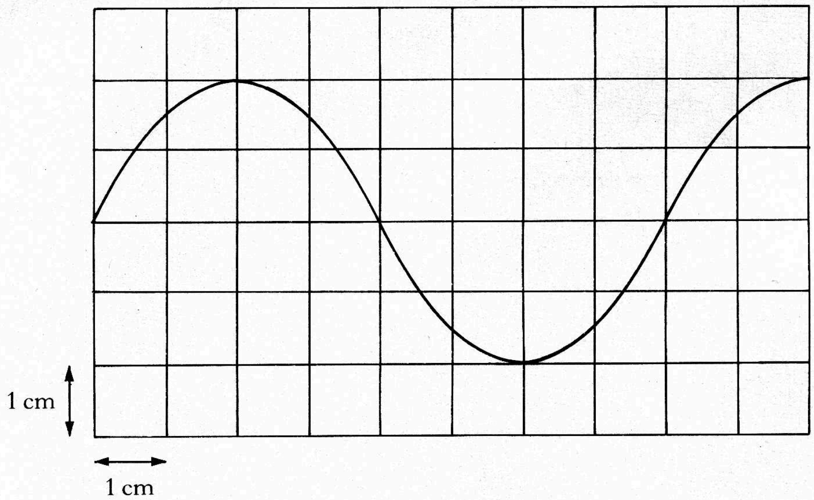


$$F_{res} = F_{inside} - F_{outside}$$

$F_{res} = (9x10^4 - 4x10^4)3$

Marks

34. An oscilloscope is connected across a resistor in a circuit. The trace obtained is shown below.



The peak voltage shown on the oscilloscope is 10 volts and the time base setting is $0{\cdot}2\,\text{ms}\,\text{cm}^{-1}$.

Calculate

(*a*) the r.m.s. voltage across the resistor

(*b*) the frequency of the a.c. voltage. **3**

35. A pupil wishes to measure the amount of energy stored in a $5\,\mu\text{F}$ capacitor which is charged to a p.d. of 10 V. He discharges the capacitor through a heating coil which is immersed in a small quantity of oil. The energy stored in the capacitor is calculated using the equation

$$\text{energy stored in capacitor} = \text{specific heat capacity of oil} \times \text{mass of oil} \times \text{rise in temperature of oil}.$$

(*a*) State the assumption made by the pupil in using this equation.

(*b*) By considering the energy stored in the capacitor, explain why the measurement of the rise in the temperature of the oil is likely to be extremely inaccurate. **3**

F_{res} = 5x10^4x3

F_{res} = 15x10^4N (to the left)

33.a. $R_P/R_Q = R_R/R_S$

When this is true the reading on the voltmeter is 0V.

b. The p.d. across the battery does not affect the above ratio of the resistors. The bridge is therefore still balanced, and the voltmeter reading will not change from 0V.

34.a. $V_{RMS} = V_{peak}$/SQRT2

V_{RMS} = 10/1.414

V_{RMS} = 7.07V

b. f = 1/T

T = 8x0.2ms = 1.6ms

T = 1.6x10^{-3}

f = 1/1.6x10^{-3}

f = 625Hz

35.a. The pupil assumes that there is 100% efficiency in the process converting the energy stored in the capacitor into heat energy. There is also the assumption that all the heat energy is absorbed by the oil.

b. The energy stored in the capacitor can be calculated using: E = $CV^2/2$

E = 5x10^{-6}x10^2/2

E = 2.5x10^{-4}J

This amount of energy would not produce a measurable change in the temperature of the oil.

36. For the first minimum:

Path difference = 1/2λ

AB-AP = 1/2λ

43-41 = 1/2λ

2 = 1/2λ

λ = 4cm

37.a. Alpha radiation.

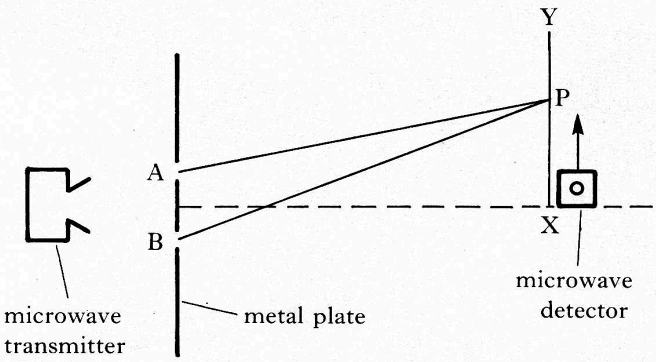
b. The fact that most of the radiation passes straight through indicates that most of the atom must be empty space. However, the fact that some "bounces back" provides evidence that the alpha particle occasionally collides with a massive body. It is therefore reasonable to conclude that atoms are mainly empty space with a large mass concentrated at the centre.

END OF QUESTION PAPER

Return to past paper index page.

Marks

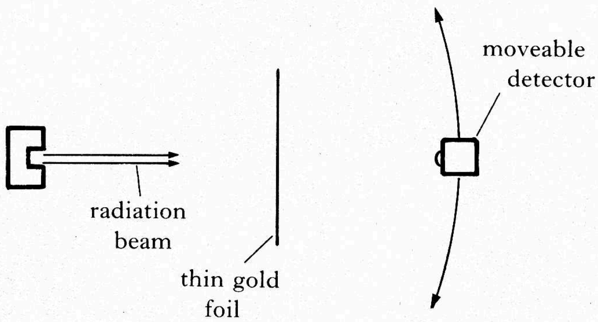
36. Microwaves are passed through two slits, A and B, in a metal plate as shown in the diagram below.



A microwave detector is moved along a straight line from X to Y. The **first minimum** of microwave intensity is detected at point P. The distance AP is 41 cm and BP is 43 cm.

Find the wavelength of the microwaves. **2**

37. In a famous experiment to investigate the structure of the atom, a beam of radiation is directed at a thin, gold foil target as shown in the diagram below.



The experiment shows that most of the radiation passes through the gold foil but some "bounces back" without passing through the foil.

(*a*) State the type of radiation used.

(*b*) Explain how the results of the experiment suggest that the mass of the atom is concentrated at its centre (nucleus). **3**

[*END OF QUESTION PAPER*]

Back to Table

$F_{res} = 5x10^4x3$
$F_{res} = 15x10^4N$ (to the left)

33.a. $R_P/R_Q = R_R/R_S$

When this is true the reading on the voltmeter is 0V.

b. The p.d. across the battery does not affect the above ratio of the resistors. The bridge is therefore still balanced, and the voltmeter reading will not change from 0V.

34.a. $V_{RMS} = V_{peak}/SQRT2$
$V_{RMS} = 10/1.414$
$V_{RMS} = 7.07V$

b. f = 1/T

T = 8x0.2ms = 1.6ms
$T = 1.6x10^{-3}$

$f = 1/1.6x10^{-3}$
f = 625Hz

35.a. The pupil assumes that there is 100% efficiency in the process converting the energy stored in the capacitor into heat energy. There is also the assumption that all the heat energy is absorbed by the oil.

b. The energy stored in the capacitor can be calculated using: $E = CV^2/2$

$E = 5x10^{-6}x10^2/2$
$E = 2.5x10^{-4}J$

This amount of energy would not produce a measurable change in the temperature of the oil.

36. For the first minimum:
Path difference = $1/2\lambda$
AB-AP = $1/2\lambda$
43-41 = $1/2\lambda$
2 = $1/2\lambda$
λ = 4cm

37.a. Alpha radiation.

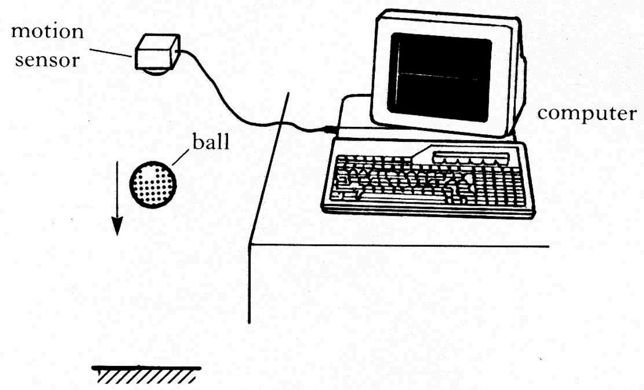
b. The fact that most of the radiation passes straight through indicates that most of the atom must be empty space. However, the fact that some "bounces back" provides evidence that the alpha particle occasionally collides with a massive body. It is therefore reasonable to conclude that atoms are mainly empty space with a large mass concentrated at the centre.

END OF QUESTION PAPER

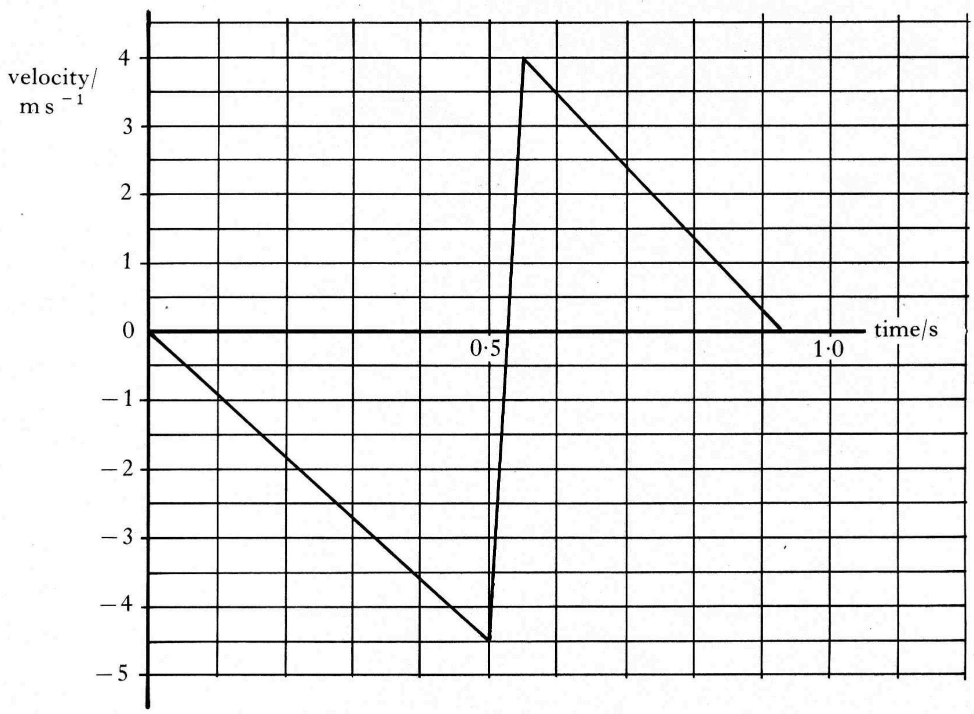
Return to past paper index page.

Marks

1. The velocity–time graph for one bounce of a ball is obtained using a motion sensor connected to a computer as shown.



The ball is dropped from a position below the motion sensor and measurement starts at the same instant as the ball is released. The graph obtained is shown below.



(*a*) Calculate the acceleration of the falling ball. **2**

(*b*) The ball loses 1·7 joules of kinetic energy during the bounce. Show that the mass of the ball is 0·80 kg. **3**

(*c*) The momentum of the ball is changed by the bounce. What is the magnitude of this change? **2**

(*d*) The ball is in contact with the ground for 50 milliseconds. Calculate the magnitude of the average force exerted by the ball on the ground during the bounce. **2**

(9)

Past Paper Solutions

Solutions to SQA examination

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Paper II Solutions

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1.a. The ball is in free fall for the first 0.5s.

u = 0m/s
v = -4.5m/s
t = 0.5s
a = ?

a = (v-u)/t
a = (-4.5-0)/0.5
a = -9.0m/s/s

b. $\Delta Ek = Ek_{after} - Ek_{before}$

$\Delta Ek = 1/2(mv^2 - mu^2)$

$2\Delta Ek = m(v^2 - u^2)$

$2\Delta Ek/(v^2 - u^2) = m$

$m = 2\Delta Ek/(v^2 - u^2)$

$m = 2x{-1.7}/(4^2 - [-4.5^2])$

m = -3.4/(16-20.25)

m = 0.8kg

c. $\Delta P = mv - mu$

$\Delta P = m(v-u)$

$\Delta P = 0.8(4-[-4.5])$

ΔP = 6.8kgm/s

d. The time that the ball is in contact with the ground(t_c) is 0.5s.

$F = \Delta P/t_c$

F = 6.8/0.5

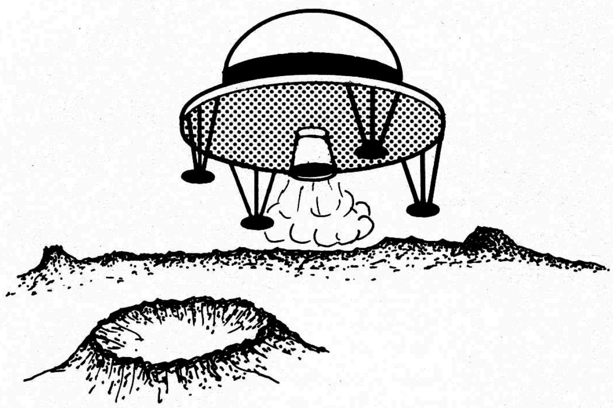
F = 13.6N

2.a.

Marks

2. A lunar landing craft descends vertically towards the surface of the Moon with a constant speed of $2{\cdot}0\,\mathrm{m\,s^{-1}}$. The craft and crew have a total mass of 15 000 kg.

Assume that the gravitational field strength on the Moon is $1{\cdot}6\,\mathrm{N\,kg^{-1}}$.



(*a*) During the first part of the descent the upward thrust of the rocket engine is 24 000 N.
Show that this results in the craft moving with a constant speed. **2**

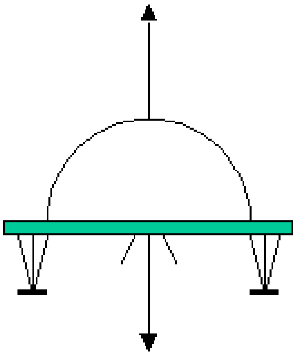
(*b*) The upward thrust of the engine is increased to 25 500 N for the last 18 seconds of the descent.

(i) Calculate the deceleration of the craft during this time.

(ii) What is the speed of the craft just before it lands?

(iii) How far is the craft above the surface of the Moon when the engine thrust is increased to 25 500 N? **7**

(9)



w = ?
m = 15000
g = 1.6N/kg

w = mg
w = 15000x1.6
w = 24000N

The upward force(F_{up}) is equal in magnitude to the weight and acts in the opposite direction. There is no unbalanced force which means the craft must be moving at a constant speed and be moving in a straight line.

b.i. $F_{unbalanced} = F_{up} - w$
$F_{unbalanced} = 25500 - 24000$
$F_{unbalanced} = 1500N$

$a = F_{unbalanced}/m$
a = 1500/15000
a = 0.1m/s/s upwards

This means that the craft has an upward deceleration of -0.1m/s/s.

b.ii. a = 0.1m/s/s
t = 18s
u = -2.0m/s
v = ?

v = u + at
v = -2.0 + 0.1x18
v = -0.2m/s

b.iii. $v^2 = u^2 + 2as$
$s = (v^2-u^2)/2a$
$s = ([-0.2]^2-[-2]^2)/2x0.1$
s = (0.04-4)/0.2
s = -3.96/0.2
s = -19.8m

This displacement is equal to that which the craft has descended from. This means the craft must have been **19.8m** above the surface of the moon to start with.

3.a. The law of conservation of linear momentum states that :
$P_{before} = P_{after}$

b.i. **Before collision**
$P_{before} = m_A u_A + m_B u_B$

Back to Table Answers

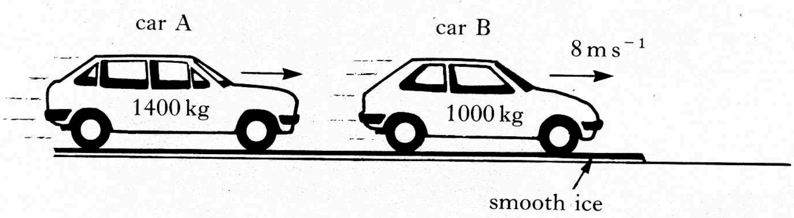
Marks

3. (*a*) State the law of conservation of linear momentum as it applies to a collision between two objects. **1**

(*b*) Two cars, travelling in the same direction, skid on a patch of smooth, level ice.

Car A, of mass 1400 kg, skids straight into the back of car B, of mass 1000 kg.

The two cars become entangled after the impact and continue to move in the same straight line.



Immediately before the impact, car B is moving with a speed of $8\,m\,s^{-1}$.

Immediately after the impact, both cars are moving with a speed of $15\,m\,s^{-1}$.

(i) Calculate the speed of car A just before the collision takes place.

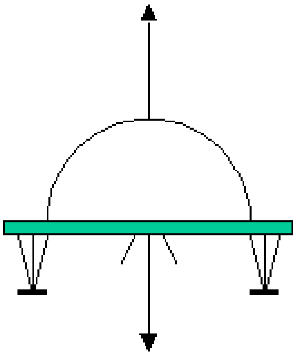
(ii) After the collision, the cars leave the patch of ice and continue skidding along the road. They come to rest in a distance of 20 metres after leaving the ice.

Calculate the average frictional force acting on the cars as they come to rest.

(iii) State what happens to the kinetic energy of the cars after they leave the ice. **7**

(8)

[Turn over



w = ?
m = 15000
g = 1.6N/kg

w = mg
w = 15000x1.6
w = 24000N

The upward force(F_{up}) is equal in magnitude to the weight and acts in the opposite direction. There is no unbalanced force which means the craft must be moving at a constant speed and be moving in a straight line.

b.i. $F_{unbalanced} = F_{up} - w$
$F_{unbalanced} = 25500 - 24000$
$F_{unbalanced} = 1500N$

a = $F_{unbalanced}/m$
a = 1500/15000
a = 0.1m/s/s upwards

This means that the craft has an upward deceleration of -0.1m/s/s.

b.ii. a = 0.1m/s/s
t = 18s
u = -2.0m/s
v = ?

v = u + at
v = -2.0 + 0.1x18
v = -0.2m/s

b.iii. $v^2 = u^2 + 2as$
$s = (v^2-u^2)/2a$
$s = ([-0.2]^2-[-2]^2)/2x0.1$
s = (0.04-4)/0.2
s = -3.96/0.2
s = -19.8m

This displacement is equal to that which the craft has descended from. This means the craft must have been **19.8m** above the surface of the moon to start with.

3.a. The law of conservation of linear momentum states that :
$\mathbf{P_{before} = P_{after}}$

b.i. **Before collision**
$P_{before} = m_A u_A + m_B u_B$

$P_{before} = 1400xu_A + 1000x8$
$P_{before} = 1400u_A + 8000$

After collision
$P_{after} = m_Av_A + m_Bv_B$
$v_A=v_B=v$
$P_{after} = (m_A + m_B)v$
$P_{after} = (1400 + 1000)15$
$P_{after} = 36000kgm/s$

Equate: P_{before} and P_{after}
$1400u_A + 8000 = 36000kgm/s$
$1400u_A = (36000-8000)/1400$
$u_A = 20m/s$

b.ii. Consider the instant after the collision to be the starting point for this calculation.

u = 15m/s
v = 0m/s
s = 20m
a = ?

$v^2 = u^2 + 2as$
$a = (v^2-u^2)/2s$
$a = (0^2-15^2)/2x20$
$a = -225/40$
$a = -5.625m/s/s$

$F_{friction} = F_{un}$
$F_{un} = ma$
$F_{un} = 2400x-5.625$
$\mathbf{F_{un} = -13,500N}$ The negative sign indicates that the force acts to the LHS.

OR

The kinetic energy lost by the car is equal to the work done by the frictional force over the 20m stopping distance.

$Ek_{lost} = E_{work}$

$Ek_{lost} = Ek_{before} - Ek_{after}$
$Ek_{lost} = (mv^2 - mu^2)/2$
$Ek_{lost} = m(v^2 - u^2)/2$
$Ek_{lost} = 2400(15^2 - 0^2)/2$
$Ek_{lost} = 27000J$

$E_{work} = Fd$
$F = E_{work}/d$
$F = 27000/20$
F = 13500N

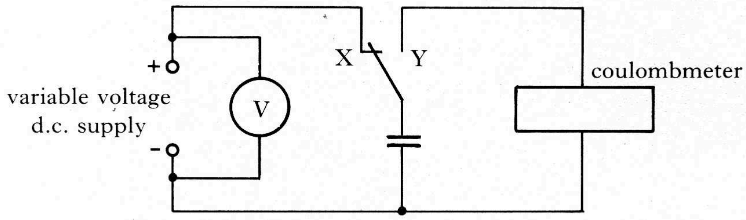
b.iii. Most of the kinetic energy will be converted into heat energy.

4.a. $P_1 = 400kPa$
$V_1 = 1000cm^3$
$P_2 = 250kPa$
$V_2 = ?$

$P_1V_1 = P_2V_2$
$V_2 = P_1V_1/P_2$

Marks

5. (*a*) The circuit shown below is used to find the capacitance of a capacitor.



With the switch in position X, the capacitor charges up to the supply voltage.

The reading on the voltmeter is noted and the switch is moved to position Y.

The coulombmeter then indicates the charge stored by the capacitor.

(i) One set of results is recorded below.

Voltmeter reading = 1·5 V
Coulombmeter reading = 24 μC.

Use these results to calculate a value for the capacitance of the capacitor.

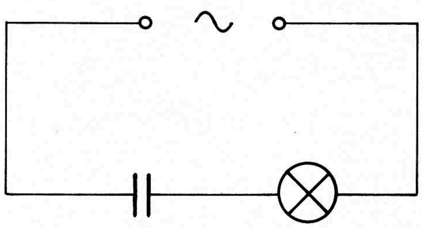
(ii) The experiment is repeated with the **same** capacitor for five different values of the supply voltage, giving the following values for the capacitance.

Capacitance in μF = 16, 18, 20, 16, 15.

Using these five results, calculate the mean value for the capacitance **and** the approximate random error in this value.

(iii) How could the approximate random error in the mean value of the capacitance be reduced? **6**

(*b*) The circuit below shows a capacitor connected to a lamp and a signal generator.



When the frequency of the signal generator is set at 100 Hz, the lamp glows.

The frequency of the signal generator is now altered while the amplitude is kept constant. The lamp glows more brightly.

Explain this effect. **2**

(8)

[Turn over

$V_2 = 400x1000/250$
$V_2 = 1600cm^3$

b. The pressure increases.
The volume remains constant.
The temperature increases.

c. The starting pressure is that indicated by point B on the graph and the final pressure is that indicated by point C. Over this period the volume is constant.

$T_1 = 300K$
$P_1 = 200kPa$
$T_2 = ?$
$P_2 = 500kPa$

$P_1/T_1 = P_2/T_2$
$T_2 = P_2(T_1/P_1)$
$T_2 = 500(300/200)$
$T_2 = 750K$

5.a.i. Q = CV
C = Q/V
$C = 24x10^{-6}/1.5$
$C = 16x10^{-6}F$
C = 16µF

a.ii. Mean = total/N
Mean(C) = (16+18+20+16+15)/5
Mean(C) = 17µF

Random error = (max-min)/N
Random error(C) = (20-15)/5
Random error(C) = +-1µF

C = (17+-1)µF

a.iii. Measure the voltage across the capacitor directly by connecting the voltmeter across it. Additionally, to prevent leakage through the voltmeter it would be better to use an oscilloscope for this purpose.

b. The effective resistance of the capacitor in the circuit decreases as the frequency of the supply increase. As the resistance decreases the current in the circuit increases and the lamp glows more brightly.

6.a. The electromotive force is the energy supplied by the power supply to each coulomb of charge.

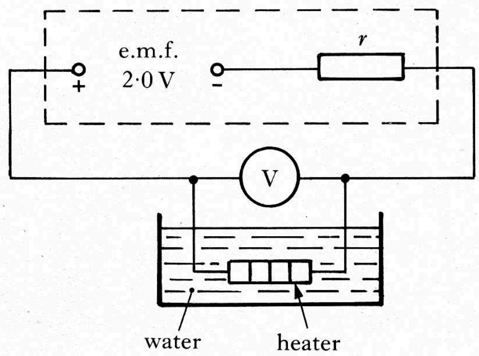
b.i. $P = I^2R$
$I^2 = P/R$
$I = (P/R)^{1/2}$
$I = (8.0/0.32)^{1/2}$
$I = 25^{1/2}$
I = 5A

b.ii. V = IR
V = 5x0.32
V = 1.6V

b.iii. $V_r = emf - V_{heater}$
$V_r = 2.0 - 1.6$
$V_r = 0.4V$

Marks

6. A heater of resistance 0·32 ohms is connected to a power supply of e.m.f. 2·0 volts and internal resistance r as shown below.



(a) State what is meant by the term electromotive force (e.m.f.). **1**

(b) The power output of the **heater** is 8·0 watts.

Calculate:

(i) the current in the heater;

(ii) the reading on the voltmeter;

(iii) the internal resistance of the power supply. **5**

(c) Another identical heater is now placed in the water and connected in parallel with the original heater.

The rest of the circuit is unaltered.

How does this affect the rate at which heat is supplied to the water?

Justify your answer by calculation. **3**

(9)

V_2 = 400x1000/250

V_2 = 1600cm^3

b. The pressure increases.
The volume remains constant.
The temperature increases.

c. The starting pressure is that indicated by point B on the graph and the final pressure is that indicated by point C. Over this period the volume is constant.

T_1 = 300K
P_1 = 200kPa
T_2 = ?
P_2 = 500kPa

$P_1/T_1 = P_2/T_2$
$T_2 = P_2(T_1/P_1)$
T_2 = 500(300/200)
T_2 = 750K

5.a.i. Q = CV
C = Q/V
C = 24x10^{-6}/1.5
C = 16x10^{-6}F
C = 16μF

a.ii. Mean = total/N
Mean(C) = (16+18+20+16+15)/5
Mean(C) = 17μF

Random error = (max-min)/N
Random error(C) = (20-15)/5
Random error(C) = +-1μF

C = (17+-1)μF

a.iii. Measure the voltage across the capacitor directly by connecting the voltmeter across it. Additionally, to prevent leakage through the voltmeter it would be better to use an oscilloscope for this purpose.

b. The effective resistance of the capacitor in the circuit decreases as the frequency of the supply increase. As the resistance decreases the current in the circuit increases and the lamp glows more brightly.

6.a. The electromotive force is the energy supplied by the power supply to each coulomb of charge.

b.i. $P = I^2R$
$I^2 = P/R$
$I = (P/R)^{1/2}$
$I = (8.0/0.32)^{1/2}$
$I = 25^{1/2}$
I = 5A

b.ii. V = IR
V = 5x0.32
V = 1.6V

b.iii. V_r = emf - V_{heater}
V_r = 2.0 - 1.6
V_r = 0.4V

$V_r = Ir$
$r = V_r/I$
$r = 0.4/5$
$r = 0.08\Omega$

c. Two heaters in parallel will reduce the resistance of the circuit. The current in the heater elements will increase which has the effect of increasing the rate at which the water is heated.

The resistance of the two heaters in parallel can be calculated as shown below:

$R_p = R_{heater}/2$
$R_p = 0.32/2$
$R_p = 0.16\Omega$

$R_{total} = R_p + r$
$R_{total} = 0.16 + 0.08$
$R_{total} = 0.24\Omega$

$I = emf/R_{total}$
$I = 2.0/0.24$
$I = 8.33A$

$V_r = Ir$
$V_r = 8.33x0.08$
$V_r = 0.67V$

$V_{heater} = emf - V_r$
$V_{heater} = 2.0 - 0.67$
$V_{heater} = 1.33V$

This is the voltage across each heater element.

$I_{heater} = V_{heater}/R_{heater}$
$I_{heater} = 1.33/0.32$
$I_{heater} = 4.16A$

The power developed in each heater can be calculated using:
$P = I^2R$

$P = 4.16^2x0.32$
$P = 5.5W$

The two heating elements develop a total power of 11W. This means that the water is heated about 1.4 times faster.

7.a.i. The amplifier is working in **inverting mode.**

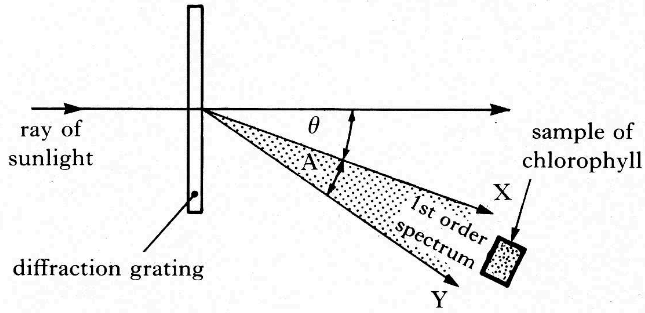
a.ii. $Gain = -R_{feedback}/R_1$
$Gain = -1x10^6/2x10^3$
Gain = 500

a.iii.

Marks

8. A biologist is studying the effect of different colours of light on a sample of chlorophyll.

The biologist sets up the apparatus shown below, using a diffraction grating with $6{\cdot}0 \times 10^5$ lines per metre to produce a first order spectrum of sunlight.



(*a*) Explain briefly how a diffraction grating produces a continuous spectrum from the ray of sunlight. **2**

(*b*) (i) The wavelength of the light at the end X of the spectrum is 410 nm. Calculate the value of the angle θ.

(ii) The angle A, in the diagram above, is 9°. Calculate the wavelength at end Y of the spectrum. **5**

(*c*) The biologist now uses a triangular glass prism to produce a continuous spectrum from a ray of sunlight.

State **two** differences between this spectrum and the spectrum produced by the grating. **2**

(9)

Back to Table

8.a. A ray of sunlight is made up of many different wavelengths that is perceived as white light. However, each individual wavelength represents a particular colour of light.
The diffraction grating diffracts the different wavelengths in sunlight by different amounts: the longer wavelengths being diffracted the most and the shorter wavelengths the least.
At position X on the screen the short wavelength violet light has interfered constructively to produce a band of violet light.
At position Y on the screen the long wavelength red light has interfered constructively to produce a band of red light.
Between X and Y the other colours of the visible spectrum produce bands of indigo, blue, green, yellow and orange light.

b.i. $d\sin\theta = n\lambda$

$d = 1/N = 1/6\text{x}10^5 = 1.667\text{x}10^{-6}\text{m}$
$\theta = ?$
$n = 1$
$\lambda = 410\text{nm} = 410\text{x}10^{-9}\text{m}$

$\sin\theta = n\lambda/d$
$\sin\theta = 1\text{x}410\text{x}10^{-9}/1.667\text{x}10^{-6}$
$\sin\theta = 0.246$
$\theta = \sin^{-1}0.246$
$\boldsymbol{\theta = 14.2^o}$

b.ii. $d = 1.667\text{x}10^{-6}\text{m}$
$\theta = 14.2^o + 9^o = 23.2^o$
$n = 1$
$\lambda = ?$

$\lambda = d\sin\theta/n$
$\lambda = 1.667\text{x}10^{-6}\sin(23.2^o)/1$
$\boldsymbol{\lambda = 656.7\text{x}10^{-9}\text{m} = 656.7\text{nm}}$

c. The diffraction grating will produce many spectra symmetrical about the $\theta = 0^o$ line.
The prism produces one spectrum by refraction.
The relative positions of each colour of light produced by refraction will be the reverse of that produced by the diffraction grating, as blue light is refracted more than red light.

9.a. Monochromatic means the laser light has a single wavelength/frequency.
Coherent means the waves are in phase/step.

b.i. $\Delta E = hf$ where $\Delta E = E_2-E_2$
$f = E_2-E_2/h$
$f = -4.67\text{x}10^{-20}-(-6.55\text{x}10^{-20})/6.63\text{x}10^{-34}$
f = 452.5nm

b.ii. The wavelength of the emitted radiation corresponds to the blue end of the spectrum.

c. The beam is intense because the energy is spread over a small area and a large number of photons per second are emitted from the laser.

10.a. Light incident on the pn-junction photodiode will increase the number of electron hole pairs and consequently increase the conductivity of the diode.

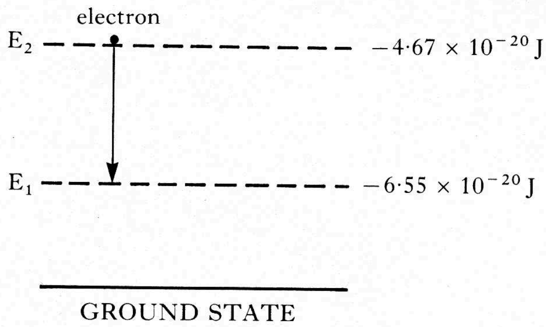
b. The diode is operating in **photoconductive mode.**

Marks

9. (*a*) Laser light is *monochromatic* and *coherent*.

Briefly explain the meaning of the terms *monochromatic* and *coherent*. **2**

(*b*) A laser radiates energy when electrons are stimulated to fall from energy level E_2 to energy level E_1 as shown in the diagram.



(i) What are the frequency and wavelength of the radiation emitted?

(ii) Name the section of the electromagnetic spectrum in which the radiation occurs. **5**

(*c*) The beam of light from a laser is very intense.

Give **two** reasons for this. **2**

(9)

[Turn over

Back to Table

8.a. A ray of sunlight is made up of many different wavelengths that is perceived as white light. However, each individual wavelength represents a particular colour of light.
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Between X and Y the other colours of the visible spectrum produce bands of indigo, blue, green, yellow and orange light.

b.i. $d\sin\theta = n\lambda$

$d = 1/N = 1/6x10^5 = 1.667x10^{-6}m$
$\theta = ?$
$n = 1$
$\lambda = 410nm = 410x10^{-9}m$

$\sin\theta = n\lambda/d$
$\sin\theta = 1x410x10^{-9}/1.667x10^{-6}$
$\sin\theta = 0.246$
$\theta = \sin^{-1}0.246$
$\boldsymbol{\theta = 14.2^o}$

b.ii. $d = 1.667x10^{-6}m$
$\theta = 14.2^o + 9^o = 23.2^o$
$n = 1$
$\lambda = ?$

$\lambda = d\sin\theta/n$
$\lambda = 1.667x10^{-6}\sin(23.2^o)/1$
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c. The diffraction grating will produce many spectra symmetrical about the $\theta = 0^o$ line.
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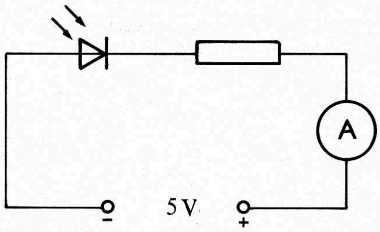
10.a. Light incident on the pn-junction photodiode will increase the number of electron hole pairs and consequently increase the conductivity of the diode.

b. The diode is operating in **photoconductive mode.**

Marks

10. The circuit below shows a photodiode connected in series with a resistor and an ammeter.

The power supply has an output voltage of 5 V and negligible internal resistance.



In a darkened room, there is no current in the circuit.

When light strikes the photodiode, there is a current in the circuit.

(*a*) Describe the effect of light on the material of which the photodiode is made. **1**

(*b*) In which mode is the photodiode operating? **1**

(*c*) When the photodiode is placed 1·0 m from a small lamp, the current in the circuit is 3·0 μA.

What is the current in the circuit when the photodiode is placed 75 cm from the same lamp? **3**

(5)

Back to Table

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$\theta = ?$
$n = 1$
$\lambda = 410\text{nm} = 410\text{x}10^{-9}\text{m}$

$\sin\theta = n\lambda/d$
$\sin\theta = 1\text{x}410\text{x}10^{-9}/1.667\text{x}10^{-6}$
$\sin\theta = 0.246$
$\theta = \sin^{-1}0.246$
$\boldsymbol{\theta = 14.2^o}$

b.ii. $d = 1.667\text{x}10^{-6}\text{m}$
$\theta = 14.2^o + 9^o = 23.2^o$
$n = 1$
$\lambda = ?$

$\lambda = d\sin\theta/n$
$\lambda = 1.667\text{x}10^{-6}\sin(23.2^o)/1$
$\boldsymbol{\lambda = 656.7\text{x}10^{-9}\text{m} = 656.7\text{nm}}$

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b. The diode is operating in **photoconductive mode.**

Back to Table

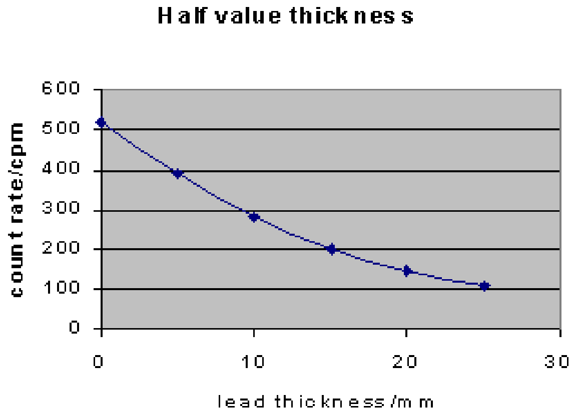
c. $I_1 d_1^2 = I_2 d_2^2$

$I_2 = I_1 d_1^2 / d_2^2$

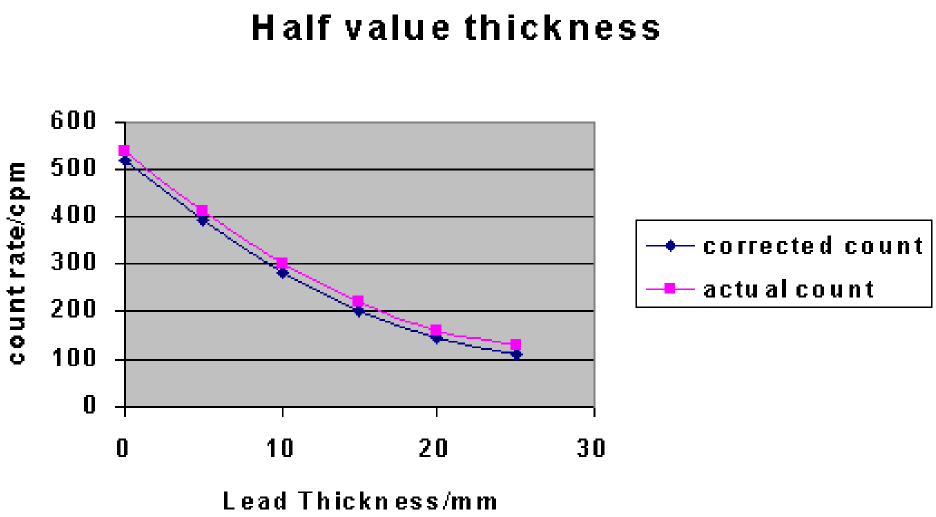
$I_2 = 3.0 \times 1^2 / 0.75^2$

$I_2 = 5.33 \mu A$

11.a.i.



a.ii. Take the background count to be 20cpm.
Add this to the corrected count rate and plot as shown below.



b.

Time/years	Corrected Count Rate/cpm
0	520
5.25	260
11.5	130
16.75	65
21	32.5

After 21 years the count rate is 32.5cpm.

END OF QUESTION PAPER

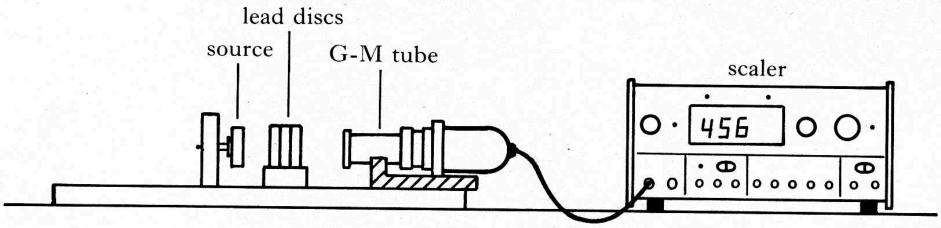
Back to Table Answers

Marks

11. (*a*) A certain radioactive source emits only gamma radiation.

A technician is asked to determine the half-value thickness of lead for the radiation from this source.

The technician sets up the apparatus shown below and keeps the distance between the source and the gamma ray detector the same throughout the experiment.



The technician measures the count rate several times for a certain thickness of lead sheet, and obtains an average value for the count rate.

The measurements are repeated with several different thicknesses of lead sheet and also with no lead present.

The source and the lead are then removed and the background count rate is measured.

The technician corrects each average count rate for background and records the results as shown in the table.

Thickness of lead sheet in mm	*Corrected average count rate in counts/minute*
0	520
5	390
10	280
15	200
20	145
25	110

(i) Draw a graph of corrected average count rate against thickness of lead sheet, using the square-ruled paper provided.

Find the half-value thickness of lead for this source.

(ii) On the same axes, sketch a graph which might be obtained if the average count rate was not corrected for background radiation. **5**

(*b*) 21 years later, another technician repeats the experiment with the same source.

The gamma ray source has a half-life of 5·25 years.

What corrected average count rate would be recorded with no lead sheet between the source and the detector? **2**

(7)

[*END OF QUESTION PAPER*]

Back to Table

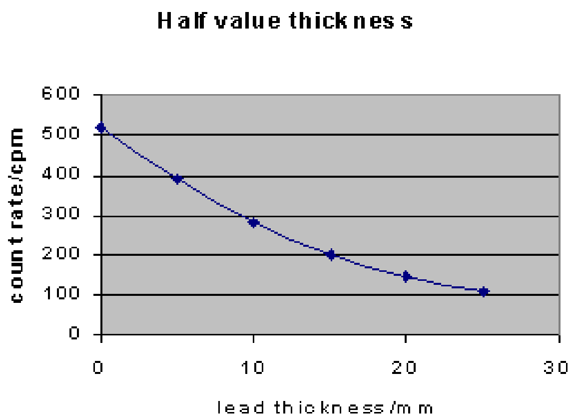
c. $I_1d_1^2 = I_2d_2^2$

$I_2 = I_1d_1^2/d_2^2$

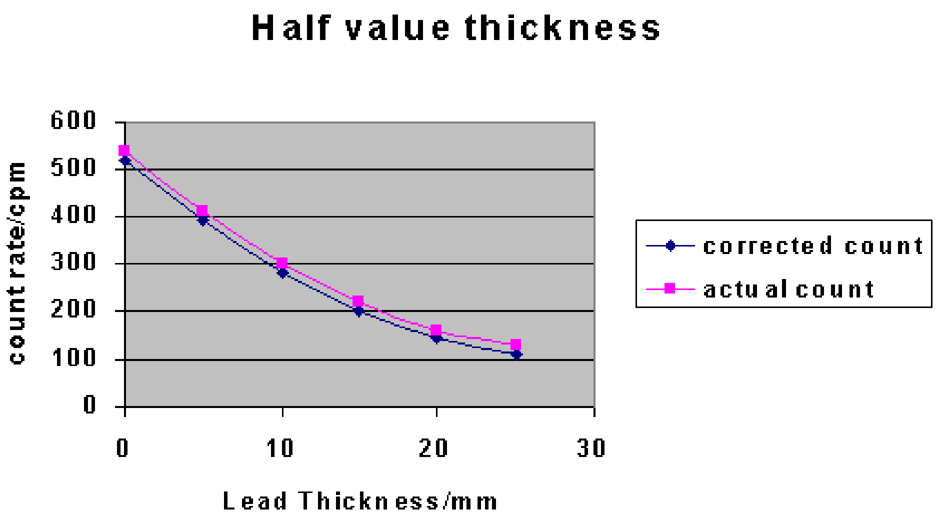
$I_2 = 3.0x1^2/0.75^2$

I_2 = 5.33µA

11.a.i.



a.ii. Take the background count to be 20cpm.
Add this to the corrected count rate and plot as shown below.



b.

Time/years	Corrected Count Rate/cpm
0	520
5.25	260
11.5	130
16.75	65
21	32.5

After 21 years the count rate is 32.5cpm.

END OF QUESTION PAPER

1994 Paper 1 (Multiple Choice)

Back to Table

1. D	11. D	21. D
2. B	12. C	22. A
3. C	13. C	23. B
4. C	14. B	24. E
5. C	15. D	25. B
6. A	16. C	26. C
7. D	17. A	27. A
8. D	18. B	28. D
9. D	19. A	29. D
10.E	20. A	30. E

SECTION A

Answer questions 1–30 on the answer sheet.

1. Consider the following three statements made by pupils about scalars and vectors.

I Scalars have direction only.

II Vectors have both size and direction.

III Speed is a scalar and velocity is a vector.

Which statement(s) is/are true?

A I only

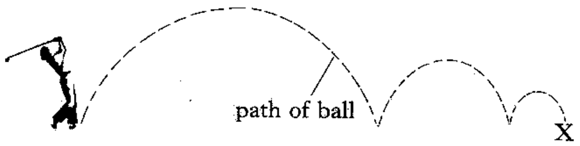
B I and II only

C I and III only

D II and III only

E I, II and III

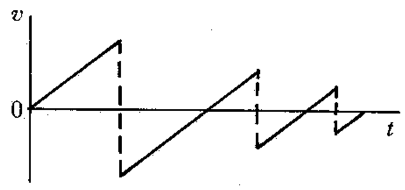
2. A golfer strikes a ball straight down the fairway.



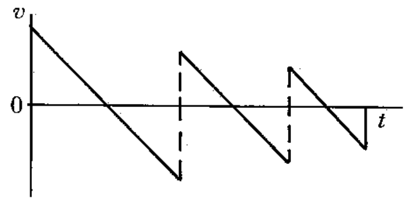
The ball bounces twice before stopping at point X.

Which of the following could be a graph of the **vertical** component of its velocity against time **after** it is struck?

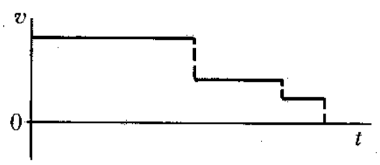
A



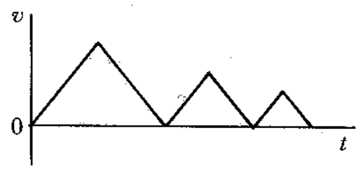
B



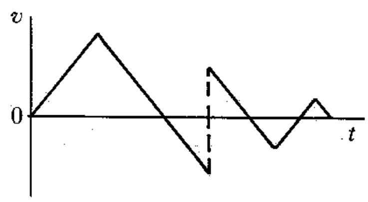
C



D



E



[Turn over

3. A car travelling at 30 m s^{-1} starts to brake when it is 50 m from a stationary lorry. The car moves in a straight line and manages to stop just before reaching the lorry.

What is the deceleration of the car, in m s^{-2}?

A 0·6

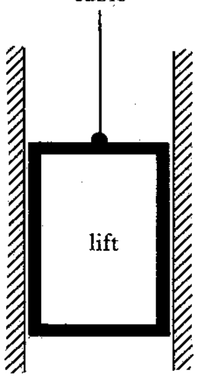
B 4·5

C 9

D 10

E 18

4. A lift is raised and lowered by means of a cable.



In which of the following situations is the tension in the cable greatest?

A The lift is travelling upwards at a constant speed.

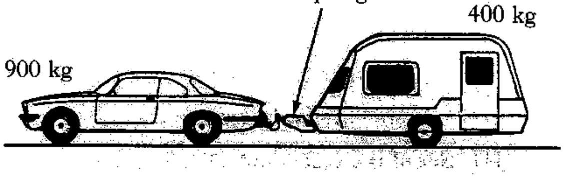
B The lift is travelling downwards at a constant speed.

C The lift is decelerating on the way down.

D The lift is accelerating on the way down.

E The lift is decelerating on the way up.

5. A car of mass 900 kg pulls a caravan of mass 400 kg along a straight, horizontal road with an acceleration of 2 m s^{-2}.



Assuming that the frictional forces are negligible, the tension in the coupling between the car and the caravan is

A 400 N

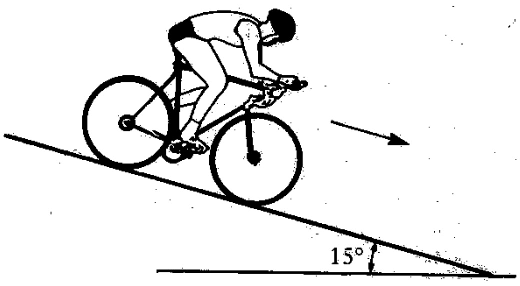
B 500 N

C 800 N

D 1800 N

E 2600 N.

6. A cyclist free-wheels down a slope, inclined at 15° to the horizontal, at a constant velocity of 3 m s^{-1}.



The combined mass of the rider and bicycle is 70 kg. If the value of the acceleration due to gravity is taken as 10 m s^{-2}, the total force of friction is

A 181 N

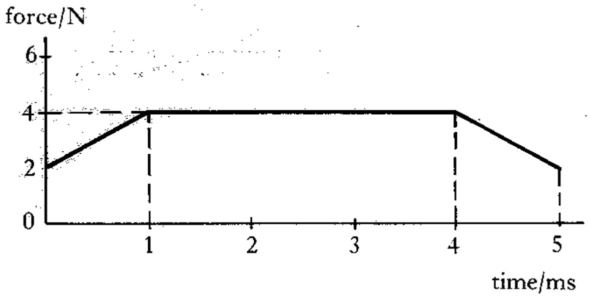
B 210 N

C 362 N

D 391 N

E 676 N.

7. A force, which is applied in a straight line to an object, varies with time as shown in the following graph.



What is the total impulse given to the object by the force in this 5 millisecond time interval?

A 8×10^{-3} N s

B 10×10^{-3} N s

C 15×10^{-3} N s

D 18×10^{-3} N s

E 20×10^{-3} N s

8. A shell of mass 5 kg is travelling horizontally with a speed of 200 m s^{-1} when it explodes into two parts. One part of mass 3 kg continues in the original direction with a speed of 100 m s^{-1}.

The other part also continues in this same direction. Its speed will be

A 150 m s^{-1}

B 200 m s^{-1}

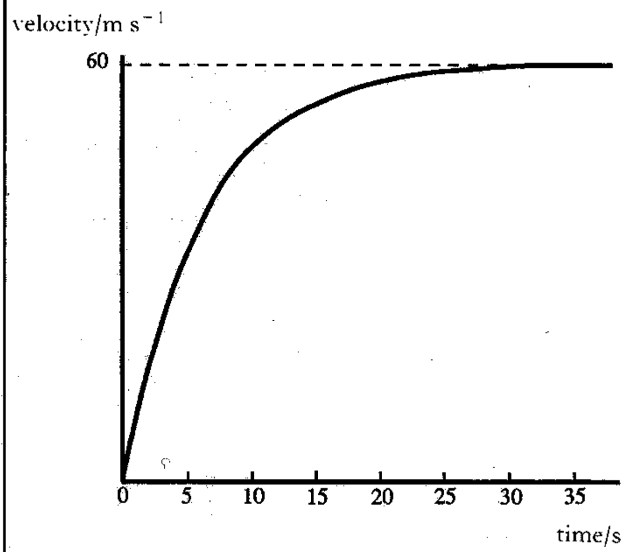
C 300 m s^{-1}

D 350 m s^{-1}

E 700 m s^{-1}.

9. An object of mass 4 kg falls from a considerable height in an area where the acceleration due to gravity is 10 m s^{-2}.

The velocity-time graph for the first 35 seconds of its motion is as follows.



Which row in the following table could give the frictional forces acting on the object at 4 seconds, 8 seconds and 32 seconds?

	Force at 4 s	*Force at 8 s*	*Force at 32 s*
A	0 N	30 N	40 N
B	40 N	30 N	0 N
C	40 N	40 N	40 N
D	20 N	30 N	40 N
E	0 N	0 N	40 N

[Turn over

10. After a car has been parked in the sun for some time, it is found that the pressure in the tyres has increased. This is because

A the volume occupied by the air molecules in the tyres has increased

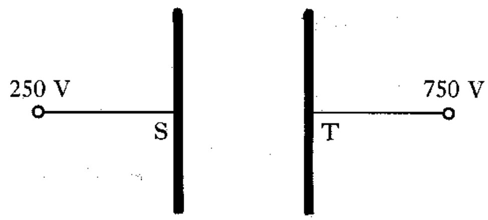
B the force produced by the air molecules in the tyres acts over a smaller area

C the average spacing between the air molecules in the tyres has increased

D the increased temperature has made the air molecules in the tyres expand

E the air molecules in the tyres are moving with greater kinetic energy.

11. In the arrangement shown below, 2 C of positive charge is moved from plate S, which is at a potential of 250 V, to plate T, which is at a potential of 750 V.



How much energy is required to move this charge from plate S to plate T?

A 0·004 J

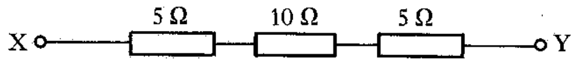
B 250 J

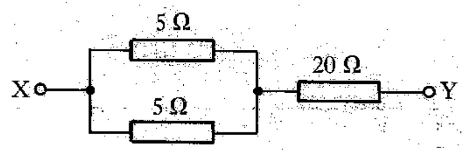
C 500 J

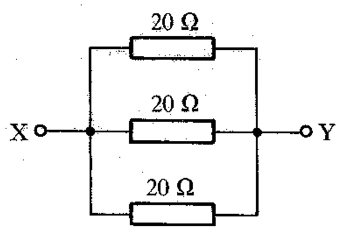
D 1000 J

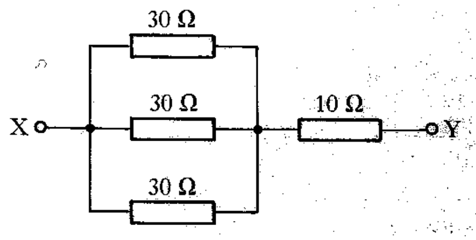
E 1500 J

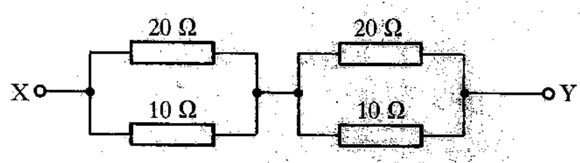
12. In which of the following arrangements of resistors is the resistance between X and Y the same?

1. 

2. 

3. 

4. 

5. 

A 1 and 2 only

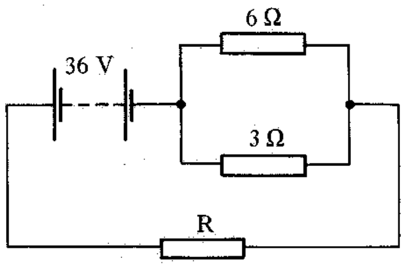
B 1 and 3 only

C 1 and 4 only

D 1, 2 and 4 only

E 1, 3 and 5 only

13. The current delivered by the battery in the following circuit is 3 A.



Assuming that the battery has negligible internal resistance, the resistance of resistor R is

A 3 Ω

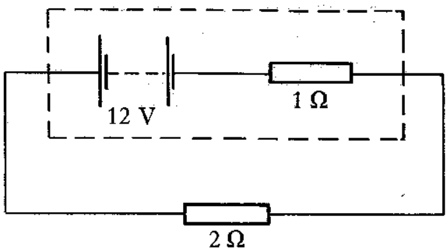
B 4 Ω

C 10 Ω

D 12 Ω

E 18 Ω.

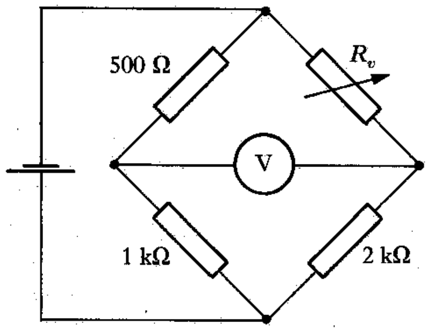
14. A battery of e.m.f. 12 V and internal resistance 1 Ω is connected across a 2 Ω resistor, as shown in the circuit below.



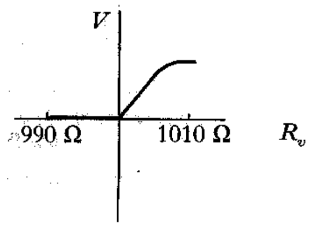
Which row in the following table shows the correct values for current, terminal potential difference and lost volts in this circuit?

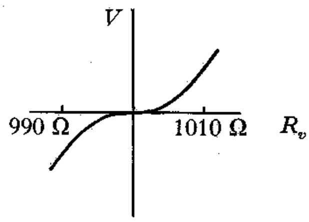
	Current/A	*t.p.d./V*	*lost volts/V*
A	4	4	8
B	4	8	4
C	6	4	8
D	6	8	4
E	12	8	4

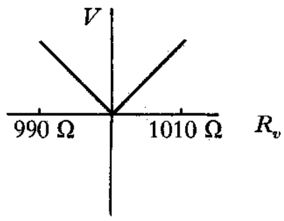
15. In the following Wheatstone bridge circuit, the reading on the voltmeter is zero when the resistance R_v of the variable resistor is set at 1 kΩ.

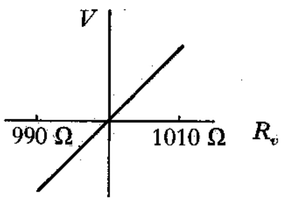


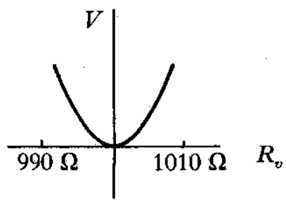
Which of the following would best represent the shape of a graph of the voltmeter reading V against the resistance R_v as it is varied between 990 Ω and 1010 Ω?

A


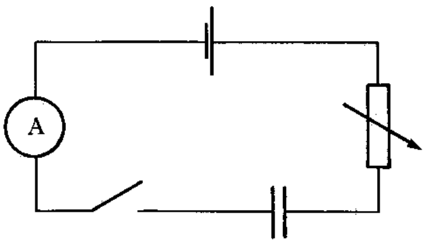
B


C


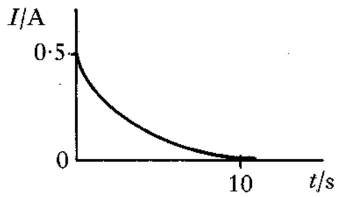
D


E


16. The circuit in the diagram below is used for charging a capacitor.

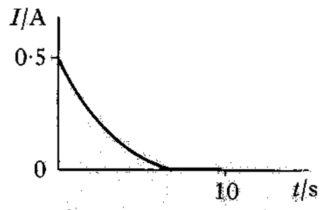


The switch is closed and the capacitor charges up. The variation of current I with time t for this circuit is shown in the following graph.

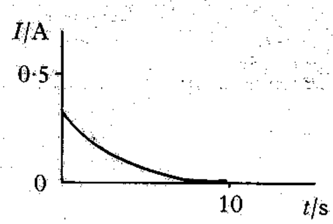


The capacitor is discharged and the value of the variable resistor is **increased.** The experiment is then repeated. Which of the following graphs shows the correct variation of current with time?

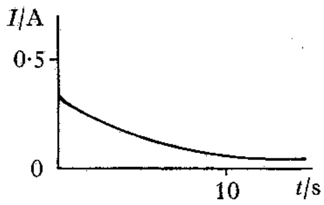
A



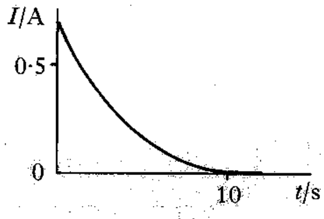
B



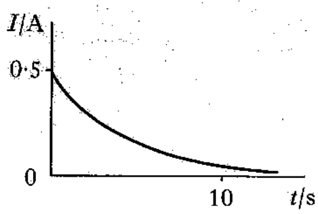
C



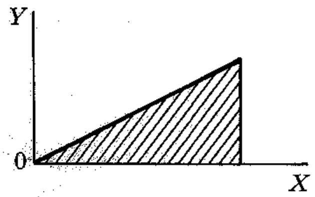
D



E



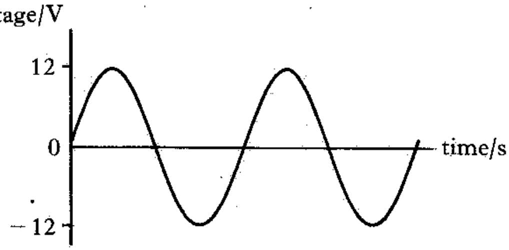
17. In the graph below, the shaded area is used to calculate the work done in charging a capacitor.



What should be the labels on the X and Y axes?

	X-axis label	*Y-axis label*
A	charge	potential difference
B	current	potential difference
C	charge	time
D	current	time
E	current	charge

18. An immersion heater can be operated either from an a.c. supply or a d.c. supply. The graph below represents the a.c. supply voltage.



What d.c. supply voltage would produce the same rate of heating from this heater?

A 6 V

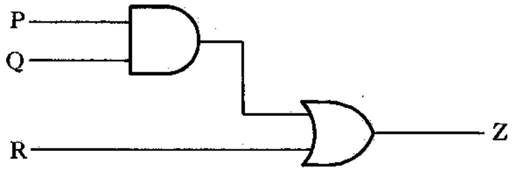
B $\frac{12}{\sqrt{2}}$ V

C 12 V

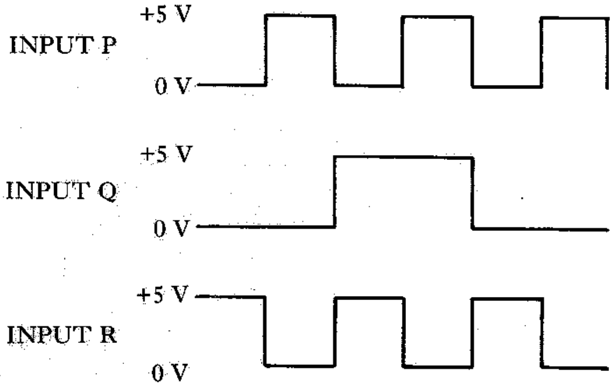
D $12\sqrt{2}$ V

E 24 V

19. Two logic gates are connected together in the following way.

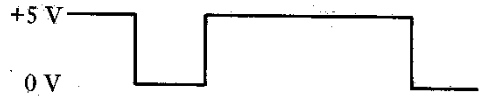


Pulse waveforms are applied to inputs P, Q and R as follows.

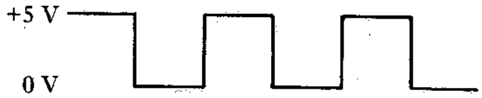


Which of the following shows the output pulse waveform at Z?

A

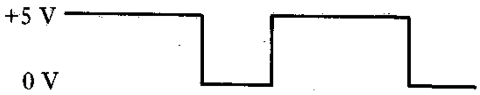


B

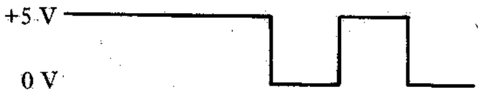


C

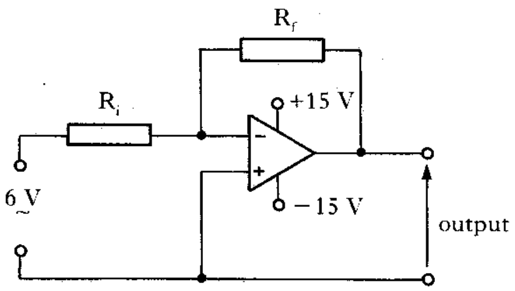
D



E



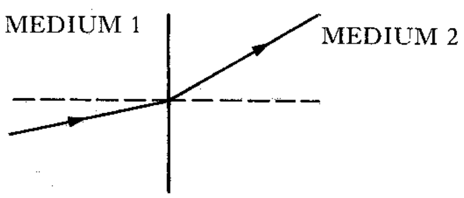
20. The circuit below is used to generate square waves.



Which values for resistors R_i and R_f will produce an approximately square wave output?

	R_i	R_f
A	1 kΩ	10 kΩ
B	5 kΩ	10 kΩ
C	10 kΩ	10 kΩ
D	10 kΩ	5 kΩ
E	10 kΩ	1 kΩ

21. A ray of light travels with speed v_1 through medium 1 and then passes into another medium 2, where it travels at speed v_2.

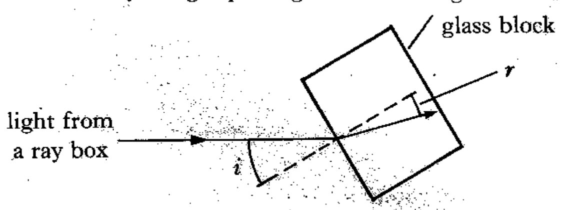


The refractive indices for medium 1 and medium 2 are n_1 and n_2 respectively.

Which row in the following table correctly compares the speeds and refractive indices for each medium?

	Speed of light	*Refractive Index*
A	v_2 is less than v_1	n_2 is less than n_1
B	v_2 is the same as v_1	n_2 is less than n_1
C	v_2 is the same as v_1	n_2 is greater than n_1
D	v_2 is greater than v_1	n_2 is less than n_1
E	v_2 is greater than v_1	n_2 is greater than n_1

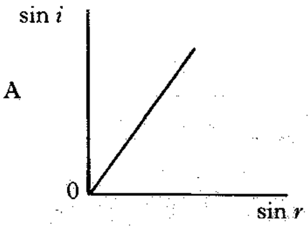
22. A pupil sets up the apparatus shown below to investigate the relationship between the angle of incidence (i) and the angle of refraction (r) for a ray of light passing from air into glass.



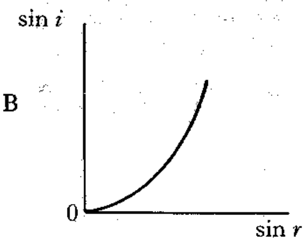
The pupil plots a graph of sin i against sin r.

Which graph shows the correct relationship between sin i and sin r?

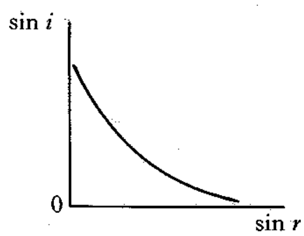
A



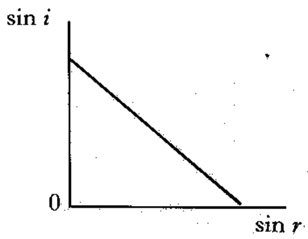
B



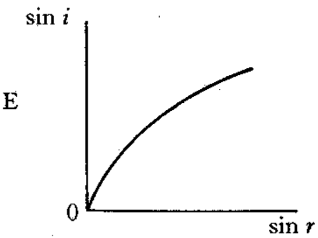
C



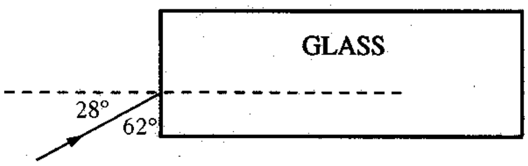
D



E

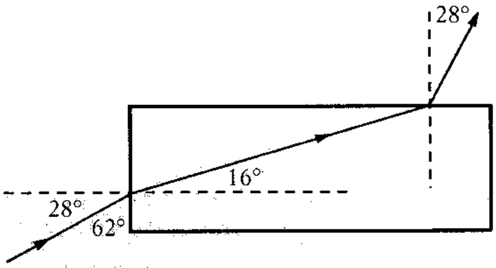


23. A ray of monochromatic light, travelling in air, strikes the side of a rectangular block of glass of refractive index 1·7, as shown below.

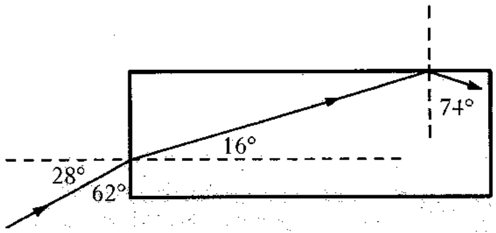


Which of the following diagrams shows correctly the subsequent path of the ray?

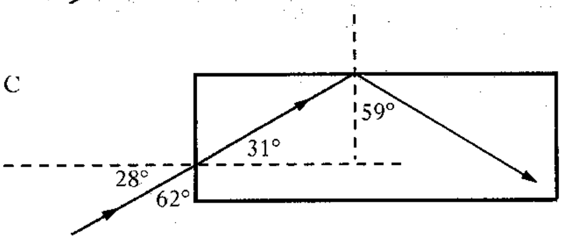
A



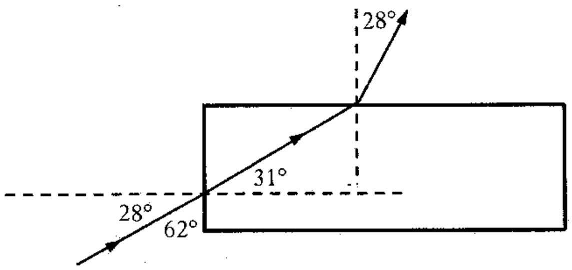
B



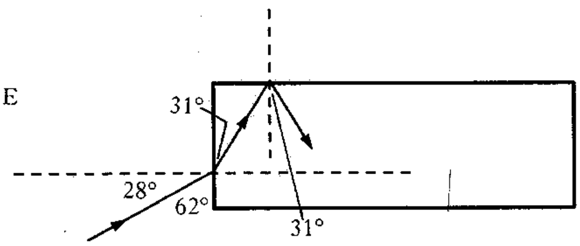
C



D



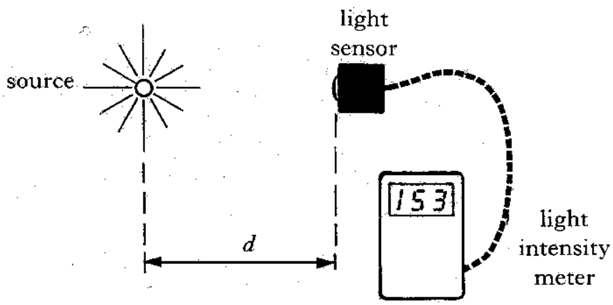
E



24. Monochromatic light of wavelength λ passes through a grating and produces a pattern of bright maxima on a screen. The separation of lines on the grating is d and the grating is at a distance L from the screen. Which of the following pairs of changes will **always** produce an **increase** in the spacing of the maxima on the screen?

A	increase L	increase d
B	increase λ	increase d
C	decrease L	decrease λ
D	increase L	decrease λ
E	increase λ	decrease d

25. An experiment is carried out to investigate the relationship between the light intensity I from a point source and the distance d from the source. The experiment is done in a darkened room and a meter connected to a light sensor indicates the intensity, as shown below.



Which of the following expressions will give an approximately constant value?

A $I \times d$

B $I \times d^2$

C $\frac{I}{d}$

D $\frac{I}{d^2}$

E $I \times \sqrt{d}$

26. A student makes a note of the following statements after a lesson about photoelectric emission.

I Photoelectric emission from a metal occurs only if the frequency of the incident radiation is greater than the threshold frequency.

II The threshold frequency depends on the metal from which photoemission takes place.

III If the frequency of the incident radiation is less than the threshold frequency, increasing its intensity will cause photoemission.

Which of the above statements is/are correct?

A I only

B II only

C I and II only

D II and III only

E I, II and III

27. The photon energies for three different radiations are as follows.

Radiation 1: $2{\cdot}78 \times 10^{-19}$ J
Radiation 2: $4{\cdot}97 \times 10^{-19}$ J
Radiation 3: $6{\cdot}35 \times 10^{-19}$ J

Which one of the following is true?

A The wavelength of radiation 1 is longer than that of radiation 2.

B The wavelength of radiation 3 is longer than that of radiation 2.

C The frequency of radiation 1 is higher than that of radiation 2.

D The frequency of radiation 1 is higher than that of radiation 3.

E The frequency of radiation 2 is higher than that of radiation 3.

28. A student reads the following passage in a physics dictionary.

"... a solid state device in which positive and negative charge carriers are produced by the action of light on a p–n junction."

The passage describes a

A light emitting diode

B laser

C capacitor

D photodiode

E thermistor.

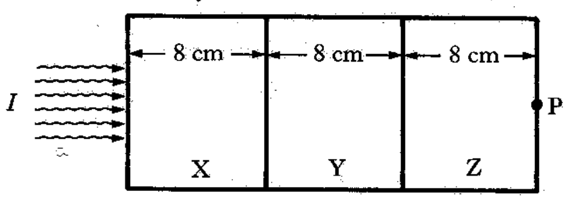
29. For the nuclear disintegration described below, which row of the table shows the correct values of x, y and z?

$$^{214}_{x}\text{Pb} \rightarrow {}^{y}_{83}\text{Bi} + {}^{0}_{z}e$$

	x	y	z
A	84	214	1
B	83	210	4
C	85	214	2
D	82	214	−1
E	82	210	−1

30. Three materials X, Y and Z are used as gamma ray absorbers. They have half-value thicknesses of 2 cm, 4 cm and 8 cm respectively.

Gamma rays of intensity I strike the left side of this "sandwich" composed of X, Y and Z.



The intensity at point P, on the right side of the "sandwich", will be

A $\frac{I}{8}$

B $\frac{I}{16}$

C $\frac{I}{32}$

D $\frac{I}{64}$

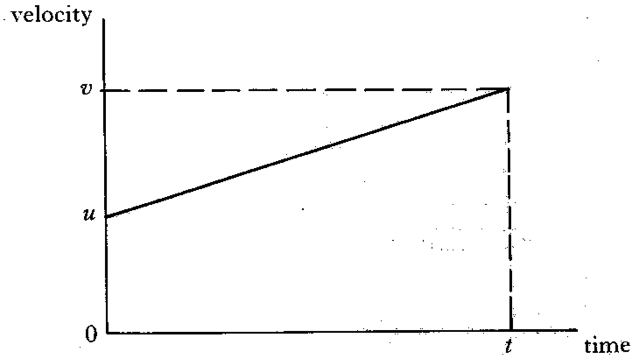
E $\frac{I}{128}$

SECTION B

Write your answers to Questions 31–37 in the answer book.

Marks

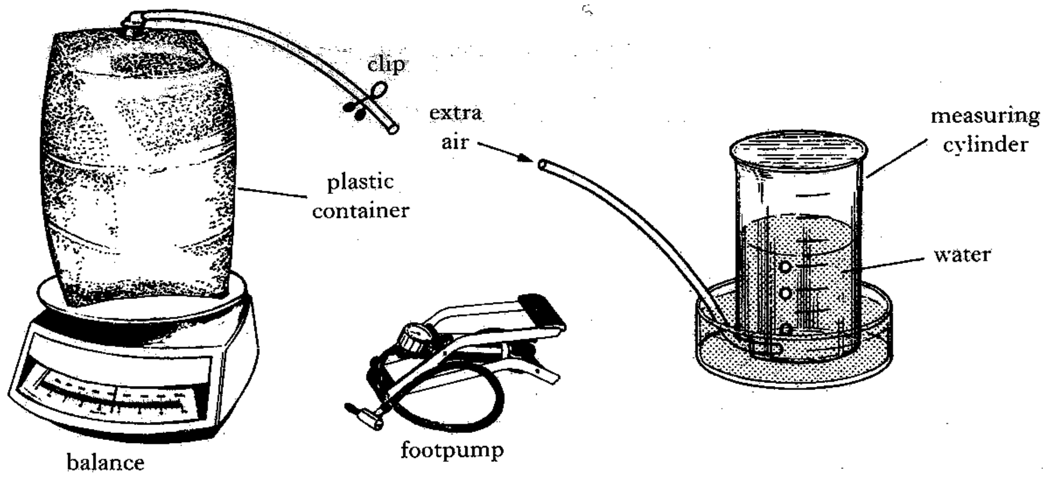
31. The velocity–time graph shown below is for an object moving with constant acceleration a.



Show that during the time interval t the object moves through a displacement s given by

$$s = ut + \tfrac{1}{2}at^2.$$ **2**

32. The apparatus in the diagram below may be used to measure the density of air.



Using the footpump, extra air is pumped into the container. This extra air is released into the measuring cylinder as shown above and its volume measured.

The following measurements are recorded.

mass of container full of air = 362·00 g
mass of container with extra air = 363·86 g
volume of air released = 1687·00 cm^3

What value do these results give for the density of air in kg m^{-3}? **3**

[Turn over

Past Paper Solutions

Solutions to SQA examination

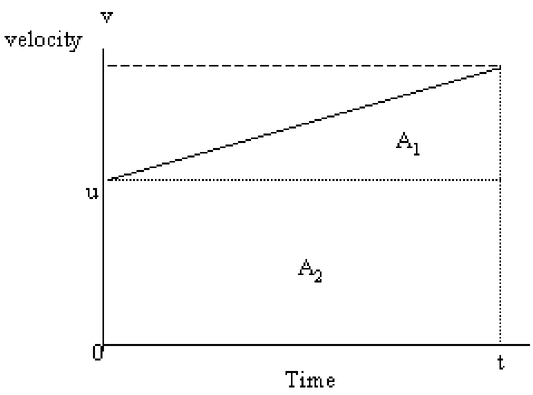
1994 Higher Grade Physics

Paper I Solutions

Return to past paper index page.

1. **D**	11. **D**	21. **D**
2. **B**	12. **C**	22. **A**
3. **C**	13. **C**	23. **B**
4. **C**	14. **B**	24. **E**
5. **C**	15. **D**	25. **B**
6. **A**	16. **C**	26. **C**
7. **D**	17. **A**	27. **A**
8. **D**	18. **B**	28. **D**
9. **D**	19. **A**	29. **D**
10.**E**	20. **A**	30. **E**

31.



The displacement(s) is equal to the total area(A_1+A_1) under the graph.

s = A_1+A_1
s = ut +(v-u)t/2

Note that from the definition of acceleration :

a = (v-u)/t
=>(v-u)= at

Substitute this into the expression above.

s = ut + att/2

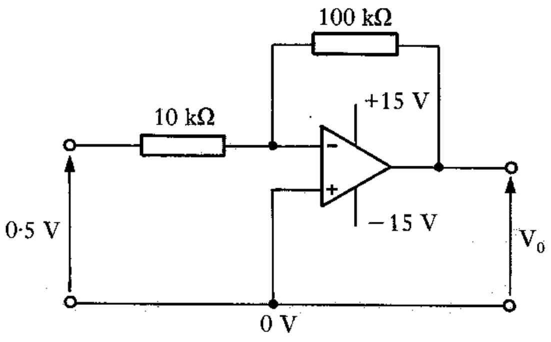
Marks

33. Liquid nitrogen changes to its gaseous state at a temperature of -196 °C.

(*a*) What is this temperature in kelvin?

(*b*) Explain why a temperature of 0 kelvin is described as "the absolute zero of temperature". **3**

34. The circuit diagram for an **ideal** op-amp connected in the inverting mode is shown below.

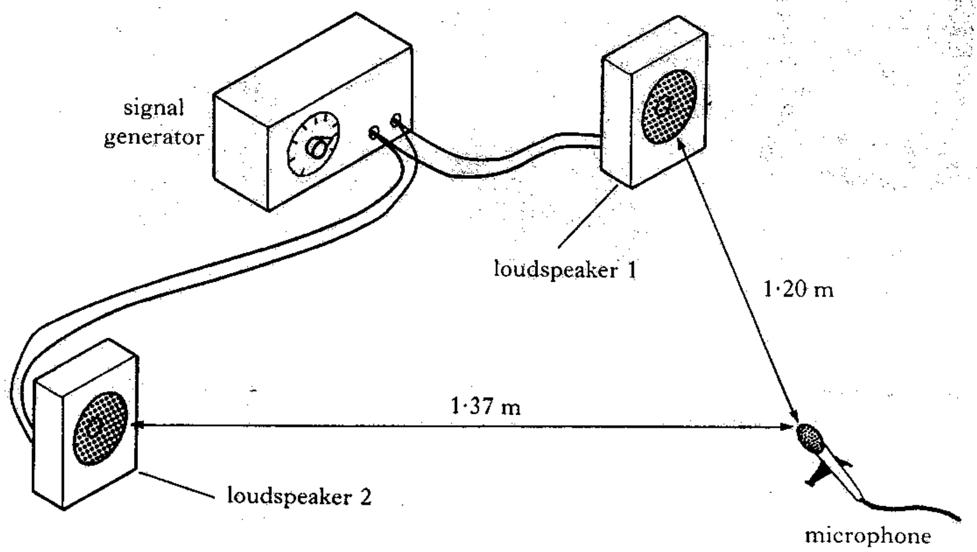


(*a*) What is the potential at the inverting input?

(*b*) What is the value of the current in the input resistor? **3**

35. Loudspeakers 1 and 2 are both connected to the same signal generator which is set to produce a 1 kHz signal.

Loudspeaker 1 is switched on but loudspeaker 2 is switched off.



State **and** explain what happens to the amplitude of the signal picked up by the microphone when loudspeaker 2 is switched on.

Your explanation should include a calculation using the value of the speed of sound in air as 340 m s^{-1}. **3**

$s = ut + at^2/2$ as required.

32. Density of air = Mass of air released/Volume of air released

$\rho = M_{air}/V_{air}$

$M_{air} = (363.86-362.00)g = 1.86g = 1.86\times10^{-3}kg$
$V_{air} = 1687.00cm^3 = 1687.00\times10^{-6}m^3$

$\rho = 1.86\times10^{-3}kg/1687.00\times10^{-6}m^3$
$\rho = 1.1025kg/m^3$

33.a. $T(K) = T(^oC) + 273$
$T(K) = -196 + 273$
$T(K) = 77K$

b. The kelvin temperature is directly proportional to the kinetic energy of particles. At 0K particles have no kinetic energy. A lower energy state/temperature, is therefore, not possible.

34.a. $V_{inverting\ input} = 0V$

b. $I = V/R$
$V = 0.5V$
$R = 10,000\Omega$

$I = 0.5/10000$
$I = 50\mu A$

35. $\lambda = v/f$
$\lambda = 340/1000$
$\lambda = 0.34m$

Path difference = (1.37-1.20)m = 0.17m

This means that loudspeaker 2 is a distance of 0.17m further away from the microphone than loudspeaker 1. This is a distance equivalent to $\lambda/2$. Therefore, the waves reach the microphone 180^o out of phase and interfere destructively, reducing the amplitude of the sound.

36.a. All metals and carbon are conductors.
Plastic and rubber are examples of insulators.
Group IV elements such as silicon are semiconductors.

b. By adding pentavalent (group V) atoms to group IV semiconductor, n-type semiconductor material is made. This material has a lower resistance than pure semiconductor, as a result of an excess of negative charge carriers in the structure.

37.a. When two atoms join, or fuse together, to produce a single atom of greater mass the reaction is called fusion.

b. The mass of the product of a fusion reaction is less than that of the initial reactants. This "missing mass" is converted into energy.

$E = mc^2$

Where: m = missing mass
c = speed of light

Marks

36. (*a*) Materials may be classified as "conductors", "semiconductors" and "insulators".

Give an example of a material from each of these groups.

(*b*) An electronics textbook states that

"... n-type semiconductor material is formed by doping a pure semiconductor with impurity atoms."

What is meant by the term "n-type" semiconductor material? **3**

37. Energy is produced within the Sun by fusion reactions.

(*a*) State what is meant by a fusion reaction.

(*b*) Explain briefly why a fusion reaction releases energy. **3**

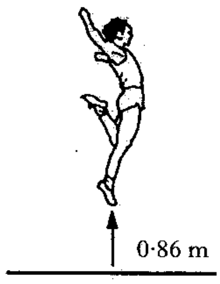
[*END OF QUESTION PAPER*]

Back to Table Answers

Marks

1. (*a*) A long jumper devises a method for estimating the horizontal component of his velocity during a jump.

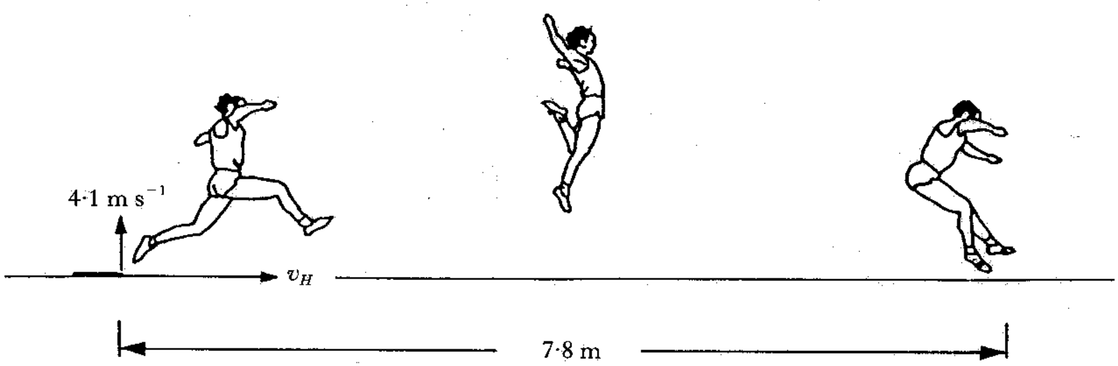
His method involves first finding out how high he can jump **vertically**.



He finds that the maximum height he can jump is 0·86 m.

(i) Show that his initial vertical velocity is $4{\cdot}1\ \mathrm{m\,s^{-1}}$.

He now assumes that when he is long jumping, the initial vertical component of his velocity at take-off is $4{\cdot}1\ \mathrm{m\,s^{-1}}$.



The length of his long jump is 7·8 m.

(ii) Calculate the value that he should obtain for the horizontal component of his velocity, v_H. **5**

(*b*) His coach tells him that, during the 7·8 m jump, his maximum height above the ground was less than 0·86 m. Ignoring air resistance, state whether his actual horizontal component of velocity was greater or less than the value calculated in part (*a*) (ii). You must justify your answer. **2**

(7)

[Turn over

Past Paper Solutions

Solutions to SQA examination

1994 Higher Grade Physics

Paper II Solutions

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1.a.i. At the maximum height the long jumpers vertical velocity(V_v) is 0m/s.

v_v = 0m/s
S_v = 0.86m
a = -9.8m/s/s
u_v = ?

To find u use : $v^2 = u^2 + 2as$

$0^2 = u^2 + 2x(-9.8)x0.86$
$u^2 = 16.856(m/s)^2$
u = 4.1m/s

Note: The positive square root is taken because the motion is in the upwards direction.

a.ii. The total time in the air for the vertical jump in part a.i. will be the same as that for the actual jump if the vertical component of velocity is the same.

The total displacement for the jump in part a.i. is 0m.

s = 0m
a = -9.8m/s/s
u = 4.1m/s
t = ?

To solve for t use: $s = ut + 1/2(at^2)$

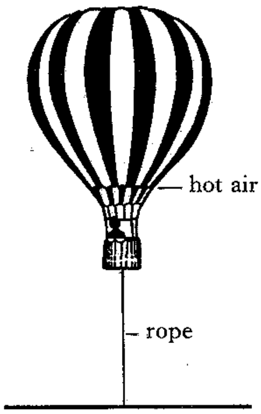
$0 = ut + 1/2(at^2)$....divide by t
0 = u + (at)/2
t = -2u/a
t = (-2x4.1)/-9.8
t = 0.84s

$v_H = s_H/t$
v_H = 7.8/0.84
v_H = 9.3m/s

b. With a maximum height of less than 0.86m the time in the air would be less than that 0.84s. This means that the horizontal distance must be covered in a shorter time. This can only be achieved if the horizontal velocity is greater than 9.3m/s.

Marks

2. (*a*) A hot air balloon, of total mass 500 kg, is held stationary by a single vertical rope.

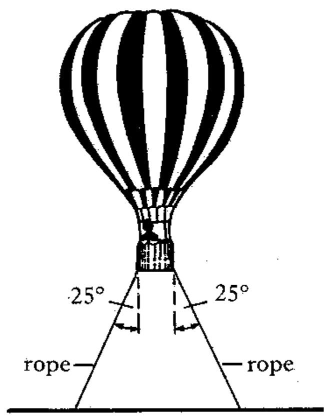


(i) Draw a sketch of the balloon. On your sketch, mark and label all the forces acting on the balloon.

(ii) When the rope is released, the balloon initially accelerates vertically upwards at $1\cdot5\ \text{m s}^{-2}$. Find the magnitude of the buoyancy force.

(iii) Calculate the tension in the rope **before** it is released. **5**

(*b*) An identical balloon is moored using two ropes, each of which makes an angle of 25° to the vertical, as shown below.



By using a scale diagram, or otherwise, calculate the tension in each rope. **2**

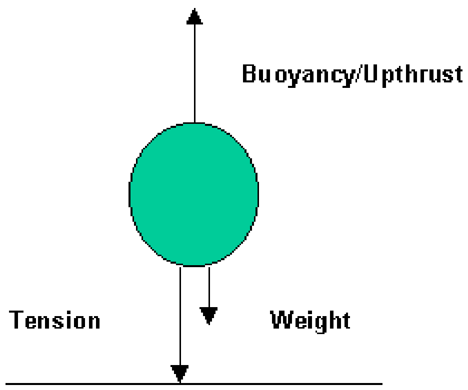
(*c*) During a flight, when a hot air balloon is travelling vertically upwards with constant velocity, some hot air is released. This allows cooler air to enter through the bottom of the balloon.

Describe **and** explain the effect of this on the motion of the balloon. You may assume that the volume of the balloon does not change. **3**

(10)

Back to Table

2.a.i.



a.ii. m = 500kg
g = 9.8N/kg
W = ?

W = mg
W = 500x9.8
W = 4900N

With no rope in position there is no tension force(T). This means that the unbalance force causing the acceleration is the difference between the buoyancy force(B) and the weight(W).

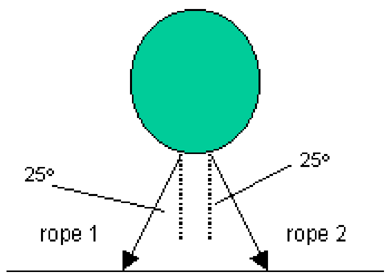
F_{un} = B - W
F_{un} = ma

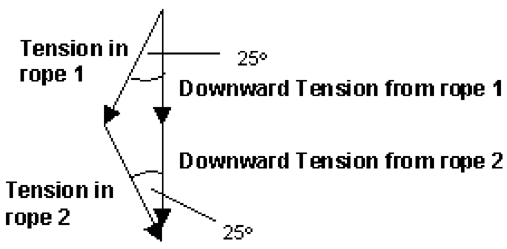
ma = B - W
B = ma + W
B = 500x1.5 + 4900
B = 5650N

a.iii.Before the release the upward force must balance the downward forces.

B = W + T
T = B - W
T = 5650 - 4900
T = 750N

b.





Each rope contributes half of the downward component of the tension.

Downward tension from rope 1 = 375N
Downward tension from rope 2 = 375N

To calculate the tension in each rope use trigonometry.

$375/T_{rope\ 1} = \cos 25^o$
$T_{rope\ 1} = 375/\cos 25^o$

Back to Table

$T_{rope\ 1}$ = 413.8N

$375/T_{rope\ 2} = \cos25^o$

$T_{rope\ 2} = 375/\cos25^o$

$T_{rope\ 2}$ = 413.8N

4.a.i. Use Boyle's law to solve this problem.

$P_1 = 1.76\times10^5$Pa

$V_1 = 750$cm^3

P_2 = ?

$V_2 = 900$cm^3

$P_1V_1 = P_2V_2$

$P_2 = P_1V_1/V_2$

$P_2 = 1.76\times10^5\times750/900$

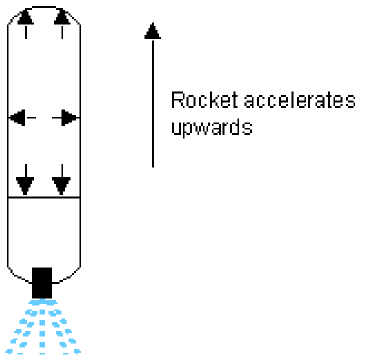
$P_2 = 1.47\times10^5$Pa

a.ii. F = PA

$F = 1.47\times10^5\times5\times10^{-3}$

F = 735N

b. The gas inside the rocket exerts the forces shown in the diagram.



- The lateral forces cancel.
- The downward force accelerates the water out of the rocket.
- The upward force accelerates the rocket.

4.a. $Ek = 1/2(mv^2)$

Collision with polyurethane block.

$Ek = 1/2(0.5\times0.33^2)$

Ek = 0.027J

Collision with rubber band.

$Ek = 1/2(0.5\times0.43^2)$

Ek = 0.046J

b. In elastic collisions kinetic energy is conserved.
In the collision with the **metal spring** the least amount of kinetic energy is lost and is therefore the most like an elastic collision.

c. To propel the vehicle with the same initial speed the force providing the impulse must be equal in each experiment. This could be achieved if the impulse was provided by a stretched elastic band and ensuring the band was pulled back by the same amount each time.

Back to Table Answers

Marks

3. A water rocket consists of a plastic bottle, partly filled with water. Air is pumped in through the water as shown in Figure 1. When the pressure inside the bottle is sufficiently high, water is forced out at the nozzle and the rocket accelerates vertically upwards as shown in Figure 2.

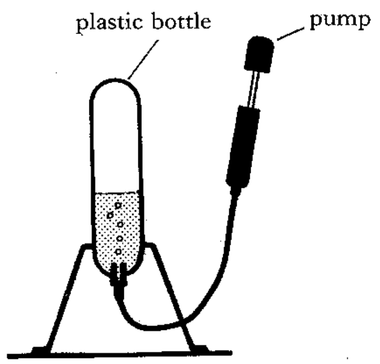


Figure 1

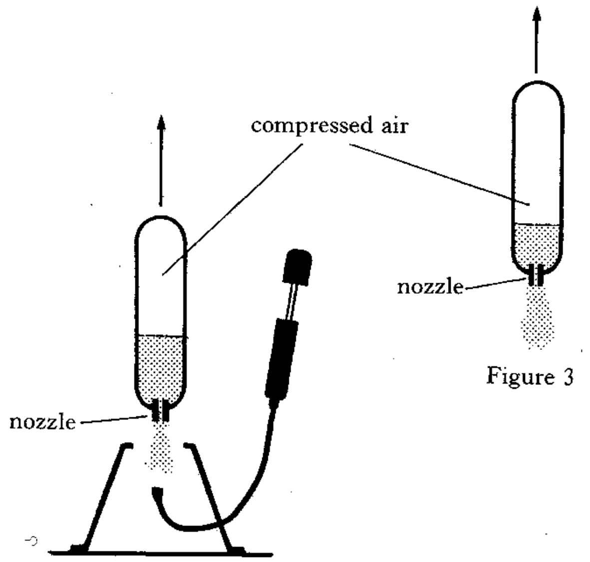


Figure 2

Figure 3

(*a*) (i) At take-off, the volume of air in the bottle is $750\,cm^3$ at a pressure of $1{\cdot}76 \times 10^5$ Pa.

Figure 3 shows the rocket at a later stage in its flight, when the volume of the air in the bottle has increased to $900\,cm^3$.

Calculate the new pressure of the compressed air at this later stage in its flight.

(ii) The area of the water surface which is in contact with the compressed air in the bottle is $5{\cdot}0 \times 10^{-3}\,m^2$.

Calculate the force exerted on the water by the compressed air at the new pressure. **4**

(*b*) Explain fully why the rocket rises as the water is forced out at the nozzle. **2**

(6)

[Turn over

Back to Table

$T_{rope\ 1} = 413.8N$

$375/T_{rope\ 2} = \cos 25^o$

$T_{rope\ 2} = 375/\cos 25^o$

$T_{rope\ 2} = 413.8N$

4.a.i. Use Boyle's law to solve this problem.

$P_1 = 1.76x10^5Pa$

$V_1 = 750cm^3$

$P_2 = ?$

$V_2 = 900cm^3$

$P_1V_1 = P_2V_2$

$P_2 = P_1V_1/V_2$

$P_2 = 1.76x10^5x750/900$

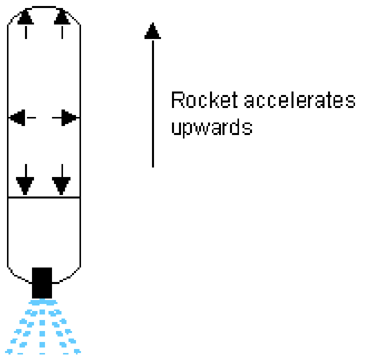
$P_2 = 1.47x10^5Pa$

a.ii. $F = PA$

$F = 1.47x10^5x5x10^{-3}$

$F = 735N$

b. The gas inside the rocket exerts the forces shown in the diagram.



- The lateral forces cancel.
- The downward force accelerates the water out of the rocket.
- The upward force accelerates the rocket.

4.a. $Ek = 1/2(mv^2)$

Collision with polyurethane block.

$Ek = 1/2(0.5x0.33^2)$

$Ek = 0.027J$

Collision with rubber band.

$Ek = 1/2(0.5x0.43^2)$

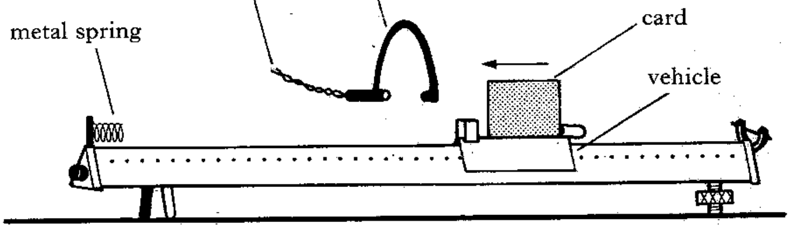
$Ek = 0.046J$

b. In elastic collisions kinetic energy is conserved.
In the collision with the **metal spring** the least amount of kinetic energy is lost and is therefore the most like an elastic collision.

c. To propel the vehicle with the same initial speed the force providing the impulse must be equal in each experiment. This could be achieved if the impulse was provided by a stretched elastic band and ensuring the band was pulled back by the same amount each time.

Marks

4. A student uses a linear air track to investigate collisions. In one experiment a vehicle, mass 0·50 kg, moves along and rebounds from a metal spring mounted at one end of the level track as shown below.



block of polyurethane foam

rubber band catapult

By using a light gate connected to a computer, she obtains values for the speed of the vehicle before and after it collides with the spring.

She then repeats this procedure, replacing the metal spring first with the block of polyurethane foam and then with the rubber band catapult. She records the results of each experiment in a table as shown below.

	Metal spring	Polyurethane block	Rubber band
Speed before collision/m s^{-1}	0·55	0·55	0·55
Speed after collision/m s^{-1}	0·49	0·33	0·43
Kinetic energy before collision/J	0·076	0·076	0·076
Kinetic energy after collision/J	0·060		

(*a*) Calculate values of kinetic energy to complete the last row of the table. **2**

(*b*) For which experiment is the collision most nearly elastic? You must justify your answer. **1**

(*c*) Describe a method she could use to give the vehicle the same initial speed each time. **1**

Back to Table

$T_{rope\ 1} = 413.8N$

$375/T_{rope\ 2} = \cos25^o$

$T_{rope\ 2} = 375/\cos25^o$

$T_{rope\ 2} = 413.8N$

4.a.i. Use Boyle's law to solve this problem.

$P_1 = 1.76x10^5Pa$

$V_1 = 750cm^3$

$P_2 = ?$

$V_2 = 900cm^3$

$P_1V_1 = P_2V_2$

$P_2 = P_1V_1/V_2$

$P_2 = 1.76x10^5x750/900$

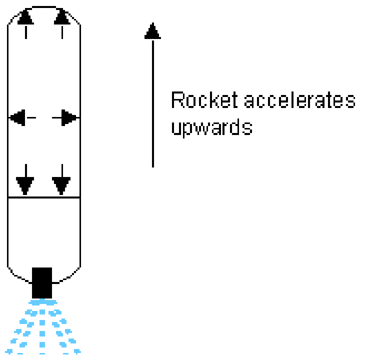
$P_2 = 1.47x10^5Pa$

a.ii. $F = PA$

$F = 1.47x10^5x5x10^{-3}$

$F = 735N$

b. The gas inside the rocket exerts the forces shown in the diagram.



- The lateral forces cancel.
- The downward force accelerates the water out of the rocket.
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4.a. $Ek = 1/2(mv^2)$

Collision with polyurethane block.

$Ek = 1/2(0.5x0.33^2)$

$Ek = 0.027J$

Collision with rubber band.

$Ek = 1/2(0.5x0.43^2)$

$Ek = 0.046J$

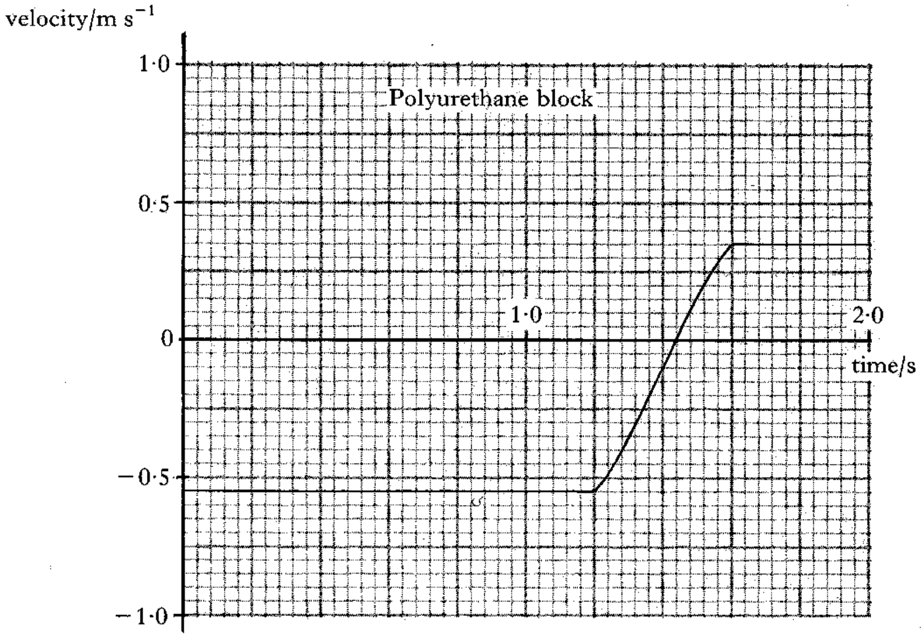
b. In elastic collisions kinetic energy is conserved.
In the collision with the **metal spring** the least amount of kinetic energy is lost and is therefore the most like an elastic collision.

c. To propel the vehicle with the same initial speed the force providing the impulse must be equal in each experiment. This could be achieved if the impulse was provided by a stretched elastic band and ensuring the band was pulled back by the same amount each time.

Marks

4. (continued)

(*d*) In order to analyse a collision in more detail, she now uses a motion sensor. This enables the computer to display a velocity–time graph of the motion.

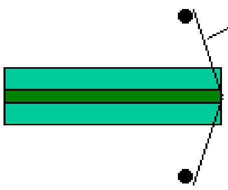


(i) Use information from this graph to calculate the average force exerted by the polyurethane block on the vehicle, mass 0·50 kg, during the time that they are in contact.

(ii) Describe the motion of the vehicle during the time that it is in contact with the polyurethane block. **4**

(8)

[Turn over



d.i. $F = (mv-mu)/t_c$

$m = 0.5kg$
t_c = contact time = 0.4s
$u = -0.55m/s$
$v = 0.35m/s$

$F = 0.5[0.35-(-0.55)]/0.4$
$F = 0.5x0.9/.4$
F = 1.125N

d.ii. The vehicle **accelerates to the right** when in contact with the block.
This is because the direction of the force causing the acceleration
is towards the right and the acceleration must be in the same direction.

5.a.i. $V_{supply} = V_x + V_y$
$V_x = V_{supply} - V_y$
$V_x = 10 - 6$
$V_x = 4V$

$I_x = V_x/R_x$
$I_x = 4/1200$
$I_x = 0.0033A$

$I_x = I_y = 0.0033A$

$V_y = I_yR_y$
$R_y = V_y/I_y$
$R_y = 6/0.0033$
$\mathbf{R_y = 1800\Omega = 1.8k\Omega}$

5.a.ii. The voltage across each resistor in a potential divider circuit
is proportional to the value of its resistance. When resistor Z
is connected in parallel with resistor Y a parallel network, with
a lower resistance than resistor Y alone, is created. The voltage across
this network, and each resistor in the network, is therefore less than
the voltage across Y alone.

5.a.iii. $1/R_p = 1/R_Y + 1/R_Z$
$1/R_p = 1/1.8 + 1/4.7$
$1/R_p = 0.5555 + 0.2128$
$1/R_p = 0.7683$
$R_p = 1.3k\Omega$

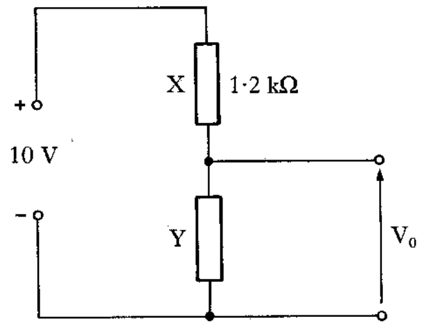
$V_{R_p} = [R_p/(R_X+R_p)]V_{supply}$

$V_{R_p} = [1.3/(1.3+1.2)]10$
$V_{R_p} = 0.52x10$
$\mathbf{V_{R_p} = 5.2V}$

5.b.i. $\mathbf{R_A/R_B = R_C/R_D}$

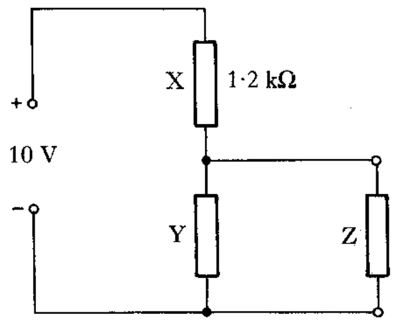
Marks

5. (*a*) A potential divider is used to provide an output voltage V_0 from a 10 V supply as shown below. The supply has negligible internal resistance.



(i) The resistance of resistor X is 1·2 kΩ and the output voltage required is 6·0 V.
Calculate the resistance of resistor Y.

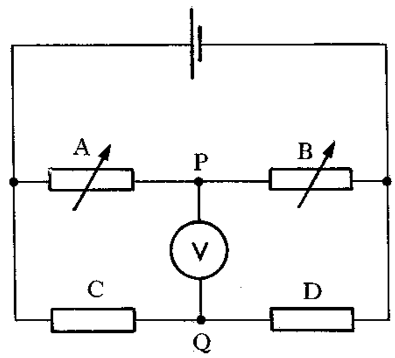
(ii) A load resistor Z is now connected across the output as shown below.



Explain why the voltage across Z is less than 6·0 V.

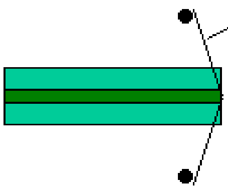
(iii) Calculate the voltage across resistor Z when its resistance is 4·7 kΩ. **6**

(*b*) A Wheatstone bridge circuit is shown below.



(i) How are the resistances of A, B, C and D related when the bridge is balanced?

Back to Table



d.i. $F = (mv-mu)/t_c$

$m = 0.5kg$
t_c = contact time = $0.4s$
$u = -0.55m/s$
$v = 0.35m/s$

$F = 0.5[0.35-(-0.55)]/0.4$
$F = 0.5x0.9/.4$
$F = 1.125N$

d.ii. The vehicle **accelerates to the right** when in contact with the block. This is because the direction of the force causing the acceleration is towards the right and the acceleration must be in the same direction.

5.a.i. $V_{supply} = V_x + V_y$
$V_x = V_{supply} - V_y$
$V_x = 10 - 6$
$V_x = 4V$

$I_x = V_x/R_x$
$I_x = 4/1200$
$I_x = 0.0033A$

$I_x = I_y = 0.0033A$

$V_y = I_yR_y$
$R_y = V_y/I_y$
$R_y = 6/0.0033$
$R_y = 1800\Omega = 1.8k\Omega$

5.a.ii. The voltage across each resistor in a potential divider circuit is proportional to the value of its resistance. When resistor Z is connected in parallel with resistor Y a parallel network, with a lower resistance than resistor Y alone, is created. The voltage across this network, and each resistor in the network, is therefore less than the voltage across Y alone.

5.a.iii. $1/R_p = 1/R_Y + 1/R_Z$
$1/R_p = 1/1.8 + 1/4.7$
$1/R_p = 0.5555 + 0.2128$
$1/R_p = 0.7683$
$R_p = 1.3k\Omega$

$V_{R_p} = [R_p/(R_X+R_p)]V_{supply}$

$V_{R_p} = [1.3/(1.3+1.2)]10$
$V_{R_p} = 0.52x10$
$V_{R_p} = 5.2V$

5.b.i. **$R_A/R_B = R_C/R_D$**

Marks

6. (*a*) A rechargeable cell is rated at 0·50 A h (ampere hour). This means that, for example, it can supply a constant current of 0·50 A for a period of 1 hour. The cell then requires to be recharged.

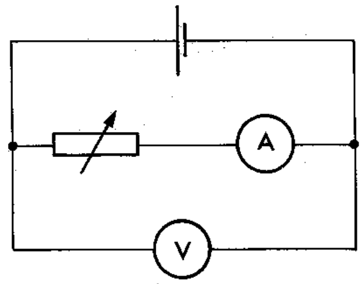
(i) What charge, in coulombs, is available from a fully charged cell?

(ii) A fully charged cell is connected to a load resistor and left until the cell requires recharging. During this time, the p.d. across the terminals of the cell remains constant at 1·2 V.

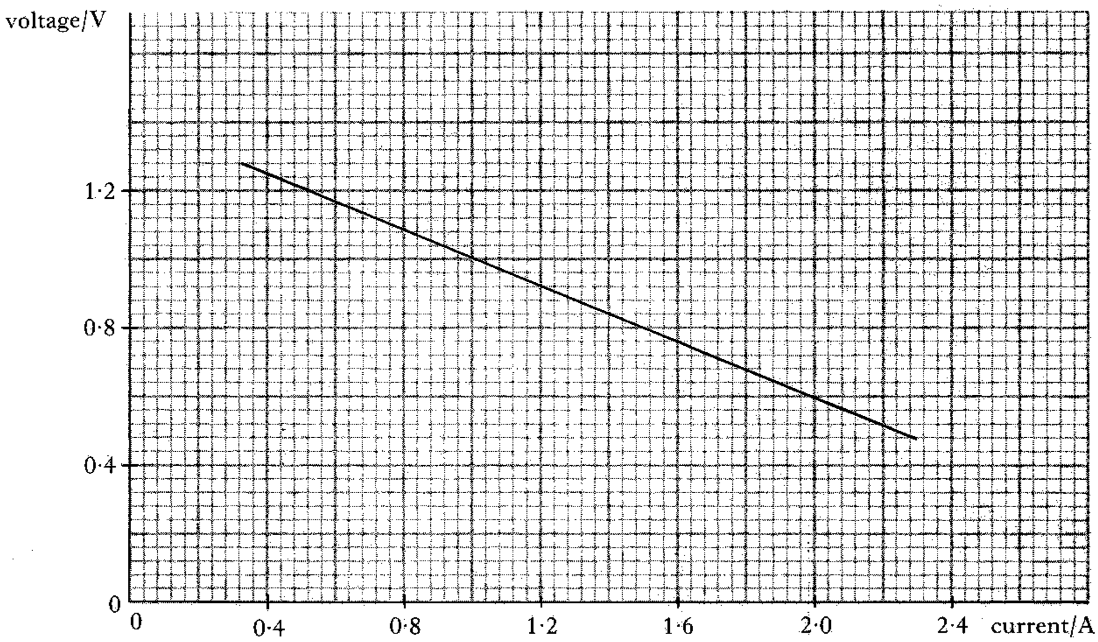
Calculate the electrical energy supplied to the load resistor in this case. **3**

(*b*) (i) State what is meant by the e.m.f. of a cell.

(ii) The circuit shown below is used in an experiment to find the e.m.f. and internal resistance of the rechargeable cell.



The voltmeter and ammeter readings for a range of settings of the variable resistor are used to produce the graph below.



Use the graph to find the values for the e.m.f. **and** internal resistance of the cell. **4**

(7)

Back to Table

b.ii.

Resistance of A/Ω	Resistance of B/Ω	Voltmeter reading/mV
120	120	0
121	120	-21
121	121	0
121	122	+21
121	119	-42

The values in the table are worked out using the fact that the voltage reading is proportional to the out of balance resistance.

6.a.i. Q = Ixt

Q = ?
I = 0.5A
t = 1h = 3600s

Q = 0.5x3600
Q = 1800C

6.a.ii. E = Pt
P = IV
=>E=ItV
E = 0.5x3600x1.2
E = 2160J

OR

E = QV (same answer)

b.i. The emf is the energy the cell supplies to each coulomb of charge passing through it.

b.ii. The emf can be found by projecting the graph line back until it cuts the voltage axis.

emf = 1.4V

The internal resistance is equal to the negative of the gradient of the line given.

$m = (y_1-y_2)/(x_1-x_2)$
m = (1.0-0.6)/(1.0-2.0)
m = 0.4/-0.1
m = -4

r = 4Ω

To justify the above consider:

y = mx + c ...1
V = mI + c ...2
V_{tpd}= E - Ir ...3
V_{tpd}= -Ir + E ...4

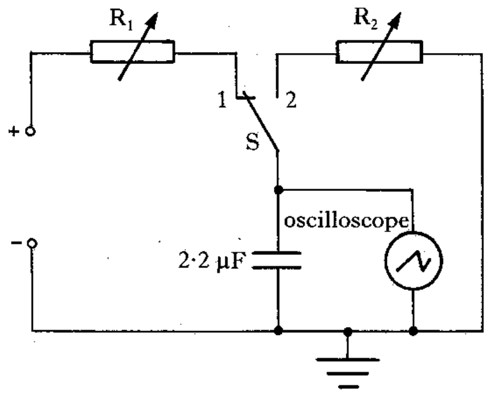
From equation (3)
When I = 0A :V_{tpd}=emf

Comparing (2) and (4)
m = -r

7.a.i. The light from the window will result in the solar cell producing a small voltage that is amplified to produce a non zero V_{out}.

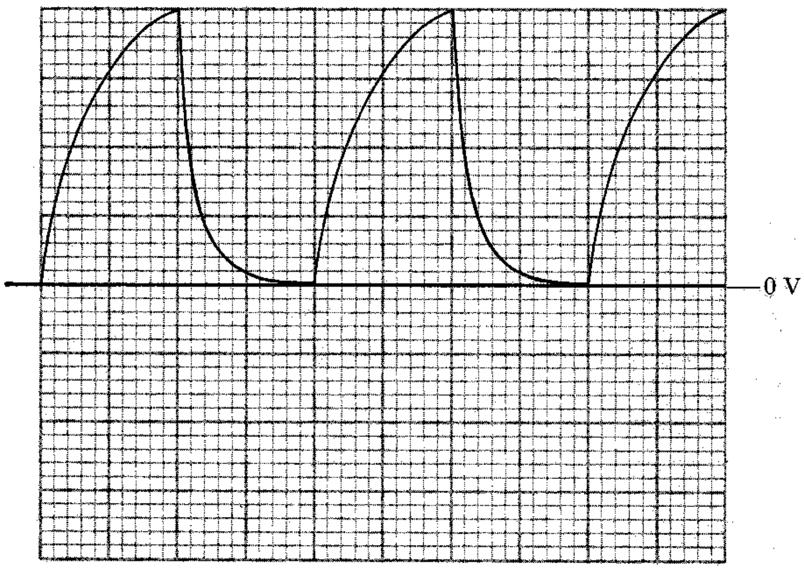
Marks

8. The circuit shown below is used to investigate the charging and discharging of a capacitor.



The capacitor is repeatedly charged and discharged by switching S between contacts 1 and 2.

(*a*) For one setting of R_1 and R_2 the following trace is obtained on the oscilloscope.



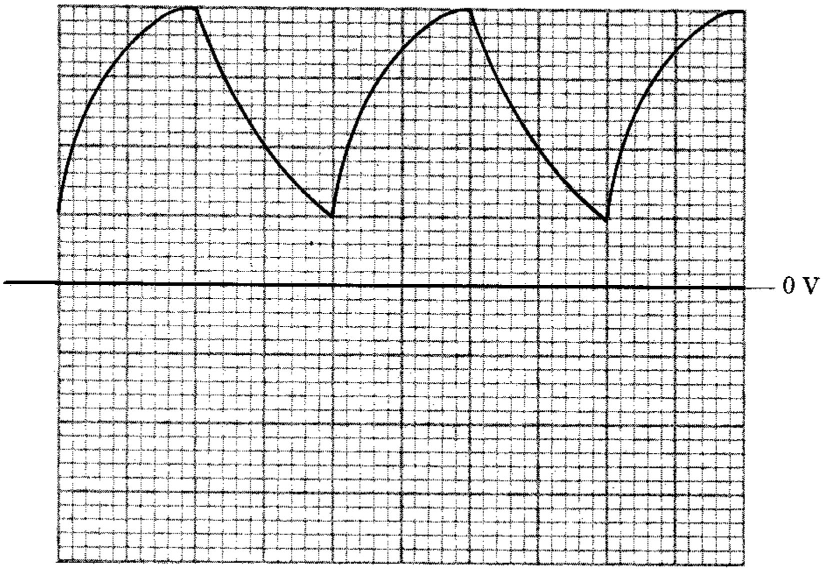
The time base of the oscilloscope is set at 5 m s per centimetre and the Y gain is set at 2 V per centimetre.

Calculate the frequency of the vibrating switch. **2**

Marks

8. **(continued)**

(*b*) With the settings of the oscilloscope unaltered, a new trace is produced when the resistance of one of the variable resistors is changed.



(i) State which one of the variable resistors was changed and whether its resistance was increased or decreased. Justify your answer.

(ii) Calculate the charge lost by the capacitor each time the switch is in the discharge position. **6**

(8)

[Turn over

Back to Table

a.ii. $V_{out}/V_{in} = R_{feedback}/R_1$
$V_{in} = -V_{out}(R_1/R_{feedback})$
$V_{in} = -(-1.75)(15/120)$
$V_{in} = 0.219V$

b.i. The differential amplifier amplifies the difference between V_1 and V_2. When V_1 is adjusted to equal V_2 there is no difference between the input voltages and the output voltage will be zero.

b.ii. $V_{out} = R_f/R_1(V_2-V_1)$
$1.5 = 220/4.7(V_2-0.219)$
$1.5 = 46.81(V_2-0.219)$
$0.032 = V_2-0.219$
$V_2 = 0.251V$

8.a. T = 4x5ms
T = 20ms

f = 1/T
$f = 1/20x10^{-3}$
f = 50Hz

b.i. The value of resistor R_2 was increased. This conclusion is drawn because the rate at which the capacitor discharges has decreased.

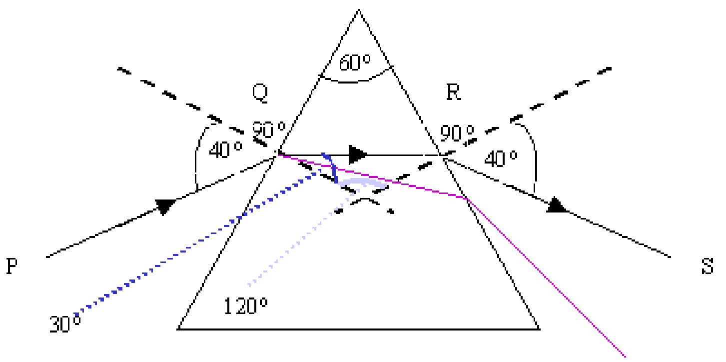
b.ii. $Q = C\Delta V$

$\Delta V = V_{initial}-V_{final}$
ΔV = 8V - 2V = 6V

$Q = 2.2x10^{-6}x6$
$Q = 1.32x10^{-5}C$

9.a.i. $n_{plastic} = \sin\theta_{air}/\sin\theta_{plastic}$
$n_{plastic} = \sin 40^o/\sin 30^o$
$n_{plastic} = 0.633/0.5$
$n_{plastic} = 1.29$

a.ii.

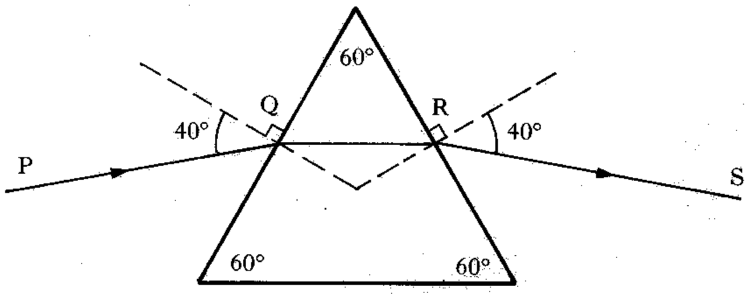


b.i. $\theta_{critical} = \sin^{-1}(1/n)$
$\theta_{critical} = \sin^{-1}(1/1.8)$
$\theta_{critical} = \sin^{-1}(0.555)$
$\theta_{critical} = 33.7^o$

b.ii. $n_{borate\ glass} = \sin\theta_{air}/\sin\theta_{borate\ glass}$
$\sin\theta_{borate\ glass} = \sin\theta_{air}/n_{borate\ glass}$

Marks

9. (*a*) The diagram below shows the path of a monochromatic beam of light through a triangular plastic prism.

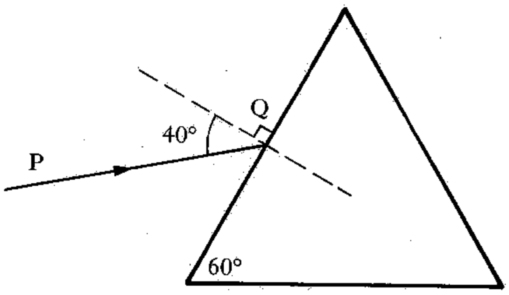


(i) Calculate the refractive index of the plastic.

(ii) Sketch a copy of the above diagram with ray PQRS clearly labelled. (Sizes of angles need not be shown.)

Add to your drawing the path which the ray PQ would take from Q if the prism were made of a plastic with a **slightly higher** refractive index. 3

(*b*) The original prism is now replaced with one of the same size and shape but made from glass of refractive index 1·80.



(i) Calculate the critical angle for this glass.

(ii) Draw an accurate diagram, showing the passage of the ray PQ through this prism until after it emerges into the air.

Mark on your diagram the values of all relevant angles. 5

(8)

Back to Table

a.ii. $V_{out}/V_{in} = R_{feedback}/R_1$
$V_{in} = -V_{out}(R_1/R_{feedback})$
$V_{in} = -(-1.75)(15/120)$
$\mathbf{V_{in} = 0.219V}$

b.i. The differential amplifier amplifies the difference between V_1 and V_2. When V_1 is adjusted to equal V_2 there is no difference between the input voltages and the output voltage will be zero.

b.ii. $V_{out} = R_f/R_1(V_2-V_1)$
$1.5 = 220/4.7(V_2-0.219)$
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$0.032 = V_2-0.219$
$\mathbf{V_2 = 0.251V}$

8.a. T = 4x5ms
T = 20ms

f = 1/T
$f = 1/20\times10^{-3}$
f = 50Hz

b.i. The value of resistor R_2 was increased. This conclusion is drawn because the rate at which the capacitor discharges has decreased.

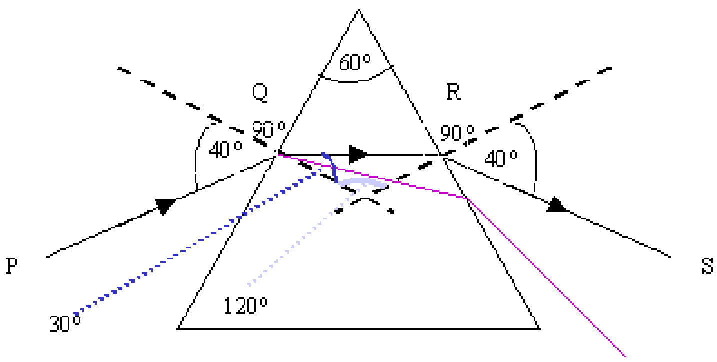
b.ii. $Q = C\Delta V$

$\Delta V = V_{initial}-V_{final}$
$\Delta V = 8V - 2V = 6V$

$Q = 2.2\times10^{-6}\times6$
$\mathbf{Q = 1.32\times10^{-5}C}$

9.a.i. $n_{plastic} = \sin\theta_{air}/\sin\theta_{plastic}$
$n_{plastic} = \sin40^o/\sin30^o$
$n_{plastic} = 0.633/0.5$
$\mathbf{n_{plastic} = 1.29}$

a.ii.



b.i. $\theta_{critical} = \sin^{-1}(1/n)$
$\theta_{critical} = \sin^{-1}(1/1.8)$
$\theta_{critical} = \sin^{-1}(0.555)$
$\mathbf{\theta_{critical} = 33.7^o}$

b.ii. $n_{borate\ glass} = \sin\theta_{air}/\sin\theta_{borate\ glass}$
$\sin\theta_{borate\ glass} = \sin\theta_{air}/n_{borate\ glass}$

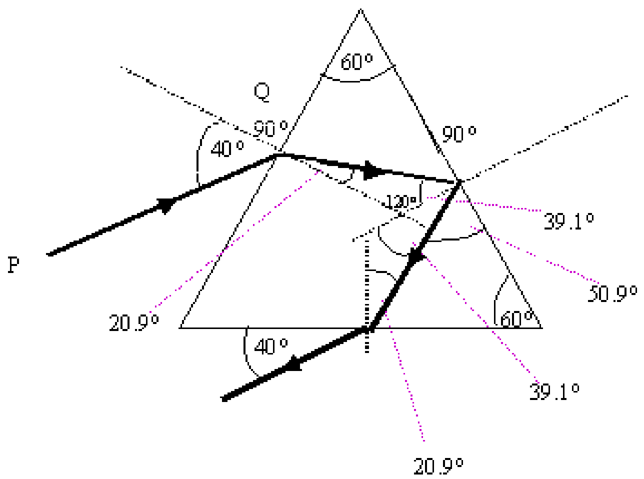
Back to Table

$\sin\theta_{\text{borate glass}} = \sin 40^o/1.8$

$\sin\theta_{\text{borate glass}} = 0.0.643/1.8$

$\sin\theta_{\text{borate glass}} = 0.357$

$\theta_{\text{borate glass}} = 20.9^o$



10.a.i. Electrons are moving from a high to low energy level within the atom. A photon of light is emitted when this happens.

a.ii. $\lambda_{\text{sodium yellow}} = 589\text{nm}$

$E_{\text{photon}} = hf$

$E_{\text{photon}} = hc/\lambda$

$E_{\text{photon}} = 6.63\text{x}10^{-34}\text{x}3\text{x}10^{8}/589\text{x}10^{-9}$

$E_{\text{photon}} = 3.38\text{x}10^{-19}\text{J}$

The photon energy and the energy difference are equal.

$\mathbf{E_{\text{difference}} = 3.38x10^{-19}J}$

b.i. Photons emitted from the sodium lamp and passing through the flame containing vaporised sodium will be absorbed by sodium electrons. This means that sodium light passing through the flame will be reduced in intensity and produce a dark shadow behind the flame.

b.ii. There is no energy gap in cadmium with the same energy as a photon emitted from the sodium lamp. Therefore, no absorption will take place and there will be no shadow region.

11.a. The activity(A), measured in becquerels(bq), is a measure of the number of disintegrations(N) per second.

A = N/t

N = At

$N = 300\text{x}10^{6}\text{x}60$

$\mathbf{N = 18x10^{9}}$

b. $H/t = 16\mu Sv/h$ (at a distance of 1m)

H = DQ

H/t = (D/t)xQ

$16\mu Sv/h = (50\mu Gy/t)\text{x}1$

$t = 50\mu Gy/16\mu Sv/h$

t = 3.125h

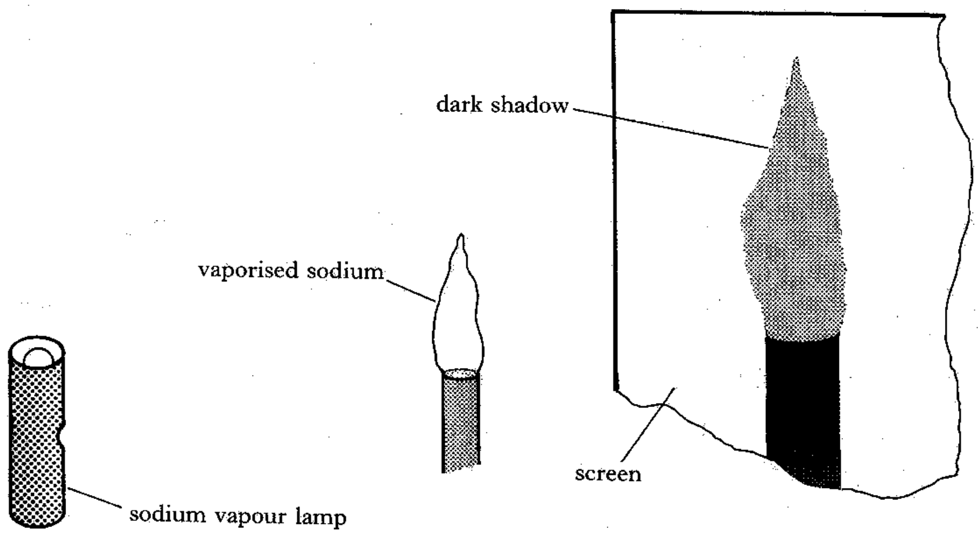
Marks

10. (*a*) A sodium vapour lamp emits bright yellow light when electrons make transitions from one energy level to another within the sodium atoms.

(i) State whether electrons are moving to higher or lower energy levels when the light is emitted.

(ii) Using information provided in the data sheet, calculate the energy difference between these two electron energy levels in the sodium atom. **4**

(*b*) A Bunsen flame containing vaporised sodium is placed between a sodium vapour lamp and a screen as shown.



(i) Explain why a dark shadow of the flame is seen on the screen.

(ii) The sodium vapour lamp is replaced with a cadmium vapour lamp.

Explain why there is now no dark shadow of the flame on the screen. **2**

(6)

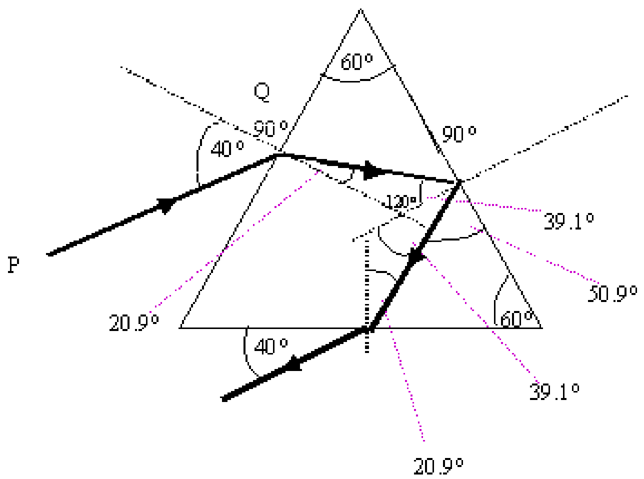
[Turn over

$\sin\theta_{borate\ glass}$ = $\sin 40^o/1.8$

$\sin\theta_{borate\ glass}$ = 0.0.643/1.8

$\sin\theta_{borate\ glass}$ = 0.357

$\theta_{borate\ glass}$ = 20.9^o



10.a.i. Electrons are moving from a high to low energy level within the atom. A photon of light is emitted when this happens.

a.ii. $\lambda_{sodium\ yellow}$ = 589nm

E_{photon} = hf

E_{photon} = hc/λ

E_{photon} = $6.63\times10^{-34}\times3\times10^{8}/589\times10^{-9}$

E_{photon} = 3.38×10^{-19}J

The photon energy and the energy difference are equal.

$E_{difference}$ = 3.38×10^{-19}J

b.i. Photons emitted from the sodium lamp and passing through the flame containing vaporised sodium will be absorbed by sodium electrons. This means that sodium light passing through the flame will be reduced in intensity and produce a dark shadow behind the flame.

b.ii. There is no energy gap in cadmium with the same energy as a photon emitted from the sodium lamp. Therefore, no absorption will take place and there will be no shadow region.

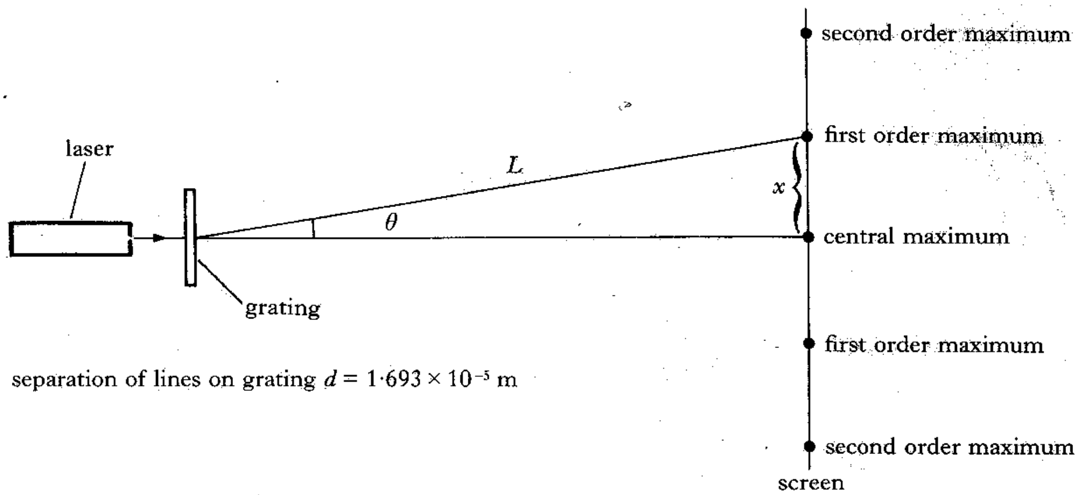
11.a. The activity(A), measured in becquerels(bq), is a measure of the number of disintegrations(N) per second.

A = N/t
N = At
N = $300\times10^{6}\times60$
N = 18×10^{9}

b. H/t = 16μSv/h (at a distance of 1m)
H = DQ
H/t = (D/t)xQ
16μSv/h = (50μGy/t)x1
t = 50μGy/16μSv/h
t = 3.125h

Marks

12. The apparatus shown below is set up to determine the wavelength of light from a laser.



separation of lines on grating $d = 1{\cdot}693 \times 10^{-5}$ m

The wavelength of the light is calculated using the equations

$$\lambda = d \sin\theta \quad \text{and} \quad \sin\theta = \frac{x}{L}$$

where angle θ and distances x and L are as shown in the diagram.

(*a*) Seven students measure the distance L with a tape measure.
Their results are as follows.

2·402 m 2·399 m 2·412 m 2·408 m
2·388 m 2·383 m 2·415 m

Calculate the mean value for L **and** the approximate random error in the mean. **2**

(*b*) The best estimate of the distance x is (91 ± 1) mm.
Show by calculation whether L or x has the larger percentage error. **2**

(*c*) Calculate the wavelength, in nanometres, of the laser light.
You must give your answer in the form

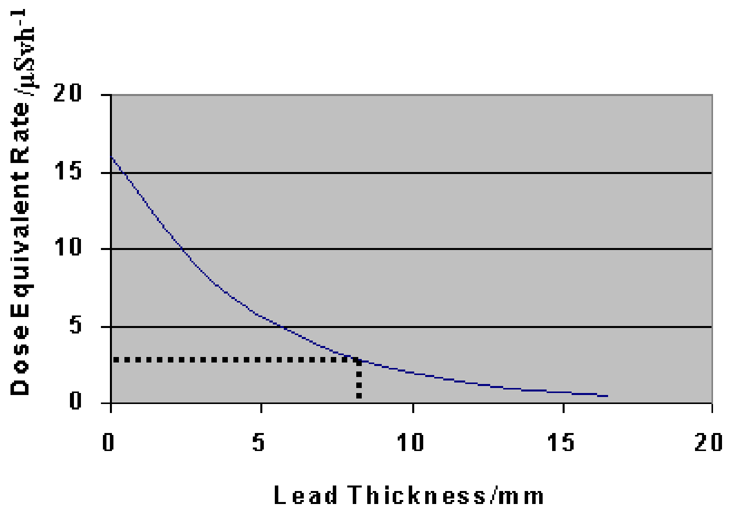
final value ± error. **3**

(*d*) Suggest an improvement which could be made so that a more accurate estimate of the wavelength could be made.
You must use only the same equipment and make the same number of measurements. **1**

(8)

[*END OF QUESTION PAPER*]

c.i.



c.ii. The graph indicates that the required lead thickness is **8.8mm.**

d. The polystyrene packaging increases the distance between the porters and the source. As the intensity at a distance(d) from the source is inversely proportional to the square of the distance the dose equivalent rate for the porters will be less.

12.a. Mean(L) = Total/Number of readings
Mean(L) = (2.402+2.399+2.412+2.408+2.388+2.383+2.415)/7
Mean(L) = 16.807/7
Mean(L) = 2.401m

Random Error(L) = Range/Number of readings
Random Error(L) = (Max-Min)/N
Random Error(L) = (2.415-2.383)/7
Random Error(L) = 0.032/7
Random Error(L) = 0.005m

b. Percentage error in L = [Random Error(L)/Mean(L)]x100
Percentage error in L = [0.005/2.401]x100
Percentage error in L = 0.21%

Percentage error in x = [Random Error(x)/Mean(x)]x100
Percentage error in x = [1/91]x100
Percentage error in x = 1.1%

The measurement with the largest percentage error is **x.**

c. $\lambda = d\sin\theta$

$\lambda = dx/L$

$\lambda = 1.693\text{x}10^{-5}91\text{x}10^{-3}/2.401$

λ = **641.66nm**

The percentage error in λ can be taken to be equal to the percentage error in x, as this is the largest individual error.

1.1% of 641.66nm = (1.1/100)x641.66 = 7.06nm
λ = **(641.66 +- 7.06)nm**

d. Increasing the distance between the grating and the screen reduces the percentage error of L and, more significantly, x.

1995 Paper 1 (Multiple Choice)

Back to Table

1. E	11. E	21. D
2. C	12. C	22. D
3. B	13. D	23. A
4. D	14. D	24. E
5. A	15. B	25. D
6. B	16. C	26. E
7. B	17. D	27. E
8. D	18. D	28. A
9. E	19. E	29. A
10.A	20. C	30. C

Back to Table Answers

SECTION A

Answer questions 1–30 on the answer sheet.

1. Which one of the following is a vector quantity?

A Distance

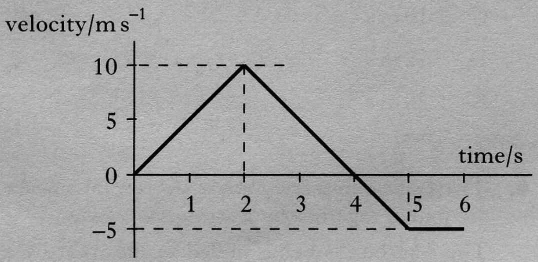
B Time

C Speed

D Energy

E Weight

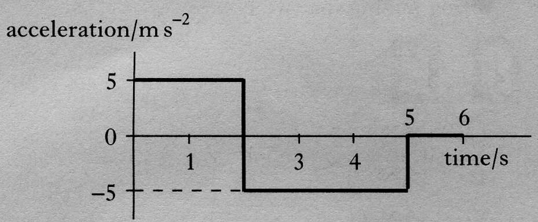
2. The velocity-time graph of the motion of an object starting from rest is shown below.



Which of the following statements about the motion of the object is/are true?

I There is a change of direction of the object at 4 s.

II The acceleration-time graph is of the form shown below.



III The displacement of the object from the starting point is greatest at 6 s.

A I only

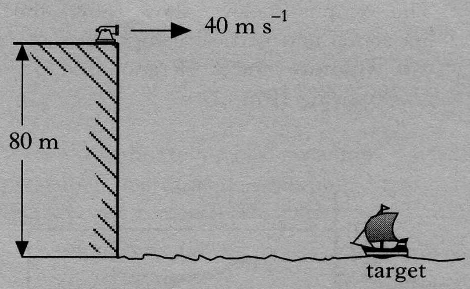
B II only

C I and II only

D I and III only

E II and III only

3. A cannonball is fired horizontally at $40\,m\,s^{-1}$ from the top of a vertical cliff and it hits its target. The height of the cliff above the level of the sea is 80 m.



How far is the target from the foot of the cliff, if air resistance is negligible and the acceleration due to gravity is $10\,m\,s^{-2}$?

A 320 m

B 160 m

C 80 m

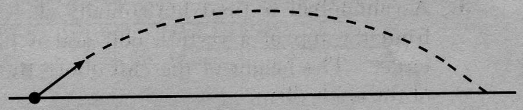
D 45 m

E 40 m

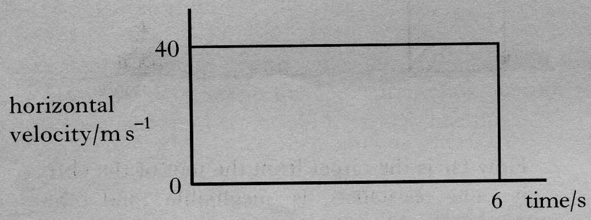
[Turn over

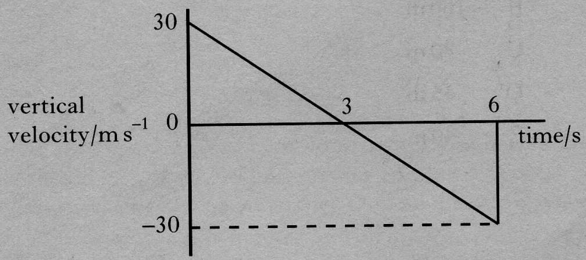
Back to Table Answers

4. A golfer strikes a golf ball which then moves off at an angle to the ground. The ball, following the path shown below, lands 6 s later.



The graphs below show how the ball's horizontal and vertical components of velocity vary with time, the acceleration due to gravity being $10\,\mathrm{m\,s^{-2}}$.





What is the speed of the ball just before it hits the ground?

A $10\,\mathrm{m\,s^{-1}}$

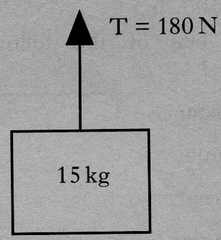
B $30\,\mathrm{m\,s^{-1}}$

C $40\,\mathrm{m\,s^{-1}}$

D $50\,\mathrm{m\,s^{-1}}$

E $70\,\mathrm{m\,s^{-1}}$

5. A tension force of 180 N is applied vertically upwards to a box of mass 15 kg.



Assuming that the acceleration due to gravity is $10\,\mathrm{m\,s^{-2}}$, the acceleration of the box is

A $2\,\mathrm{m\,s^{-2}}$

B $8\,\mathrm{m\,s^{-2}}$

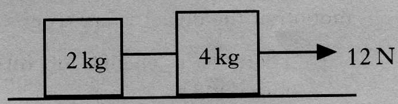
C $10\,\mathrm{m\,s^{-2}}$

D $12\,\mathrm{m\,s^{-2}}$

E $20\,\mathrm{m\,s^{-2}}$.

6. Two boxes on a frictionless horizontal surface are joined together by a string, as shown.

The 4 kg box is being pulled to the right by a constant horizontal force of 12 N.



What is the value of the force of tension in the string joining the two boxes?

A 2 N

B 4 N

C 6 N

D 8 N

E 12 N

7. The total mass of a motorcycle and rider is 250 kg. During braking, they are brought to rest from a speed of $15\,\mathrm{m\,s^{-1}}$ in a time of 10 s. The maximum energy which could be converted to heat by the brakes is

A 3 750 J

B 28 125 J

C 37 500 J

D 56 250 J

E 375 000 J.

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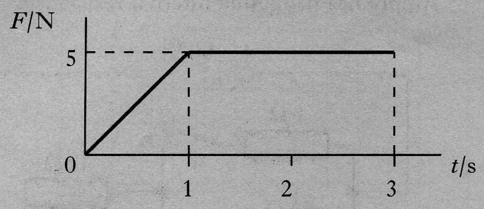
8. A model car of mass 3 kg, initially at rest, is acted upon by an unbalanced force F, as shown in the following force-time graph.



What is the momentum of the model car at time $t = 3$ s?

A $0\,kg\,m\,s^{-1}$

B $2{\cdot}5\,kg\,m\,s^{-1}$

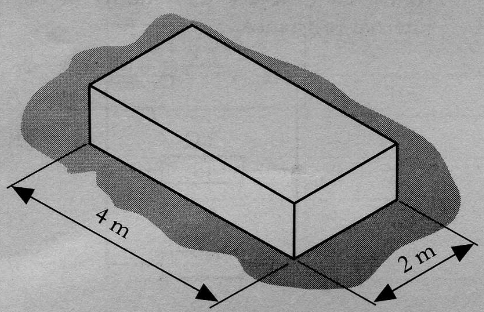
C $5\,kg\,m\,s^{-1}$

D $12{\cdot}5\,kg\,m\,s^{-1}$

E $15\,kg\,m\,s^{-1}$

9. A rectangular box of mass 10 kg is lying on a flat surface on a planet where the gravitational field strength is $4\,N\,kg^{-1}$.

The base of the box measures 4 m by 2 m.



Which of the following statements is/are correct?

I The weight of the box is 100 N.

II The weight of the box is 40 N.

III The pressure which the box exerts on the flat surface is 5 Pa.

A I only

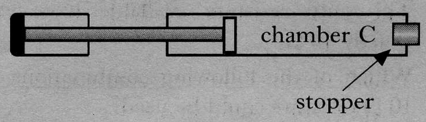
B II only

C III only

D I and III only

E II and III only

10. The end of a bicycle pump is sealed with a small rubber stopper. The air in chamber C is now trapped.



The plunger is then pushed in slowly, causing the air in the chamber C to be compressed. As a result of this, the pressure of the air increases.

Which of the following explain(s) why the pressure increases, assuming that the temperature remains constant?

I The air molecules increase their average speed.

II The air molecules are colliding more often with the walls of the chamber.

III Each air molecule is striking the walls of the chamber with greater force.

A II only

B III only

C I and II only

D I and III only

E I, II and III

11. An electron is accelerated from rest in an electron gun, across a potential difference of 2×10^3 V.

The kinetic energy gained by the electron as it goes through the electron gun is

A $8{\cdot}0 \times 10^{-23}$ J

B $8{\cdot}0 \times 10^{-20}$ J

C $3{\cdot}2 \times 10^{-19}$ J

D $1{\cdot}6 \times 10^{-16}$ J

E $3{\cdot}2 \times 10^{-16}$ J.

[Turn over

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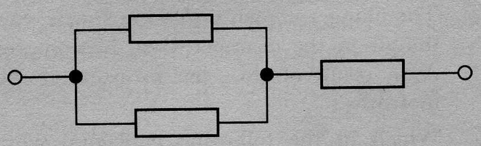
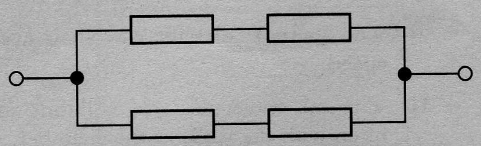
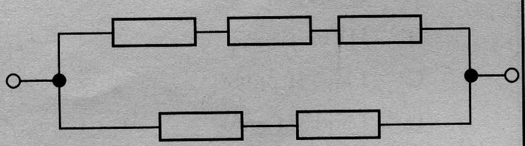
12. A student requires a resistor for an electronics project and its value must lie in the range $(15 \pm 3)\ \Omega$.

The only resistors available have values of exactly $10\ \Omega$.

Which of the following combinations of these $10\ \Omega$ resistors could be used?

I 

II 

III 

A I only

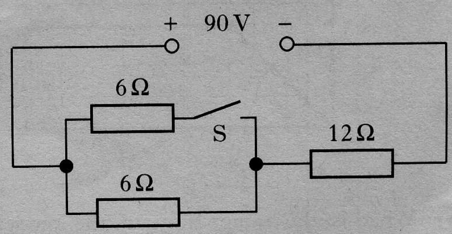
B I and II only

C I and III only

D II and III only

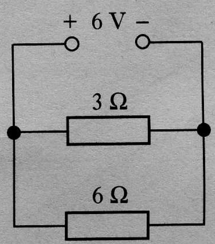
E I, II and III

13. In the following circuit, what is the potential difference across the $12\ \Omega$ resistor when the switch S is (i) open, and (ii) closed? The supply has negligible internal resistance.



	(i) p.d. when switch S open	*(ii) p.d. when switch S closed*
A	30 V	18 V
B	45 V	45 V
C	60 V	45 V
D	60 V	72 V
E	72 V	60 V

14. The circuit below shows two resistors connected to a 6 V d.c. supply of negligible internal resistance.



The power dissipated in the $3\ \Omega$ resistor is

A 3 W

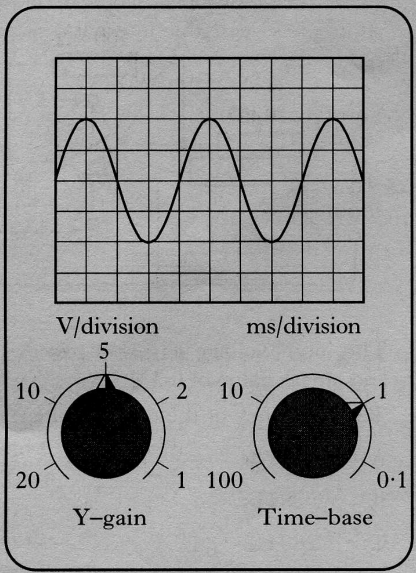
B 6 W

C 9 W

D 12 W

E 18 W.

15. An alternating voltage signal is displayed on an oscilloscope, with the settings shown.



Which row in the following table gives the correct values for the peak voltage and frequency of the signal?

	Peak Voltage/V	*Frequency*/Hz
A	10	100
B	10	250
C	20	250
D	10	500
E	20	1000

16. The heating element in a boiler operates at 2400 W from a 120 V r.m.s. power supply.

What is the r.m.s. current, in amperes, in this element?

A 10

B $\dfrac{20}{\sqrt{2}}$

C 20

D $20\sqrt{2}$

E 40

17. The "coulomb per volt" is a unit of

A charge

B energy

C power

D capacitance

E potential difference.

18. The energy stored in a $500\,\mu F$ capacitor charged to a voltage of 20 V is

A 5×10^{-3} J

B $2{\cdot}5 \times 10^{-2}$ J

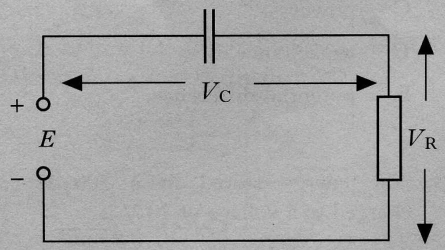
C 5×10^{-2} J

D 1×10^{-1} J

E 2×10^{-1} J.

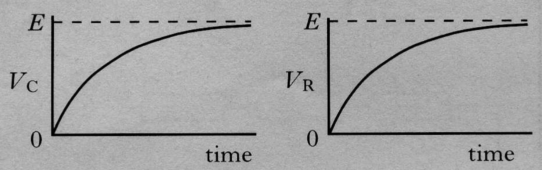
[Turn over

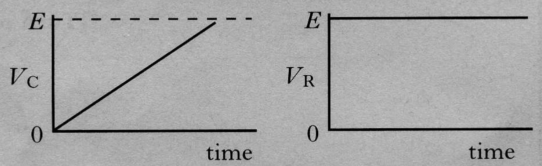
19. In the following circuit, a capacitor is being charged up from a d.c. source of e.m.f. E. The capacitor has a resistor in series with it, as shown.

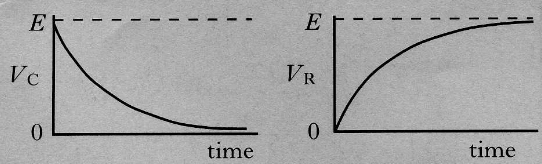


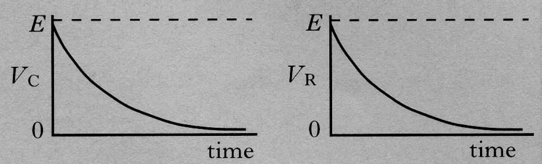
The voltages, V_C and V_R, across the components are recorded at regular time intervals as the capacitor charges up.

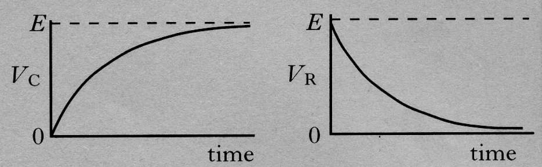
Which of the pairs of graphs shown below correctly represents the voltages across the capacitor and the resistor during charging?

A


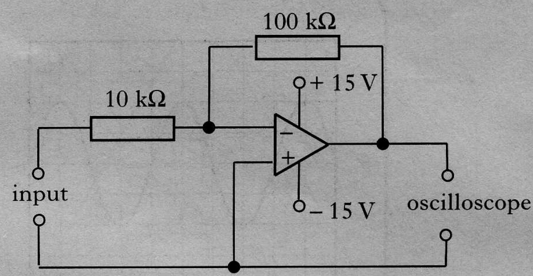
B


C


D


E


20. An oscilloscope is used to measure the frequency of the output voltage from an operational amplifier.



The input voltage has a frequency of 280 Hz and a peak value of 0·5 V.

The frequency of the output voltage is

A 14 Hz

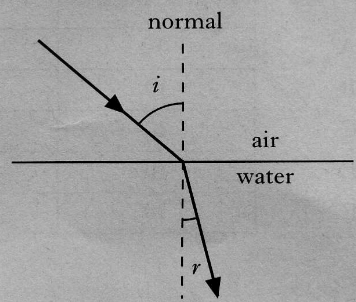
B 28 Hz

C 280 Hz

D 560 Hz

E 2800 Hz.

21. A ray of light passing from air into water is refracted towards the normal.



Which of the following statements is/are true?

I The speed of the light in water is less than the speed of the light in air.

II The frequency of the light in water is less than the frequency of the light in air.

III The wavelength of the light in water is less than the wavelength of the light in air.

A I only

B III only

C I and II only

D I and III only

E I, II and III

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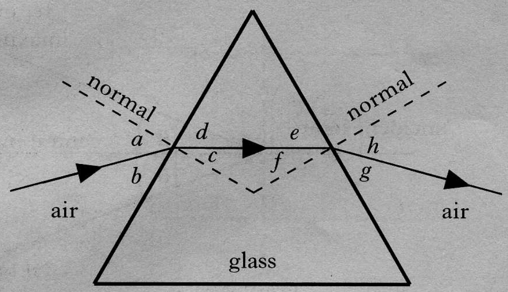
22. A ray of monochromatic light is directed towards a glass prism and travels through it.



Which of the following expressions can be used to calculate the refractive index of the glass used for this prism?

A $\dfrac{\sin c}{\sin a}$

B $\dfrac{\sin b}{\sin c}$

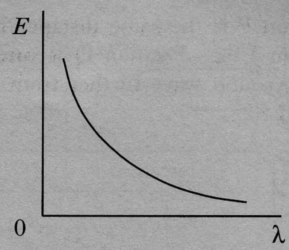
C $\dfrac{\sin f}{\sin h}$

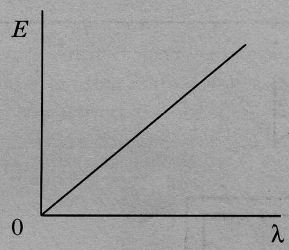
D $\dfrac{\sin h}{\sin f}$

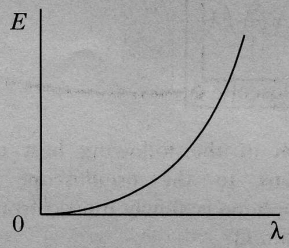
E $\dfrac{\sin e}{\sin h}$

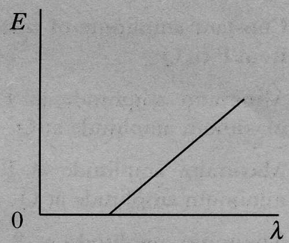
23. The energy, E, of a photon of light depends on its wavelength λ.

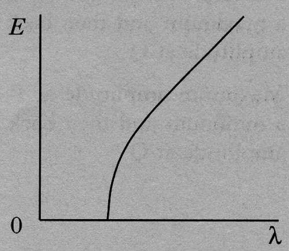
Which of the following graphs correctly illustrates the relationship between E and λ?

A


B


C


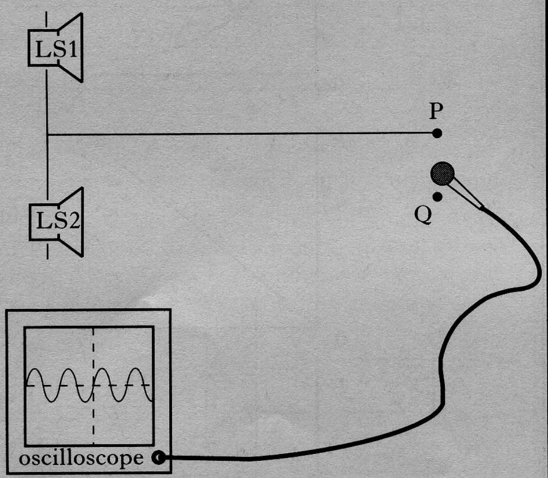
D


E


[Turn over

24. Two loudspeakers LS1 and LS2, connected to the same output of a signal generator, provide coherent sources of sound waves. A microphone, connected to an oscilloscope, is used to detect the sound.

Position P is the same distance from LS1 as it is from LS2. Position Q is **one wavelength** of the sound wave further from LS1 than it is from LS2.



Which of the following best describes what happens to the oscilloscope trace as the microphone is slowly moved from position P to position Q?

A Constant amplitude of trace when moved from P to Q

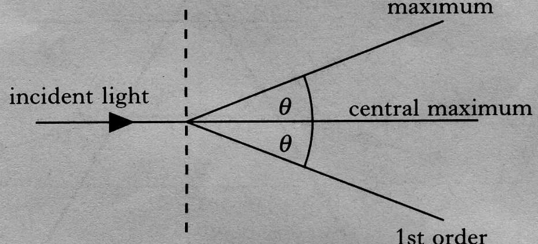
B Minimum amplitude at P increasing to maximum amplitude at Q

C Maximum amplitude at P decreasing to minimum amplitude at Q

D Minimum amplitude at P, going through a maximum and then back to a minimum amplitude at Q

E Maximum amplitude at P, going through a minimum and then back to a maximum amplitude at Q

25. When monochromatic light is passed through a grating, a pattern of maxima and minima is observed as shown below.



Which row in the following table represents the arrangement which would produce the greatest angle θ between the central and first order maxima?

	Grating (lines per mm)	*Colour of light*
A	100	Red
B	100	Green
C	100	Blue
D	200	Red
E	200	Blue

26. A point source S emits radiation equally in all directions.

Source

The distance from S to Q is nine times the distance from S to P.

The intensity of radiation at P is I. The intensity at point Q is

A $9I$

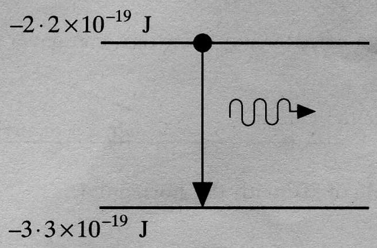
B $3I$

C $\frac{I}{3}$

D $\frac{I}{9}$

E $\frac{I}{81}$.

27. In a laser, a photon of light is emitted when an electron makes a transition from a higher energy level to a lower one, as shown below.



If the energy in each pulse of light from the laser is 10 J, how many photons are there in each pulse?

A $\dfrac{10}{5{\cdot}5\times10^{-19}}$

B $\dfrac{10}{(1{\cdot}1+1{\cdot}6)\times10^{-19}}$

C $\dfrac{10}{3{\cdot}3\times10^{-19}}$

D $\dfrac{10}{2{\cdot}2\times10^{-19}}$

E $\dfrac{10}{1{\cdot}1\times10^{-19}}$

28. An element X emits an alpha particle to form a new element.

Which of the following statements is/are correct about this **new** element?

I The total number of protons and neutrons is 4 less than in element X.

II The number of protons is the same as in element X.

III The new element is an isotope of element X.

A I only

B II only

C III only

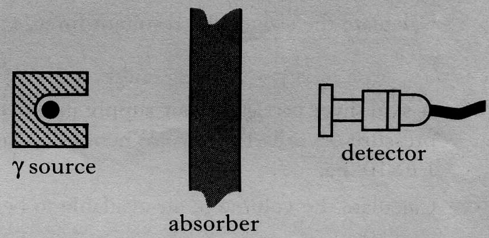
D I and III only

E II and III only

29. Which row in the following table shows the correct units for all three quantities listed?

	Absorbed Dose	*Dose Equivalent*	*Activity*
A	gray	sievert	becquerel
B	becquerel	gray	sievert
C	sievert	becquerel	gray
D	sievert	gray	becquerel
E	gray	becquerel	sievert

30. A 60 mm thick lead absorber is placed between a gamma source and a detector. The reading measured by the detector is 240 Bq. The half-value thickness of the lead is 30 mm.



What will the reading be if the 60 mm absorber is replaced by one of thickness 120 mm?

A 120 Bq

B 80 Bq

C 60 Bq

D 40 Bq

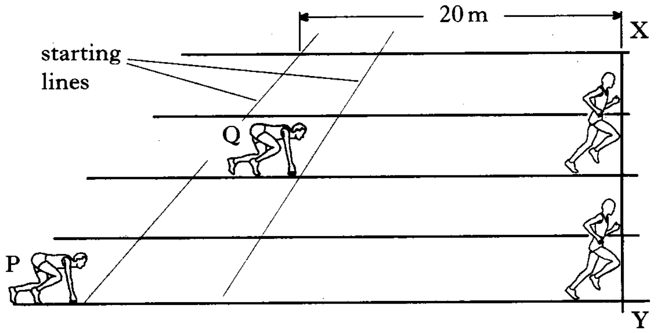
E 30 Bq

[Turn over

Marks

2. In a "handicap" sprint race, sprinters P and Q both start the race at the same time but from different starting lines on the track.

The handicapping is such that both sprinters reach the line XY, as shown below, at the same time.



Sprinter P has a constant acceleration of $1{\cdot}6\,m\,s^{-2}$ from the start line to the line XY. Sprinter Q has a constant acceleration of $1{\cdot}2\,m\,s^{-2}$ from the start line to XY.

(*a*) Calculate the time taken by the sprinters to reach line XY. **2**

(*b*) Find the speed of **each** sprinter at this line. **3**

(*c*) What is the distance, in metres, between the starting lines for sprinters P and Q? **2**

(7)

t_1 = 466.67s

=>v_{Andy} = 535.7/466.67
v_{Andy} = 1.15m/s

The velocity bearing is also 067.5^o

v = 1.15m/s (067.5^o)

b.iii.**v_{Paul} = 2.5s (067.5^o)**

b.iv. t_2 = Total distance(d)/Speed
t_2 = 535.7/2.5
t_2 = 215.1s

Including Paul's five minutes waiting time the total time($t_{total)}$)
for Pauls journey, in seconds, is can be calculated.

$t_{total)}$ = t_2 + 215.1
$t_{total)}$ = 5x60 + 215.1
$t_{total)}$ = 515.1s

Pauls total time = 515.1s
Andy's journey time(t_1) = 466.67s

Andy reaches the checkpoint ahead of Paul by 48.4s

2.a. Sprinters P and Q have the same journey time.

For sprinter P:
s = 20m
a = 1.6m/s/s
u = 0m/s
t = ?

Use: s = ut + 1/2(at^2)

20 = 0xt + 1/2(1.6xt^2)
t^2 = 20/0.8
t^2 = 25
t = 5s

The time for both sprinters is 5s

b. v_P = u + at
v_P = 0 + 1.6x5
v_P = 8m/s

v_Q = u + at
v_Q = 0 + 1.2x5
v_Q = 6m/s

c. To calculate the displacement of Q from their starting point
to the finishing line use: s = ut + 1/2(at^2).

s = 0xt + 1/2(1.2x5^2)
s = 15m

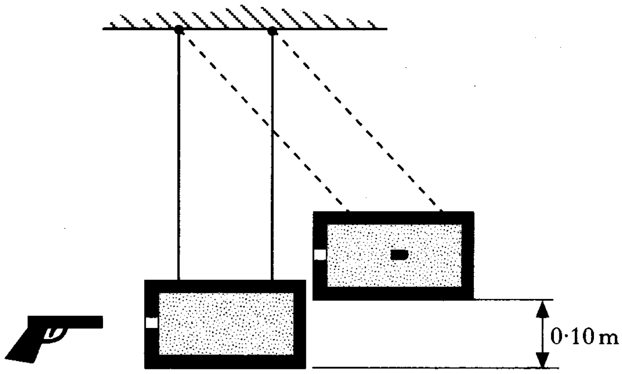
The distance between starting points is therefore 5m

3.a.i. Initially the sand filled box is at rest and has no kinetic energy.
The bullet embeds itself in the sand filled box and its kinetic
energy is shared with the box. This constitutes an inelastic collision

Marks

3. (*a*) A bullet of mass 25 g is fired horizontally into a sand-filled box which is suspended by long strings from the ceiling. The combined mass of the bullet, box and sand is 10 kg.

After impact, the box swings upwards to reach a maximum height as shown in the diagram.

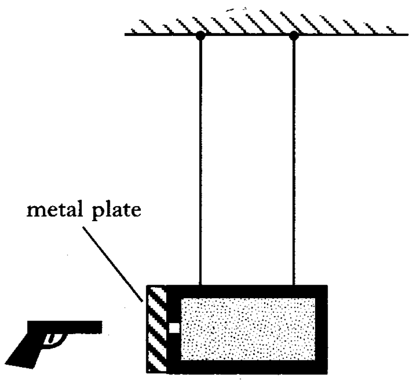


Calculate:

(i) the maximum velocity of the box after impact;

(ii) the velocity of the bullet just before impact. **5**

(*b*) The experiment is repeated with a metal plate fixed to one end of the box as shown.



The mass of sand is reduced so that the combined mass of the sand, box and metal plate is 10 kg.

In this experiment, the bullet bounces back from the metal plate. Explain how this would affect the maximum height reached by the box compared with the maximum height reached in part (*a*). **2**

(7)

[Turn over

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2.a. Sprinters P and Q have the same journey time.

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a = 1.6m/s/s
u = 0m/s
t = ?

Use: s = ut + 1/2(at^2)

20 = 0xt + 1/2(1.6xt^2)
t^2 = 20/0.8
t^2 = 25
t = 5s

The time for both sprinters is 5s

b. v_P = u + at
v_P = 0 + 1.6x5
v_P = 8m/s

v_Q = u + at
v_Q = 0 + 1.2x5
v_Q = 6m/s

c. To calculate the displacement of Q from their starting point
to the finishing line use: s = ut + 1/2(at^2).

s = 0xt + 1/2(1.2x5^2)
s = 15m

The distance between starting points is therefore 5m

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energy is shared with the box. This constitutes an inelastic collision

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and kinetic energy is not conserved. However, after this event the kinetic energy of the bullet and box system can be calculated using the principle of conservation of energy.

This means that the potential energy gain of the bullet and box, at their maximum height, is equal to the initial kinetic energy of the bullet and box.

Note: the bullet and box have no kinetic energy at the maximum height.

$Ep_{gain} = Ek_{initial}$
$mgh = 1/2(mv^2)$
$v^2 = 2gh$
$v^2 = 2x9.8x0.1$
$v^2 = 1.96$
v = 1.4m/s

a.ii. To solve this problem apply the law of conservation of linear momentum.

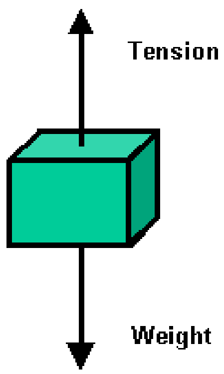
Momentum before(P_{before}) = Momentum after(P_{after})
$m_{bullet}u_{bullet} + m_{box}u_{box} = (m_{bullet}+m_{box})v$

The initial velocity of the box is zero therefore the term with this value can be ignored.

$u_{bullet} = (m_{bullet}+m_{box})v/m_{bullet}$
$u_{bullet} = (10x1.4)/0.025$
u_{bullet} = 560m/s

b. The change in momentum of the bullet in this collision will be greater than in the first experiment. To conserve momentum this means that the change in momentum of the box of sand will also be greater. The only way that this change in momentum can be increased is if the box moves off with a greater velocity. The box thus has a greater initial kinetic energy that will be transferred into potential energy resulting in the box reaching a greater height.

4.a. The tension force provided by the cable will be equal in size to the weight of the block, but act in the opposite direction.

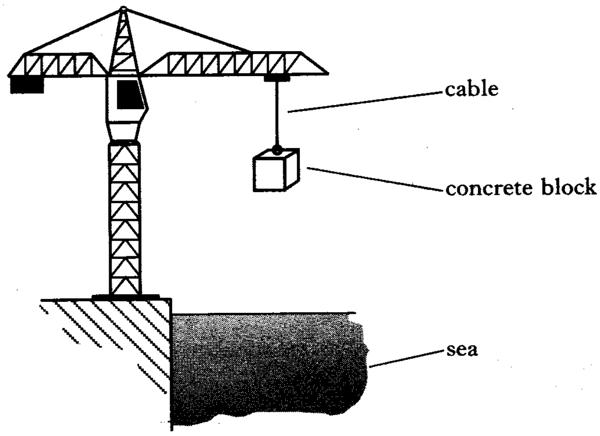


W = ?	w = mg
m = $5.0x10^3$kg	w = $5.0x10^3$x9.8
g = 9.8N/kg	**w = 49000N**

b.i.

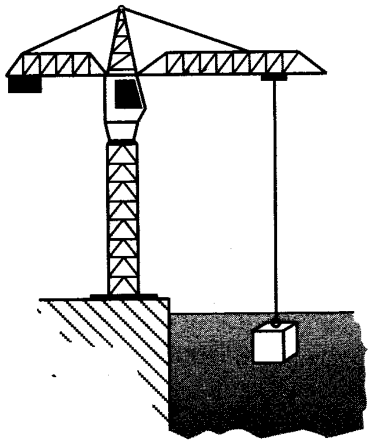
Marks

4. A crane is used to lower a concrete block of mass $5{\cdot}0 \times 10^3$ kg into the sea.



(*a*) The crane lowers the block towards the sea at a constant speed.
Calculate the tension in the cable supporting the block. **1**

(*b*) The crane lowers the block into the sea. The block is held stationary just below the surface of the sea as shown in the diagram below.



The tension in the cable is now $2{\cdot}9 \times 10^4$ N.

(i) Calculate the size of the buoyancy force acting on the block.

(ii) Explain how this buoyancy force is produced. **4**

(*c*) The block is now lowered to a greater depth.
What effect, if any, does this have on the tension in the cable?
Justify your answer. **2**

(7)

Back to Table

and kinetic energy is not conserved. However, after this event the kinetic energy of the bullet and box system can be calculated using the principle of conservation of energy.

This means that the potential energy gain of the bullet and box, at their maximum height, is equal to the initial kinetic energy of the bullet and box.

Note: the bullet and box have no kinetic energy at the maximum height.

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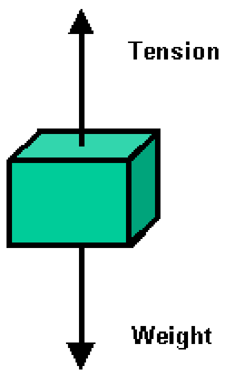
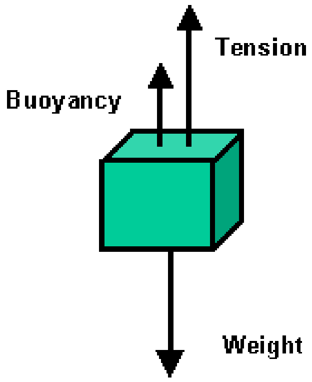
b. The change in momentum of the bullet in this collision will be greater than in the first experiment. To conserve momentum this means that the change in momentum of the box of sand will also be greater. The only way that this change in momentum can be increased is if the box moves off with a greater velocity. The box thus has a greater initial kinetic energy that will be transferred into potential energy resulting in the box reaching a greater height.

4.a. The tension force provided by the cable will be equal in size to the weight of the block, but act in the opposite direction.



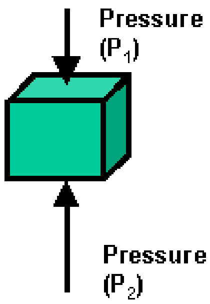
W = ?	w = mg
$m = 5.0x10^3$kg	$w = 5.0x10^3x9.8$
g = 9.8N/kg	**w = 49000N**

b.i.



Weight(W) = Tension(T) + Buoyancy(B)
T = W - B
B = W - T
B = 49000 - 29000
B = 20000N

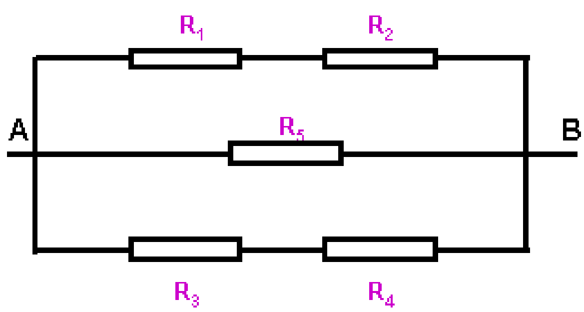
b.ii. The pressure acting on the lower surface of the block is greater than the pressure acting on the upper surface, because the lower surface is at a greater depth.



As the force on each surface is given by the equation F = PA, the upward force is greater than the downward force. This net upward force is called **buoyancy** or **upthrust**.

c. The pressure difference will be the same at all depths. This will result in the upthrust being the same at any depth.

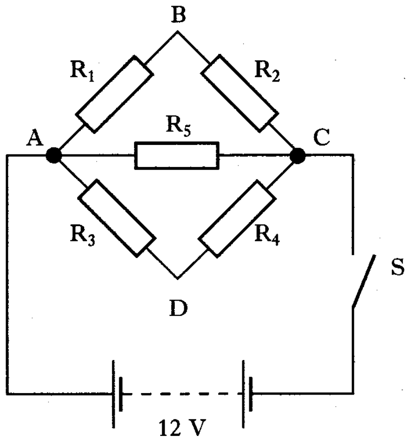
5.a. The circuit in the problem can be drawn in the more familiar form as shown in the diagram below.



R_1 is in series with R_2

Marks

5. Four 10 Ω resistors R_1, R_2, R_3 and R_4 are connected in the form of a square ABCD. A fifth resistor R_5 of the same value is connected between A and C. This arrangement of resistors is connected in a circuit as shown below. The battery in the circuit has negligible internal resistance.



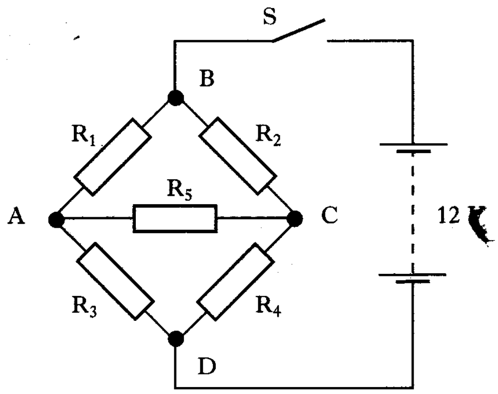
(*a*) Determine the total resistance between A and C. **2**

(*b*) The switch S is now closed.

(i) In which of the resistors is the greatest power developed?

(ii) Calculate the value of **this** power. **3**

(*c*) In a second experiment with the same resistors, the battery is connected across BD.



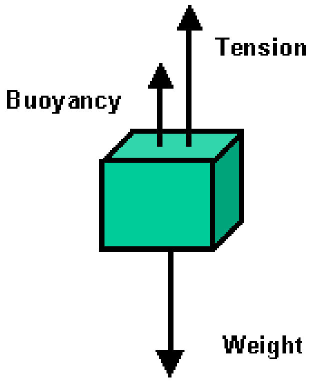
The switch S is now closed.

(i) Explain why there is no current in resistor R_5.

(ii) Calculate the current drawn from the battery. **4**

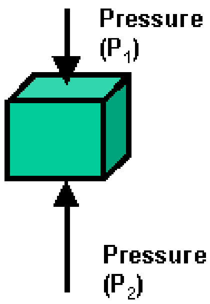
(9)

[Turn over




```
Weight(W) = Tension(T) + Buoyancy(B)
T = W - B
B = W - T
B = 49000 - 29000
```
B = 20000N

b.ii. The pressure acting on the lower surface of the block is greater than the pressure acting on the upper surface, because the lower surface is at a greater depth.



As the force on each surface is given by the equation F = PA, the upward force is greater than the downward force. This net upward force is called **buoyancy** or **upthrust**.

c. The pressure difference will be the same at all depths. This will result in the upthrust being the same at any depth.

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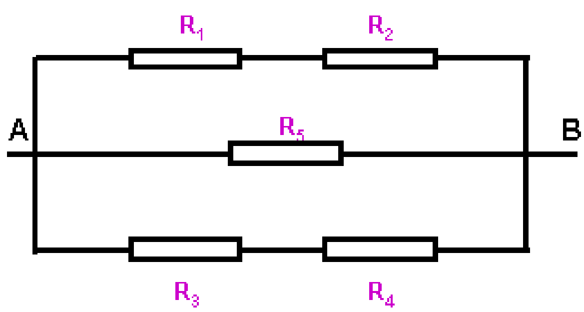


R_1 is in series with R_2

[Back to Table]

$R_{1+2} = 20\Omega$

R_3 is in series with R_4

$R_{3+4} = 20\Omega$

R_{1+2}, R_{3+4} and R_5 are in parallel.

$1/R_{total} = 1/R_{1+2} + 1/R_{1+2} + 1/R_5$
$1/R_{total} = 1/20 + 1/20 + 1/10$
$1/R_{total} = 4/20$
$R_{total} = 20/4 = 5\Omega$

b.i. The greatest current will flow through R_5 thus this is where the greatest power will develop.

b.ii. $I_{R_5} = V/R_5$
$I_{R_5} = 12/10$
$I_{R_5} = 1.2A$

$P = I_{R_5}^2 R_5$
$P = 1.2^2 x10$
$P = 14.4W$

c.i. The electric potential is the same at points A and C. With no no potential difference across R_5 no current will be flowing through it.

c.ii. Resistors R_1 and R_2 are in series. The current flowing through branch BCD can be calculated using ohms law.

$I_{BCD} = V_{BD}/R_{2+3}$
$I_{BCD} = 12/20$
$I_{BCD} = 0.6A$

Similarly the current flowing through branch BAD can be calculated.

$I_{BAD} = V_{BD}/R_{2+3}$
$I_{BAD} = 12/20$
$I_{BAD} = 0.6A$

$I_{battery} = I_{BCD} + I_{BAD}$
$I_{battery} = 0.6 + 0.6$
$I_{battery} = 1.2A$

6.a. "Lost volts" = Ir
"Lost volts" = 0.5x.2
"Lost volts" = 0.1V

emf(E) = Terminal Potential Difference(V_{tpd}) + "Lost volts"
$V_{tpd} = V_1$

$V_1 = E$ - "Lost volts"
$V_1 = 12.0 - 0.1$
$V_1 = 11.9V$

7.a. $E = I(R+r)$
$E/I = R+r$
$R = E/I-r$ As required

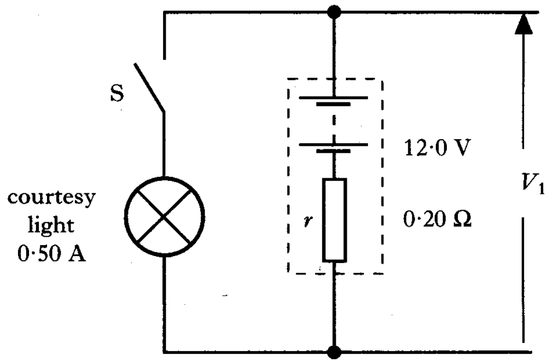
b.i. The above equation can be written as: $R = E(1/I) - r$
Compare this to: $y = mx + c$

Marks

6. A certain car alarm system is triggered when the opening of a door of the car switches on the courtesy light.

The car alarm works by detecting the very small change in the voltage across the car battery which occurs when the courtesy light is switched on.

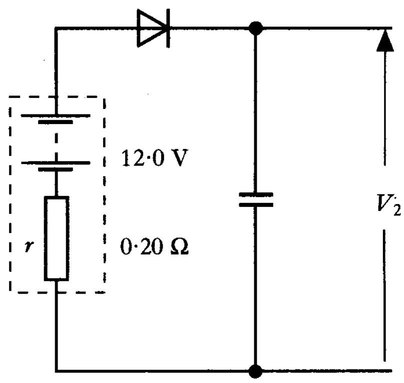
(*a*) The car battery has an e.m.f. of 12·0 V and an internal resistance r of 0·20 Ω as shown below.



When the car door is opened, the switch S closes and the courtesy light draws a current of 0·50 A from the battery.

Show that the voltage V_1 across the battery falls to 11·9 V when the switch S is closed. **2**

(*b*) A capacitor and diode are **also** connected across the battery, as shown below, to provide a voltage V_2 of 12·0 V across the capacitor.



Explain why the voltage V_2 across the capacitor does not decrease from 12·0 V immediately after the car door is opened and the courtesy light comes on. **1**

Back to Table

$R_{1+2} = 20\Omega$

R_3 is in series with R_4

$R_{3+4} = 20\Omega$

R_{1+2}, R_{3+4} and R_5 are in parallel.

$1/R_{total} = 1/R_{1+2} + 1/R_{1+2} + 1/R_5$
$1/R_{total} = 1/20 + 1/20 + 1/10$
$1/R_{total} = 4/20$
$R_{total} = 20/4 = 5\Omega$

b.i. The greatest current will flow through R_5 thus this is where the greatest power will develop.

b.ii. $I_{R_5} = V/R_5$
$I_{R_5} = 12/10$
$I_{R_5} = 1.2A$

$P = I_{R_5}^2 R_5$
$P = 1.2^2 x10$
$P = 14.4W$

c.i. The electric potential is the same at points A and C. With no no potential difference across R_5 no current will be flowing through it.

c.ii. Resistors R_1 and R_2 are in series. The current flowing through branch BCD can be calculated using ohms law.

$I_{BCD} = V_{BD}/R_{2+3}$
$I_{BCD} = 12/20$
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Similarly the current flowing through branch BAD can be calculated.

$I_{BAD} = V_{BD}/R_{2+3}$
$I_{BAD} = 12/20$
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$I_{battery} = I_{BCD} + I_{BAD}$
$I_{battery} = 0.6 + 0.6$
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6.a. "Lost volts" = Ir
"Lost volts" = 0.5x.2
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emf(E) = Terminal Potential Difference(V_{tpd}) + "Lost volts"
$V_{tpd} = V_1$

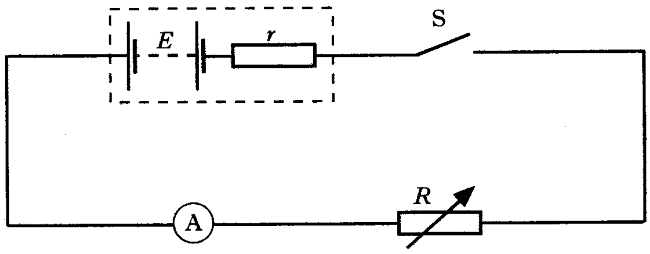
V_1 = E - "Lost volts"
$V_1 = 12.0 - 0.1$
$V_1 = 11.9V$

7.a. E = I(R+r)
E/I = R+r
R = E/I-r As required

b.i. The above equation can be written as: R = E(1/I) - r
Compare this to: y = mx + c

Marks

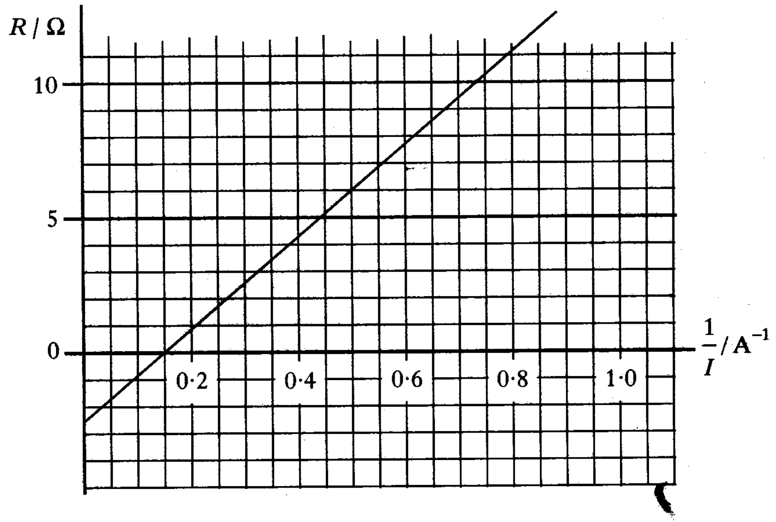
7. The circuit below is used to determine the internal resistance r of a battery of e.m.f. E.



The variable resistor provides known values of resistance R.
For each value of resistance R, the switch S is closed and the current I is noted.

For each current, the value of $\frac{1}{I}$ is calculated.

In one such experiment, the following graph of R against $\frac{1}{I}$ is obtained.



(*a*) Conservation of energy applied to the complete circuit gives the following relationship.

$$E = I(R + r)$$

Show that this relationship can be written in the form

$$R = \frac{E}{I} - r\ .$$ **1**

(*b*) Use information from the graph to find:

(i) the internal resistance of the battery;

(ii) the e.m.f. of the battery. **3**

(*c*) The battery is accidentally short-circuited.
Calculate the current in the battery when this happens. **2**

(6)

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$I_{BAD} = V_{BD}/R_{2+3}$
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V_1 = E - "Lost volts"
V_1 = 12.0 - 0.1
$\mathbf{V_1 = 11.9V}$

7.a. E = I(R+r)
E/I = R+r
R = E/I-r **As required**

b.i. The above equation can be written as: R = E(1/I) - r
Compare this to: y = mx + c

Back to Table

The y-intercept(c) is equal to -r.
The gradient(m) is equal to E.

c = -2.5
=>**r = 2.5Ω**

b.ii. $m = (y_2-y_1)/(x_2-x_1)$
m = (6-0)/(0.5-0.15)
m = 6/0.35
m = 17.1
=>**E = 17.1V**

c. I = E/r
I = 17.1/2.5
I = 6.8A

8.a. The minimum energy an electron needs to absorb to escape from an atom is called the work function.

b.i. $E_{photon} = hf$
$E_{photon} = 6.63\text{x}10^{-34}\text{x}6.1\text{x}10^{14}$
$E_{photon} = 4.04\text{x}10^{-19}\text{J}$

$E_{max.\ kinetic} = E_{photon} - E_{work}$
$E_{max.\ kinetic} = 4.04\text{x}10^{-19} - 3.04\text{x}10^{-19}$

$\mathbf{E_{max.\ kinetic} = 1.00\text{x}10^{-19}\text{J}}$

b.ii. $Ek_{total} = E_{max.\ kinetic} + E_{field}$

Note: E_{field} is the energy gained by the electron in the electric field.

$E_{field} = qV$
$E_{field} = 1.6\text{x}10^{-19}\text{x}0.8$
$E_{field} = 1.28\text{x}10^{-19}$

$Ek_{total} = 1.00\text{x}10^{-19} + 1.28\text{x}10^{-19}$
$\mathbf{Ek_{total} = 2.28\text{x}10^{-19}\text{J}}$

c. To stop the photoelectrons the wok done by the electric field must equal the maximum kinetic energy of the photoelectrons.

$E_{field} = E_{max.\ kinetic}$
$qV = E_{max.\ kinetic}$
$V = E_{max.\ kinetic}/q$
$V = 1.00\text{x}10^{-19}/1.6\text{x}10^{-19}$
V = 0.625V

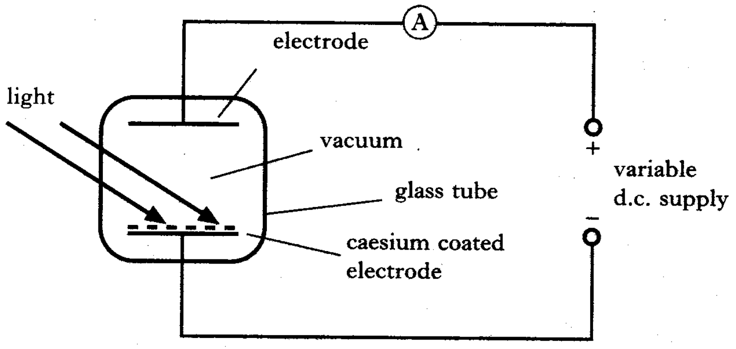
9.a. $\theta_{crit} = \sin^{-1}(1/n)$
$\theta_{crit} = \sin^{-1}(1/1.33)$
$\theta_{crit} = \sin^{-1}(0.752)$
$\mathbf{\theta_{crit} = 48.7^o}$

Back to Table Answers

Marks

8. (*a*) It is quoted in a text book that
"the work function of caesium is $3{\cdot}04 \times 10^{-19}$ J".
Explain what is meant by the above statement. **1**

(*b*) In an experiment to investigate the photoelectric effect, a glass vacuum tube is arranged as shown below.



The tube has two electrodes, one of which is coated with caesium.
Light of frequency $6{\cdot}1 \times 10^{14}$ Hz is shone on to the caesium coated electrode.

(i) Calculate the maximum kinetic energy of a photoelectron leaving the caesium coated electrode.

(ii) An electron leaves the caesium coated electrode with this maximum kinetic energy.
Calculate its kinetic energy as it reaches the upper electrode when the p.d. across the electrodes is $0{\cdot}8$ V. **6**

(*c*) The polarity of the supply voltage is now reversed.
Calculate the minimum voltage which should be supplied across the electrodes to stop photoelectrons from reaching the upper electrode. **2**

(9)

[Turn over

The y-intercept(c) is equal to -r.
The gradient(m) is equal to E.

c = -2.5
=>**r = 2.5Ω**

b.ii. $m = (y_2-y_1)/(x_2-x_1)$
m = (6-0)/(0.5-0.15)
m = 6/0.35
m = 17.1
=>**E = 17.1V**

c. I = E/r
I = 17.1/2.5
I = 6.8A

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b.i. $E_{photon} = hf$
$E_{photon} = 6.63x10^{-34}x6.1x10^{14}$
$E_{photon} = 4.04x10^{-19}J$

$E_{max.\ kinetic} = E_{photon} - E_{work}$
$E_{max.\ kinetic} = 4.04x10^{-19} - 3.04x10^{-19}$

$\mathbf{E_{max.\ kinetic} = 1.00x10^{-19}J}$

b.ii. $Ek_{total} = E_{max.\ kinetic} + E_{field}$

Note: E_{field} is the energy gained by the electron in the electric field.

$E_{field} = qV$
$E_{field} = 1.6x10^{-19}x0.8$
$E_{field} = 1.28x10^{-19}$

$Ek_{total} = 1.00x10^{-19} + 1.28x10^{-19}$
$\mathbf{Ek_{total} = 2.28x10^{-19}J}$

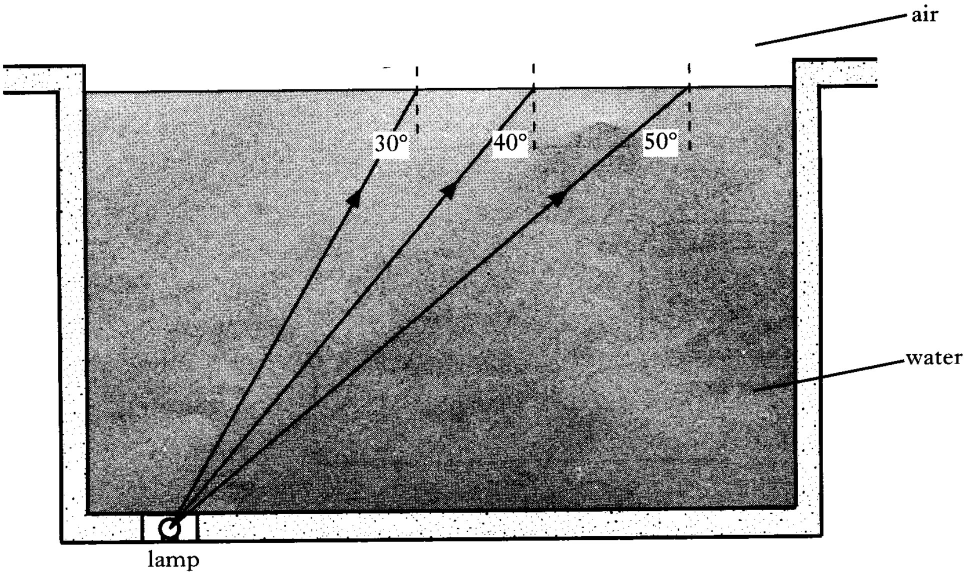
c. To stop the photoelectrons the wok done by the electric field must equal the maximum kinetic energy of the photoelectrons.

$E_{field} = E_{max.\ kinetic}$
$qV = E_{max.\ kinetic}$
$V = E_{max.\ kinetic}/q$
$V = 1.00x10^{-19}/1.6x10^{-19}$
V = 0.625V

9.a. $\theta_{crit} = \sin^{-1}(1/n)$
$\theta_{crit} = \sin^{-1}(1/1.33)$
$\theta_{crit} = \sin^{-1}(0.752)$
$\mathbf{\theta_{crit} = 48.7^o}$

Marks

9. A swimming pool is illuminated by a lamp built into the bottom of the pool.



Three rays of light from the same point in the lamp are incident on the water-air boundary with angles of incidence of 30°, 40° and 50°, as shown above.

The refractive index of the water in the pool is 1·33.

(*a*) Draw a diagram to show clearly what happens to each ray at the boundary. Indicate on your diagram the sizes of appropriate angles.
All necessary calculations must be shown. **5**

(*b*) An observer stands at the side of the pool and looks into the water.
Explain, with the aid of a diagram, why the image of the lamp appears to be at a shallower depth than the bottom of the pool. **2**

(7)

Back to Table

The y-intercept(c) is equal to -r.
The gradient(m) is equal to E.

c = -2.5
=>**r = 2.5Ω**

b.ii. $m = (y_2-y_1)/(x_2-x_1)$
m = (6-0)/(0.5-0.15)
m = 6/0.35
m = 17.1
=>**E = 17.1V**

c. I = E/r
I = 17.1/2.5
I = 6.8A

8.a. The minimum energy an electron needs to absorb to escape from an atom is called the work function.

b.i. $E_{photon} = hf$
$E_{photon} = 6.63\times10^{-34}\times6.1\times10^{14}$
$E_{photon} = 4.04\times10^{-19}J$

$E_{max.\ kinetic} = E_{photon} - E_{work}$
$E_{max.\ kinetic} = 4.04\times10^{-19} - 3.04\times10^{-19}$

$\mathbf{E_{max.\ kinetic} = 1.00\times10^{-19}J}$

b.ii. $Ek_{total} = E_{max.\ kinetic} + E_{field}$

Note: E_{field} is the energy gained by the electron in the electric field.

$E_{field} = qV$
$E_{field} = 1.6\times10^{-19}\times0.8$
$E_{field} = 1.28\times10^{-19}$

$Ek_{total} = 1.00\times10^{-19} + 1.28\times10^{-19}$
$\mathbf{Ek_{total} = 2.28\times10^{-19}J}$

c. To stop the photoelectrons the wok done by the electric field must equal the maximum kinetic energy of the photoelectrons.

$E_{field} = E_{max.\ kinetic}$
$qV = E_{max.\ kinetic}$
$V = E_{max.\ kinetic}/q$
$V = 1.00\times10^{-19}/1.6\times10^{-19}$
V = 0.625V

9.a. $\theta_{crit} = \sin^{-1}(1/n)$
$\theta_{crit} = \sin^{-1}(1/1.33)$
$\theta_{crit} = \sin^{-1}(0.752)$
$\mathbf{\theta_{crit} = 48.7^o}$

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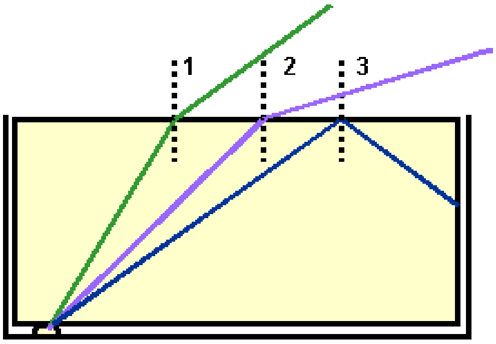
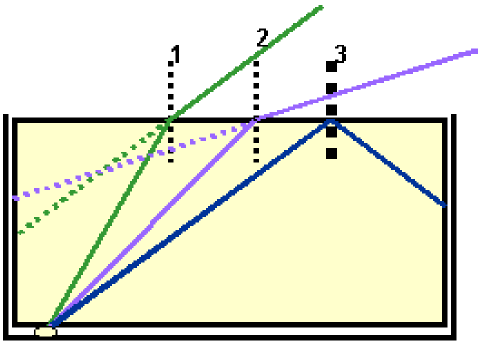
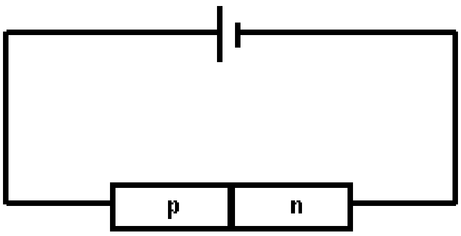


Note: Some internal reflection occurs for the light incident at the first and second boundary, however, for clarity these reflected rays have been omitted from the diagram.

9.b. To an observer the light appears to originate from where the broken rays cross. This produces a virtual image of the lamp at the apparently shallower depth.



10.a.i.



a.ii. When forward biased the majority charge carriers in the n-type material, electrons, flow to the p-type material. This movement of electrons also makes it appear that holes in the p-type material move towards the n-type material.

a.iii. When conduction band electrons in the n-type material pass into the p-type material they fall into lower energy holes and emit energy as as a visible photon, if the energy loss is equal to the energy of a visible photon.

Marks

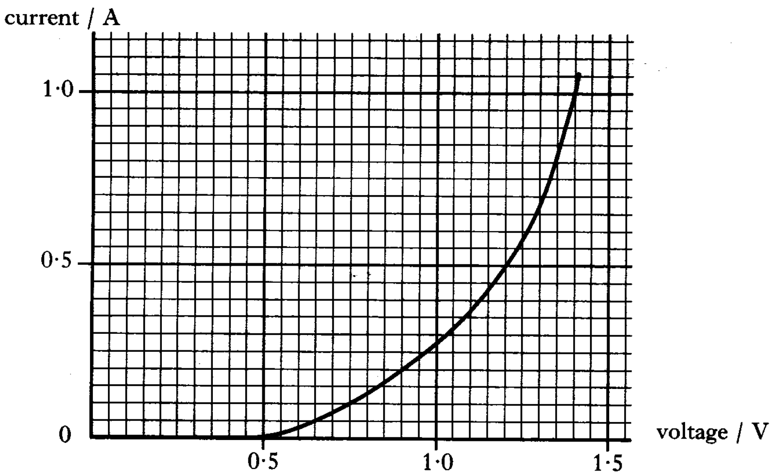
10. (*a*) The diagram below represents the p–n junction of a light emitting diode (LED).

(i) Draw a diagram showing the above p–n junction connected to a battery so that the junction is forward biased.

(ii) When the junction is forward biased, there is a current in the diode. Describe the movement of the charge carriers which produces this current.

(iii) Describe how the charge carriers in the light emitting diode enable light to be produced. **5**

(*b*) The following graph shows the variation of current with voltage for a diode when it is forward biased.



(i) What is the minimum voltage required for this diode to conduct?

(ii) What happens to the resistance of the diode as the voltage is increased above this minimum value?

Use information from the graph to justify your answer. **3**

(8)

[Turn over

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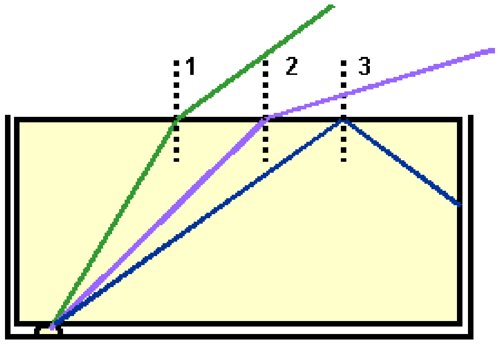
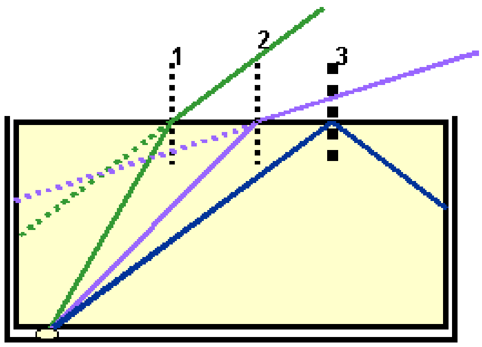
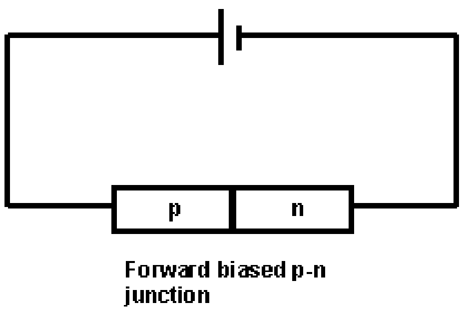


Note: Some internal reflection occurs for the light incident at the first and second boundary, however, for clarity these reflected rays have been omitted from the diagram.

9.b. To an observer the light appears to originate from where the broken rays cross. This produces a virtual image of the lamp at the apparently shallower depth.



10.a.i.



a.ii. When forward biased the majority charge carriers in the n-type material, electrons, flow to the p-type material. This movement of electrons also makes it appear that holes in the p-type material move towards the n-type material.

a.iii. When conduction band electrons in the n-type material pass into the p-type material they fall into lower energy holes and emit energy as as a visible photon, if the energy loss is equal to the energy of a visible photon.

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b.i Conduction starts when the applied voltage is **0.5V.**

b.ii. The resistance of the diode **decreases** as the applied voltage increases. This can be justified by using ohms law to calculate the resistance at different applied voltages.

$R = V/I$

$R_1 = V_1/I_1$
$R_1 = 1.0/0.275$
$R_1 = 3.6\Omega$

$R_2 = V_2/I_2$
$R_2 = 1.2/0.5$
$R_2 = 2.4\Omega$

11.a. The reaction is an example of **nuclear fusion.**

b. The total mass of the products from the fusion reaction is less than the mass of the initial reactants. The difference in mass is converted into energy. The amount of energy produced can be calculated using the equation: $E = mc^2$, where m is the difference in mass and c is the speed of light.

c. $M_{reactants} = (5.00890 \times 10^{-27} + 3.34441 \times 10^{-27})kg$
$M_{reactants} = 8.35331 \times 10^{-27}kg$

$M_{products} = (6.64632 \times 10^{-27} + 1.67490 \times 10^{-27})kg$
$M_{products} = 8.32122 \times 10^{-27}kg$

Mass defect = $M_{reactants} - M_{products}$
Mass defect = $8.35331 \times 10^{-27} - 8.32122 \times 10^{-27}$
Mass defect = $0.03209 \times 10^{-27}kg$

$E = M_{defect}c^2$
$E = 0.03209 \times 10^{-27} \times (3 \times 10^8)^2$
$\mathbf{E = 2.8881 \times 10^{-12}J}$

d. Number of reactions = Total energy per second/energy per reaction
Number of reactions = $25 \times 10^6/2.8881 \times 10^{-12}$
Number of reactions = 8.658×10^{18}

Return to past paper index page.

Marks

11. The following statement represents a nuclear reaction which may form the basis of a nuclear power station of the future.

$$ {}^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n} $$

(*a*) State the name given to the above type of nuclear reaction. **1**

(*b*) Explain, using $E = mc^2$, how this nuclear reaction results in the production of energy. **2**

(*c*) Using the information given below, and any other data required from the Data Sheet, calculate the energy released in the above nuclear reaction.

mass of ${}^{3}_{1}\mathrm{H}$ $= 5{\cdot}00890 \times 10^{-27}$ kg
mass of ${}^{2}_{1}\mathrm{H}$ $= 3{\cdot}34441 \times 10^{-27}$ kg
mass of ${}^{4}_{2}\mathrm{He}$ $= 6{\cdot}64632 \times 10^{-27}$ kg
mass of ${}^{1}_{0}\mathrm{n}$ $= 1{\cdot}67490 \times 10^{-27}$ kg **3**

(*d*) Calculate how many of the reactions of the type represented above would occur each second to produce a power of 25 MW. **2**

(8)

[*END OF QUESTION PAPER*]

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b.i Conduction starts when the applied voltage is **0.5V.**

b.ii. The resistance of the diode **decreases** as the applied voltage increases. This can be justified by using ohms law to calculate the resistance at different applied voltages.

$R = V/I$

$R_1 = V_1/I_1$
$R_1 = 1.0/0.275$
$R_1 = 3.6\Omega$

$R_2 = V_2/I_2$
$R_2 = 1.2/0.5$
$R_2 = 2.4\Omega$

11.a. The reaction is an example of **nuclear fusion.**

b. The total mass of the products from the fusion reaction is less than the mass of the initial reactants. The difference in mass is converted into energy. The amount of energy produced can be calculated using the equation: $E = mc^2$, where m is the difference in mass and c is the speed of light.

c. $M_{reactants} = (5.00890\text{x}10^{-27}+3.34441\text{x}10^{-27})\text{kg}$
$M_{reactants} = 8.35331\text{x}10^{-27}\text{kg}$

$M_{products} = (6.64632\text{x}10^{-27}+1.67490\text{x}10^{-27})\text{kg}$
$M_{products} = 8.32122\text{x}10^{-27}\text{kg}$

Mass defect = $M_{reactants} - M_{products}$
Mass defect = $8.35331\text{x}10^{-27} - 8.32122\text{x}10^{-27}$
Mass defect = $0.03209\text{x}10^{-27}\text{kg}$

$E = M_{defect}c^2$
$E = 0.03209\text{x}10^{-27} \text{ x } (3\text{x}10^8)^2$
$\mathbf{E = 2.8881\text{x}10^{-12}J}$

d. Number of reactions = Total energy per second/energy per reaction
Number of reactions = $25\text{x}10^6/2.8881\text{x}10^{-12}$
Number of reactions = $8.658\text{x}10^{18}$

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1996 Paper 1 (Multiple Choice)

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1. C	11. E	21. C
2. C	12. D	22. E
3. B	13. A	23. A
4. D	14. D	24. B
5. B	15. D	25. E
6. B	16. C	26. A
7. E	17. A	27. A
8. C	18. E	28. B
9. C	19. E	29. B
10.C	20. C	30. E

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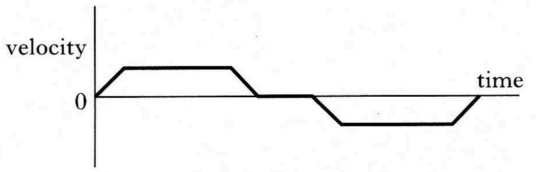
SECTION A

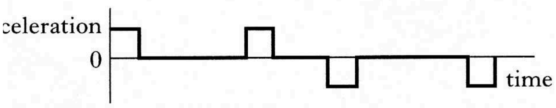
Answer questions 1–30 on the answer sheet.

1. A lift in a hotel makes a return journey from the ground floor to the top floor and then back again. The corresponding velocity-time graph is shown below.

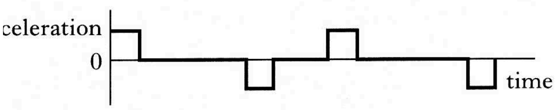


Which of the following shows the acceleration-time graph for the same journey?

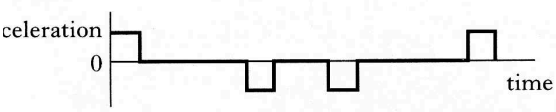
A



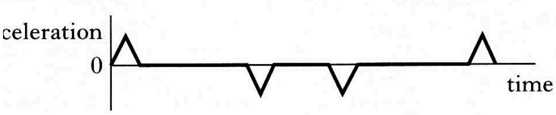
B



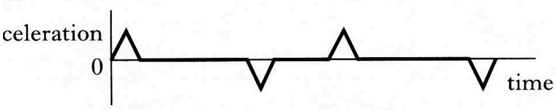
C



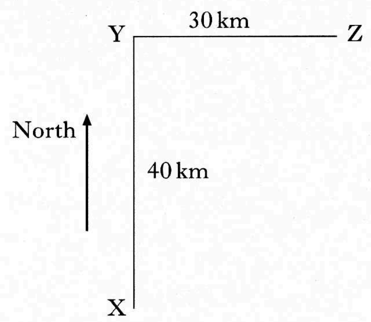
D



E



2. A car travels from X to Y and then it travels from Y to Z, as shown in the following diagram.



X to Y takes a time of one hour. Y to Z also takes one hour. Which of the following is a correct list of the magnitudes of the final displacement, average speed and average velocity for the complete journey?

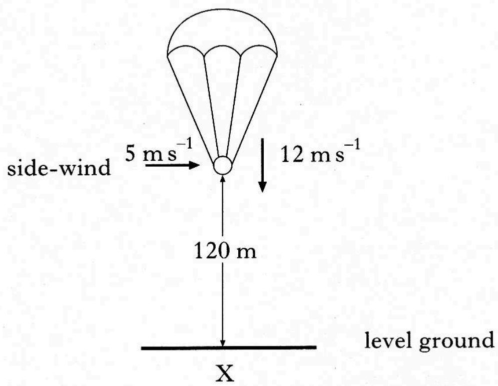
	Displacement (km)	*Average speed* (km hr^{-1})	*Average velocity* (km hr^{-1})
A	50	35	35
B	70	35	25
C	50	35	25
D	70	70	50
E	50	70	25

[Turn over

Back to Table Answers

3. An object attached to a parachute falls from a helicopter which is hovering at a height of 120 m above point X.

The object falls with a constant vertical component of velocity of value $12\ \mathrm{m\,s^{-1}}$. A steady side-wind gives the object a constant horizontal component of velocity of value $5\ \mathrm{m\,s^{-1}}$.



How far from point X does the object hit the ground?

A 24 m

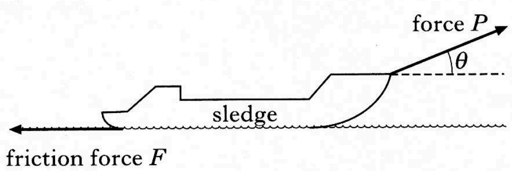
B 50 m

C 60 m

D 120 m

E 150 m

4. A sledge is dragged at a **constant velocity** along the snow against a horizontal frictional force F. The rope pulling the sledge is at an angle of θ to the horizontal, as shown.



When the sledge is moving horizontally with a constant velocity, the force P pulling the rope is equal to

A F

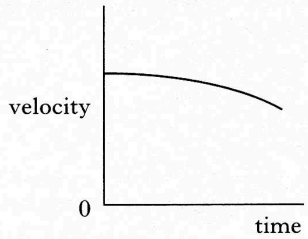
B $F\cos\theta$

C $F\sin\theta$

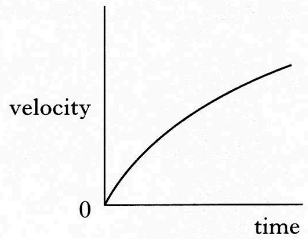
D $\dfrac{F}{\cos\theta}$

E $\dfrac{F}{\sin\theta}$.

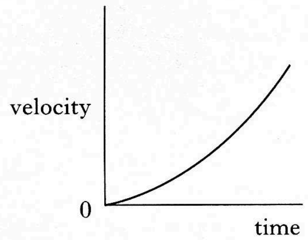
5. A ball is thrown horizontally over the edge of a cliff. When air resistance **is taken into account,** which graphs represent the horizontal and vertical components of the velocity of the ball during its flight?



graph X



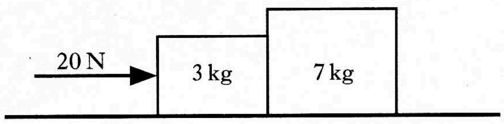
graph Y



graph Z

	Horizontal component of velocity	*Vertical component of velocity*
A	graph X	graph X
B	graph X	graph Y
C	graph Y	graph X
D	graph Y	graph Z
E	graph Z	graph Z

6. A horizontal force of 20 N is applied as shown to two wooden blocks of masses 3 kg and 7 kg. The blocks are in contact with each other on a frictionless horizontal surface.



What is the size of the horizontal force acting on the 7 kg block?

A 20 N

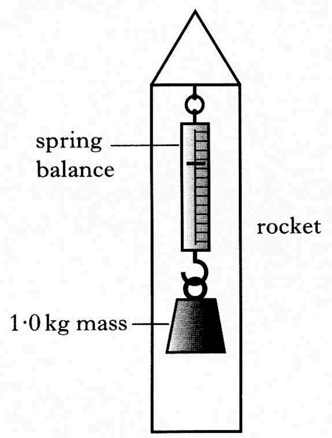
B 14 N

C 10 N

D 8 N

E 6 N

7. An object of mass 1·0 kg hangs from a spring balance which is suspended on the inside of a small rocket, as shown below.



What is the reading on the balance when the rocket is accelerating upwards from the Earth's surface at 2·0 m s^{-2}? Use g = 9·8 m s^{-2}.

A 0 N

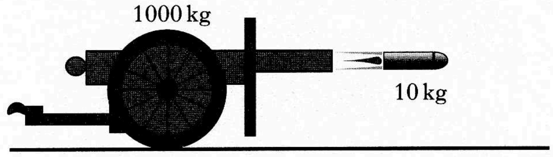
B 2·0 N

C 7·8 N

D 9·8 N

E 11·8 N

8. A field-gun of mass 1000 kg fires a shell of mass 10 kg with a velocity of 100 m s^{-1} East.



The velocity of the field-gun just after firing the shell is

A 0 m s^{-1}

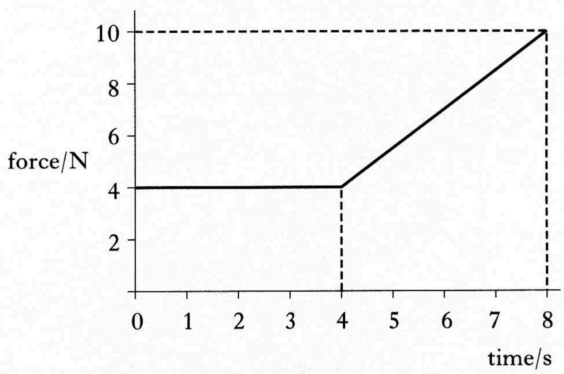
B 1 m s^{-1} East

C 1 m s^{-1} West

D 10 m s^{-1} East

E 10 m s^{-1} West.

9. The graph below shows the force which acts on an object over a time interval of 8 seconds.



The momentum gained by the object during this 8 seconds is

A 12 N s

B 32 N s

C 44 N s

D 52 N s

E 72 N s.

[Turn over

10. An aircraft cruises at an altitude at which the air pressure is $0{\cdot}4 \times 10^5$ Pa. The inside of the aircraft cabin is maintained at a pressure of $1{\cdot}0 \times 10^5$ Pa. The area of an external cabin door is $2\ m^2$.

What is the outward force produced on this door by the pressures stated?

A $0{\cdot}3 \times 10^5$ N

B $0{\cdot}7 \times 10^5$ N

C $1{\cdot}2 \times 10^5$ N

D $2{\cdot}0 \times 10^5$ N

E $2{\cdot}8 \times 10^5$ N

11. The volt is equivalent to the

A farad/coulomb

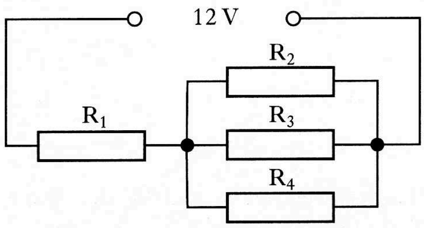
B ampere/ohm

C joule/ampere

D joule/ohm

E joule/coulomb.

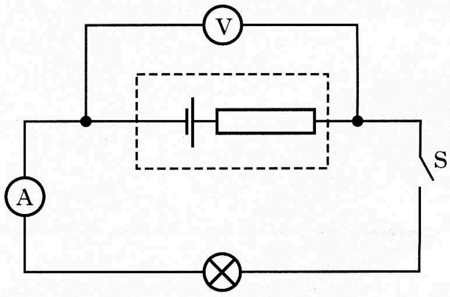
12. The diagram below illustrates a circuit in which the supply has an e.m.f. of 12 V and negligible internal resistance. Four load resistors, each of resistance 3 kΩ, are connected in the circuit as shown.



Which line in the table below indicates the potential differences in volts that would exist across the resistors?

	p.d. across R_1	p.d. across R_2	p.d. across R_3	p.d. across R_4
A	3 V	3 V	3 V	3 V
B	6 V	6 V	6 V	6 V
C	3 V	9 V	9 V	9 V
D	9 V	3 V	3 V	3 V
E	9 V	1 V	1 V	1 V

13. The circuit below can be used to determine the e.m.f. and the internal resistance of a cell.



Ammeter and voltmeter readings are taken when switch S is open and again when it is closed. The results are as follows:

Switch S open: Current = zero : Voltage = V_1

Switch S closed: Current = I : Voltage = V_2

The e.m.f. of the cell is equal to

A V_1

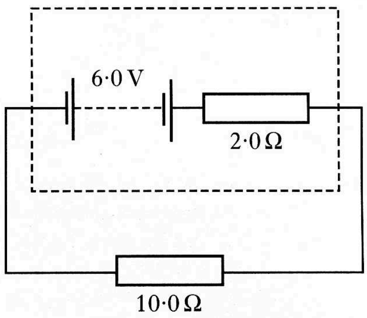
B V_2

C $V_1 - V_2$

D $\dfrac{V_1}{I}$

E $\dfrac{(V_2 - V_1)}{I}$.

14. A battery has an e.m.f. of 6·0 V and an internal resistance of 2·0 Ω. It is connected to a 10·0 Ω resistor, as shown below.



The p.d. across the 10·0 Ω resistor is

A 1·0 V

B 1·2 V

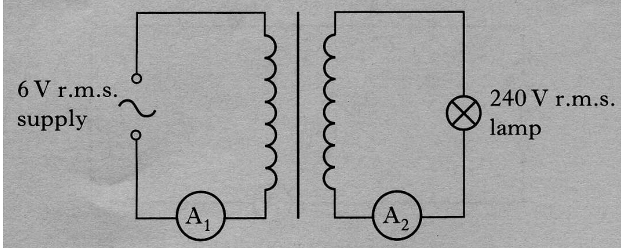
C 4·8 V

D 5·0 V

E 6·0 V.

Back to Table Answers

15. The step-up transformer shown below is used to light a mains lamp at its correct rating. The input voltage to the primary is 6 V r.m.s. and the voltage across the lamp is 240 V r.m.s.



The a.c. ammeters A_1 and A_2 have negligible resistance.

The reading on A_1 is 5·0 A r.m.s. and the reading on A_2 is 0·1 A r.m.s.

The efficiency of the transformer is

A 2·5%

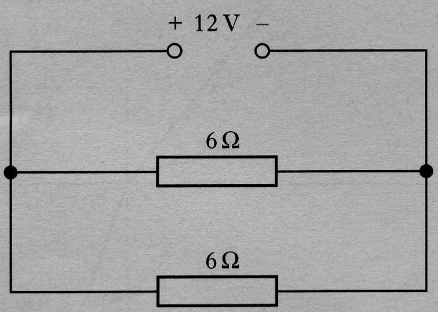
B 40%

C 50%

D 80%

E 100%.

16. The circuit below shows two 6 Ω resistors connected in parallel to a 12 V d.c. supply of negligible resistance.



The total power developed in this circuit is

A 12 W

B 24 W

C 48 W

D 300 W

E 1200 W.

17. An 8 μF capacitor requires

A 8 μC to charge it to 1 V

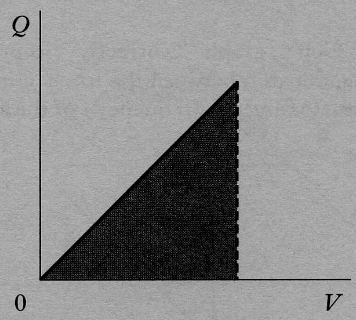
B 1 μC to charge it to 8 V

C 8 μC to charge it to 8 V

D 8 C to charge it to 8 μV

E 1 C to charge it to 8 μV.

18. The following graph shows how the charge Q on a capacitor is related to the p.d. V applied across its plates.



What does the shaded area under this graph represent?

A The distance between the plates of the capacitor

B The capacitance of the capacitor

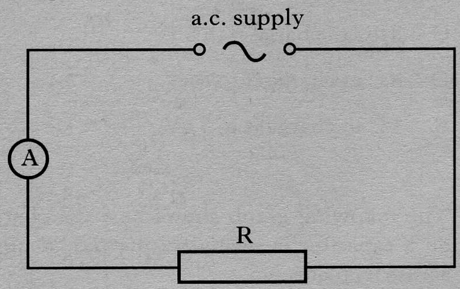
C The working voltage of the capacitor

D The charge stored on the plates of the capacitor

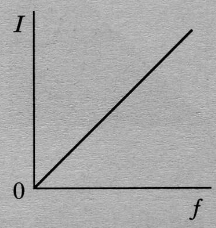
E The energy stored in the capacitor

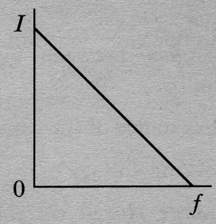
[Turn over

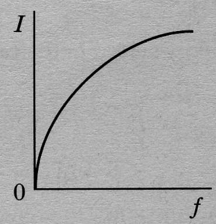
19. A resistor is connected in a circuit as shown. The output of the alternating supply can be varied in frequency but has a constant peak voltage.

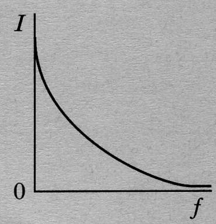


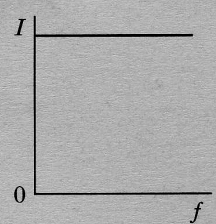
Which graph correctly represents the relationship between the r.m.s. current I in the resistor and the frequency f of the supply?

A


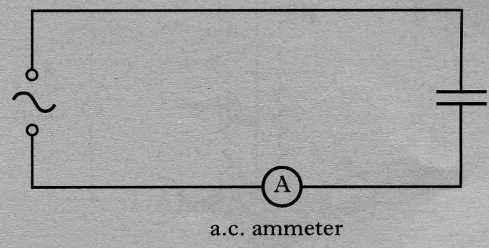
B


C


D


E


20. A capacitor is connected to a circuit as shown. The output of the alternating supply can be varied in frequency but has a constant peak voltage.



When the frequency of the output from the supply is steadily increased from 50 Hz to 5000 Hz, the reading on the a.c. ammeter will

A remain constant

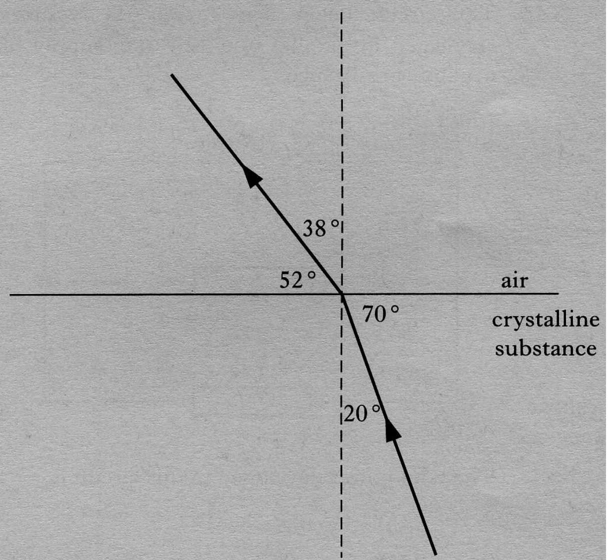
B decrease steadily

C increase steadily

D increase then decrease

E decrease then increase.

21. The diagram shows a ray of light going into air from a crystalline substance.



What is the refractive index of the crystalline substance?

A 1·2

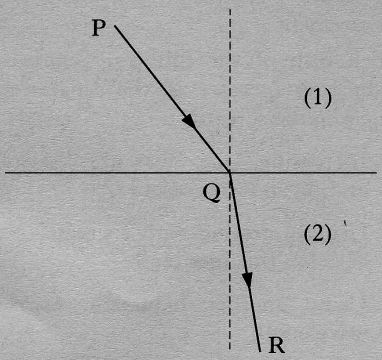
B 1·3

C 1·8

D 1·9

E 2·3

22. A ray of monochromatic light passing from medium (1) into medium (2) follows the path PQR.



When the light passes from medium (1) to medium (2), its

A frequency is increased

B frequency is decreased

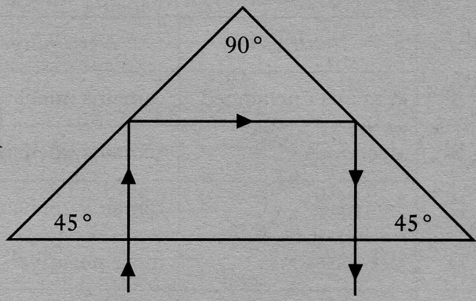
C wavelength is unchanged

D speed is increased

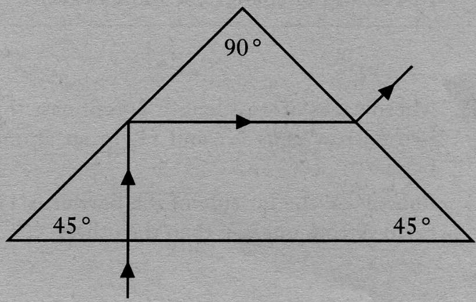
E speed is decreased.

23. Which one of the following diagrams shows the correct path for a ray of light travelling from air into a glass prism whose angles are 45°, 90° and 45°? The refractive index of the glass is 1·5.

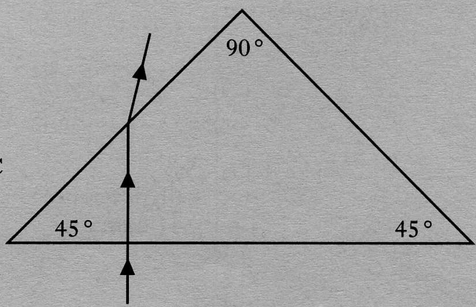
A



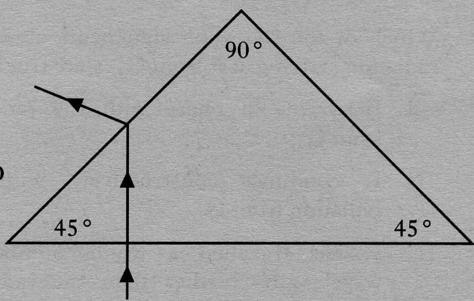
B



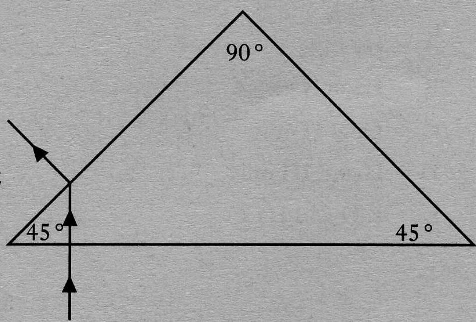
C



D



E

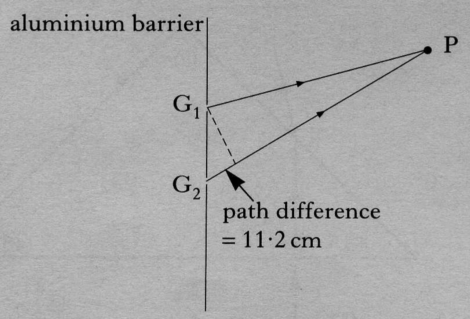


24. An n-type semiconductor is produced by adding arsenic impurity atoms to silicon. Which row in the following table describes the effect that this process has on the resistance and overall net charge of the material?

	Resistance	*Net Charge*
A	remains unchanged	remains unchanged
B	decreases	remains unchanged
C	increases	remains unchanged
D	decreases	more negative
E	remains unchanged	more negative

25. Microwaves of wavelength 2·8 cm pass through two narrow gaps G_1 and G_2 in an aluminium barrier.

Point P on the far side of the barrier is 11·2 cm further from one gap than the other.



Which of the following statements about the radiation arriving at P from G_2 is/are true?

I It arrives in phase with the radiation from G_1.

II It combines constructively with the radiation from G_1.

III It has travelled a whole number of wavelengths further than the radiation from G_1.

A II only

B III only

C I and II only

D II and III only

E I, II and III

26. When a grating was set up to produce an interference pattern on a screen using a monochromatic light source, the fringes were too close together to allow accurate measurement.

Which **one** of the following changes would produce an increase in the separation of the fringes on the screen?

A Increasing the distance between the grating and the screen

B Using a grating with a greater separation between the lines on it

C Using another light source of shorter wavelength

D Using another light source of greater intensity

E Increasing the distance between the source and the grating

27. A small lamp is placed 1 metre above a desk. At a point on the desk directly below the lamp, the intensity of the light is I. The lamp may be treated as a point source of light.

The lamp is now raised until it is 2 metres above the desk. What is the new intensity of light at the same point on the desk?

A $\frac{I}{4}$

B $\frac{I}{2\sqrt{2}}$

C $\frac{I}{2}$

D $\frac{I}{\sqrt{2}}$

E $\sqrt{2}\,I$

28. The last two changes in a radioactive decay series are shown below.

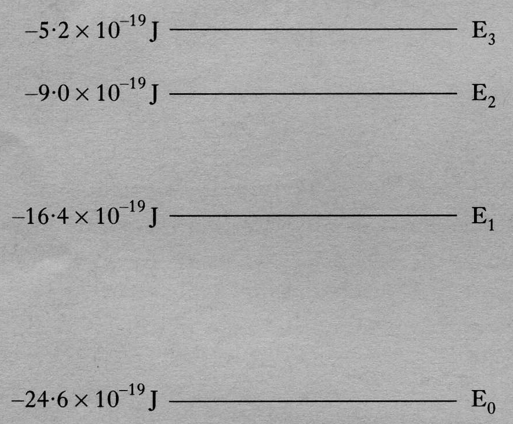
A Bismuth nucleus emits a beta particle and its product, a Polonium nucleus, emits an alpha particle.

$$ {}^{P}_{Q}\mathrm{Bi} \xrightarrow[\text{decay}]{\beta} {}^{R}_{S}\mathrm{Po} \xrightarrow[\text{decay}]{\alpha} {}^{208}_{82}\mathrm{Pb} $$

Which numbers are represented by P, Q, R and S?

	P	Q	R	S
A	212	85	212	84
B	212	83	212	84
C	211	85	207	86
D	210	83	208	81
E	210	83	210	84

29. The diagram below shows the energy levels in an atom.



An electron is excited from energy level E_2 to level E_3 by absorbing energy. What is the frequency of light being used to excite the electron?

A $1{\cdot}74 \times 10^{-15}$ Hz

B $5{\cdot}73 \times 10^{14}$ Hz

C $1{\cdot}69 \times 10^{15}$ Hz

D $2{\cdot}14 \times 10^{15}$ Hz

E $2{\cdot}92 \times 10^{15}$ Hz

30. A detector placed near a source of gamma rays records a count rate of 480 counts per second.

A slab of material of thickness 3 cm is then placed between the source and the detector. The half-value thickness of this material is 1 cm and the half-life of the source is 1 day.

After 1 day, what is the count rate recorded by the detector ?

A 240 counts per second

B 160 counts per second

C 80 counts per second

D 60 counts per second

E 30 counts per second

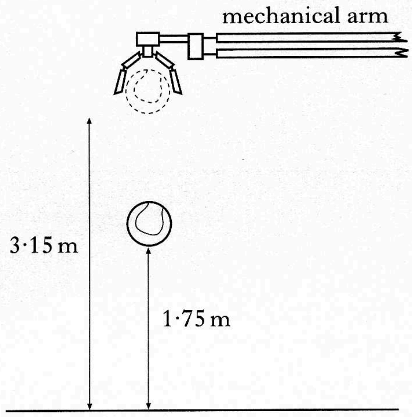
[Turn over

Marks

1. The manufacturers of tennis balls require that the balls meet a given standard.

When dropped from a certain height onto a test surface, the balls must rebound to within a limited range of heights.

The ideal ball is one which, when dropped from rest from a height of 3·15 m, rebounds to a height of 1·75 m as shown below.



(*a*) Assuming air resistance is negligible, calculate

(i) the speed of an ideal ball just before contact with the ground

(ii) the speed of this ball just after contact with the ground. **3**

(*b*) When a ball is tested six times, the rebound heights are measured to be

1·71 m, 1·78 m, 1·72 m, 1·76 m, 1·73 m, 1·74 m.

Calculate

(i) the mean value of the height of the bounce

(ii) the random error in this value. **3**

(6)

[Turn over

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1996 HIGHER PHYSICS SOLUTIONS

PAPER II

QUESTION 1

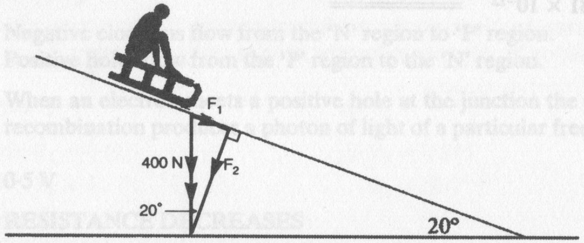
(a) (i) $V^2 = U^2 + 2as$
$V^2 = 0^2 + 2 \times (-9{\cdot}8) \times (-3{\cdot}15)$
$V^2 = 61{\cdot}74$
$V = \underline{\underline{7{\cdot}86 \text{ m s}^{-1}}}$

(ii) $V^2 = U^2 + 2as$
$0^2 = U^2 + 2 \times (-9{\cdot}8) \times (+1{\cdot}75)$
$U^2 = 34{\cdot}3$
$U = \underline{\underline{5{\cdot}86 \text{ m s}^{-1}}}$

(b) (i) Mean = $\underline{\underline{1{\cdot}74 \text{ m}}}$

(ii) Random error $= \dfrac{1{\cdot}78 - 1{\cdot}71}{6}$
$= \dfrac{0{\cdot}07}{6}$
$= \underline{\underline{0{\cdot}01 \text{ m}}}$

QUESTION 2



(a) (i) We require F_1
$\sin 20 = \dfrac{F_1}{400}$
$F_1 = 400 \sin 20$
$= \underline{\underline{136{\cdot}8 \text{ N}}}$

(ii) $a = \dfrac{F}{M} = \dfrac{(136{\cdot}8 - 20{\cdot}0)}{\left(\dfrac{400}{9{\cdot}8}\right)}$
$= \dfrac{116{\cdot}8}{40{\cdot}82}$
$= \underline{\underline{2{\cdot}86 \text{ ms}^{-2}}}$

(b) No effect.
The initial acceleration depends only upon
(i) Angle of slope.
(ii) Force of friction.

(c) As the speed of the sledge increases the frictional forces acting on it increases. It will eventually reach a TERMINAL VELOCITY when the forces acting on it are BALANCED. In this case the component of gravity is balanced by friction and air resistance.

QUESTION 3

(a) (i) $m_1u_1 + m_2u_2 = (m_1 + m_2)V$
$(1200 \times 18) + (1000 \times -10{\cdot}8) = (2200)V$
$21\,600 - 10\,800 = 2200\,V$
$V = \dfrac{10\,800}{2200} = \underline{\underline{+4{\cdot}90 \text{ ms}^{-1}}}$

(ii) If E_k is not conserved it is inelastic.

BEFORE collision

$E_k = \left(\frac{1}{2} \times 1200 \times 18^2\right) + \left(\frac{1}{2} \times 1000 \times 10{\cdot}8^2\right)$
$= 194\,400 + 58\,320$
$= 252\,720 \text{ J}$

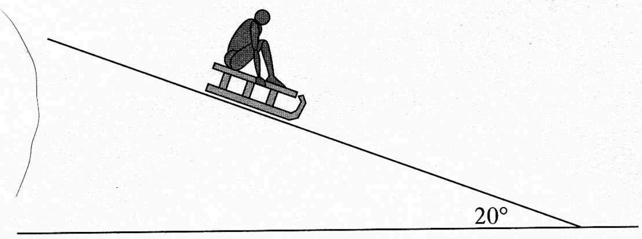
AFTER collision

$E_k = \frac{1}{2} \times 2200 \times (4{\cdot}9)^2$
$= 26\,411 \text{ J}$

Therefore kinetic energy is lost. Therefore collision is inelastic.

Marks

2. A child on a sledge slides down a slope which is at an angle of 20° to the horizontal as shown below.



The combined weight of the child and the sledge is 400 N. The frictional force acting on the sledge and child at the start of the slide is 20·0 N.

(*a*) (i) Calculate the component of the combined weight of the child and sledge down the slope.

(ii) Calculate the initial acceleration of the sledge and child. **4**

(*b*) The child decides to start the slide from further up the slope. Explain whether or not this has any effect on the initial acceleration. **2**

(*c*) During the slide, the sledge does not continue to accelerate but reaches a constant speed. Explain why this happens. **2**

(8)

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PAPER II

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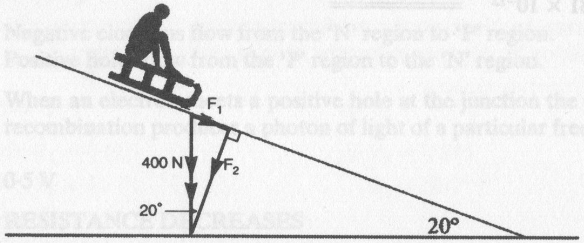

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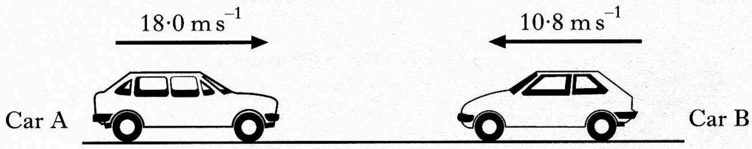
Marks

3. During a test on car safety, two cars as shown below are crashed together on a test track.



(*a*) Car A, which has a mass of 1200 kg and is moving at 18·0 m s^{-1}, approaches car B, which has a mass of 1000 kg and is moving at 10·8 m s^{-1}, in the opposite direction.

The cars collide head on, lock together and move off in the direction of car A.

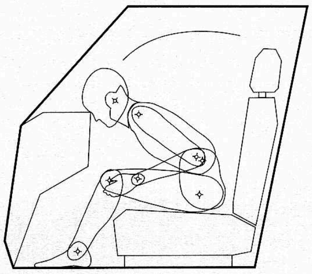
(i) Calculate the speed of the cars immediately after the collision.

(ii) Show by calculation that this collision is inelastic. **4**

(*b*) During a second safety test, a dummy in a car is used to demonstrate the effects of a collision.

During the collision, the head of the dummy strikes the dashboard at 20 m s^{-1} as shown below and comes to rest in 0·02 s.

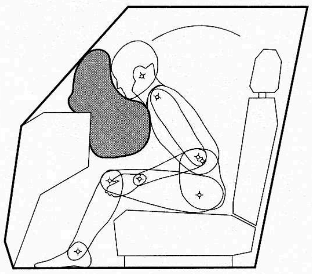
The mass of the head is 5 kg.



(i) Calculate the average force exerted by the dashboard on the head of the dummy during the collision.

(ii) If the contact area between the head and the dashboard is 5×10^{-4} m^2, calculate the pressure which this force produces on the head of the dummy.

(iii) The test on the dummy is repeated with an airbag which inflates during the collision. During the collision, the head of the dummy again travels forward at 20 m s^{-1} and is brought to rest by the airbag.



Explain why there is less risk of damage to the head of the dummy when the airbag is used. **5**

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1996 HIGHER PHYSICS SOLUTIONS

PAPER II

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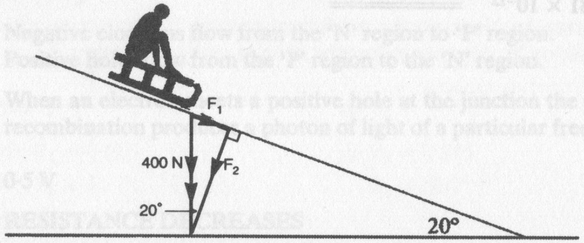

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Back to Table

(b) (i) $\overline{F} = \frac{m(v-u)}{t}$

$\overline{F} = \frac{5(0-20)}{0 \cdot 02}$

$= \frac{-100}{0 \cdot 02}$

$= \underline{\underline{-5000\ N}}$

(ii) $P = \frac{F}{A}$

$= \frac{5000}{5 \times 10^{-4}}$

$= \underline{\underline{1 \times 10^7\ Pa}}$

(iii) The airbag increases the time for head to decelerate hence decreasing the average force.
Also the head is in contact with a much larger area, decreasing the pressure on the skull.

QUESTION 4

(a)

P(k Pa)	100	150	200	250
Vol cm^3	14·7	9·9	7·4	5·9
$P \times V$	1470	1485	1480	1475

Average $P \times V = 1478$

$P \times V = \underline{\underline{\text{constant (approx.)}}}$

(b) Assuming constant = 1478
then $P \times V = 1478$
$P \times 5 = 1478$

$P = \frac{1478}{5} = \underline{\underline{295 \cdot 6\ k\ Pa}}$

(c) The piston will be forced back up the syringe. When compressed, the air molecules in the syringe hit the inside of the piston MORE OFTEN than particles hit the outside and will force it upwards until the pressure inside equals the pressure outside.

(d) The results would be less accurate. The volume of trapped air would be greater than that shown on the syringe. $P \times V$ values would not be constant.

QUESTION 5

(a) (i) 0 V

(ii) $\frac{6 \cdot 6}{3 \cdot 3} = \frac{1}{R}$

$\therefore 2 = \frac{1}{R}$

$\therefore R = \underline{\underline{0 \cdot 5\ k\Omega}}$

(b) (i) 420 Ω

(ii) $\frac{1000}{1420} \times 9\ V$

$= \underline{\underline{6 \cdot 34\ V}}$

(iii) Voltage across 6·6 k = 6·0 V
Meter will read 6·34 – 6·0 = $\underline{\underline{0 \cdot 34\ V}}$

QUESTION 6

(a) $W = QV$

$= 1 \cdot 6 \times 10^{-19} \times 25 \times 10^3$

$= 40 \times 10^{-16}$

$= \underline{\underline{4 \times 10^{-15}\ J}}$

(b) KE at B $= 1 \cdot 3 \times 10^{-16} + 4 \times 10^{-15}$

$= 41 \cdot 3 \times 10^{-16}$

$\frac{1}{2} mv^2 = 41 \cdot 3 \times 10^{-16}$

$v^2 = \frac{2 \times 41 \cdot 3 \times 10^{-6}}{1 \cdot 673 \times 10^{-27}}$

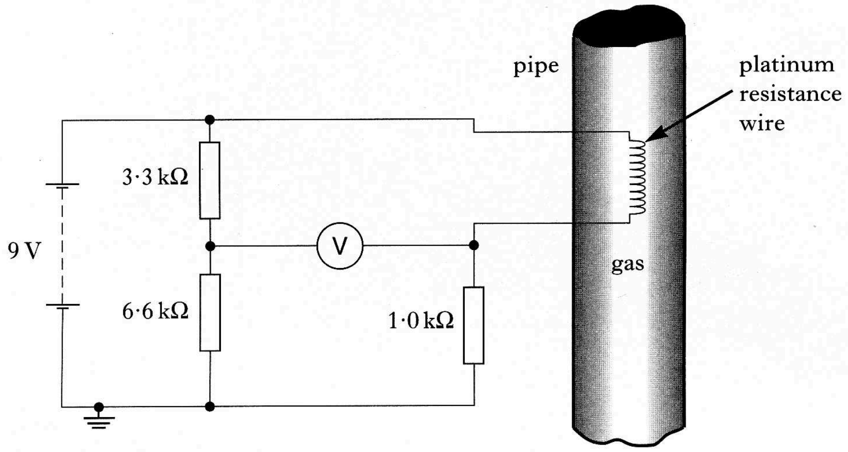
$v^2 = 4 \cdot 94 \times 10^{12}$

$v = \underline{\underline{2 \cdot 22 \times 10^6\ m\ s^{-1}}}$

Marks

5. A Wheatstone bridge is used to monitor the temperature of gas in a pipe.

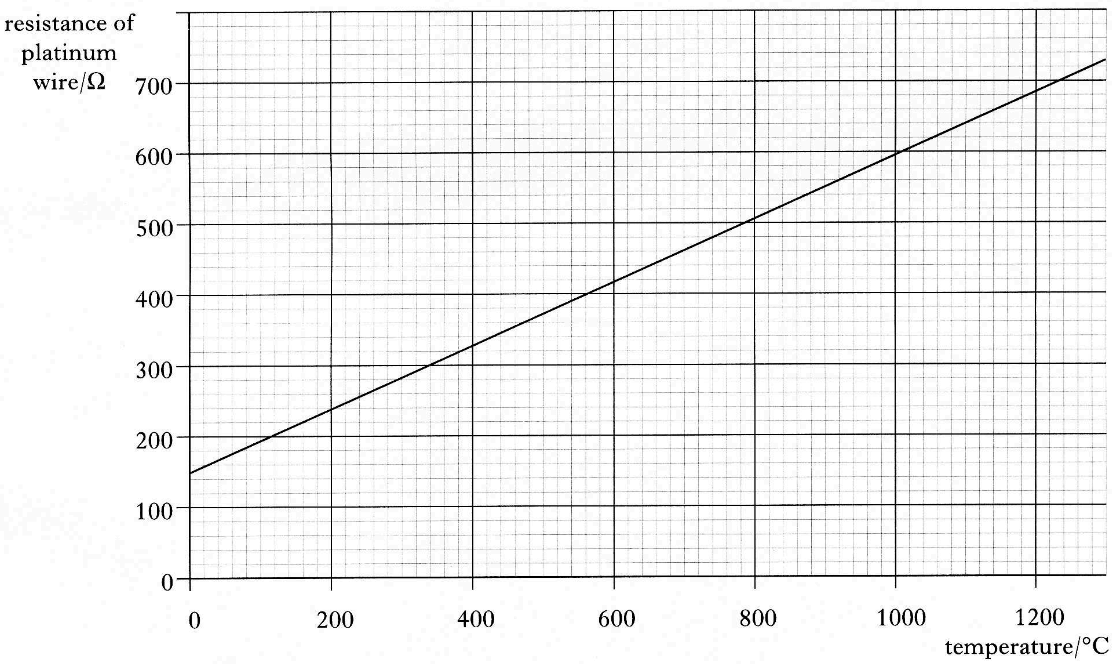
A length of platinum resistance wire forms one part of the Wheatstone bridge circuit. The wire is inserted into the pipe containing the gas as shown below. The 9 V supply has negligible internal resistance.



(*a*) (i) The bridge is initially balanced. What is the reading on the voltmeter?

(ii) Calculate the resistance of the platinum wire. **3**

(*b*) The graph below shows how the resistance of the platinum wire varies with temperature.



The temperature of the gas and the platinum wire is changed to 600 °C. The Wheatstone bridge is now out of balance.

(i) What is the resistance of the platinum wire at 600 °C?

(ii) Calculate the p.d. across the 1·0 kΩ resistor.

(iii) Calculate the reading on the voltmeter. **6**

(9)

Back to Table

(b) (i) $\overline{F} = \dfrac{m(v-u)}{t}$

$\overline{F} = \dfrac{5(0-20)}{0{\cdot}02}$

$= \dfrac{-100}{0{\cdot}02}$

$= \underline{-5000\ \text{N}}$

(ii) $P = \dfrac{F}{A}$

$= \dfrac{5000}{5 \times 10^{-4}}$

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(b) (i) 420 Ω

(ii) $\dfrac{1000}{1420} \times 9\ \text{V}$

$= \underline{6{\cdot}34\ \text{V}}$

(iii) Voltage across 6·6 k = 6·0 V
Meter will read 6·34 – 6·0 = $\underline{0{\cdot}34\ \text{V}}$

QUESTION 6

(a) $W = QV$

$= 1{\cdot}6 \times 10^{-19} \times 25 \times 10^{3}$

$= 40 \times 10^{-16}$

$= \underline{4 \times 10^{-15}\ \text{J}}$

(b) KE at B $= 1{\cdot}3 \times 10^{-16} + 4 \times 10^{-15}$

$= 41{\cdot}3 \times 10^{-16}$

$\frac{1}{2}mv^2 = 41{\cdot}3 \times 10^{-16}$

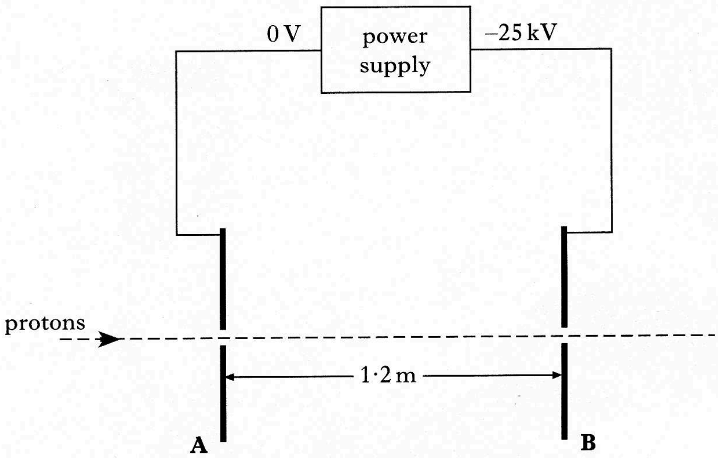
$v^2 = \dfrac{2 \times 41{\cdot}3 \times 10^{-6}}{1{\cdot}673 \times 10^{-27}}$

$v^2 = 4{\cdot}94 \times 10^{12}$

$v = \underline{2{\cdot}22 \times 10^{6}\ \text{m s}^{-1}}$

Marks

6. A particle accelerator increases the speed of protons by accelerating them between a pair of parallel metal plates, **A** and **B**, connected to a power supply as shown below.



The potential difference between **A** and **B** is 25 kV.

(*a*) Show that the kinetic energy gained by a proton between plates **A** and **B** is $4 \cdot 0 \times 10^{-15}$ J. **2**

(*b*) The kinetic energy of a proton at plate **A** is $1 \cdot 3 \times 10^{-16}$ J.

Calculate the velocity of the proton on reaching plate **B**. **3**

(*c*) The plates are separated by a distance of 1·2 m.

Calculate the force produced by the particle accelerator on a proton as it travels between plates **A** and **B**. **2**

(7)

Back to Table

(b) (i) $\overline{F} = \dfrac{m(v-u)}{t}$

$\overline{F} = \dfrac{5(0-20)}{0{\cdot}02}$

$= \dfrac{-100}{0{\cdot}02}$

$= \underline{\underline{-5000\text{ N}}}$

(ii) $P = \dfrac{F}{A}$

$= \dfrac{5000}{5 \times 10^{-4}}$

$= \underline{\underline{1 \times 10^{7}\text{ Pa}}}$

(iii) The airbag increases the time for head to decelerate hence decreasing the average force.
Also the head is in contact with a much larger area, decreasing the pressure on the skull.

QUESTION 4

(a)

P(k Pa)	100	150	200	250
Vol cm^3	14·7	9·9	7·4	5·9
$P \times V$	1470	1485	1480	1475

Average $P \times V = 1478$

$P \times V = \underline{\underline{\text{constant (approx.)}}}$

(b) Assuming constant = 1478
then $P \times V = 1478$
$P \times 5 = 1478$

$P = \dfrac{1478}{5} = \underline{\underline{295{\cdot}6\text{ k Pa}}}$

(c) The piston will be forced back up the syringe. When compressed, the air molecules in the syringe hit the inside of the piston MORE OFTEN than particles hit the outside and will force it upwards until the pressure inside equals the pressure outside.

(d) The results would be less accurate. The volume of trapped air would be greater than that shown on the syringe. $P \times V$ values would not be constant.

QUESTION 5

(a) (i) 0 V

(ii) $\dfrac{6{\cdot}6}{3{\cdot}3} = \dfrac{1}{R}$

$\therefore 2 = \dfrac{1}{R}$

$\therefore R = \underline{\underline{0{\cdot}5\text{ k}\Omega}}$

(b) (i) 420 Ω

(ii) $\dfrac{1000}{1420} \times 9\text{ V}$

$= \underline{\underline{6{\cdot}34\text{ V}}}$

(iii) Voltage across 6·6 k = 6·0 V
Meter will read 6·34 – 6·0 = $\underline{\underline{0{\cdot}34\text{ V}}}$

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(b) KE at B $= 1{\cdot}3 \times 10^{-16} + 4 \times 10^{-15}$

$= 41{\cdot}3 \times 10^{-16}$

$\frac{1}{2}mv^2 = 41{\cdot}3 \times 10^{-16}$

$v^2 = \dfrac{2 \times 41{\cdot}3 \times 10^{-6}}{1{\cdot}673 \times 10^{-27}}$

$v^2 = 4{\cdot}94 \times 10^{12}$

$v = \underline{\underline{2{\cdot}22 \times 10^{6}\text{ m s}^{-1}}}$

Back to Table

(c) $Fd = QV$

$$\therefore F = \frac{QV}{d}$$

$$= \frac{1{\cdot}6 \times 10^{-19} \times 25 \times 10^{3}}{1{\cdot}2}$$

$$= \underline{\underline{3{\cdot}33 \times 10^{-15}\ \text{N}}}$$

QUESTION 7

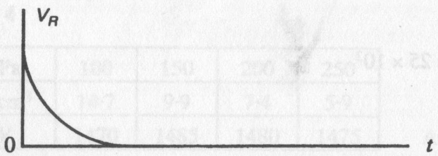
(a) (i) 6 V

(ii) $I_{\text{MAX}} = \frac{V}{R}$

$$= \frac{6}{800}$$

$$= \underline{\underline{7{\cdot}5\ \text{mA}}}$$

(iii)



(b) The discharge curve is much steeper than the charging curve, and has a higher initial value, indicating that resistance must have been lower since

$$\underline{\underline{I \propto \frac{1}{R}}}$$

(c) $E = \frac{1}{2} CV^2$

$$= \frac{1}{2} \times 10\,000 \times 10^{-6} \times 6^2$$

$$= \underline{\underline{0{\cdot}18\ \text{J}}}$$

QUESTION 8

(a) (i) Differential mode

(ii) $V_0 = \frac{R_f}{R_1}(V_2 - V_1)$

$$V_0 = \frac{10 \times 10^3}{2 \times 10^3}(0{\cdot}4 - 0{\cdot}3)$$

$$V_0 = 5(0{\cdot}1)$$

$$V_0 = \underline{\underline{0{\cdot}5\ \text{V}}}$$

(b) (i) This amplifier is in inverting mode.

$$V_0 = \frac{R_f}{R_1}(-V_1)$$

$$-4{\cdot}0 = \frac{R_f}{2 \times 10^3}(-0{\cdot}5)$$

$$\left(\frac{-4{\cdot}0}{-0{\cdot}5}\right) \times 2 \times 10^3 = R_f$$

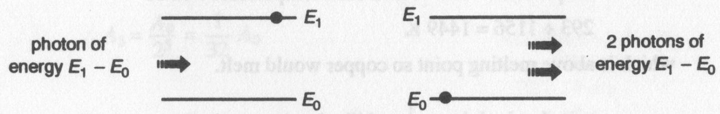
$$8 \times 2 \times 10^3 = R_f$$

$$R_f = \underline{\underline{16\ \text{k}\Omega}}$$

(ii) As R is increased feedback is decreased resulting in increased gain therefore V_0 increases until eventual saturation.

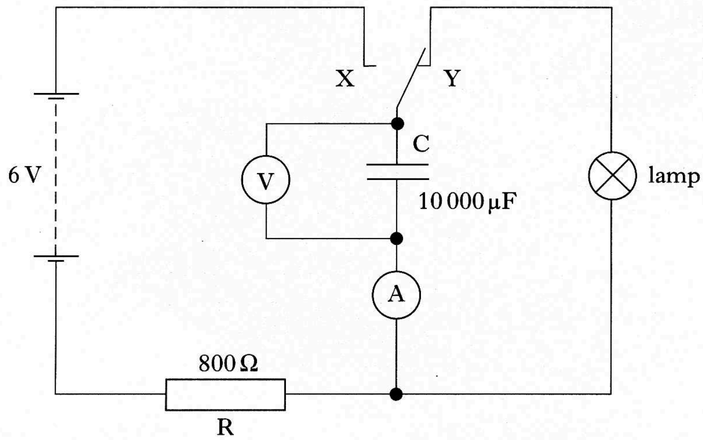
QUESTION 9

(a) "Simulated emission" occurs when electrons are deliberately encouraged to fall from higher to lower energy levels and emit a photon of energy. This can be achieved by sending another photon of the same energy towards the electron and stimulating it to fall.



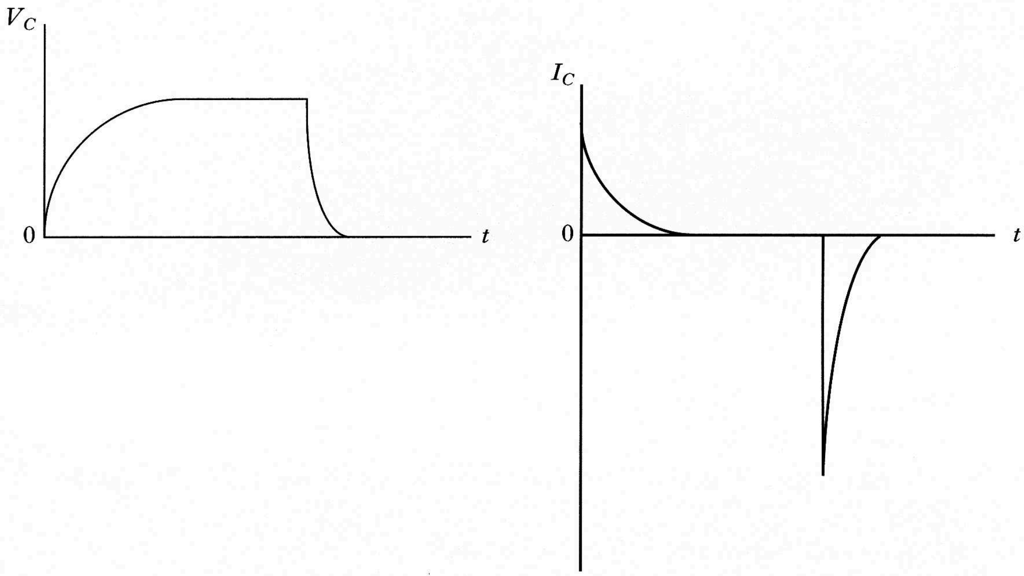
Marks

7. A student is investigating the charging and discharging of a 10 000 μF capacitor using the circuit shown below. The 6 V supply has negligible internal resistance.



Initially the capacitor is uncharged and the switch is in position Y. The switch is moved to position X until the capacitor is fully charged and then finally back to position Y.

The graphs below show the p.d. V_C across the capacitor and the current I_C in the ammeter during this process.



(*a*) (i) State the value of the p.d. across the capacitor when it is fully charged.

(ii) Calculate the maximum current during the charging process.

(iii) Sketch a graph showing how the p.d. across resistor R varies with time during the charging process. Numerical values are not required. **4**

(*b*) The student deduces from the graph of current against time for the discharge that the resistance of the lamp is less than 800 Ω.

Explain why the student's deduction is correct. **1**

(*c*) Calculate the energy stored in the capacitor when it is fully charged. **2**

(7)

Back to Table

(c) $Fd = QV$

$$\therefore F = \frac{QV}{d}$$

$$= \frac{1{\cdot}6 \times 10^{-19} \times 25 \times 10^{3}}{1{\cdot}2}$$

$$= \underline{\underline{3{\cdot}33 \times 10^{-15}\ \text{N}}}$$

QUESTION 7

(a) (i) 6 V

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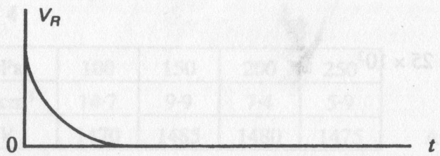
$$= \underline{\underline{7{\cdot}5\ \text{mA}}}$$

(iii)



(b) The discharge curve is much steeper than the charging curve, and has a higher initial value, indicating that resistance must have been lower since

$$\underline{\underline{I \propto \frac{1}{R}}}$$

(c) $E = \frac{1}{2} CV^2$

$$= \frac{1}{2} \times 10\,000 \times 10^{-6} \times 6^2$$

$$= \underline{\underline{0{\cdot}18\ \text{J}}}$$

QUESTION 8

(a) (i) Differential mode

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$$V_0 = \underline{\underline{0{\cdot}5\ \text{V}}}$$

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$$8 \times 2 \times 10^3 = R_f$$

$$R_f = \underline{\underline{16\ \text{k}\Omega}}$$

(ii) As R is increased feedback is decreased resulting in increased gain therefore V_0 increases until eventual saturation.

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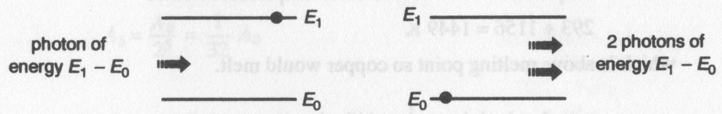


Marks

11. (*a*) Two possible nuclear reactions involving uranium are represented by the statements shown below.

Statement **A** $\quad {}^{235}_{92}U + {}^{1}_{0}n = {}^{134}_{52}Te + {}^{98}_{40}Zr + 4\,{}^{1}_{0}n$

Statement **B** $\quad {}^{235}_{92}U + {}^{1}_{0}n = {}^{144}_{56}Ba + {}^{90}_{36}Kr + 2\,{}^{1}_{0}n$

The masses of the nuclei and particles involved in the reactions are as follows.

	Mass
${}^{235}_{92}U$	$3{\cdot}901 \times 10^{-25}$ kg
${}^{134}_{52}Te$	$2{\cdot}221 \times 10^{-25}$ kg
${}^{98}_{40}Zr$	$1{\cdot}626 \times 10^{-25}$ kg
${}^{144}_{56}Ba$	$2{\cdot}388 \times 10^{-25}$ kg
${}^{90}_{36}Kr$	$1{\cdot}492 \times 10^{-25}$ kg
${}^{1}_{0}n$	$0{\cdot}017 \times 10^{-25}$ kg

(i) What type of nuclear reaction is described by statements **A** and **B**?

(ii) Show by calculation how much mass is "lost" in each of reactions **A** and **B**.

(iii) Explain which of the reactions **A** and **B** releases the greater amount of energy. **6**

(*b*) A third possible nuclear reaction involving ${}^{235}_{92}U$ is represented by the following statement.

$${}^{235}_{92}U + {}^{1}_{0}n = {}^{98}_{42}Mo + {}^{136}_{y}Xe + 2\,{}^{1}_{0}n + 4\,{}^{0}_{-1}e$$

(i) The symbol for the uranium nucleus is ${}^{235}_{92}U$. What information about the particles in the nucleus is provided by the numbers 92 and 235?

(ii) Determine the number represented by y. **3**

(9)

[*END OF QUESTION PAPER*]

Back to Table

HIGHER PHYSICS ANSWERS — 1996

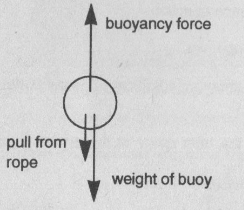
Paper I — Section A

1. C	2. C	3. B	4. D	5. B
6. B	7. E	8. C	9. C	10. C
11. E	12. D	13. A	14. D	15. D
16. C	17. A	18. E	19. E	20. C
21. C	22. E	23. A	24. B	25. E
26. A	27. A	28. B	29. B	30. E

Section B

31. Flight time = 0·3 s
Distance arrow falls in this time $= \frac{1}{2} g t^2$
$= 0{\cdot}44$
Thus distance < 0·6 m so arrow hits target.

32. *(a)* (i)



(ii) 1250 N (b) 1250 N

33. Brightness decreases. Larger current reduces the terminal p.d. Voltage across lamp is reduced. Power of lamp is reduced.

34. *(a)* 8·48 V *(b)* 17·9 W

35. 8·6°

36. *(a)* 6 *(b)* E_3 to E_2 *(c)* More electrons make these transitions in a given time.

37. $7{\cdot}8 \times 10^{-20}$ J

QUESTION 11

(a) (i) **Neutron induced nuclear fission.**

(ii) Statement A masses $\times 10^{-25}$ kg

LHS	RHS
3·091	2·221
0·017	1·626
	0·068
3·918	3·915

Difference = $0{\cdot}003 \times 10^{-25}$ kg

Statement B masses $\times 10^{-25}$ kg

LHS	RHS
3·091	2·388
0·017	1·492
	0·034
3·918	3·914

Difference = $0{\cdot}004 \times 10^{-25}$ kg

(iii) Reaction B will release greater amounts of energy as $E = mc^2$ and E is proportional to mass loss, m.

(b) (i) **92 = Atomic number stating there are 92 protons in nucleus.**

235 = Mass number. This is total number of neutrons plus protons in the nucleus. By subtraction there must be 143 neutrons.

(ii) To determine y use principle of charge conservation and atomic numbers.

LHS	RHS
92	42
0	y
	0
	−4

If LHS = RHS then

$92 = 42 + y - 4$

$y = 92 - 38$

$= \underline{\underline{54}}$

1997 Paper 1 (Multiple Choice)

Back to Table

1. B	11. A	21. C
2. C	12. B	22. E
3. A	13. E	23. D
4. D	14. A	24. D
5. D	15. A	25. C
6. C	16. B	26. D
7. B	17. A	27. A
8. A	18. C	28. E
9. C	19. A	29. D
10.A	20. E	30. E

SECTION A

Answer questions 1–30 on the answer sheet.

1. Which of the following groups contains two vector quantities and one scalar quantity?

A Time, distance and force

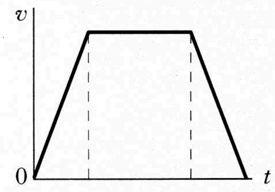
B Acceleration, mass and momentum

C Velocity, force and momentum

D Displacement, velocity and acceleration

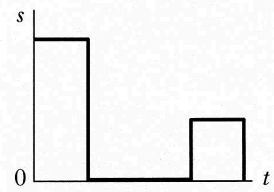
E Speed, distance and momentum

2. The diagram below is the velocity-time graph for a model train moving along a straight track.

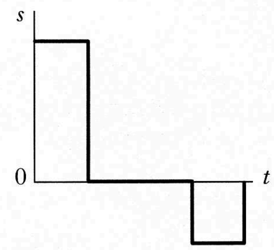


Which of the following could represent the displacement-time graph for the same motion?

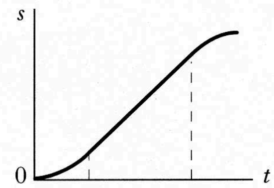
A



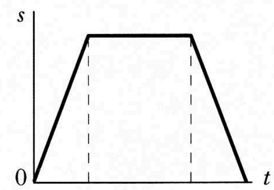
B



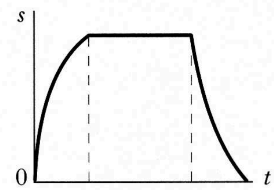
C



D



E



3. A train decelerates uniformly from $12{\cdot}0\ \mathrm{m\,s^{-1}}$ to $5{\cdot}0\ \mathrm{m\,s^{-1}}$ while travelling a distance of $119{\cdot}0$ m along a straight track. The deceleration of the train is

A $0{\cdot}5\ \mathrm{m\,s^{-2}}$

B $0{\cdot}7\ \mathrm{m\,s^{-2}}$

C $1{\cdot}2\ \mathrm{m\,s^{-2}}$

D $7{\cdot}0\ \mathrm{m\,s^{-2}}$

E $14{\cdot}0\ \mathrm{m\,s^{-2}}$.

4. A ball is projected vertically upwards with an initial speed of $40\ \mathrm{m\,s^{-1}}$. The acceleration due to gravity can be taken to be $10\ \mathrm{m\,s^{-2}}$.

What total time will the ball take to rise to its highest point and then return to its starting point?

A 2 s

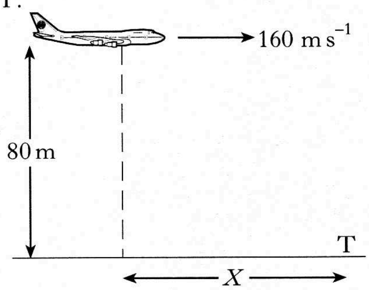
B 4 s

C 6 s

D 8 s

E 16 s

5. An aeroplane is flying at $160\ \mathrm{m\,s^{-1}}$ in level flight 80 m above the ground. It releases a package at a horizontal distance X from the target T.



The effect of air resistance can be neglected and the acceleration due to gravity can be taken as $10\ \mathrm{m\,s^{-2}}$.

The package will score a direct hit on the target T if X is

A 40 m

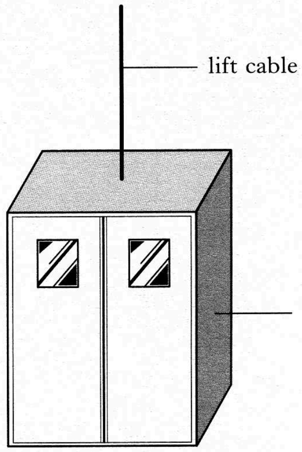
B 160 m

C 320 m

D 640 m

E 2560 m.

6. The lift in a department store has a mass of 1100 kg.



The lift is descending with a uniform downwards acceleration of $2\ \mathrm{m\,s^{-2}}$. The acceleration due to gravity can be taken as $10\ \mathrm{m\,s^{-2}}$.

What is the force applied to the lift by the lift cable?

A 1100 N

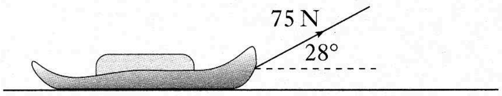
B 2200 N

C 8800 N

D 11 000 N

E 13 200 N

7. A sledge is pulled a distance of 8 m in a straight line along a horizontal surface.

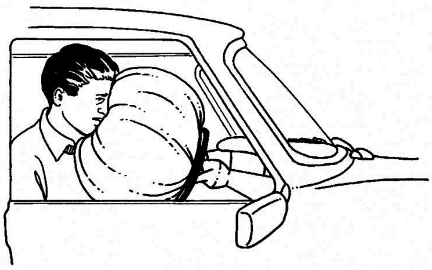


The tension in the rope is 75 N and the angle between the rope and the horizontal surface is 28°.

Which row in the following table is correct?

	Horizontal component of tension/N	*Vertical component of tension*/N	*Work done by rope*/J
A	75 sin 28°	75 sin 62°	600
B	75 cos 28°	75 sin 28°	530
C	75 sin 62°	75 sin 28°	600
D	75 cos 28°	75 sin 62°	600
E	75 sin 28°	75 cos 28°	35

8. Many car manufacturers are now fitting airbags which inflate automatically during an accident, as shown below.



The purpose of the airbag is to protect the driver by

A reducing his change of momentum per second

B increasing his change of momentum per second

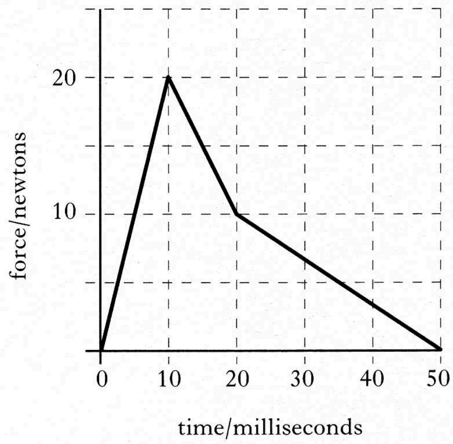
C reducing his final velocity

D reducing his total change in momentum

E increasing his total change in momentum.

9. The force acting on an object is measured and the results are stored in a computer.

The force-time graph obtained from the computer is shown below.



What is the average force acting on the object during the 50 milliseconds?

A 15 N

B 10 N

C 8 N

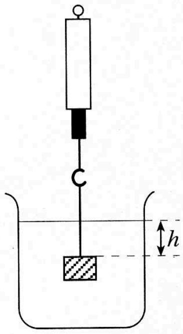
D 2·5 N

E 1 N

[Turn over

Back to Table Answers

10. A small metal block is suspended from a spring balance at a depth h below the surface of a liquid in a large beaker.



Which of the following statements is/are true?

I The reading on the spring balance depends on the density of the liquid in the beaker.

II The reading on the spring balance is equal to the upthrust of the liquid on the metal block.

III The reading on the spring balance will increase as the depth h is increased.

A I only

B II only

C III only

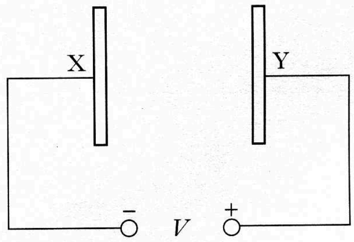
D I and II only

E I and III only

11. Which of the following gives the approximate relative spacings of molecules in ice, water and water vapour?

	Molecular spacing in ice/units	*Molecular spacing in water/units*	*Molecular spacing in water vapour/units*
A	1	1	10
B	1	3	1
C	1	3	3
D	1	10	10
E	3	1	10

12. Two parallel metal plates X and Y in a vacuum have a potential difference V across them.



An electron of charge e and mass m, initially at rest, is released from plate X.

The speed of the electron when it reaches plate Y is given by

A $\dfrac{2eV}{m}$

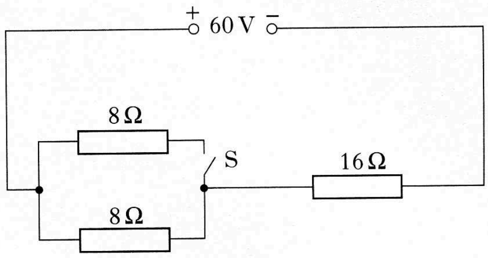
B $\sqrt{\dfrac{2eV}{m}}$

C $\sqrt{\dfrac{2V}{em}}$

D $\dfrac{2V}{em}$

E $\dfrac{2mV}{e}$.

13. In the following circuit, the p.d. across the 16 Ω resistor is 40 V when switch S is **open**.



The p.d. across the 16 Ω resistor when switch S is **closed** is

A 12 V

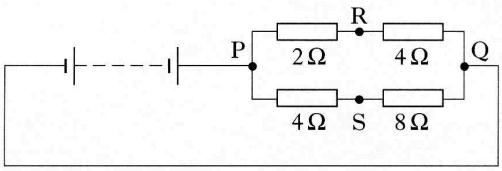
B 15 V

C 30 V

D 45 V

E 48 V.

14. In the circuit shown, the p.d. between points P and Q is 12 V.



The reading on a voltmeter connected across points R and S is

A 0 V

B 2 V

C 4 V

D 6 V

E 8 V.

15. When there is a potential difference of V volts across a resistor, the power dissipated in the resistor is P watts.

The current in the resistor, in amperes, is given by

A $\frac{P}{V}$

B $\frac{P}{V^2}$

C $\frac{V}{P}$

D $\frac{V^2}{P}$

E $\sqrt{\frac{P}{V}}$.

16. The unit for capacitance can be written as

A $\mathrm{V\,C^{-1}}$

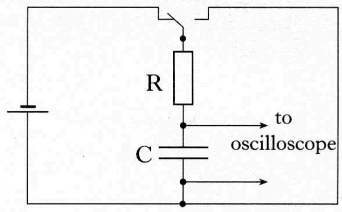
B $\mathrm{C\,V^{-1}}$

C $\mathrm{J\,s^{-1}}$

D $\mathrm{C\,J^{-1}}$

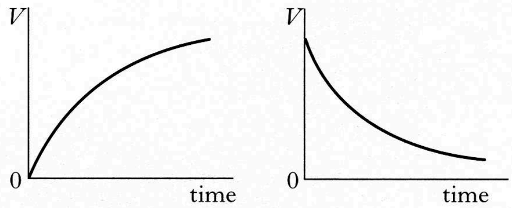
E $\mathrm{J\,C^{-1}}$.

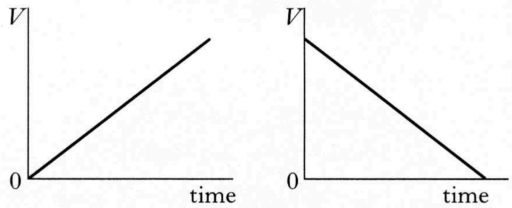
17. The following circuit is used to charge and then discharge a capacitor C.

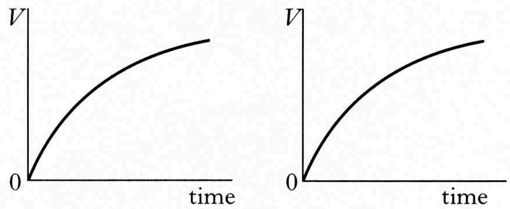


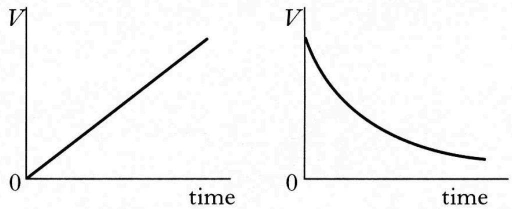
Which of the following pairs of graphs correctly shows how the voltage V across the capacitor varies with time during charging and discharging?

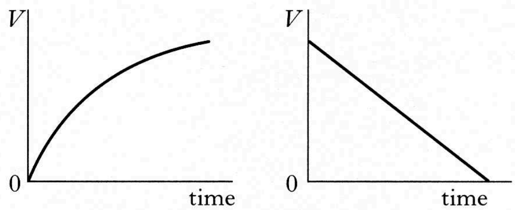
Charging **Discharging**

A


B


C


D


E


18. A capacitor is to be connected across a 230 V r.m.s. a.c. supply. To prevent damage to the capacitor, its minimum voltage rating must be

A 163 V

B 230 V

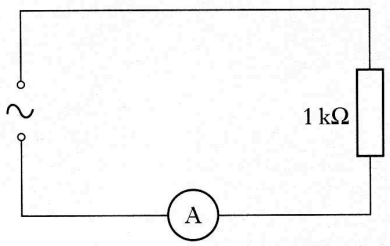
C 325 V

D 460 V

E 650 V.

19. A resistor is connected in a circuit as shown below.

The output from the a.c. supply can be varied in frequency but has a constant r.m.s. voltage.



The frequency of the output from the supply is increased steadily from 50 Hz to 5 kHz.

The reading on the a.c. ammeter

A remains constant

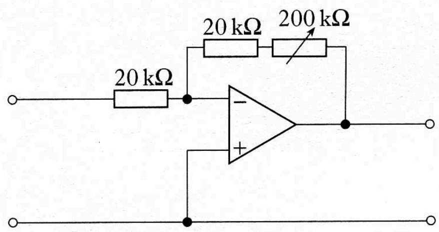
B falls steadily

C rises steadily

D rises then falls

E falls then rises.

20. A physicist designs the amplifier circuit shown below.



In this circuit, adjustment of the resistance of the variable resistor from zero to 200 kΩ allows the voltage gain to be altered over the range

A zero to one

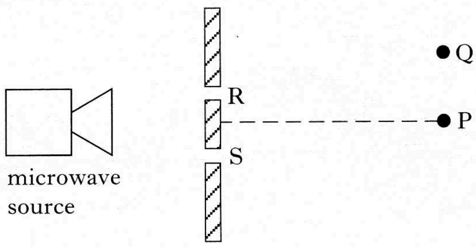
B zero to ten

C zero to eleven

D one to ten

E one to eleven.

21. A source of microwaves of wavelength λ is placed behind two slits, R and S. A microwave detector records the maximum response when it is placed at P, where RP = SP.



The microwave detector is moved and the **next** maximum is recorded at Q.

The path difference (SQ–RQ) must be

A 0

B $\frac{\lambda}{2}$

C λ

D (any odd number) $\times \frac{\lambda}{2}$

E (any whole number) $\times \lambda$.

22. A liquid and a solid have the same refractive index.

What would happen to the speed and the wavelength of light waves passing from the liquid into the solid?

	Speed	*Wavelength*
A	decreases	decreases
B	decreases	increases
C	increases	increases
D	increases	decreases
E	stays the same	stays the same

23. The intensity of light can be measured in

A W

B $W\,m^{-1}$

C $W\,m$

D $W\,m^{-2}$

E $W\,m^{2}$.

24. The light intensity is 160 units at a distance of 0·50 m from a point source of light in a darkened room.

At 2·0 m from this source, the light intensity is

A 160 units

B 80 units

C 40 units

D 10 units

E 5 units.

25. The diagram below shows some of the energy levels for the hydrogen atom.

E_3 ———— $-1{\cdot}360 \times 10^{-19}\,J$

E_2 ———— $-2{\cdot}416 \times 10^{-19}\,J$

E_1 ———— $-5{\cdot}424 \times 10^{-19}\,J$

E_0 ———— $-21{\cdot}76 \times 10^{-19}\,J$

The highest frequency of radiation emitted due to a transition between two of these energy levels is

A $2{\cdot}04 \times 10^{20}\,Hz$

B $1{\cdot}63 \times 10^{20}\,Hz$

C $3{\cdot}08 \times 10^{15}\,Hz$

D $2{\cdot}46 \times 10^{15}\,Hz$

E $1{\cdot}59 \times 10^{14}\,Hz$.

26. A light emitting diode produces light of wavelength λ.

The energy of a photon of light emitted by this diode is given by

A $h\lambda$

B $\frac{h}{\lambda}$

C $\frac{h\lambda}{c}$

D $\frac{hc}{\lambda}$

E $hc\lambda$.

[Turn over

27. Which of the following statements could explain the faint dark lines observed in the spectrum of sunlight when viewed through a high quality spectroscope?

I Gases in the outer layers of the Sun absorb certain frequencies of light.

II Gases in the inner layers of the Sun emit only certain frequencies of light.

III Gases within the Sun produce only a line emission spectrum.

A I only

B II only

C III only

D I and II only

E I and III only

28. A physicist varied the distance between a radioactive source and a detector. She obtained the following results which have been corrected for background radiation.

Distance from source to detector/cm	10	20	30	40	50
Corrected count-rate/s^{-1}	127	31	14	8	5

From these results, what is the relationship between the corrected count-rate R and the distance d from the source to the detector?

A $R \propto d^2$

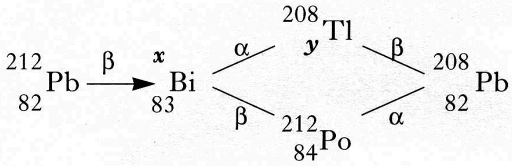
B $R \propto d$

C $R \propto \sqrt{d}$

D $R \propto \frac{1}{d}$

E $R \propto \frac{1}{d^2}$

29. Part of a radioactive decay series is shown below.



The numbers x and y in the series have been omitted.
What are the correct values for x and y?

	x	y
A	212	84
B	211	81
C	213	84
D	212	81
E	211	83

30. The process of nuclear fission occurs in the core of a nuclear reactor.

Which of the following statements about this process is/are true?

I Two nuclei are produced when an unstable nucleus fissions.

II Two unstable nuclei combine.

III Neutrons are released when an unstable nucleus fissions.

A I only

B II only

C III only

D I and II only

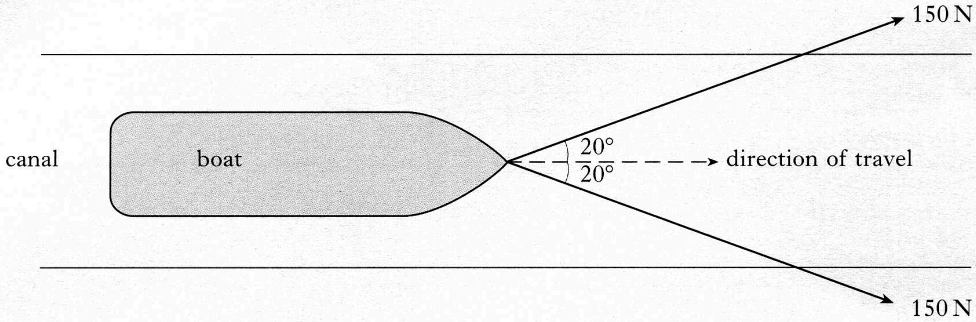
E I and III only

SECTION B

Write your answers to questions 31 to 38 in the answer book.

Marks

31. Two ropes are used to pull a boat at constant speed along a canal.

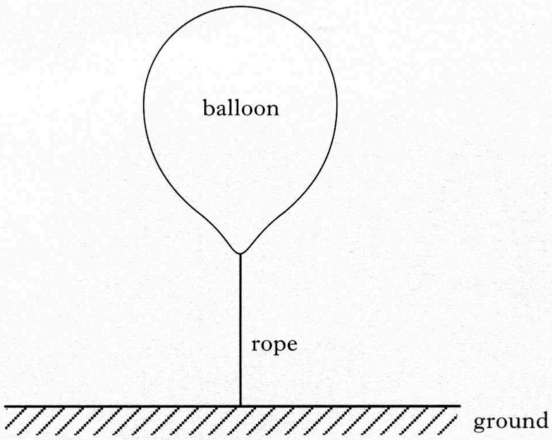


Each rope exerts a force of 150 N at 20° to the direction of travel of the boat as shown.

(*a*) Calculate the magnitude of the resultant force exerted by the ropes.

(*b*) What is the magnitude of the frictional force acting on the boat? **3**

32. The diagram shows a weather balloon of mass *m* tethered by a rope to the ground.



(*a*) Draw a sketch of the balloon. Mark and name all the forces acting vertically on the balloon.

(*b*) What is the resultant force acting on the balloon? **2**

[Turn over

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Solutions to SQA examination

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Paper I Solutions

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1. **B**	11. **A**	21. **C**
2. **C**	12. **B**	22. **E**
3. **A**	13. **E**	23. **D**
4. **D**	14. **A**	24. **D**
5. **D**	15. **A**	25. **C**
6. **C**	16. **B**	26. **D**
7. **B**	17. **A**	27. **A**
8. **A**	18. **C**	28. **E**
9. **C**	19. **A**	29. **D**
10.**A**	20. **E**	30. **E**

31.a. Each rope exerts a force in the direction of travel.
To calculate the component of the force in the direction of travel use basic trigonometry.

The force from each rope is:

$F_{Direction\ of\ travel} = F_{Resultant}\cos 20^o$

$F_{Direction\ of\ travel} = 150 \times \cos 20^o$

$F_{Direction\ of\ travel} = 140.95N$

The total force from both ropes (F_{total}) can now be calculated.

$F_{total} = 2 \times 140.95N$

$\mathbf{F_{total} = 281.9N}$

b. As the boat is moving at constant speed, and in a straight line, the frictional force must be equal in magnitude to the pulling but acting in the opposite direction to the pulling force.
$\mathbf{F_{friction} = -281.9N}$ (-ve sign indicates direction)

32.a.

Marks

33. A pupil carries out an experiment on a linear air track with two vehicles X and Y. Vehicle X is propelled towards vehicle Y which is initially at rest and the vehicles are allowed to collide.

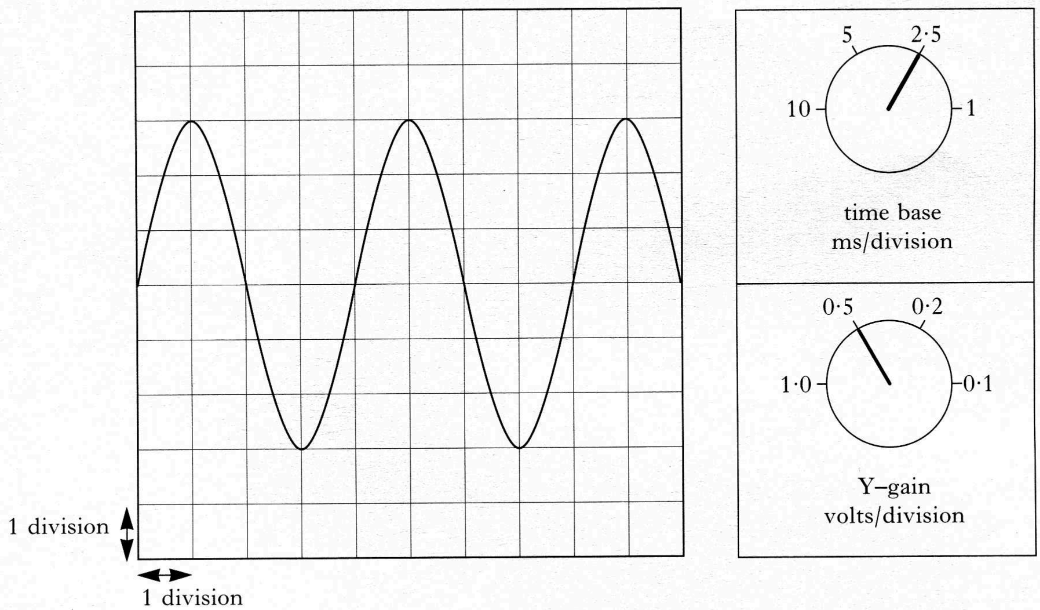
The results obtained are shown in the tables below.

Before Collision			
Momentum of X/ kg m s^{-1}	*Momentum of Y*/ kg m s^{-1}	*Kinetic energy of X*/J	*Kinetic energy of Y*/J
0·12	0	0·036	0

After Collision			
Momentum of X/ kg m s^{-1}	*Momentum of Y*/ kg m s^{-1}	*Kinetic energy of X*/J	*Kinetic energy of Y*/J
0·06	0·06	0·009	0·018

Explain whether the collision between the vehicles is elastic or inelastic. **2**

34. The output from a signal generator is connected to the input terminals of an oscilloscope. A trace is obtained on the oscilloscope screen. The oscilloscope control settings and the trace on the oscilloscope screen are shown in the diagram below.



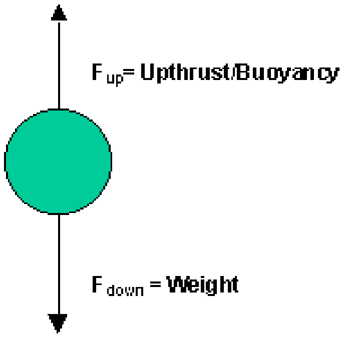
(*a*) Calculate the frequency of the output from the signal generator.

(*b*) The frequency and amplitude of the output from the signal generator are kept constant.

The time base control setting is changed to 5 ms/division.

What will be the effect on the trace shown on the oscilloscope? **3**

Back to Table



b. Newton's first law states that: "an object will remain at rest or move with a constant velocity in a straight line unless acted upon by an unbalanced force".
This means there are no unbalanced/resultant forces acting on the balloon, as it is at rest.

33. To determine the type of collision the kinetic energy before the collision [E_k(before)] and the [E_k(after)] must be considered.

Elastic collision => Kinetic energy conserved.
Inelastic collision => Kinetic energy not conserved.

Before collision

Total [E_k(before)]= 0.036J +0J
Total [E_k(before)]= 0.036J

Total [E_k(after)]= 0.009J +0.018J
Total [E_k(after)]= 0.027J

Kinetic energy is not conserved, therefore, the collision is inelastic.

34.a. Wave period(T) = 4x2.5ms
T = 10×10^{-3}s

f=1/T
f=1/10×10^{-3}s
f=100Hz

b. The amplitude of the waves displayed on the oscilloscope will be unchanged, but, five complete waves will now appear on the screen.

35.a. V = E-Ir or V = -rI + E
Compare this to: y = mx + c

y = V
m = -r
x = I
c = E

m = (4-1)/(1-3) = 3/-2 = -1.5

=>r = -m = 1.5
=>**r = 1.5Ω**

b. I = E/r
E is the emf of the battery, found by noting where the graph cuts the voltage axis.
E = 5.5V
=>I = 5.5/1.5
I = 3.67A

36.a. The refractive index of paraffin(n_p) is found by calculating the ratio of the speed of light in air to the speed of light in paraffin.

$n_p = 3x10^8/2.1x10^8$
n_p = 1.43

b. The frequency of the light is unchanged when moving from air into paraffin.
$f=4.85x10^{14}Hz$

37.

- The lamp produces photons of light that have an energy that can be calculated using the equation E=hf.
- Some of this energy is absorbed by the semiconductor material of the photodiode.
- The absorbed energy creates electron hole pairs in the photodiode that increases the conductivity of the photodiode.
- There is a reduction in the potential barrier at the pn junction and therefore a reduction in the voltmeter reading.

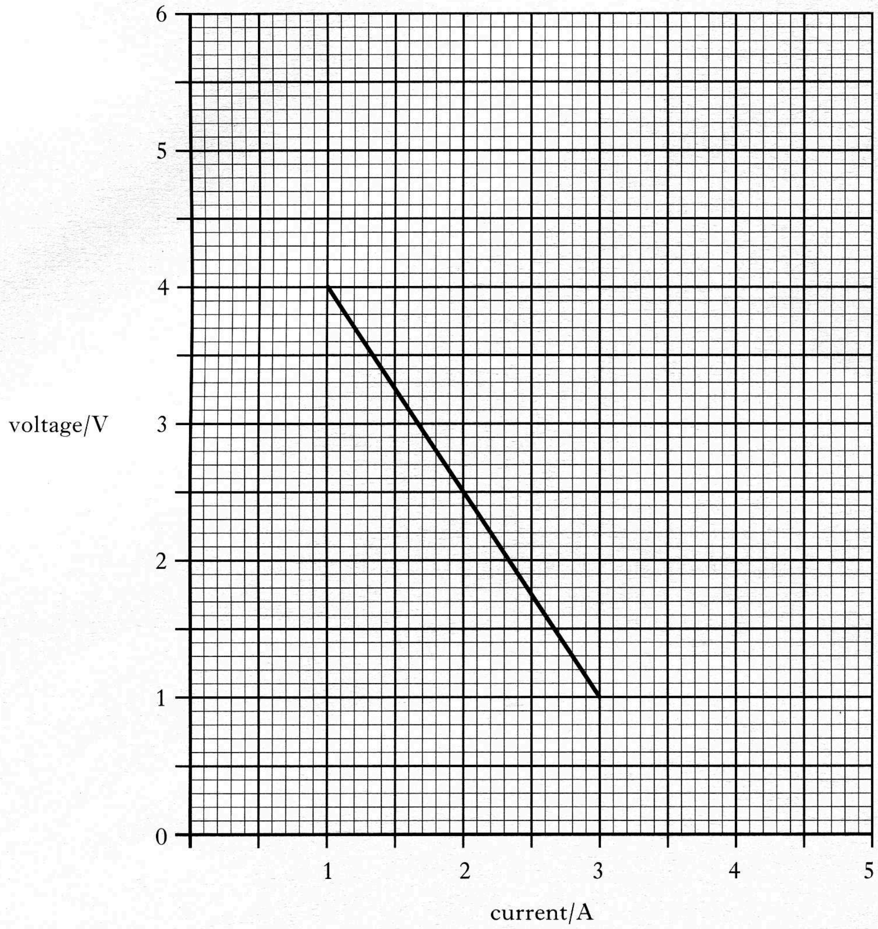
38. The spectrum produced by the prism is a result of refraction, whereas the grating produces a spectrum as a result of diffraction. Furtheremore, only one spectrum of white light is produced using a prism, whereas, several are produced using a diffraction grating.

END OF QUESTION PAPER

Return to past paper index page.

Marks

35. The graph shows how the voltage across the terminals of a battery changes as the current from the battery is varied.



(*a*) Calculate the internal resistance of the battery.

(*b*) What is the value of the current from the battery when it is short-circuited? **3**

36. A beam of monochromatic light of frequency $4{\cdot}85 \times 10^{14}$ Hz passes from air into liquid paraffin. In liquid paraffin the light has a speed of $2{\cdot}10 \times 10^{8}$ m s^{-1}.

(*a*) Calculate the refractive index of the liquid paraffin.

(*b*) What is the frequency of the light when it is in the liquid paraffin? **3**

[Turn over for Question 37 on *Page fourteen*

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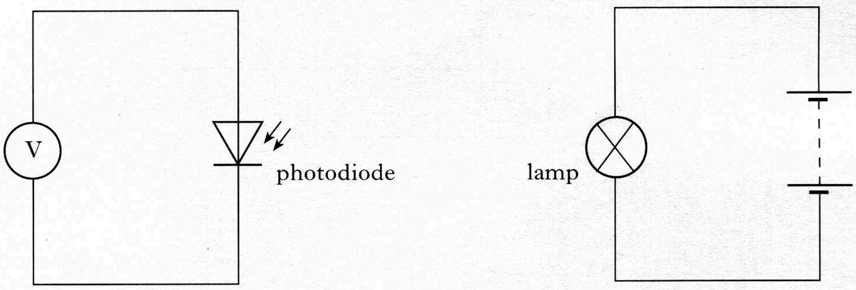
Marks

37. The diagram shows a photodiode connected to a voltmeter. A lamp is used to shine light onto the photodiode.



The reading on the voltmeter is 0·5 V.

The lamp is now moved closer to the photodiode.

Using the terms **photons**, **electrons** and **holes**, explain why the voltmeter reading changes. **2**

38. A grating or a prism can be used to produce spectra from a source of white light.

Give **two** differences between the spectra obtained using the grating and the prism. Diagrams may be used to illustrate your answer. **2**

[*END OF QUESTION PAPER*]

$n_p = 3x10^8/2.1x10^8$
$n_p = 1.43$

b. The frequency of the light is unchanged when moving from air into paraffin.
$f=4.85x10^{14}Hz$

37.

- The lamp produces photons of light that have an energy that can be calculated using the equation E=hf.
- Some of this energy is absorbed by the semiconductor material of the photodiode.
- The absorbed energy creates electron hole pairs in the photodiode that increases the conductivity of the photodiode.
- There is a reduction in the potential barrier at the pn junction and therefore a reduction in the voltmeter reading.

38. The spectrum produced by the prism is a result of refraction, whereas the grating produces a spectrum as a result of diffraction. Furtheremore, only one spectrum of white light is produced using a prism, whereas, several are produced using a diffraction grating.

END OF QUESTION PAPER

Return to past paper index page.

Marks

1. (*a*) An object starts from rest and moves with constant acceleration a. After a time t, the velocity v and displacement s are given by

$$v = at \text{ and } s = \tfrac{1}{2}at^2 \text{ respectively.}$$

Use these relationships, to show that

$$v^2 = 2as.$$ **2**

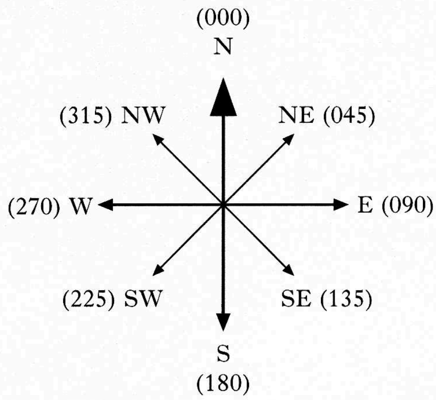
(*b*) An aircraft of mass of 1000 kg has to reach a speed of 33 m s^{-1} before it takes off from a runway. The engine of the aircraft provides a constant thrust of 3150 N. A constant frictional force of 450 N acts on the aircraft as it moves along the runway.

(i) Calculate the acceleration of the aircraft along the runway.

(ii) The aircraft starts from rest. What is the minimum length of runway required for a take-off? **4**

(*c*) During a flight the aircraft is travelling with a velocity of 36 m s^{-1} due north (000).

A wind with a speed of 12 m s^{-1} starts to blow **towards** the direction 40° west of north (320).



Find the magnitude and direction of the resultant velocity of the aircraft. **3**

(9)

[Turn over

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Past Paper Solutions

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Paper II Solutions

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1.a. Squaring the equation v = at gives:

$v^2 = a^2t^2$ **equation 1**

The equation $s = 1/2(at^2)$ can be rearranged to give:

$t^2 = 2s/a$ which can be substituted into **equation 1**

$v^2 = a^2(2s/a)$

$\Rightarrow$ $\mathbf{v^2 = 2as}$

b.i. $F_{unbalanced} = F_{thrust} - F_{friction}$

$F_{unbalanced} = 3150 - 450$

$F_{unbalanced} = 2700N$

$a = F_{unbalanced}/m$

$a = 2700/1000$

$a = 2.7m/s/s$

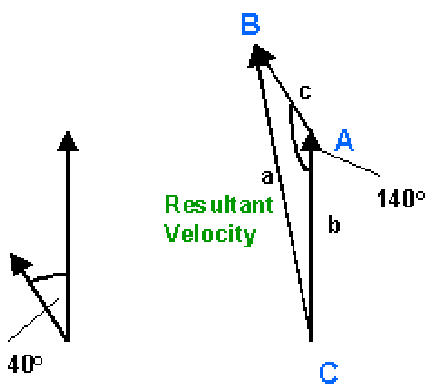
b.ii. To calculate the length of the track use : $v^2 = u^2 + 2as$

$s = (v^2 - u^2)/2a$

$s = (33^2 - 0^2)/2x2.7$

$s = 201.67m$

c.



Use the cosine rule to calculate the resultant velocity,or, draw an accurate scale diagram.

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$a^2 = b^2 + c^2 - 2bcCosA$
$a^2 = 36^2 + 12^2 - 2x36x12Cos140$
$a^2 = 1296 + 144 - 864Cos140$
$a^2 = 1296 + 144 - 864x-0.766$
$a^2 = 2101.9$
a = 45.8m/s

Use the sine rule to calculate angle C.

a/sinA = c/sinC
sinC = csinA/a
sinC = $12sin140^o/45.8$
sinC = 0.168
angle C = 9.7^o

Resultant velocity = 45.8m/s with a bearing of 350.3^o

2.a.i. $V_{horizontal} = Vcos36^o$
$V_{horizontal} = 41.7cos36^o$
$V_{horizontal}$ = 33.74m/s

a.ii. $V_{vertical} = Vsin36^o$
$V_{vertical} = 41.7sin36^o$
$V_{vertical}$ = 24.5m/s

b. The time for the ball to reach Q(t_{total}) can be calculated by summing the time to travel from O to P(t_1) and the time to travel from P to Q(t_2).

$t_{total} = t_1 + t_2$

When P is reached the vertical component of the velocity is 0m/s.
This velocity is the final velocity(v) of the first part of the journey.
The initial component of the vertical velocity(u) for this part of the journey is 24.5m/s.

v = 0m/s	$v = u + at_1$
u = 24.5m/s	$t_1 = (v-u)/a$
a = -9.8m/s/s	$t_1 = (0-24.5)/-9.8$
t_1 = ?	$t_1 = 2.5s$

When falling from P to Q take the initial velocity(u) as 0m/s for this part of the journey.

u = 0m/s	$s = ut_2 + 1/2(at_2^2)$
s = -19.6m	$s = 1/2(at_2^2)$
a = -9.8m/s	$t_2^2 = 2s/a$
t_2 = ?	$t_2^2 = 2x-19.6/-9.8$
	$t_2^2 = 4$
	$t_2 = 2s$

$t_{total} = t_1 + t_2$
$t_{total} = 2.5 + 2$
t_{total} = 4.5s (As required)

c. $S_{horizontal} = V_{horizontal} x t_{total}$
$S_{horizontal} = 33.74x4.5$
$S_{horizontal}$ = 151.8m/s

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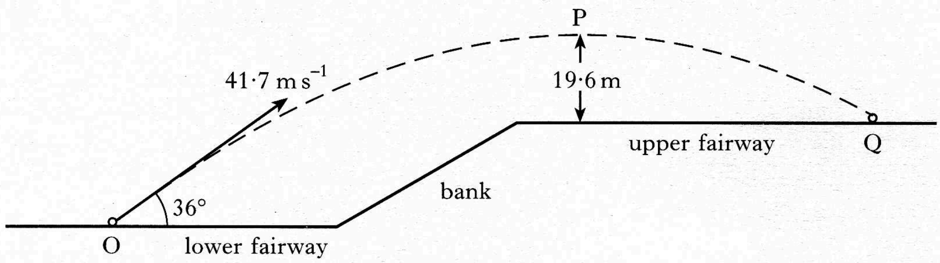
Marks

2. The fairway on a golf course is in two horizontal parts separated by a steep bank as shown below.



A golf ball at point O is given an initial velocity of $41\cdot7\ \text{m s}^{-1}$ at 36° to the horizontal.

The ball reaches a maximum vertical height at point P above the upper fairway. Point P is 19·6 m above the upper fairway as shown. The ball hits the ground at point Q.

The effect of air friction on the ball may be neglected.

(*a*) Calculate:

(i) the horizontal component of the initial velocity of the ball;

(ii) the vertical component of the initial velocity of the ball. **2**

(*b*) Show that the time taken for the ball to travel from point O to point Q is 4·5 s. **3**

(*c*) Calculate the horizontal distance travelled by the ball. **2**

(7)

Back to Table

$a^2 = b^2 + c^2 - 2bcCosA$
$a^2 = 36^2 + 12^2 - 2x36x12Cos140$
$a^2 = 1296 + 144 - 864Cos140$
$a^2 = 1296 + 144 - 864x-0.766$
$a^2 = 2101.9$
a = 45.8m/s

Use the sine rule to calculate angle C.

a/sinA = c/sinC
sinC = csinA/a
sinC = $12sin140^o/45.8$
sinC = 0.168
angle C = 9.7^o

Resultant velocity = 45.8m/s with a bearing of 350.3^o

2.a.i. $V_{horizontal} = Vcos36^o$
$V_{horizontal} = 41.7cos36^o$
$V_{horizontal}$ = 33.74m/s

a.ii. $V_{vertical} = Vsin36^o$
$V_{vertical} = 41.7sin36^o$
$V_{vertical}$ = 24.5m/s

b. The time for the ball to reach Q(t_{total}) can be calculated by summing the time to travel from O to P(t_1) and the time to travel from P to Q(t_2).

$t_{total} = t_1 + t_2$

When P is reached the vertical component of the velocity is 0m/s. This velocity is the final velocity(v) of the first part of the journey. The initial component of the vertical velocity(u) for this part of the journey is 24.5m/s.

v = 0m/s	$v = u + at_1$
u = 24.5m/s	$t_1 = (v-u)/a$
a = -9.8m/s/s	$t_1 = (0-24.5)/-9.8$
t_1 = ?	$t_1 = 2.5s$

When falling from P to Q take the initial velocity(u) as 0m/s for this part of the journey.

u = 0m/s	$s = ut_2 + 1/2(at_2^2)$
s = -19.6m	$s = 1/2(at_2^2)$
a = -9.8m/s	$t_2^2 = 2s/a$
t_2 = ?	$t_2^2 = 2x-19.6/-9.8$
	$t_2^2 = 4$
	$t_2 = 2s$

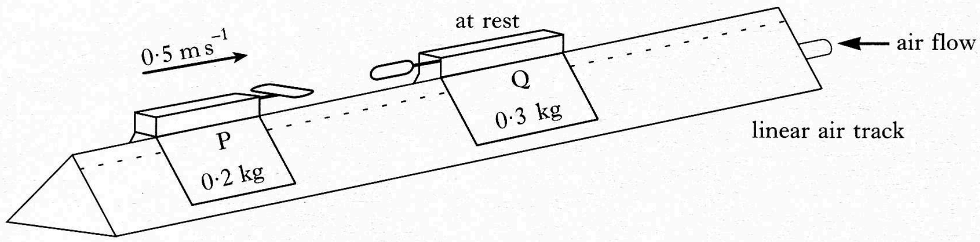
$t_{total} = t_1 + t_2$
$t_{total} = 2.5 + 2$
t_{total} = 4.5s (As required)

c. $S_{horizontal} = V_{horizontal}xt_{total}$
$S_{horizontal} = 33.74x4.5$
$S_{horizontal}$ = 151.8m/s

Back to Table Answers

Marks

3. The diagram below shows two vehicles P and Q on a linear air track.



Vehicle P, of mass 0·2 kg, is projected with a velocity of 0·5 m s^{-1} to the right along the linear air track.

It collides with vehicle Q, of mass 0·3 kg, which is initially at rest.

After the collision, the vehicles move in opposite directions. Vehicle Q moves off with a velocity of 0·4 m s^{-1} to the right.

(*a*) Show that vehicle P rebounds with a speed of 0·1 m s^{-1} after the collision. **2**

(*b*) Calculate the change in momentum of vehicle P as a result of the collision. **2**

(*c*) During the collision, a timing device records the time of contact between the two vehicles as 0·06 s.

(i) Calculate the average force acting on vehicle P during the collision.

(ii) Sketch a graph showing how the force on vehicle P could vary with time while the two vehicles are in contact. **3**

(7)

[Turn over

3.a. Use the law of conservation of momentum to solve this problem.
$P_{before} = P_{after}$

Before collision
$P_{before} = m_P u_P + m_Q u_Q$
$P_{before} = 0.2 \times 0 .5 + 0.3 \times 0$
$P_{before} = 0.1 kgm/s$

After collision
$P_{after} = m_P v_P + m_Q v_Q$
$0.1 = 0.2 v_P + 0.3 \times 0.4$
$v_P = (0.1 - 0.3 \times 0.4)/0.2$
$v_P = -0.1 m/s$ The negative sign indicates the direction is to the left.

b. $\Delta P_p = P_p(after) - P_p(before)$

$P_p(after) = m_P v_P$
$P_p(after) = 0.2 \times -0.1$
$P_p(after) = -0.02 kgm/s$

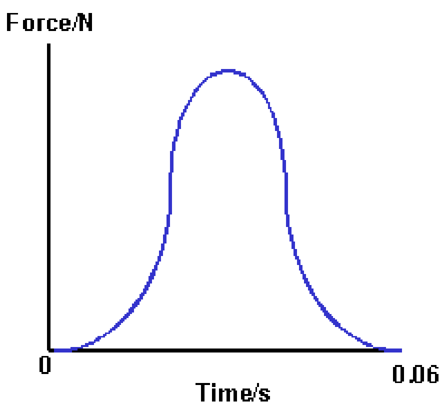
$P_p(before) = m_P u_P$
$P_p(before) = 0.2 \times 0.5$
$P_p(before) = 0.1 kgm/s$

$\Delta P_p = -0.02 - 0.1$
$\Delta P_p = -0.12 kgm/s$

c.i. $F_{average} t = m_P(u_P - v_P)$
$F_{average} = m_P(u_P - v_P)/t$
$F_{average} = 0.2[(0.5-(-0.1)]/0.06$
$F_{average} = 2N$

Note: the direction of this force is to the left.

c.ii.



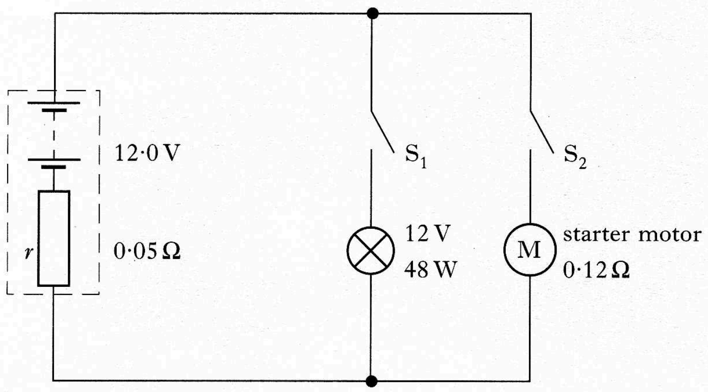
4.a. The assumption in this experiment is that the gas in the container is the same as the water temperature. To facilitate this the can must be fully immersed to allow the gas and water temperature to equilibrate.

b. $P_1 = 100kPa$
$T_1 = (17+273)K = 290K$

$P_2 = ?$

Marks

5. The diagram shows a circuit for part of the electrical system of a car.



The battery has an e.m.f. of 12·0 V and an internal resistance r of 0·05 Ω. The battery is connected across a 12 V, 48 W headlamp and a starter motor of resistance 0·12 Ω as shown.

(*a*) State what is meant by "the battery has an e.m.f. of 12·0 V". **1**

(*b*) (i) What is the resistance of the headlamp when used at its rated voltage?

(ii) Show that there is a p.d. of 11·8 V across the headlamp when switch S_1 is closed and switch S_2 is open. Assume that the resistance of the headlamp does not change. **4**

(*c*) Both switches S_1 and S_2 are now closed.

Assuming that the resistance of the headlamp does not change, calculate:

(i) the total resistance of the circuit;

(ii) the current from the battery. **4**

(9)

[Turn over

T_2 = (75+273)K = 348K

$P_1/T_1 = P_2/T_2$
$P_2 = P_1T_2/T_1$
P_2 = 100x348/290
P_2 = 120kPa

c. P = F/A
F = PA
F = 120x10^3x0.001
F = 120N

d. The mass and the volume of gas are fixed in this experiment,therefore, the density(mass/volume) must also remain constant.

5.a. A battery emf of 12V will supply 12J of energy to each coulomb of charge passing through the cell.

b.i. P = V^2/R
R = V^2/P
R = 12^2/48
R = 3Ω

b.ii. When S_1 is closed the circuit can be treated as a simple series circuit with the internal resistor(r) in series with the headlamp resistance(R_h).

$R_{total} = R_h + r$
R_{total} = 3 + 0.05
R_{total} = 3.05Ω

I = emf/R_{total}
I = 12/3.05
I = 3.93A

$V_{headlamp} = IR_h$
$V_{headlamp}$ = 3.93x3
$V_{headlamp}$ = 11.8V (as required)

c.i. The bulb and the starter motor are in parallel. The resistance of this network R_p is calculated as shown below:

$1/R_p = 1/R_{bulb} + 1/R_{motor}$
$1/R_p$ = 1/3 + 1/0.12
$1/R_p$ = 8.66...
R_p = 0.1154Ω

$R_{total} = R_p + r$
R_{total} = 0.115 + 0.05
R_{total} = 0.165Ω

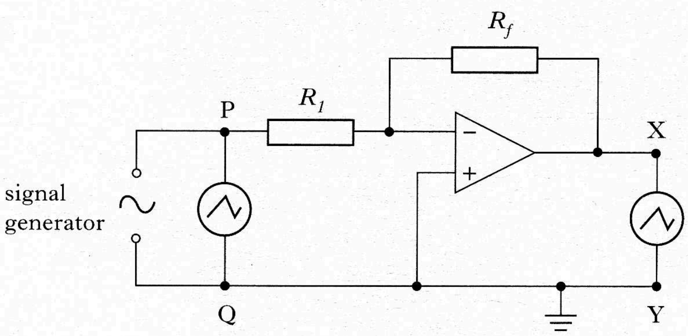
c.ii. I = emf/R_{total}
I = 12/0.165
I = 72.7A

6.a.i. Gain = V_{output}/V_{input}
Gain = -9x30mv/5x2mV
Gain = -270mV/10mv
Gain = 27

a.ii. $V_{peak} = 1.414V_{rms}$
$V_{rms} = V_{peak}/1.414$

Marks

6. (*a*) An operational amplifier circuit is set up with oscilloscopes connected across PQ and XY as shown.



The trace on the oscilloscope connected across PQ is shown in figure 1 below. The Y–gain setting of this oscilloscope is 2 mV/division.

The trace on the oscilloscope connected across XY is shown in figure 2 below. The Y–gain setting of this oscilloscope is 30 mV/division.

The time base on each oscilloscope is set at 0·1 ms/division.

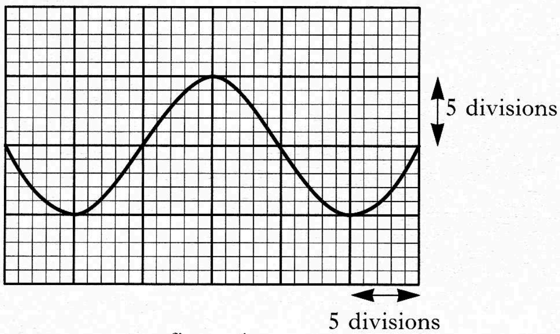


figure 1

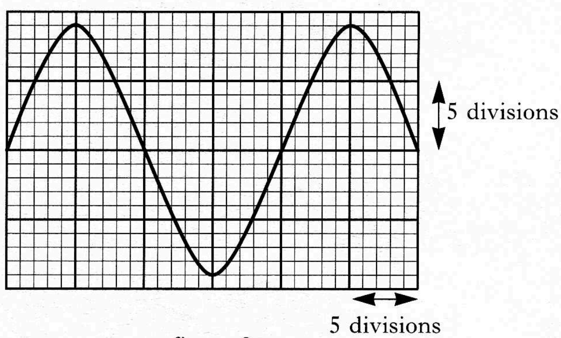


figure 2

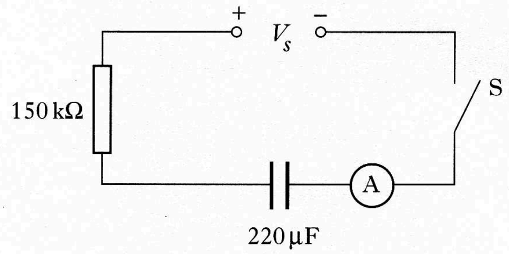
(i) Calculate the voltage gain of the amplifier.

(ii) Calculate the r.m.s. value of the output voltage from the amplifier.

(iii) Suggest suitable values for R_f and R_1 which would produce the trace shown in figure 2. **5**

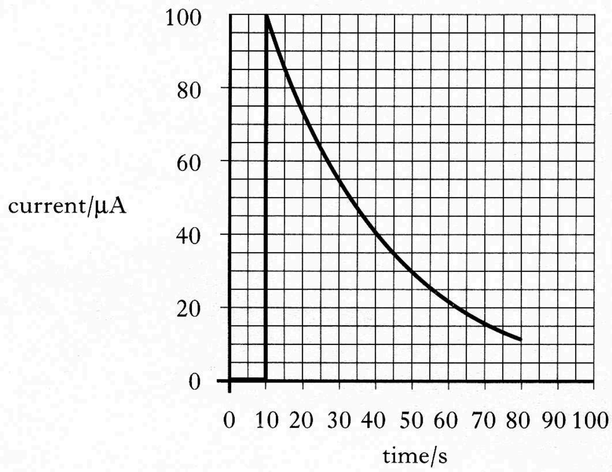
Marks

7. (*a*) A capacitor of capacitance 220 μF is connected in series with a 150 kΩ resistor, a switch and an ammeter. A d.c. power supply of negligible internal resistance is connected to the circuit as shown below.



A stopclock is started and after 10 seconds the switch S is closed. Ammeter readings are noted at regular intervals until a time of 80 s is shown on the stopclock.

The graph below shows how the current in the circuit varies with time.



(i) Calculate the voltage V_s of the d.c. power supply.

(ii) At what time on the stopclock does the p.d. across the resistor equal 6 V?

(iii) What is the p.d. across the capacitor when the p.d. across the resistor is 6 V? **5**

(*b*) A magazine article on the resuscitation of a heart attack victim describes the equipment used. This equipment uses a 16 μF capacitor which is charged until the p.d. across it is 6 kV. The capacitor is then fully discharged to give the heart a shock. The discharge time is 2 ms.

(i) When the capacitor is fully charged, calculate:

(A) the charge stored;

(B) the energy stored.

(ii) Calculate the average current during discharge. **6**

(11)

V_{rms} = 190.9mV

a.iii. Gain = $V_{output}/V_{input} = -R_f/R_1$

To produce a gain of magnitude 27 choose:

$R_f = 270k\Omega$

$R_1 = 10k\Omega$

Other values are acceptable as long as the ratio of R_f to R_1 is 27.

b.i. The bridge is balanced when the digital voltmeter reads 0V. This means the potential at X and Y are equal and there is no potential difference between these points.

b.ii. $V_{output} = (-R_f/R_-)(V_- - V_+)$

$(V_- - V_+) = -V_{output}(R_-/R_f)$

$(V_- - V_+) = -(-0.18)(100x10^3/1x10^6)$

$(V_- - V_+) = 0.18(0.1)$

$(V_- - V_+) = 0.018V$

$V_Y - V_X$ = 0.018V

b.iii. At 20°C the potential at $Y(V_Y)$ falls to a value less than it was when the bridge was balanced at 23°C.

As V_Y is less than V_X => $V_Y - V_X$ is negative.

=> $V_{output} = (-R_f/R_-)(V_Y - V_X)$

V_{output} = positive value.

Note: If the resistance of the thermistor varies linearly with temperature in range 20°C to 26°C the output voltage at 20°C will be **+0.18V.**

7.a.i. All the supply voltage is across the resistor at the instant the switch is closed. At this instant $V_{supply} = V_{resistor}$.

$I = 100x10^{-6}$

$R = 150,000\Omega$

$V_{resistor}$ = ?

$V_{resistor} = IR_{resistor}$

$V_{resistor} = 100x10^{-6}x150000$

$V_{resistor} = 15V$

$V_{supply} = V_{resistor}$ = 15V

a.ii. The current in the circuit must first be calculated when the voltage across the resistor is 6V.

I = ?

$V_{resistor} = 6V$

$R = 150,000\Omega$

I = V/R

I = 6/150000

$I = 40x10^{-6}A = 40\mu A$

From the graph read the time when the current is 40µA.

Back to Table

Time = 40s

a.iii. $V_{supply} = V_{resistor} + V_{capacitor}$
$V_{capacitor} = V_{supply} - V_{resistor}$
$V_{capacitor} = 15 - 6$
$V_{capacitor} = 9V$

b.i.A Q = CV

C = 16μF = 16×10^{-6}
V = 6kV = 6000V (This is the voltage across the capacitor when fully charged)
Q = ?

Q = 16×10^{-6} x 6000
Q = 0.096C

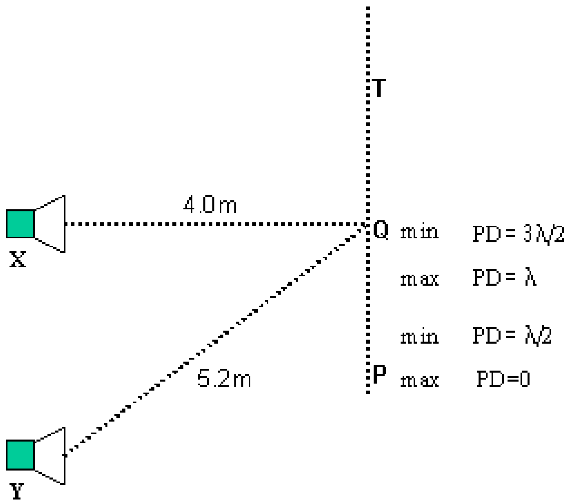
b.i.B E = 1/2(QV)
E = 1/2(0.096X6000)
E = 288J

b.ii. I = Q/t
I = $0.096/2 \times 10^{-3}$
I = 48A

8.a.i. A maxima occurs when two waves interfere constructively. This happens when waves are in phase.

A minima occurs when two waves interfere destructively. This happens when the two waves are 180^{o} out of phase.

a.ii.



The minima is produced when the path difference YQ-XQ is equal to 3/2λ.

YQ-XQ = (5.2-4.0)m = 1.2m
YQ-XQ = 3/2λ
λ=(2x1.2)/3
λ = 0.8m

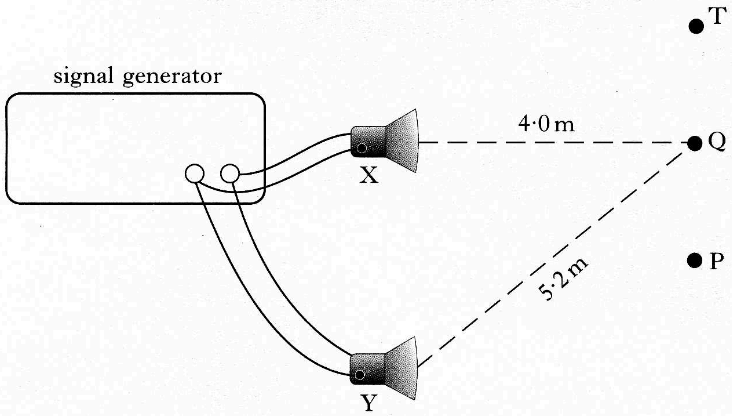
b.i. The speed of sound is constant in air, therefore increasing the frequency will decrease the wavelength. If the frequency is increased by a factor of 5 the wavelength will decrease by a factor of 5.

Wavelength at 1000Hz = 1.2/5 = 0.24m

b.ii. If the path difference is fixed at 1.2m this will represent a whole

Marks

8. Two identical loudspeakers X and Y are set up in a room which has been designed to eliminate the reflection of sound. The loudspeakers are connected to the same signal generator as shown.



(*a*) (i) When a sound level meter is moved from P to T, maxima and minima of sound intensity are detected.

Explain, in terms of waves, why the maxima and minima are produced.

(ii) The sound level meter detects a maximum at P.

As the sound level meter is moved from P, it detects a minimum then a maximum then another minimum when it reaches Q.

Calculate the wavelength of the sound used. **4**

(*b*) The sound level meter is now fixed at Q.

The frequency of the output from the signal generator is increased steadily from 200 Hz to 1000 Hz.

(i) What happens to the wavelength of the sound as the frequency of the output is increased?

(ii) Explain why the sound level meter detects a series of maxima and minima as the frequency of the output is increased. **3**

(7)

[Turn over

Back to Table

Time = 40s

a.iii. $V_{supply} = V_{resistor} + V_{capacitor}$
$V_{capacitor} = V_{supply} - V_{resistor}$
$V_{capacitor} = 15 - 6$
$\mathbf{V_{capacitor} = 9V}$

b.i.A Q = CV

C = 16μF = 16×10^{-6}
V = 6kV = 6000V (This is the voltage across the capacitor when fully charged)
Q = ?

Q = 16×10^{-6} x 6000
Q = 0.096C

b.i.B E = 1/2(QV)
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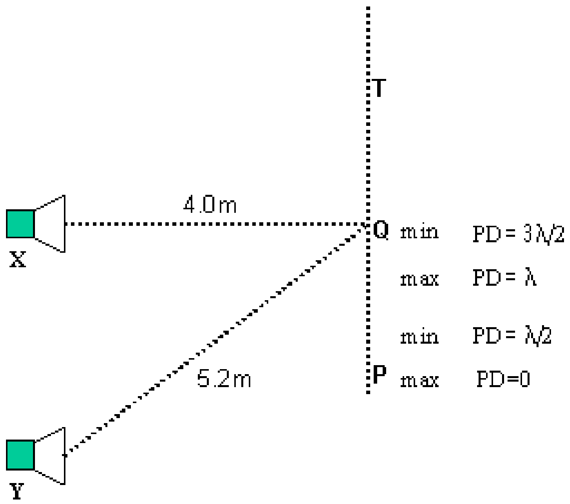


The minima is produced when the path difference YQ-XQ is equal to 3/2λ.

YQ-XQ = (5.2-4.0)m = 1.2m
YQ-XQ = 3/2λ
λ=(2x1.2)/3
λ = 0.8m

b.i. The speed of sound is constant in air, therefore increasing the frequency will decrease the wavelength. If the frequency is increased by a factor of 5 the wavelength will decrease by a factor of 5.

Wavelength at 1000Hz = 1.2/5 = 0.24m

b.ii. If the path difference is fixed at 1.2m this will represent a whole

Back to Table

number of wavelengths for certain frequencies and produce maxima, however, for other frequencies this will represent a whole number of half wavelengths and produce minima. For this reason a series of maxima and minima are produced.

9.a. $n_{plastic} = \sin\theta_{air}/\sin\theta_{plastic}$

$n_{plastic} = \sin 15^o/\sin 10^o$ (Note that it is the angle between the ray and the normal that must be used.)

$\mathbf{n_{plastic} = 1.49}$

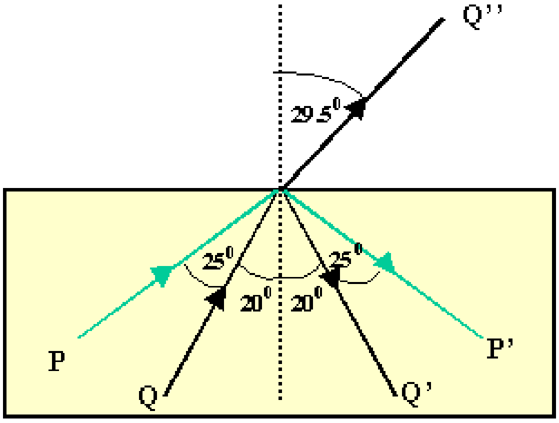
b.i. $\theta_{crit} = \sin^{-1}(1/n_{glass})$

$\theta_{crit} = \sin^{-1}(1/1.44)$

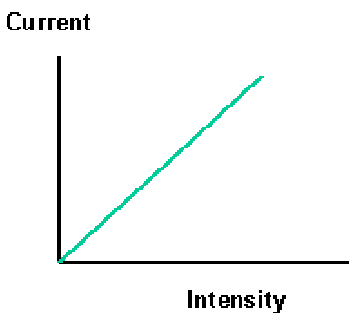
$\theta_{crit} = \sin^{-1}(0.694)$

$\mathbf{\theta_{crit} = 44.0^o}$

b.ii. Ray Q will be refracted and partially reflected.
Ray P will be totally internally reflected because the incident angle of 45^o is greater than the critical angle.



10.a.i.

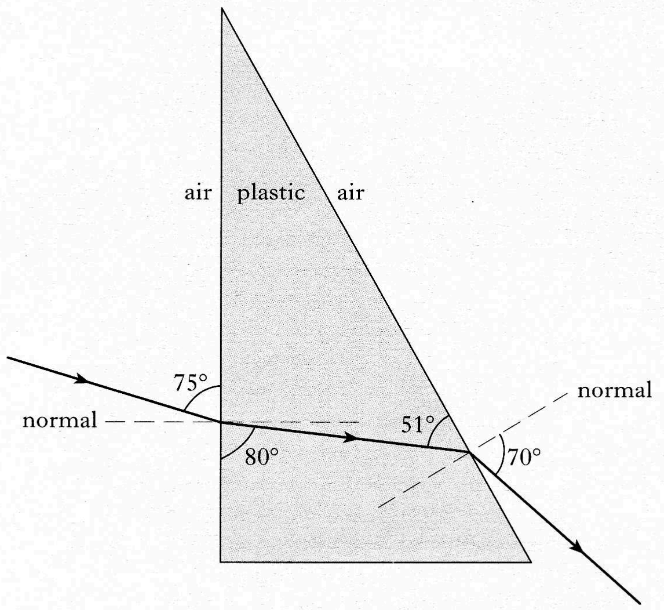


a.ii. Individual electrons in the metal atom absorb the energy of a single photon, the energy of which is dependent on the frequency of the photon. The photon energy can be calculated using the equation E = hf. Below a certain frequency the energy absorbed by an electronin the metal, from the photon, is below that required to escape from the metal atom, thus the current in the circuit will be zero.

b.i. The threshold frequency will provide electrons with just enough energy to overcome the work function of the metal and eject electrons with no excess kinetic energy. Thus to estimate the work function from the

Marks

9. (*a*) The diagram below shows the refraction of a ray of red light as it passes through a plastic prism.

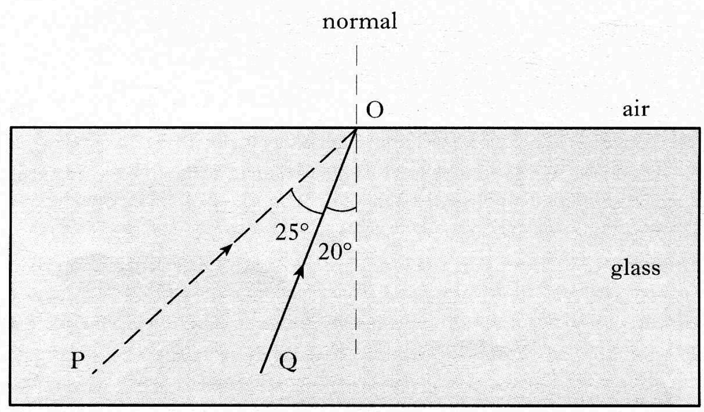


Calculate the refractive index of the plastic for this red light. **2**

(*b*) The refractive index of a glass block is found to be 1·44 when red light is used.

(i) What is the value of the critical angle for this red light in the glass?

(ii) The diagram shows the paths of two rays of this red light, PO and QO, in the glass block.



When rays PO and QO strike the glass-air boundary, **three** further rays of light are observed.

Copy and complete the diagram to show **all five** rays.

Clearly indicate which of the three rays came from P and which came from Q.

The values of all angles should be shown on the diagram. **6**

(8)

Back to Table

number of wavelengths for certain frequencies and produce maxima, however, for other frequencies this will represent a whole number of half wavelengths and produce minima. For this reason a series of maxima and minima are produced.

9.a. $n_{plastic} = \sin\theta_{air}/\sin\theta_{plastic}$

$n_{plastic} = \sin 15^o/\sin 10^o$ (Note that it is the angle between the ray and the normal that must be used.)

$\mathbf{n_{plastic} = 1.49}$

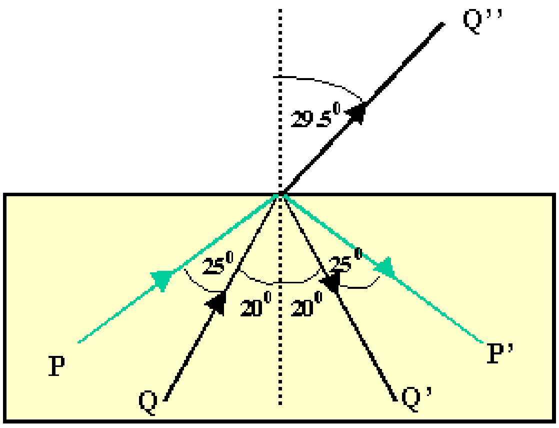
b.i. $\theta_{crit} = \sin^{-1}(1/n_{glass})$

$\theta_{crit} = \sin^{-1}(1/1.44)$

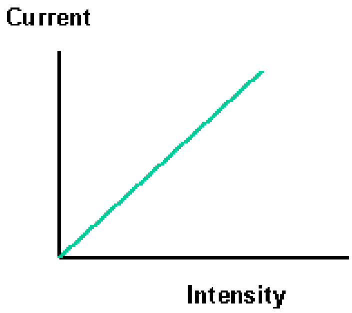
$\theta_{crit} = \sin^{-1}(0.694)$

$\mathbf{\theta_{crit} = 44.0^o}$

b.ii. Ray Q will be refracted and partially reflected.
Ray P will be totally internally reflected because the incident angle of 45^o is greater than the critical angle.



10.a.i.



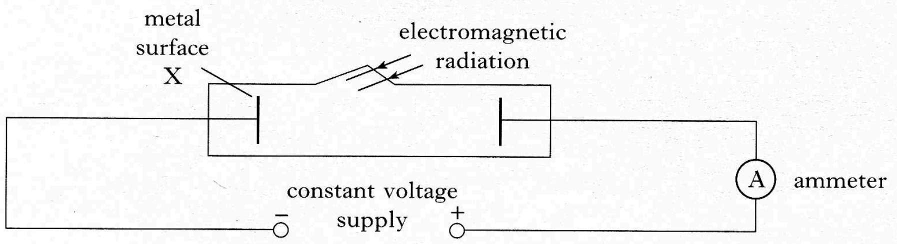
a.ii. Individual electrons in the metal atom absorb the energy of a single photon, the energy of which is dependent on the frequency of the photon. The photon energy can be calculated using the equation E = hf. Below a certain frequency the energy absorbed by an electronin the metal, from the photon, is below that required to escape from the metal atom, thus the current in the circuit will be zero.

b.i. The threshold frequency will provide electrons with just enough energy to overcome the work function of the metal and eject electrons with no excess kinetic energy. Thus to estimate the work function from the

Marks

10. (*a*) The apparatus shown below is used to investigate photoelectric emission from the metal surface X when electromagnetic radiation is shone on the surface.

The frequency of the electromagnetic radiation can be varied.



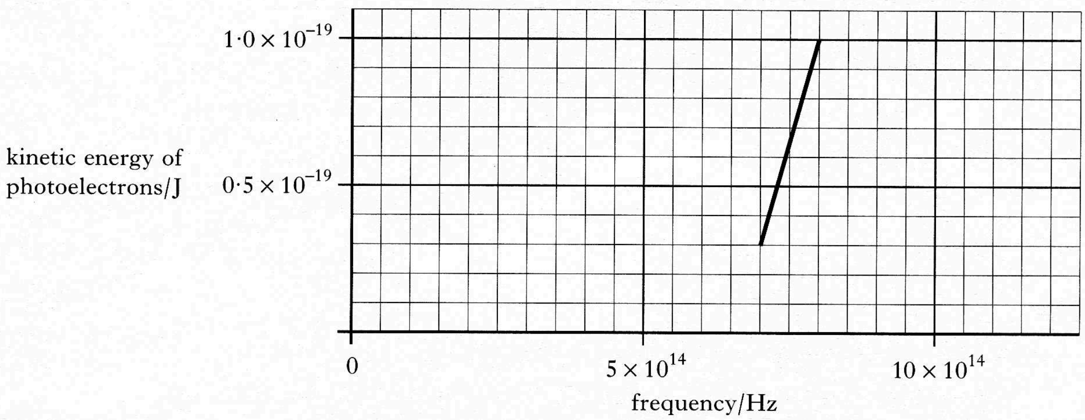
(i) When radiation of a certain frequency is shone on the metal surface X, a reading is obtained on the ammeter.

Sketch a graph to show how the current in the circuit varies with the intensity of the radiation.

(ii) Explain why there is no reading on the ammeter when the frequency of the radiation is decreased below a particular value. **3**

(*b*) The maximum kinetic energy of the photoelectrons emitted from metal X is measured for a number of different frequencies of the radiation.

The graph shows how this kinetic energy varies with frequency.



(i) Use the graph to find the threshold frequency for metal X.

(ii) The table below gives the work function of different metals.

Metal	*Work function*/J
Potassium	$3{\cdot}2 \times 10^{-19}$
Calcium	$4{\cdot}3 \times 10^{-19}$
Zinc	$6{\cdot}9 \times 10^{-19}$
Gold	$7{\cdot}8 \times 10^{-19}$

Which one of these metals was used in the investigation?

You must justify your answer using the information given in the table. **4**

(7)

 [Turn over for Question 11 on *Page fourteen*

Back to Table

number of wavelengths for certain frequencies and produce maxima, however, for other frequencies this will represent a whole number of half wavelengths and produce minima. For this reason a series of maxima and minima are produced.

9.a. $n_{plastic} = \sin\theta_{air}/\sin\theta_{plastic}$

$n_{plastic} = \sin 15^o/\sin 10^o$ (Note that it is the angle between the ray and the normal that must be used.)

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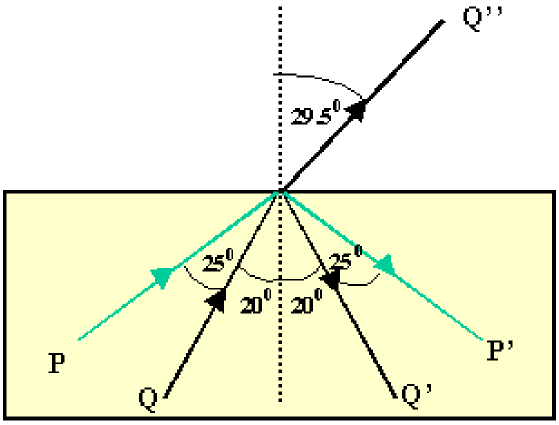

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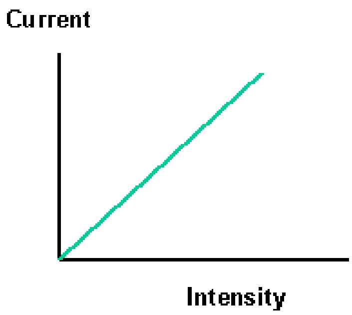

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b.i. The threshold frequency will provide electrons with just enough energy to overcome the work function of the metal and eject electrons with no excess kinetic energy. Thus to estimate the work function from the

graph the line must be extrapolated until it cuts the x-axis of the graph.

X-axis intercept = 6.7×10^{14}Hz
This is the threshold frequency.

b.ii. The work function is calculated using:

$E_{work\ function} = hf_{threshold}$
$E_{work\ function} = 6.63\times10^{-34}\times6.6\times10^{14}$
$E_{work\ function} = 4.4\times10^{-19}$J

This is closest to the work function of the metal **calcium**

11.a. Alpha particles have a positive charge. It was therefore concluded that electrostatic repulsion from a like charge, of very large mass, was required to produce a large angle deflection. However, as large angle deflections were very rare, and most alpha particles were undeviated from their original path, it led Rutherford to conclude that most of the atom was empty space with the large positive mass concentrated at the centre of the atom.

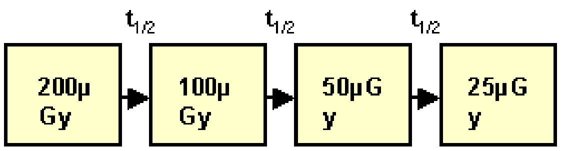
b.i. The total dose equivalent received is calculated using the equation: H =QD.

$H_{gamma} = Q_{gamma}D_{gamma}$
$H_{gamma} = 1\times200$
$H_{gamma} = 200\mu Sv$

$H_{neutrons} = Q_{neutrons}D_{neutrons}$
$H_{neutrons} = 3\times100$
$H_{neutrons} = 300\mu Sv$

$H_{total} = H_{gamma} + H_{neutrons}$
$H_{total} = 200 + 300$
$\mathbf{H_{total} = 500\mu Sv}$

b.ii.



Three half value thicknesses are required.
$\mathbf{3t_{1/2} = 3\times8 = 24mm}$

END OF QUESTION PAPER

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1998 Paper 1 (Multiple Choice)

Back to Table

1. D	11. D	21. B
2. A	12. C	22. A
3. D	13. D	23. B
4. D	14. B	24. C
5. B	15. B	25. E
6. D	16. A	26. A
7. B	17. C	27. E
8. E	18. D	28. B
9. C	19. B	29. E
10.B	20. C	30. E

SECTION A

Answer questions 1–30 on the answer sheet.

1. Consider the following three statements made by pupils about scalars and vectors.

I Scalars have direction only.

II Vectors have both size and direction.

III Speed is a scalar and velocity is a vector.

Which statement(s) is/are true?

A I only

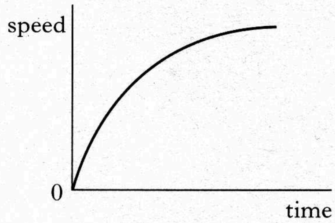
B I and II only

C I and III only

D II and III only

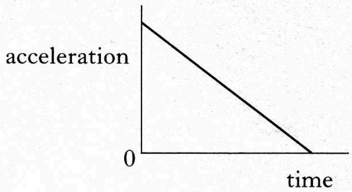
E I, II and III

2. The following is a speed-time graph of the beginning of a cyclist's journey along a straight track.

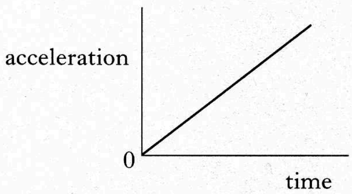


Which of the following could be the corresponding acceleration-time graph for the same period?

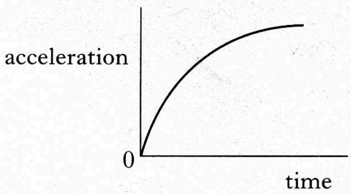
A



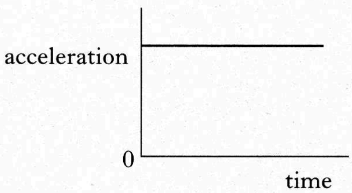
B



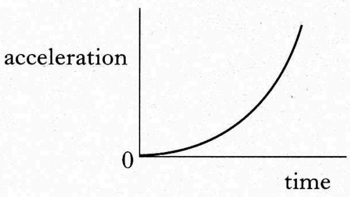
C



D



E



3. A cyclist is travelling along a straight, level road at 10 $m\,s^{-1}$. She applies her brakes and comes to rest after travelling a further 20 m.

The braking force is constant. What is her deceleration?

A $0{\cdot}25\ m\,s^{-2}$

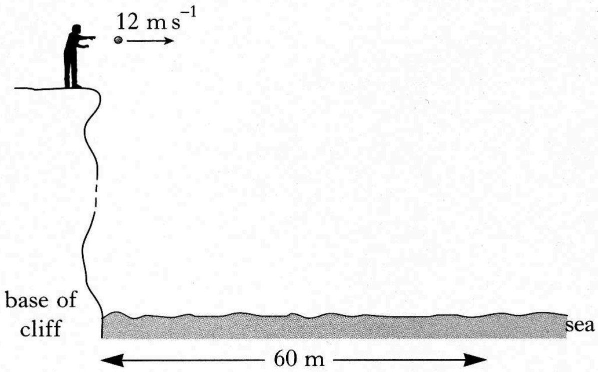
B $0{\cdot}50\ m\,s^{-2}$

C $2{\cdot}0\ m\,s^{-2}$

D $2{\cdot}5\ m\,s^{-2}$

E $5{\cdot}0\ m\,s^{-2}$

4. A stone is thrown horizontally with a speed of 12 $m\,s^{-1}$ over the edge of a vertical cliff. It hits the sea at a horizontal distance of 60 m out from the base of the cliff.



Assuming that air resistance is negligible and that the acceleration due to gravity is 10 $m\,s^{-2}$, the height from which the stone was projected above the level of the sea is

A 5 m

B 25 m

C 50 m

D 125 m

E 250 m.

5. A rocket of mass 200 kg accelerates vertically upwards from the surface of a planet at 2 $m\,s^{-2}$.

The gravitational field strength on the planet is 4 $N\,kg^{-1}$.

What is the size of the force being supplied by the rocket's engines?

A 800 N

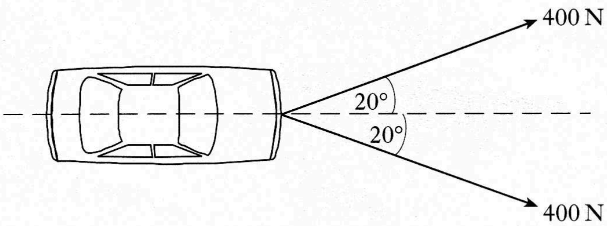
B 1200 N

C 2000 N

D 2400 N

E 4800 N

6. Two boys are pulling a car of mass 800 kg along a level surface with a pair of ropes attached horizontally as shown below.



When the pull on each rope is 400 N in the directions indicated, the acceleration of the car is $0{\cdot}1\ m\,s^{-2}$.

What is the size of the frictional force acting on the car in the above situation?

A 194 N

B 434 N

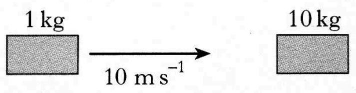
C 533 N

D 672 N

E 832 N

7. A block of mass 1 kg slides along a frictionless surface at $10\,m\,s^{-1}$ and it collides with a stationary block of mass 10 kg. After the collision, the first block rebounds at $5\,m\,s^{-1}$ and the other one moves off at $1{\cdot}5\,m\,s^{-1}$.

before impact

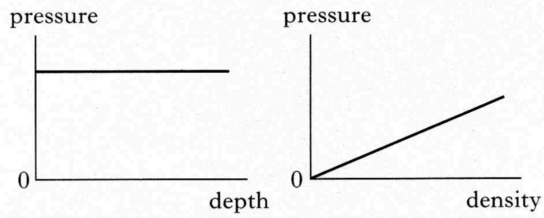


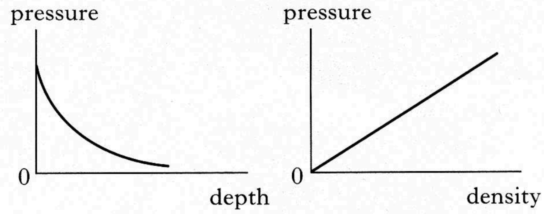
after impact

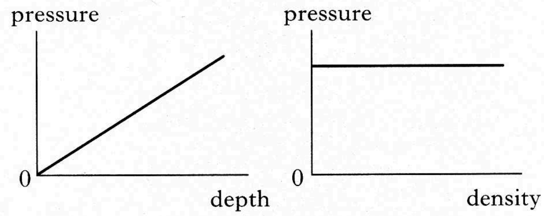
Which row in the following table is correct?

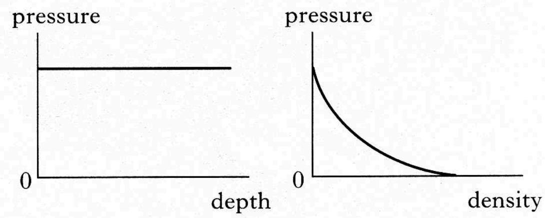
	Momentum of system	*Kinetic energy of system*	*Type of collision*
A	conserved	conserved	elastic
B	conserved	not conserved	inelastic
C	conserved	not conserved	elastic
D	not conserved	not conserved	inelastic
E	not conserved	not conserved	elastic

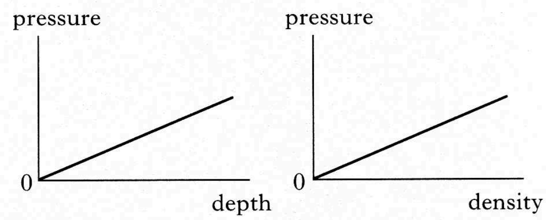
8. Which pair of graphs correctly shows how the pressure produced by a liquid depends on the depth and the density of the liquid?

A


B


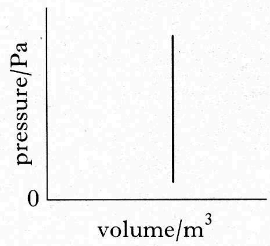
C


D


E


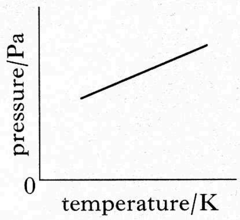
[Turn over

9. The pressure-volume graph below describes the behaviour of a constant mass of gas when it is heated.

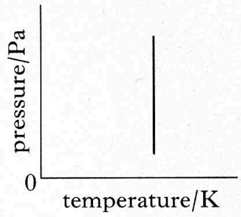


Which of the following shows the corresponding pressure-temperature graph?

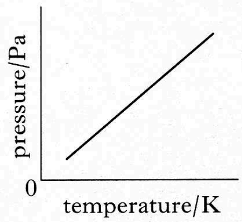
A



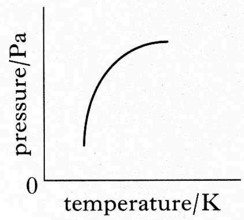
B



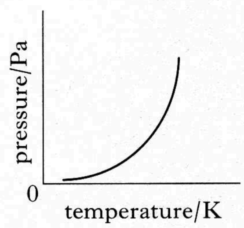
C



D



E

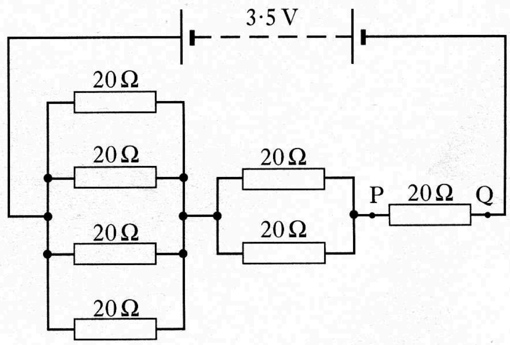


10. A balloon of mass 10 kg accelerates vertically upwards with a constant acceleration of 1 m s^{-2}. The air resistance acting on the balloon is 100 N.

Assuming that the acceleration due to gravity is 10 m s^{-2}, which row in the following table shows the size and direction of the forces acting on the balloon?

	Weight	*Air resistance*	*Upthrust*
A	↓ 100 N	↓ 100 N	↑ 200 N
B	↓ 100 N	↓ 100 N	↑ 210 N
C	↓ 100 N	↑ 100 N	↑ 10 N
D	↓ 10 N	↓ 100 N	↑ 120 N
E	↓ 100 N	↑ 100 N	↑ 100 N

11. In the circuit below, each resistor has a resistance of 20 Ω and the battery has negligible internal resistance.



The voltage across PQ is

A 0·5 V

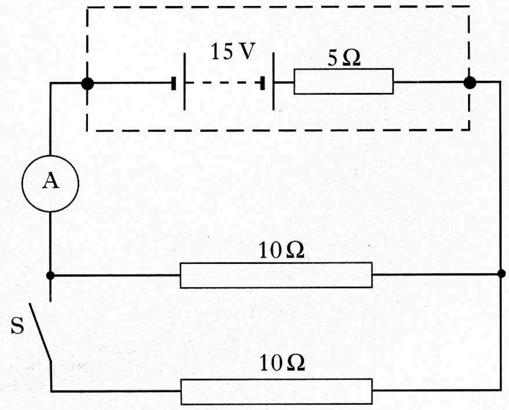
B 1·0 V

C 1·5 V

D 2·0 V

E 3·5 V.

12. A battery, of e.m.f. 15 V and internal resistance 5 Ω, is connected to two 10 Ω resistors as shown. Switch S is initially open.



When switch S is closed, the reading on the ammeter changes

A from 1 A to 2 A

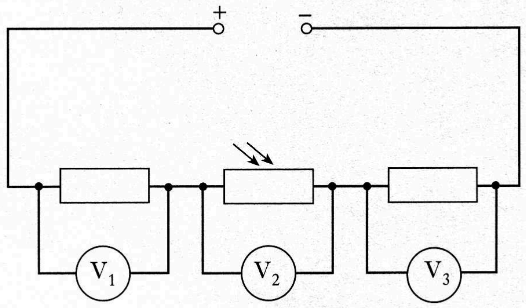
B from 1·5 A to 3 A

C from 1 A to 1·5 A

D from 1·5 A to 0·75 A

E from 1 A to 0·6 A.

13. A student sets up the following potential divider circuit which includes a light-dependent resistor (LDR).

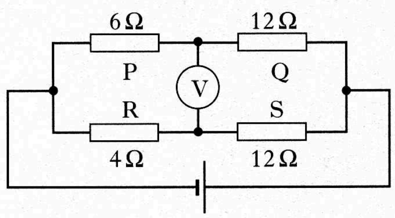


The resistance of the LDR decreases when the light intensity on it increases.

Which row in the table below correctly shows how the voltmeter readings are affected when the student switches off all the lights in the laboratory?

	Reading on voltmeter V_1	*Reading on voltmeter* V_2	*Reading on voltmeter* V_3
A	increases	increases	increases
B	decreases	decreases	decreases
C	increases	decreases	increases
D	decreases	increases	decreases
E	no change	increases	no change

14. In the Wheatstone bridge shown below, there is a small reading on the voltmeter.



What should be done to balance the Wheatstone bridge?

A Increase the value of resistor P by 6 Ω.

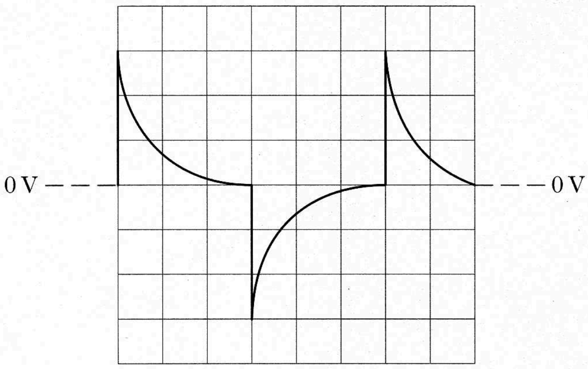
B Increase the value of resistor Q by 6 Ω.

C Increase the value of resistor R by 6 Ω.

D Increase the value of resistor S by 6 Ω.

E Insert a 6 Ω resistor in series with the voltmeter.

15. The output from an electrical device produces the following trace on an oscilloscope.



The time-base setting of the oscilloscope is 2 ms per division and the voltage-gain setting is 5 mV per division.

What is the frequency and maximum voltage of the output from this electrical device?

	Frequency of the device/Hz	*Maximum voltage output from the device*/mV
A	33	15
B	83	15
C	83	30
D	166	30
E	166	15

16. What is the relationship between the r.m.s. and peak values for an alternating current?

A $I_{\text{r.m.s.}} = \dfrac{I_p}{\sqrt{2}}$

B $I_{\text{r.m.s.}} = \sqrt{2}\, I_p$

C $I_{\text{r.m.s.}} = 2\, I_p^2$

D $I_{\text{r.m.s.}} = \dfrac{\sqrt{I_p}}{2}$

E $I_{\text{r.m.s.}} = \dfrac{I_p^2}{2}$

17. A 25 μF capacitor is charged until the potential difference across it is 500 V. The charge stored in the capacitor is

A $5{\cdot}00 \times 10^{-8}$ C

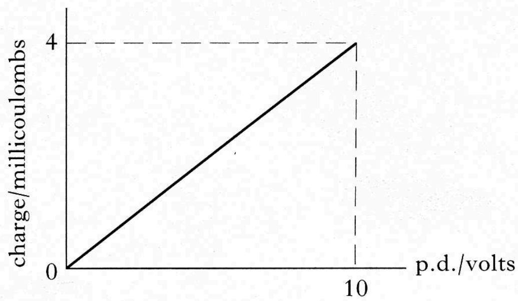
B $2{\cdot}00 \times 10^{-5}$ C

C $1{\cdot}25 \times 10^{-2}$ C

D $1{\cdot}25 \times 10^{4}$ C

E $2{\cdot}00 \times 10^{7}$ C.

18. The graph shows how the charge stored on a capacitor varies as the p.d. applied across it is increased.



What is the energy stored in the capacitor when the p.d. across it is 10 V?

A 0·4 mJ

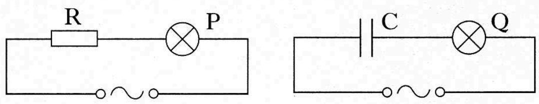
B 2·5 mJ

C 10 mJ

D 20 mJ

E 40 mJ

19. In the circuits shown below, P and Q are identical lamps and the a.c. supplies have the same r.m.s. voltage output. The lamps glow with equal brightness.

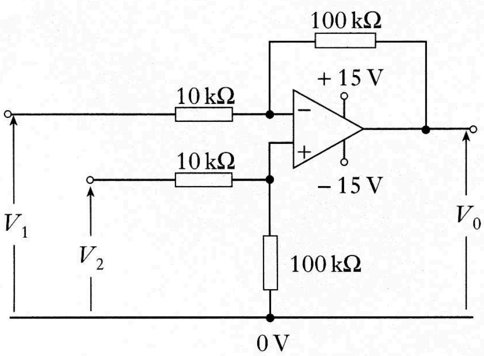


The frequency of each supply voltage is increased without altering the value of the r.m.s. voltage output.

Which row in the following table correctly describes how the brightness of each lamp is affected?

	Lamp P	*Lamp Q*
A	brighter	unchanged
B	unchanged	brighter
C	dimmer	unchanged
D	unchanged	dimmer
E	dimmer	brighter

20. The amplifier shown below is operating in the differential mode.



When $V_0 = 0{\cdot}60$ V and $V_1 = 2{\cdot}70$ V, what is the value of V_2?

A 2·10 V

B 2·16 V

C 2·76 V

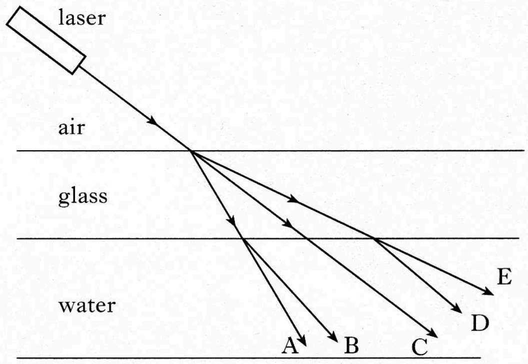
D 3·30 V

E 3·36 V

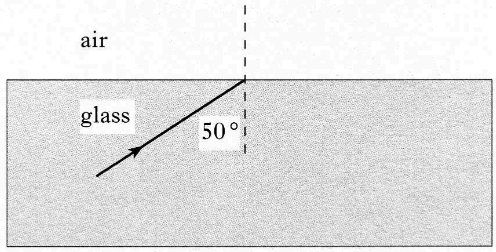
21. The diagram below shows a ray of light from a laser passing from air into glass and then into water.

The refractive index of glass is greater than that of water.

Which is the correct path for the light?

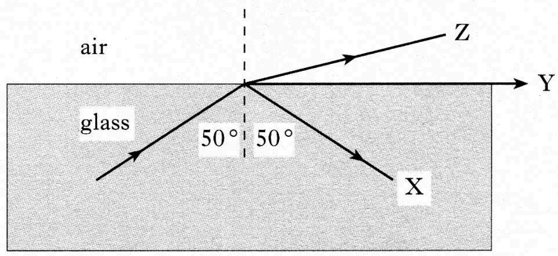


22. A ray of light travelling through glass approaches air, as shown below.



The refractive index of the glass is 1·5.

Which of the following paths will the ray follow?



A X only

B Y only

C Z only

D X and Z only

E Y and Z only

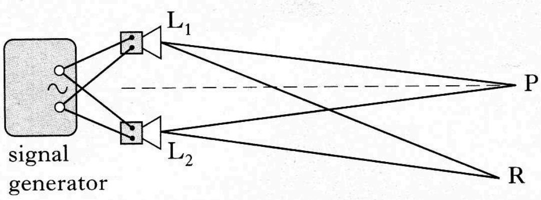
[Turn over

23. Light travels from air into glass.

Which row in the following table correctly describes what happens to the speed, frequency and wavelength of the light?

	Speed	*Frequency*	*Wavelength*
A	increases	decreases	stays constant
B	decreases	stays constant	decreases
C	stays constant	decreases	decreases
D	increases	stays constant	increases
E	decreases	decreases	stays constant

24. Two identical loudspeakers, L_1 and L_2, are operated at the same frequency and in phase with each other by connecting them in parallel across the output of a signal generator, as shown below. A sound interference pattern is produced.



At position P, which is the same distance from both loudspeakers, a microphone registers a maximum intensity of sound.

The next maximum is registered at position R, where $L_1R = 4{\cdot}6\,\text{m}$ and $L_2R = 4{\cdot}3\,\text{m}$.

If the speed of sound is $330\ \text{m s}^{-1}$, then the frequency of the sound emitted by the loudspeakers is given by

A $\dfrac{(4{\cdot}6 - 4{\cdot}3)}{330}$ Hz

B $\dfrac{330}{(4{\cdot}6 + 4{\cdot}3)}$ Hz

C $\dfrac{330}{(4{\cdot}6 - 4{\cdot}3)}$ Hz

D $330 \times (4{\cdot}6 - 4{\cdot}3)$ Hz

E $330 \times (4{\cdot}6 + 4{\cdot}3)$ Hz.

25. The intensity of radiation emitted from a point source of light varies

A directly as the distance from the source

B directly as the square of the distance from the source

C directly as the square root of the distance from the source

D inversely as the distance from the source

E inversely as the square of the distance from the source.

26. Certain materials can be "doped" to make a semiconductor called an n-type material.

In an n-type material,

A the majority charge carriers are electrons

B the majority charge carriers are neutrons

C the majority charge carriers are protons

D there are more electrons than protons

E there are more electrons than neutrons.

27. The symbols for two isotopes of carbon, carbon 14 and carbon 12, are as follows.

$${}^{14}_{6}\text{C} \qquad\qquad {}^{12}_{6}\text{C}$$

Which of the following statements is true?

Carbon 14 and carbon 12 are said to be isotopes of carbon because

A carbon 14 has the same mass number as carbon 12

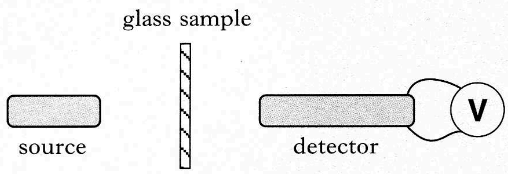
B carbon 14 has a different atomic number from carbon 12

C carbon 14 is radioactive

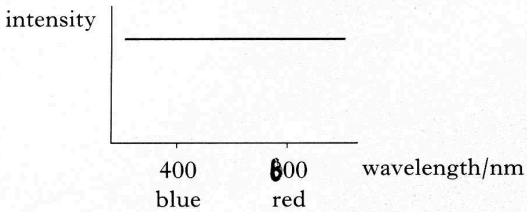
D carbon 14 has the same number of neutrons as carbon 12

E carbon 14 and carbon 12 have different mass numbers but the same atomic number.

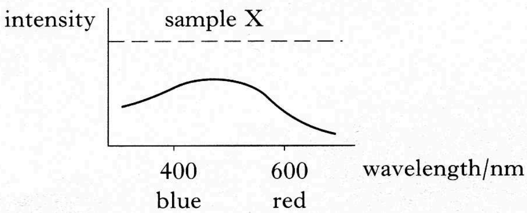
28. Two different types of tinted glass, X and Y, are used to make filters for sunglasses. A sample of each glass is placed in turn between a source and a detector, as shown in the following diagram. Both samples are identical in size and shape.

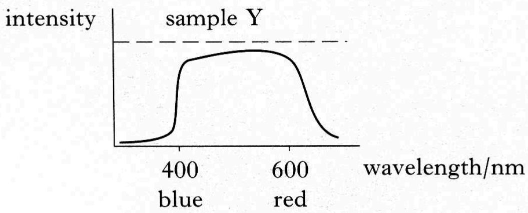


The source emits electromagnetic radiation with a wide range of wavelengths, all of the same intensity as shown below.



The following graphs show the intensities measured by the detector after the electromagnetic radiation passed through each of the glass samples.





Which of the following statement(s) is/are correct?

I Sample X is better at absorbing red light than sample Y.

II Sample Y is better at protecting the eye from ultraviolet radiation.

III The view would appear darker when seen through sample Y than when seen through sample X.

A I only

B I and II only

C I and III only

D II and III only

E I, II and III

29. There are a number of equations involving the following quantities.

A, the activity of a radioactive source
D, the absorbed dose
H, the dose equivalent
$\dot{H}$, the dose equivalent rate
Q, the quality factor
N, the number of nuclei decaying
t, the time

Which row of the following table states **three** of these equations correctly?

A	$A = \frac{N}{t}$	$H = DQ$	$\dot{H} = Ht$
B	$A = Nt$	$H = DQ$	$\dot{H} = \frac{H}{t}$
C	$A = \frac{N}{t}$	$H = \frac{D}{Q}$	$\dot{H} = Ht$
D	$A = Nt$	$H = \frac{D}{Q}$	$\dot{H} = \frac{H}{t}$
E	$A = \frac{N}{t}$	$H = DQ$	$\dot{H} = \frac{H}{t}$

30. The three statements below refer to the fission process.

I Fission may be spontaneous.

II Fission can be produced when neutrons bombard a nucleus, which has a large mass number.

III When fission occurs, a nucleus with a large mass number may split into nuclei with smaller mass numbers, along with several neutrons.

Which statement(s) is/are true?

A III only

B I and II only

C I and III only

D II and III only

E I, II and III

[Turn over

Back to Table Answers

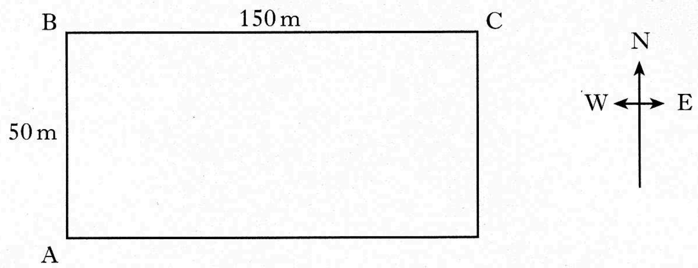
SECTION B

Write your answers to questions 31 to 37 in the answer book.

Marks

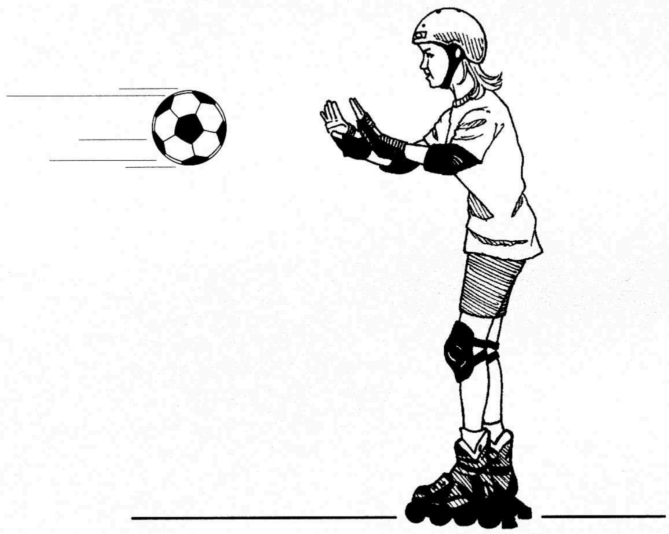
31. A spectator at A walks to C, the opposite corner of a playing field, by walking from A to B and then from B to C as shown in the diagram below.

The distance from A to B is 50 m. The distance from B to C is 150 m.



By scale drawing or otherwise, find the resultant displacement. Magnitude and direction are required. **2**

32. A football of mass 0·42 kg is thrown at a stationary student of mass 50·0 kg who is wearing roller blades, as shown in the diagram below. When the student catches the moving ball she moves to the right.



The instantaneous speed immediately after she catches the ball is 0·10 m s^{-1}.

Calculate the speed of the ball just before it is caught. **2**

Past Paper Solutions

Solutions to SQA examination

1998 Higher Grade Physics

Paper I Solutions

Return to past paper index page.

1. **D**	11. **D**	21. **B**
2. **A**	12. **C**	22. **A**
3. **D**	13. **D**	23. **B**
4. **D**	14. **B**	24. **C**
5. **B**	15. **B**	25. **E**
6. **D**	16. **A**	26. **A**
7. **B**	17. **C**	27. **E**
8. **E**	18. **D**	28. **B**
9. **C**	19. **B**	29. **E**
10.**B**	20. **C**	30. **E**

31. Calculate the magnitude of the displacement vector (**s**) using Pythagoras' theorem and calculate the corresponding bearing using basic trigonometry.

$s^2 = AB^2+BC^2$
$s^2 = 50^2+150^2$
$s^2 = 2{,}500+22{,}500$
$s^2 = 25{,}000$
$s = (25000)^{1/2}$
$s = 158.11m$

Let angle BAC = θ
$\tan\theta = BC/BA$
$\tan\theta = 150/50$
$\tan\theta = 3$
$\theta = TAN^{-1}3$
$\theta = 71.6^0$

S=158.11m at a bearing of **071.6^0**

32. To solve this problem use conservation of momentum.

$P_{before} = P_{after}$

$P_{before} = m_{ball}u_{ball}+m_{student}u_{student}$
$P_{before} = 0.42xu_{ball}+50x0$
$P_{before} = 0.42xu_{ball}$

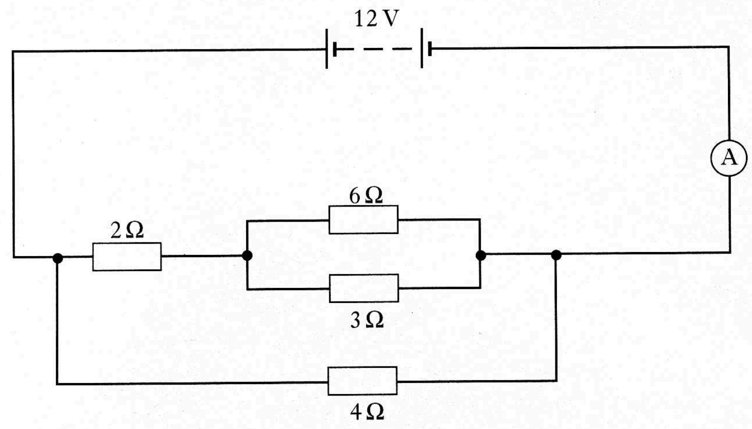
$P_{after} = (m_{ball}+m_{student})x\ v$
$P_{after} = (0.42+50)0.10$
$P_{after} = 50.42x0.1$
$P_{after} = 5.042kgm/s$

Equating P_{before} to P_{after} leads to:

$0.42xu_{ball} = 5.042$
$u_{ball} = 5.042/0.42\ (m/s)$

Marks

33. Calculate the size of the current in the ammeter in the circuit below. The battery has negligible internal resistance.



3

[Turn over

u_{ball} = 12.00m/s

33. Step 1 :Calculate the effective resistance of the parallel network containing the 6Ω and 3Ω resistors.

$1/R_p=1/R_1+1/R_2$
$1/R_p=1/6_1+1/3_2$
$1/R_p=3/6$
$R_p=6/3$
$R_p=2\Omega$

Step 2 :Add the 2Ω resistor to the value calculated above.
$R=2\Omega+2\Omega$
$R=4\Omega$

Step 3 :The 4Ω resistor is in parallel with the resistance calculated in step 2. The total resistance is therefore given by:

$1/R_{total}= 1/4 + 1/4$
$1/R_{total}= 2/4$
$R_{total} = 2\Omega$

34.a. When the wheatstone bridge is balanced:

$R_1/R_2 = R_v/R_t$
$R_t = R_v x R_2/R_1$
$R_t = 0.225x2.2/3.3$
$R_t = 0.15k\Omega$
$R_t = 150\Omega$

b. At 80mV the temperature of the thermistor has increased by 4^oC.
The temperature of the thermistor is therefore **24^oC**.

35.a. $E = hf$ $f=v/\lambda$
$E = hv/\lambda$
$\lambda = hv/E$
$\lambda = 6.63x10^{-34}x3x10^8/6.9x10^{-19}$
$\lambda = 2.88x10^{-7}m$

b. As $4.0x10^{-7}m$ is greater than the maximum wavelength that will cause an electron to be emitted, no electrons will be emitted from the zinc surface.

36.a. When an electron in a high energy level is made to fall to a lower energy level in an atom as a result of a passing photon, with an energy equal to the energy gap between the high energy level and the lower energy level, a photon produced. This is called stimulated emission of radiation where the passing photon is called the stimulating photon.

b. The stimulating and the stimulated radiation have the same frequency and wavelength. They are also travelling in the same direction and are in phase.

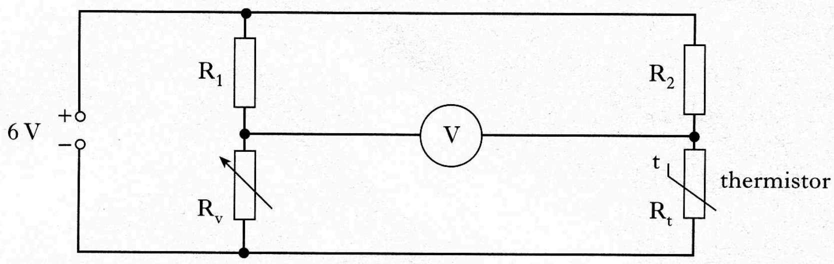
37. To solve this problem use the grating equation **$d\sin\theta = n\lambda$**.

$d = 1/300$ mm $= (1/300)x10^{-3}m = 3.33x10^{-6}m$
$\theta = 24.5^o$
$n = 2$
$\lambda = ?$

$\lambda = d\sin\theta/n$
$\lambda = 3.33x10^{-6}\sin 24.5^o/2$

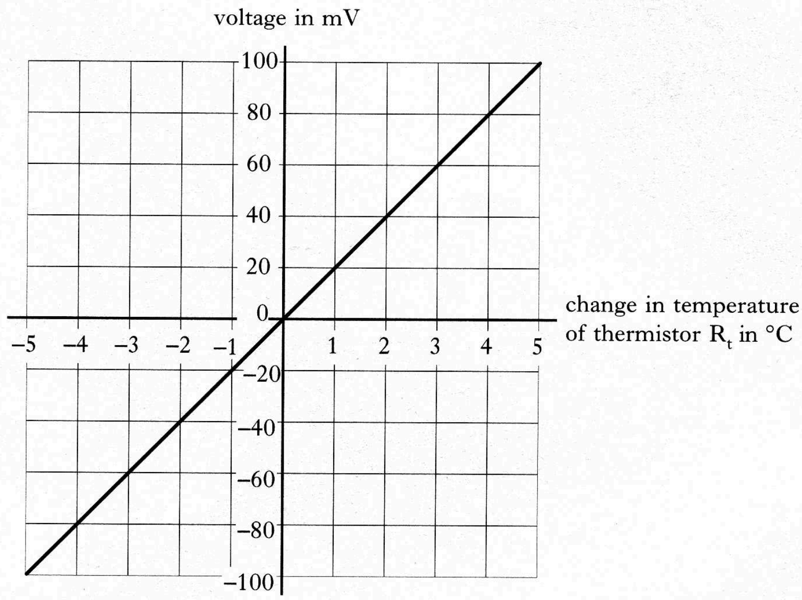
Marks

34. The Wheatstone bridge shown below is balanced.



(*a*) R_1 has a resistance of $3{\cdot}3\,k\Omega$, R_2 has a resistance of $2{\cdot}2\,k\Omega$ and the variable resistor R_v is set at $225\,\Omega$. Calculate the resistance of the thermistor R_t.

(*b*) The graph below shows what happens to the reading on the voltmeter as the temperature of thermistor R_t is changed.



The bridge was initially balanced at 20 °C.

The temperature of R_t is increased until the reading on the voltmeter is 80 mV. What is the new temperature of the thermistor R_t? **3**

35. The minimum energy required to cause an electron to be emitted from a clean zinc surface is $6{\cdot}9 \times 10^{-19}$ J.

(*a*) Calculate the maximum wavelength of electromagnetic radiation which will cause an electron to be emitted from the clean zinc surface.

(*b*) What would be the effect of irradiating a clean zinc surface with radiation of wavelength $4{\cdot}0 \times 10^{-7}$ m? You must justify your answer. **4**

u_{ball} = 12.00m/s

33. Step 1 :Calculate the effective resistance of the parallel network containing the 6Ω and 3Ω resistors.

$1/R_p=1/R_1+1/R_2$
$1/R_p=1/6_1+1/3_2$
$1/R_p=3/6$
$R_p=6/3$
$R_p=2\Omega$

Step 2 :Add the 2Ω resistor to the value calculated above.
$R=2\Omega+2\Omega$
$R=4\Omega$

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$1/R_{total}= 1/4 + 1/4$
$1/R_{total}= 2/4$
$\mathbf{R_{total} = 2\Omega}$

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$R_1/R_2 = R_v/R_t$
$R_t = R_v x R_2/R_1$
$R_t = 0.225x2.2/3.3$
$R_t = 0.15k\Omega$
$\mathbf{R_t = 150\Omega}$

b. At 80mV the temperature of the thermistor has increased by 4^oC.
The temperature of the thermistor is therefore **24^oC**.

35.a. $E = hf$ $f=v/\lambda$
$E = hv/\lambda$
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$\lambda = 6.63x10^{-34}x3x10^8/6.9x10^{-19}$
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b. As $4.0x10^{-7}$m is greater than the maximum wavelength that will cause an electron to be emitted, no electrons will be emitted from the zinc surface.

36.a. When an electron in a high energy level is made to fall to a lower energy level in an atom as a result of a passing photon, with an energy equal to the energy gap between the high energy level and the lower energy level, a photon produced. This is called stimulated emission of radiation where the passing photon is called the stimulating photon.

b. The stimulating and the stimulated radiation have the same frequency and wavelength. They are also travelling in the same direction and are in phase.

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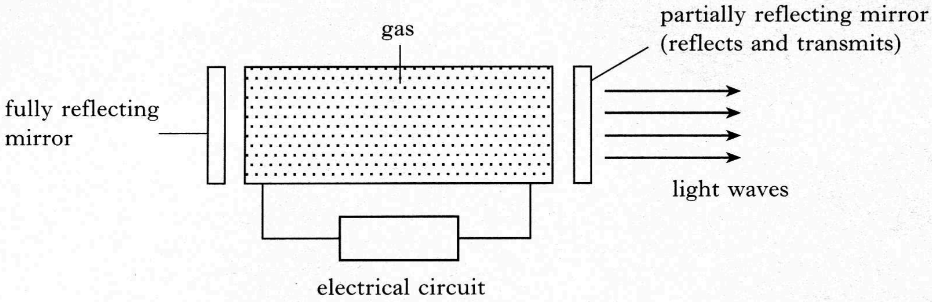
$d = 1/300 \text{ mm} = (1/300)x10^{-3}m = 3.33x10^{-6}m$
$\theta = 24.5^o$
$n = 2$
$\lambda = ?$

$\lambda = d\sin\theta/n$
$\lambda = 3.33x10^{-6}\sin24.5^o/2$

Marks

36. The diagram shows a simplified view of a gas laser.

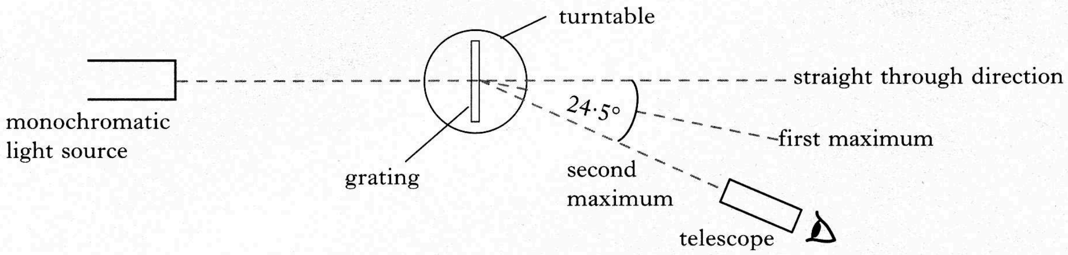


Laser stands for Light Amplification by Stimulated Emission of Radiation.

(*a*) Explain what is meant by *stimulated emission of radiation*.

(*b*) State **two** ways in which the incident radiation and the radiation it stimulates are similar. **3**

37. A grating with 300 lines/mm is used with a spectrometer and a source of monochromatic light to view an interference pattern as shown below.



The second maximum of interference is observed when the telescope is at an angle of 24·5°.

Calculate the wavelength of the light. **3**

[*END OF QUESTION PAPER*]

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u_{ball} = 12.00m/s

33. Step 1 :Calculate the effective resistance of the parallel network containing the 6Ω and 3Ω resistors.

$1/R_p=1/R_1+1/R_2$
$1/R_p=1/6_1+1/3_2$
$1/R_p=3/6$
$R_p=6/3$
$R_p=2\Omega$

Step 2 :Add the 2Ω resistor to the value calculated above.
$R=2\Omega+2\Omega$
$R=4\Omega$

Step 3 :The 4Ω resistor is in parallel with the resistance calculated in step 2. The total resistance is therefore given by:

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$1/R_{total}= 2/4$
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34.a. When the wheatstone bridge is balanced:

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$R_t = 0.15k\Omega$
$\mathbf{R_t = 150\Omega}$

b. At 80mV the temperature of the thermistor has increased by 4^oC. The temperature of the thermistor is therefore **24^oC**.

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$\lambda = 6.63x10^{-34}x3x10^8/6.9x10^{-19}$
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36.a. When an electron in a high energy level is made to fall to a lower energy level in an atom as a result of a passing photon, with an energy equal to the energy gap between the high energy level and the lower energy level, a photon produced. This is called stimulated emission of radiation where the passing photon is called the stimulating photon.

b. The stimulating and the stimulated radiation have the same frequency and wavelength. They are also travelling in the same direction and are in phase.

37. To solve this problem use the grating equation **$d\sin\theta = n\lambda$**.

$d = 1/300\ mm = (1/300)x10^{-3}m = 3.33x10^{-6}m$
$\theta = 24.5^o$
$n = 2$
$\lambda = ?$

$\lambda = d\sin\theta/n$
$\lambda = 3.33x10^{-6}\sin24.5^o/2$

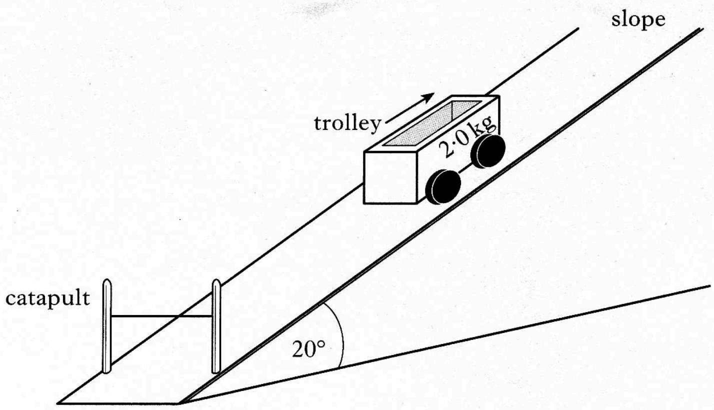
λ = 6.91x10^{-7}m = 691nm

END OF QUESTION PAPER

Return to past paper index page.

Marks

1. A trolley of mass 2·0 kg is catapulted up a slope. The slope is at an angle of 20° to the horizontal as shown in the diagram below. The speed of the trolley when it loses contact with the catapult is 3·0 m s^{-1}.



The size of the force of friction acting on the trolley as it moves up the slope is 1·3 N.

(*a*) (i) Calculate the component of the weight of the trolley acting parallel to the slope.

(ii) Draw a diagram to show the forces acting on the trolley as it moves **up the slope** and is no longer in contact with the catapult.

Show only forces or components of forces acting parallel to the slope. Name the forces.

(iii) Show that, as the trolley moves up the slope, it has a deceleration of magnitude 4·0 m s^{-2}.

(iv) Calculate the time taken for the trolley to reach its furthest point up the slope.

(v) Calculate the maximum distance the trolley travels along the slope. **9**

The trolley now moves back down the slope.

(*b*) (i) Draw a diagram to show the forces acting on the trolley as it moves **down the slope**.

Show only forces or components of forces acting parallel to the slope. Name the forces.

(ii) The magnitude of the deceleration of the trolley is 4·0 m s^{-2} as it moves up the slope. Explain why the magnitude of the acceleration is not 4·0 m s^{-2} when the trolley moves down the slope. **2**

(11)

[Turn over

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Solutions to SQA examination

1998 Higher Grade Physics

Paper II Solutions

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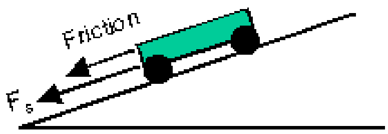
1.a.i. Component of the force acting parallel to the slope(F_s) is calculated using:

$F_s = mg\sin\theta$

$F_s = 2.0 \times 9.8 \times \sin 20^o$

$F_s = 6.7N$

a.ii.



a.iii.To calculate the acceleration use [N2]

$a = F_{unbalanced}/m$

$F_{unbalanced} = F_{Friction} + F_s$

$F_{unbalanced} = -1.3 + (-6.7)$ Where vectors acting down the slope are taken as negative.

$F_{unbalanced} = -8N$

$a = -8/2.0$

$a = -4m/s^2$

Which equates to a deceleration of $4m/s^2$, as required.

a.iv. At its furthest point up the slope the trolley will be at rest.

$v = 0m/s$	$v = u + at$
$u = 3m/s$	$t = (v-u)/a$
$a = -4m/s^2$	$t = (0-3)/-4$
$t = ?$	**$t = 0.75s$**

a.v. $v^2 = u^2 + 2as$

$s = (v^2 - u^2)/2a$

$s = (0^2 - 3^2)/(2 \times -4)$

$s = -9/-8$

$s = 1.125m$

b.i.

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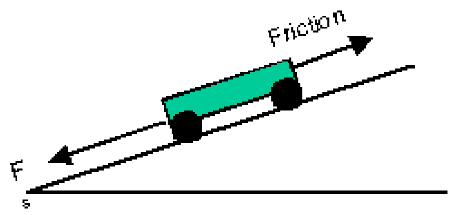
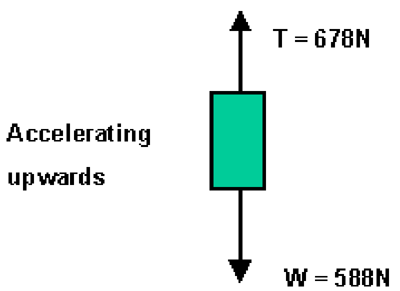


b.ii. The force vectors in the above diagram are acting in opposite directions. This will produce a smaller unbalanced force than that calculated in part a.iii. This means that the magnitude of the acceleration will be less when the trolley moves down the slope.

2.a. The weight of the student is equal to the scale reading when the lift is moving at a steady speed. This weight is used to calculate the mass of the student.

w = mg
m = w/g
m = 588/9.8
m = 60kg

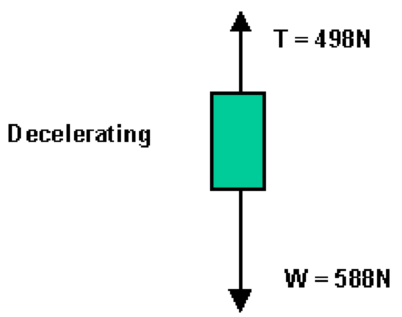
b. The boy is accelerating at the same rate as the lift. The unbalanced force producing this acceleration is equal to the scale reading when accelerating minus the steady state scale reading. The diagram below illustrates this with the scale reading represented by the the upward force labelled **T** and downward force, weight, represented by **W**.



$F_{unbalanced}$ = 678-588
$F_{unbalanced}$ = 90N

a = $F_{unbalanced}$/m
a = 90/60
a = 1.5m/s^2

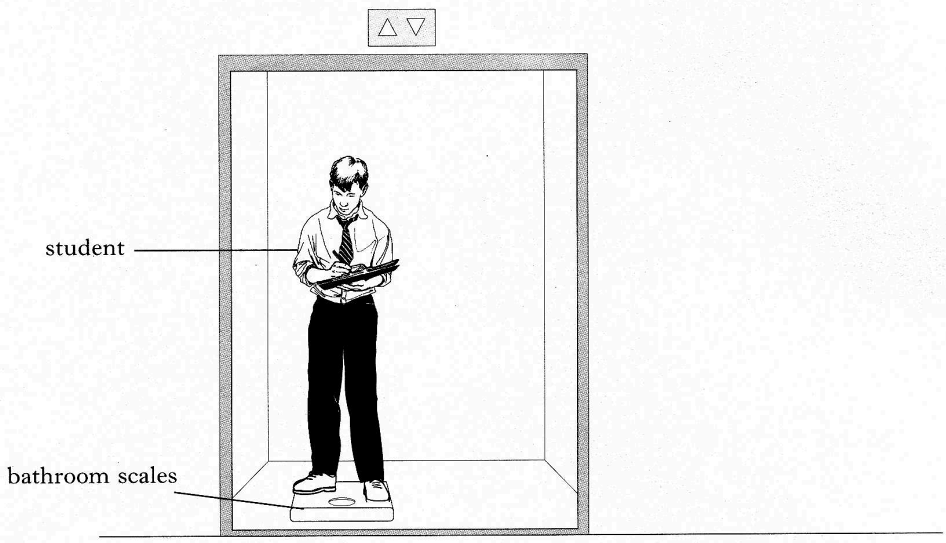
c. The lift is decelerating when the upward force is less than the weight.



$F_{unbalanced}$ = 498 - 588

Marks

2. A student performs an experiment to study the motion of the school lift as it moves upwards.



The student stands on bathroom scales during the lift's journey upwards.

The student records the reading on the scales at different parts of the lift's journey as follows.

Part of journey	*Reading on scales*
At the start (while the lift is accelerating)	678 N
In the middle (while the lift is moving at a steady speed)	588 N
At the end (while the lift is decelerating)	498 N

(*a*) Show that the mass of the student is 60 kg. **2**

(*b*) Calculate the initial acceleration of the lift. **2**

(*c*) Calculate the deceleration of the lift. **1**

(*d*) During the journey, the lift accelerates for 1·0 s, moves at a steady speed for 3·0 s and decelerates for a further 1·0 s before coming to rest.

Sketch the acceleration-time graph for this journey. **2**

(7)

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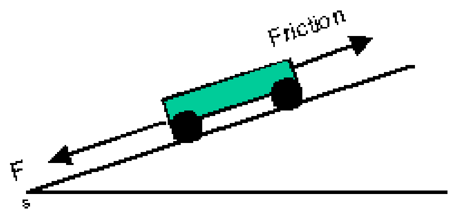
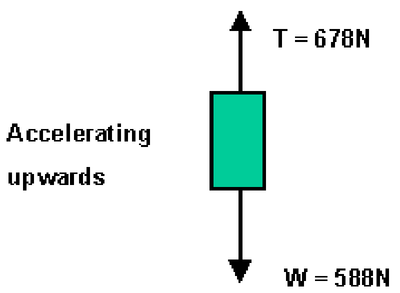


b.ii. The force vectors in the above diagram are acting in opposite directions. This will produce a smaller unbalanced force than that calculated in part a.iii. This means that the magnitude of the acceleration will be less when the trolley moves down the slope.

2.a. The weight of the student is equal to the scale reading when the lift is moving at a steady speed. This weight is used to calculate the mass of the student.

w = mg
m = w/g
m = 588/9.8
m = 60kg

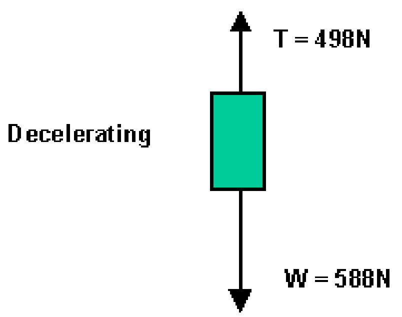
b. The boy is accelerating at the same rate as the lift. The unbalanced force producing this acceleration is equal to the scale reading when accelerating minus the steady state scale reading. The diagram below illustrates this with the scale reading represented by the the upward force labelled **T** and downward force, weight, represented by **W**.



$F_{unbalanced}$ = 678-588
$F_{unbalanced}$ = 90N

a = $F_{unbalanced}$/m
a = 90/60
a = 1.5m/s^2

c. The lift is decelerating when the upward force is less than the weight.



$F_{unbalanced}$ = 498 - 588

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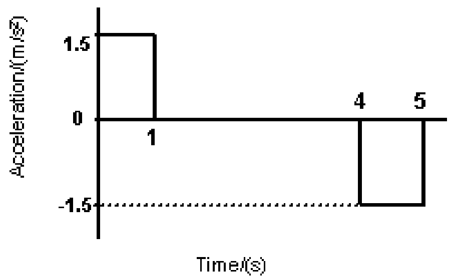
$F_{unbalanced}$ = -90N The negative indicates that the unbalanced force acts in the downwards direction.

a = $F_{unbalanced}$/m
a = -90/60
a = -1.5m/s^2

This can be thought of as an upward deceleration of 1.5m/s^2

d.



3.a.i. V = d/t_1 d = diameter of ball = 24mm = 0.024m
t = time for ball to pass through light gate = 0.060s

V = 0.024/0.060
V = 0.4m/s

a.ii. F_{avg} = change in momentum/contact time
F_{avg} = (mv-mu)/t
F_{avg} = m(v-u)/t
F_{avg} = 0.045(0.4-0)/0.005
F_{avg} = 3.6N

b.i.

Percentage error in mass	= (0.01/45)x100	= 0.02%
Percentage error in contact time	= (0.001/0.005)x100	= 20%
Percentage error in t_1	= (0.001/0.060)x100	= 1.67%
Percentage error in ball diameter	= (1/24)x100	= 4.17%

The greatest uncertainty is in the contact time measurement.

b.ii. The percentage error in the result can be taken as equal to the largest individual error.

20% of 3.6N = (20/100)x3.6 = 0.72N

F_{avg} = (3.6 +- 0.72)N

4.a. Initial volume of gas (V_1) in the container = (8-5)litres = 3 litres = 3 x$10^{-3}$$m^3$
Density of gas (ρ) = 1.29kg/m^3

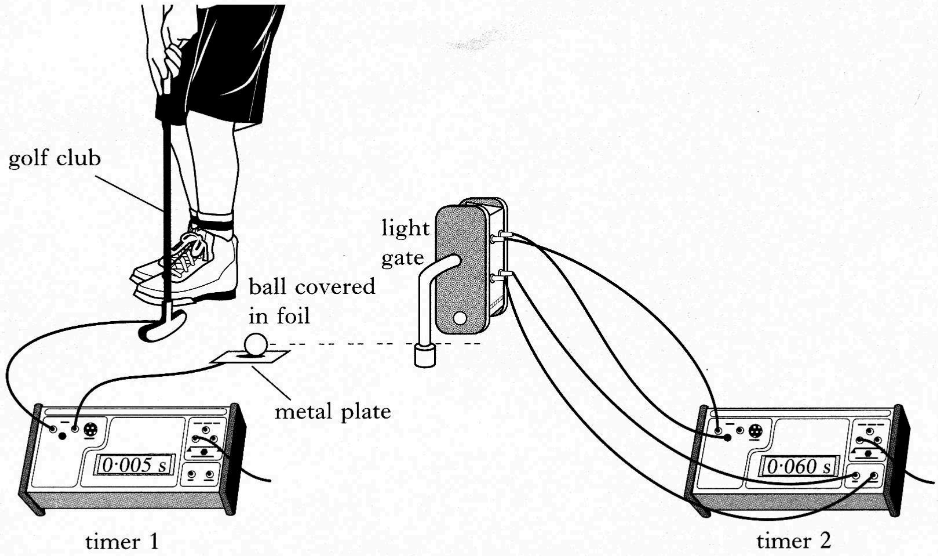
m = ρV_1
m = 1.293x(3x$10^{-3}$$m^3$)
m = 3.87x10^{-3}Kg

b.i. Pressure before pumping (P_{before}) = 1.01x10^5Pa
Pressure after pumping (P_1) = 3.0x10^5Pa

Volume of air before and after pumping(V_1) is fixed at 3x$10^{-3}$$m^3$
Area(A) = 7.0x$10^3$$m^2$

Marks

3. The apparatus in the diagram is being used to investigate the average force exerted by a golf club on a ball.



The club hits the stationary ball. Timer 1 records the time of contact between the club and the ball. Timer 2 records the time taken for the ball to pass through the light gate beam.

The mass of the ball is $45 \cdot 00 \pm 0 \cdot 01$ g.

The time of the contact between club and ball is $0 \cdot 005 \pm 0 \cdot 001$ s.

The time for the ball to pass through the light gate beam is $0 \cdot 060 \pm 0 \cdot 001$ s.

The diameter of the ball is 24 ± 1 mm.

(*a*) (i) Calculate the speed of the ball as it passes through the light gate.

(ii) Calculate the average force exerted on the ball by the golf club. **3**

(*b*) (i) Show by calculation which measurement contributes the largest percentage error in the final value of the average force on the ball.

(ii) Express your numerical answer to (*a*)(ii) in the form

final value $\pm$ absolute error. **3**

(6)

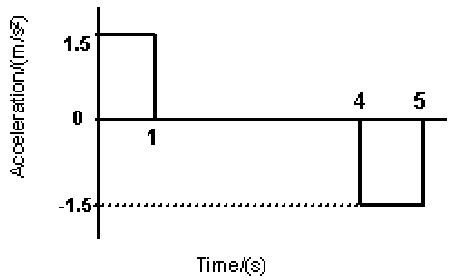
[Turn over

$F_{unbalanced} = -90N$ The negative indicates that the unbalanced force acts in the downwards direction.

$a = F_{unbalanced}/m$
$a = -90/60$
$a = -1.5m/s^2$

This can be thought of as an upward deceleration of 1.5m/s²

d.



3.a.i. $V = d/t_1$ d = diameter of ball = 24mm = 0.024m
t = time for ball to pass through light gate = 0.060s

V = 0.024/0.060
V = 0.4m/s

a.ii. F_{avg} = change in momentum/contact time
$F_{avg} = (mv-mu)/t$
$F_{avg} = m(v-u)/t$
$F_{avg} = 0.045(0.4-0)/0.005$
F_{avg} = 3.6N

b.i.

Percentage error in mass	= (0.01/45)x100	= 0.02%
Percentage error in contact time	= (0.001/0.005)x100	= 20%
Percentage error in t_1	= (0.001/0.060)x100	= 1.67%
Percentage error in ball diameter	= (1/24)x100	= 4.17%

The greatest uncertainty is in the contact time measurement.

b.ii. The percentage error in the result can be taken as equal to the largest individual error.

20% of 3.6N = (20/100)x3.6 = 0.72N

F_{avg} = (3.6 +- 0.72)N

4.a. Initial volume of gas (V_1) in the container = (8-5)litres = 3 litres = 3 x$10^{-3}m^3$
Density of gas (ρ) = $1.29kg/m^3$

$m = \rho V_1$
$m = 1.293x(3x10^{-3}m^3)$
$m = 3.87x10^{-3}Kg$

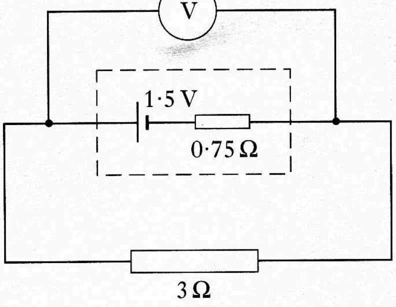
b.i. Pressure before pumping (P_{before}) = $1.01x10^5Pa$
Pressure after pumping (P_1) = $3.0x10^5Pa$

Volume of air before and after pumping(V_1) is fixed at $3x10^{-3}m^3$
Area(A) = $7.0x10^3m^2$

Back to Table Answers

Marks

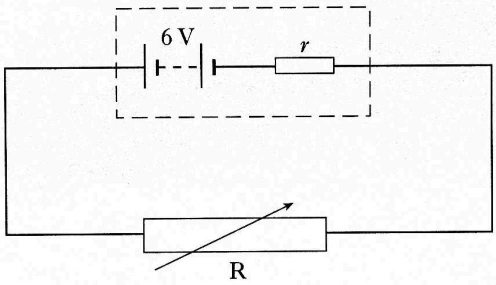
5. (*a*) A cell of e.m.f. 1·5 V and internal resistance 0·75 Ω is connected as shown in the following circuit.



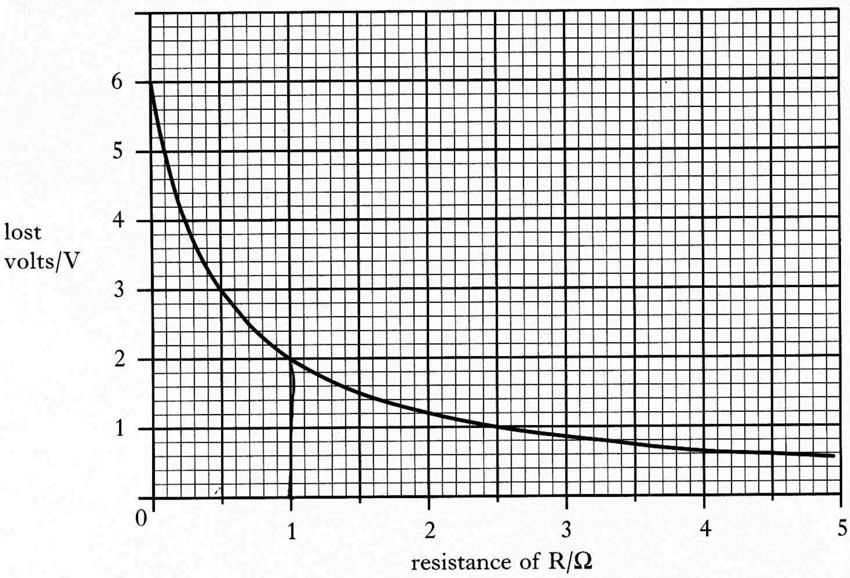
(i) Calculate the value of the reading on the voltmeter.

(ii) What is the value of the "lost volts" in this circuit? **5**

(*b*) A battery of e.m.f. 6 V and internal resistance, *r*, is connected to a variable resistor R as shown in the following circuit diagram.



The graph below shows how the "lost volts" of this battery changes as the resistance of R increases.



(i) Use information from the graph to calculate the p.d. across the terminals of the battery (t.p.d.) when the resistance of R is 1 Ω.

(ii) Calculate the internal resistance, *r*, of the battery. **4**

(9)

To calculate the force, after pumping, use: $P_1 = F/A$

$F = P_1A$

$F = 3.0x10^5x7.0x10^{-3}$

$F = 2100N$

b.ii. When the volume of the water is 2 litres, the volume of the gas in the container(V_2) is 6 litres,or $6x10^{-3}m^3$. The pressure at this time is P_2.

$P_1V_1 = P_2V_2$

$P_2 = P_1V_1/V_2$

$P_2 = 3x10^5x3x10^{-3}/6x10^{-3}$

$P_2 = 1.5x10^5Pa$

5.a.i. $V_{tpd} = emf - Ir$

$I = emf/(R+r)$

$I = 1.5/(3+0.75)$

$I = 1.5/3.75$

$I = 0.4A$

$V_{tpd} = 1.5 - 0.4x0.75$

$V_{tpd} = 1.2V$

a.ii. $V_{lost} = Ir$

$V_{lost} = 0.4x0.75$

$V_{lost} = 0.3V$

or

$emf = V_{tpd}+V_{lost}$

$V_{lost} = emf - V_{tpd}$

$V_{lost} = 1.5 - 1.2 = 0.3V$

b.i. $R = 1\Omega$

$V_{lost} = 2V$

$V_{tpd} = emf - V_{lost}$

$V_{tpd} = 6 - 2$

$V_{tpd} = 4V$

b.ii. $I = V_{tpd}/R_{variable}$

$I = 4/1$

$I = 4A$

$V_{lost} = Ir$

$r = V_{lost}/I$

$r = 2/4$

$r = 0.5\Omega$

$V_{lost} = emf - V_{tpd}$

$V_{lost} = 6 - 4 = 2V$

6.a. A capacitor of value 5μF will store 5 coulombs of charge per volt across it.

b.i. Initially all the supply voltage is across the resistor in the circuit. The current in the circuit at this point($I_{initial}$) is 30μA, as read from the graph.

$I_{initial} = 30\mu A = 30x10^{-6}A$

$V = 6V$

$R = ?$

$R = V/I$

$R = 6/30x10^{-6}$

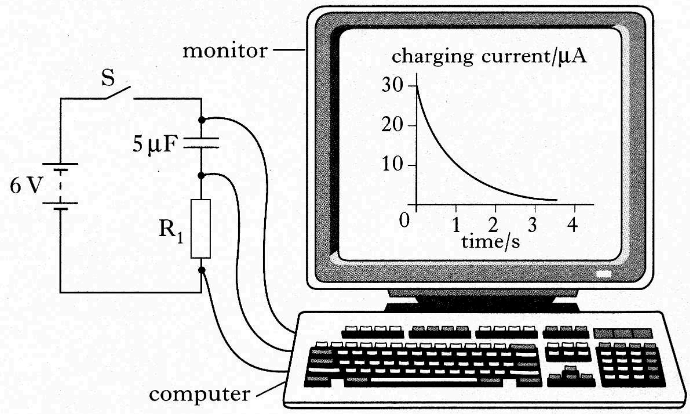
$R = 2x10^5\Omega$

b.ii. Halving the value of the resistor will double the initial charging current. Lowering

Marks

6. (*a*) A capacitor has a value of 5 μF. Explain in terms of electric charge what this means. **1**

(*b*) The 5 μF capacitor shown in the circuit below is initially uncharged. The circuit is connected to a computer and switch S is closed. The monitor of the computer displays a graph of current against time as the capacitor charges.



The battery has negligible internal resistance.

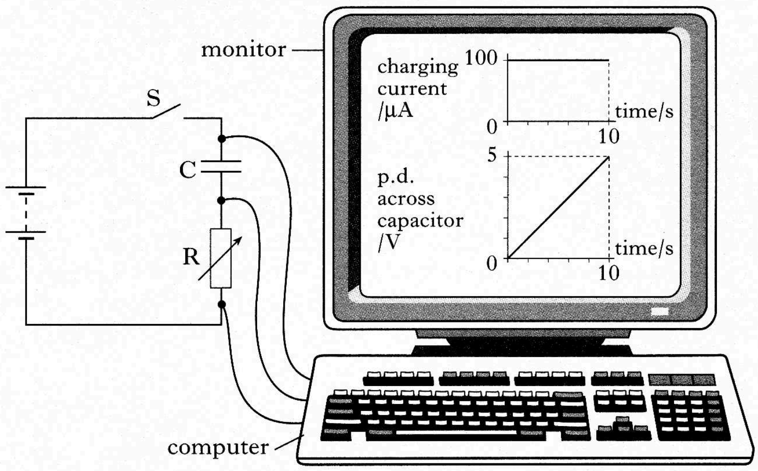
(i) Calculate the resistance of R_1.

(ii) The resistor R_1 is replaced by another resistor R_2. The resistance of R_2 is half that of R_1.

The capacitor is discharged and the experiment repeated.

Sketch the graph of charging current against time when R_2 is used. Include values on the axes. **3**

(*c*) In the following circuit a variable resistor R is used to keep the current constant as a different capacitor charges. The graphs on the monitor show how the charging current and p.d. across the capacitor vary with time after switch S is closed.



(i) What adjustment must be made to the variable resistor R so that a constant charging current is produced?

(ii) Show by calculation that 10 seconds after switch S is closed, the charge on the capacitor is 1mC.

(iii) Calculate the capacitance of C. **4**

(8)

To calculate the force, after pumping, use: $P_1 = F/A$

$F = P_1A$
$F = 3.0x10^5x7.0x10^{-3}$
$F = 2100N$

b.ii. When the volume of the water is 2 litres, the volume of the gas in the container(V_2) is 6 litres,or $6x10^{-3}m^3$. The pressure at this time is P_2.

$P_1V_1 = P_2V_2$
$P_2 = P_1V_1/V_2$
$P_2 = 3x10^5x3x10^{-3}/6x10^{-3}$
$P_2 = 1.5x10^5Pa$

5.a.i. $V_{tpd} = emf - Ir$

$I = emf/(R+r)$
$I = 1.5/(3+0.75)$
$I = 1.5/3.75$
$I = 0.4A$

$V_{tpd} = 1.5 - 0.4x0.75$
$V_{tpd} = 1.2V$

a.ii. $V_{lost} = Ir$ or $emf = V_{tpd}+V_{lost}$
$V_{lost} = 0.4x0.75$ $V_{lost} = emf - V_{tpd}$
$V_{lost} = 0.3V$ $V_{lost} = 1.5 - 1.2 = 0.3V$

b.i. $R = 1\Omega$
$V_{lost} = 2V$

$V_{tpd} = emf - V_{lost}$
$V_{tpd} = 6 - 2$
$V_{tpd} = 4V$

b.ii. $I = V_{tpd}/R_{variable}$
$I = 4/1$
$I = 4A$

$V_{lost} = Ir$ $V_{lost} = emf - V_{tpd}$
$r = V_{lost}/I$ $V_{lost} = 6 - 4 = 2V$
$r = 2/4$
$r = 0.5\Omega$

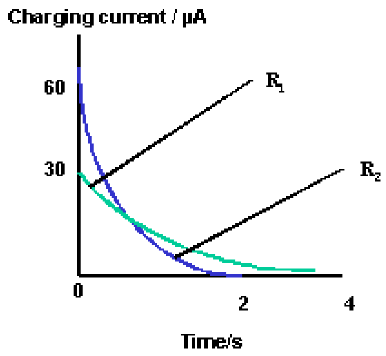
6.a. A capacitor of value 5μF will store 5 coulombs of charge per volt across it.

b.i. Initially all the supply voltage is across the resistor in the circuit. The current in the circuit at this point($I_{initial}$) is 30μA, as read from the graph.

$I_{initial} = 30\mu A = 30x10^{-6}A$
$V = 6V$
$R = ?$

$R = V/I$
$R = 6/30x10^{-6}$
$R = 2x10^5\Omega$

b.ii. Halving the value of the resistor will double the initial charging current. Lowering the resistance will also decrease the charging time.



c.i. The resistance of the variable resistor must be decreased to keep the charging current constant.

c.ii. To calculate the total charge transferred use: $Q = It$
The values for I and t are read from the graph.

$Q = ?$
$I = 100\mu A = 100\times10^{-6}A$
$t = 10s$

$Q = I\times t$
$Q = 100\times10^{-6}\times10$
$\mathbf{Q = 100\times10^{-5}C = 1\times10^{-3}C = 1mC}$

c.iii. To calculate the capacitance use: $Q = CV_{capacitor}$
At 10s $V_{capacitor} = 5V$

$Q = 1\times10^{-3}C$
$V_{capacitor} = 5V$
$C = ?$

$C = Q/V_{capacitor}$
$C = 1\times10^{-3}/5$
$\mathbf{C = 2\times10^{-4}F = 200\mu F}$

7.a.i. To calculate the kinetic energy(E_k) use : $E_k = mv^2/2$

$E_k = ?$
$m_e = 9.11\times10^{-31}kg$
$v = 4.2\times10^7 m/s$

$E_k = mv^2/2$
$E_k = 9.11\times10^{-31}\times(4.2\times10^7)^2/2$
$\mathbf{E_k = 8.03\times10^{-16}J}$

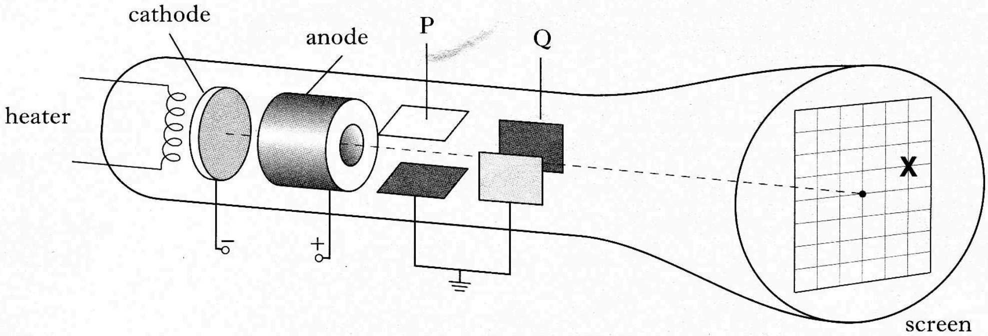
7.a.ii. The gain in the kinetic energy of the electron, with charge e, is a result of it being accelerated by a potential difference V.

$E_k(gain) = eV$
$V = E_k(gain)/e$
$V = 8.03\times10^{-16}/1.6\times10^{-19}$
$\mathbf{V = 5021.9V}$

b. Plate P can be made more positive to attract the electron. This will move the spot up vertically towards X.

Marks

7. The diagram below shows a cathode ray tube used in an oscilloscope.



The electrons which are emitted from the cathode start from rest and reach the anode with a speed of $4{\cdot}2 \times 10^7\ \mathrm{m\,s^{-1}}$.

(*a*) (i) Calculate the kinetic energy in joules of each electron just before is reaches the anode.

(ii) Calculate the p.d. between the anode and the cathode. **4**

(*b*) Describe how the spot at the centre of the screen produced by the electrons can be moved to position **X**.

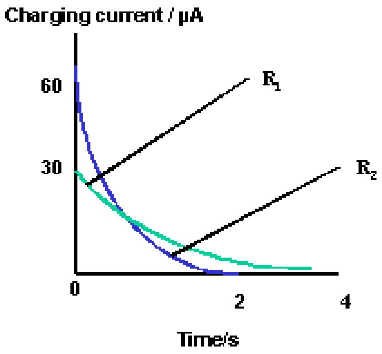
Your answer must make reference to the relative sizes and polarity (signs) of the voltages applied to plates P and Q. **2**

(6)

[Turn over

Back to Table

the resistance will also decrease the charging time.



c.i. The resistance of the variable resistor must be decreased to keep the charging current constant.

c.ii. To calculate the total charge transferred use: Q = It
The values for I and t are read from the graph.

$Q = ?$
$I = 100\mu A = 100\times10^{-6}A$
$t = 10s$

$Q = I\times t$
$Q = 100\times10^{-6}\times10$
$Q = 100\times10^{-5}C = 1\times10^{-3}C = 1mC$

c.iii. To calculate the capacitance use: $Q = CV_{capacitor}$
At 10s $V_{capacitor} = 5V$

$Q = 1\times10^{-3}C$
$V_{capacitor} = 5V$
$C = ?$

$C = Q/V_{capacitor}$
$C = 1\times10^{-3}/5$
$C = 2\times10^{-4}F = 200\mu F$

7.a.i. To calculate the kinetic energy(E_k) use : $E_k = mv^2/2$

$E_k = ?$
$m_e = 9.11\times10^{-31}kg$
$v = 4.2\times10^7 m/s$

$E_k = mv^2/2$
$E_k = 9.11\times10^{-31}\times(4.2\times10^7)^2/2$
$E_k = 8.03\times10^{-16}J$

7.a.ii. The gain in the kinetic energy of the electron, with charge e, is a result of it being accelerated by a potential difference V.

$E_k(gain) = eV$
$V = E_k(gain)/e$
$V = 8.03\times10^{-16}/1.6\times10^{-19}$
$V = 5021.9V$

b. Plate P can be made more positive to attract the electron. This will move the spot up vertically towards X.

[Back to Table]

Making Q more positive will attract the electron and move it horizontally towards X.If plate Q is made twice as positive as plate P the combined effect will be to move the spot to position X.

8.a.i. The amplifier is working in **inverting mode.**

a.ii. Gain = $-R_{feedback}/R_{input}$

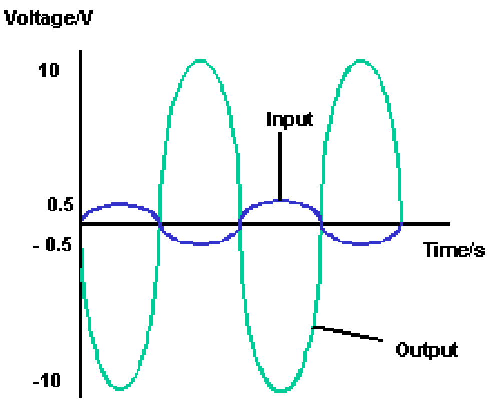
$R_{feedback} = 2\text{x}10^6\Omega$

$R_{input} = 100\text{x}10^3\Omega$

Gain = $-2\text{x}10^6/100\text{x}10^3$

Gain = -20

a.iii.



b.i. Between 2ms and 8ms the gain of the amplifier is said to be saturated. This is due to the fact that the output voltage from the amplifier cannot be greater than that supplied to it.

b.ii. To produce saturation you can:

- increase the size of the feedback resistor;
- decrease the size of the input resistor;
- increase the size of the input voltage.

9.a. $\Delta E_{32} = E_3 - E_2$

$\Delta E_{32} = -2.416\text{x}10^{-19} - (-5.524\text{x}10^{-19})$

$\Delta E_{32} = 3.006\text{x}10^{-19}\text{J}$

To calculate the wavelength of a photon of this energy use : $E = hf = hc/\lambda$

$\lambda = hc/E_{32}$

$\lambda = 6.63\text{x}10^{-34}\text{x}3\text{x}10^8/3.006\text{x}10^{-19}$

$\boldsymbol{\lambda = 6.617\text{x}10^{-7}\text{m} = 661.7\text{nm}}$

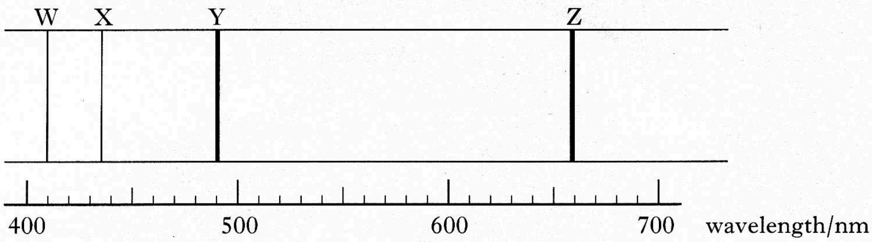
This corresponds to spectral line **Z.**

This answer can also be deduced by the fact that the photon produced by the transition between the energy levels E_3 and E_2has the lowest energy of the four in the diagram. This lowest energy photon will also have the longest wavelength,which is Z.

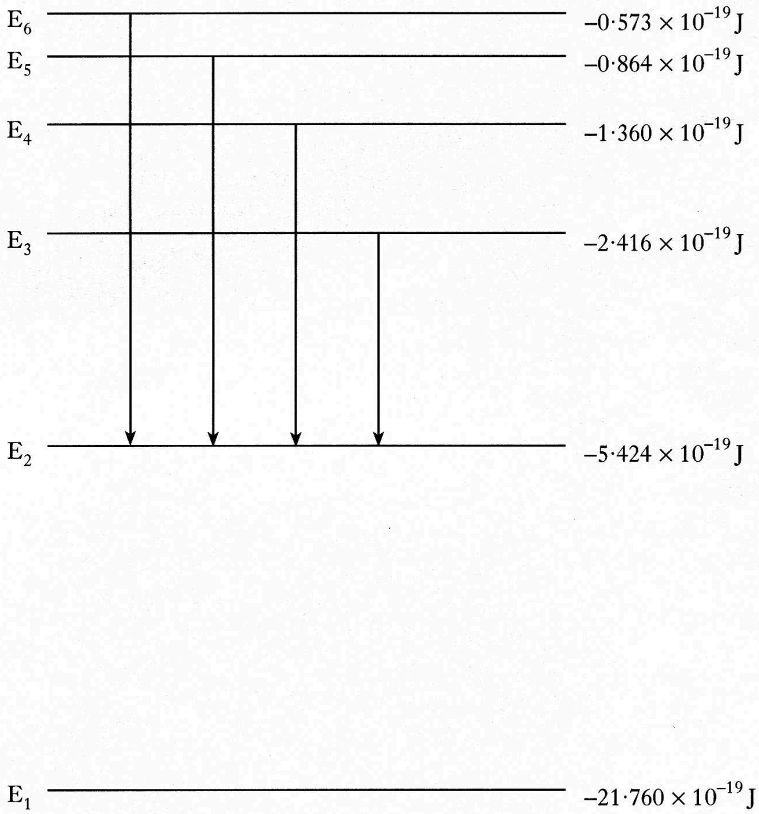
b. The more photons of a particular frequency emitted the brighter the spectral line will be. This means that there must be more electron transitions between the energy levels producing the lines Y and Z.

Marks

9. The line emission spectrum of hydrogen has four lines in the visible spectrum as shown in the following diagram.



These four lines are caused by electron transitions in a hydrogen atom from high energy levels to a low energy level E_2 as shown below.



(*a*) From the information above, state which spectral line W, X, Y or Z is produced by an electron transition from E_3 to E_2. **1**

(*b*) Explain why lines Y and Z in the line emission spectrum are brighter than the other two lines. **1**

(*c*) Infrared radiation of frequency $7{\cdot}48 \times 10^{13}$ Hz is emitted from a hydrogen atom.

(i) Calculate the energy of one photon of this radiation.

(ii) Show by calculation which electron transition produces this radiation. **4**

(6)

[Turn over

Back to Table

Making Q more positive will attract the electron and move it horizontally towards X.If plate Q is made twice as positive as plate P the combined effect will be to move the spot to position X.

8.a.i. The amplifier is working in **inverting mode.**

a.ii. Gain = $-R_{feedback}/R_{input}$

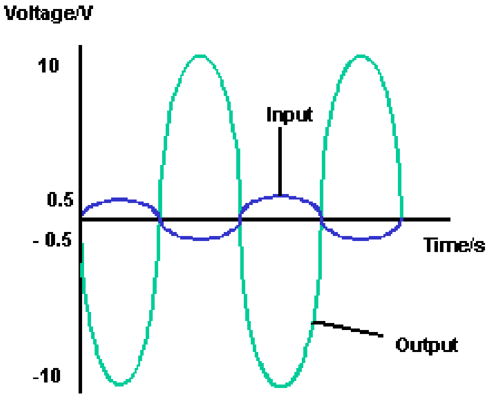
$R_{feedback} = 2x10^6\Omega$

$R_{input} = 100x10^3\Omega$

Gain = $-2x10^6/100x10^3$

Gain = -20

a.iii.



b.i. Between 2ms and 8ms the gain of the amplifier is said to be saturated. This is due to the fact that the output voltage from the amplifier cannot be greater than that supplied to it.

b.ii. To produce saturation you can:

- increase the size of the feedback resistor;
- decrease the size of the input resistor;
- increase the size of the input voltage.

9.a. $\Delta E_{32} = E_3 - E_2$

$\Delta E_{32} = -2.416x10^{-19} - (-5.524x10^{-19})$

$\Delta E_{32} = 3.006x10^{-19}J$

To calculate the wavelength of a photon of this energy use : $E = hf = hc/\lambda$

$\lambda = hc/E_{32}$

$\lambda = 6.63x10^{-34}x3x10^8/3.006x10^{-19}$

λ = **$6.617x10^{-7}$m = 661.7nm**

This corresponds to spectral line **Z.**

This answer can also be deduced by the fact that the photon produced by the transition between the energy levels E_3 and E_2has the lowest energy of the four in the diagram. This lowest energy photon will also have the longest wavelength,which is Z.

b. The more photons of a particular frequency emitted the brighter the spectral line will be. This means that there must be more electron transitions between the energy levels producing the lines Y and Z.

Back to Table

c.i. $E = hf$

$E = 6.63\text{x}10^{-34}\text{x}7.486\text{x}10^{13}$

$\mathbf{E = 4.96x10^{-20}J}$

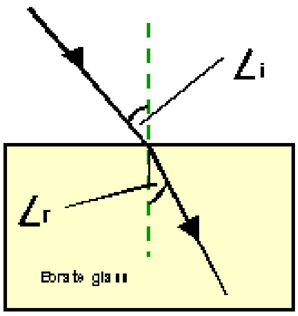
c.ii. $\Delta E_{54} = E_5 - E_4$

$\Delta E_{54} = -0.864\text{x}10^{-19} - (-1.360\text{x}10^{-19})$

$\Delta E_{54} = 4.96\text{X}10^{-20}\text{J}$

The transition between energy levels E_5 and E_4 produces the infrared photon.

10.a.i.



Angle i = 50^o

Angle r = 28^o

$n_{glass} = \sin(i)/\sin(r)$

$n_{glass} = \sin 50^o/\sin 28^o$

$n_{glass} = 0.766/0.496$

$n_{glass} = 1.63$

a.ii. $\theta_{critical} = \sin^{-1}(1/n)$

$\theta_{critical} = \sin^{-1}(1/1.63)$

$\theta_{critical} = \sin^{-1}(0.613)$

$\mathbf{\theta_{critical} = 37.8^o}$

b.i. $n_{quartz} = \lambda_{air}/\lambda_{quartz}$

$\lambda_{quartz} = \lambda_{air}/n_{quartz}$

$\lambda_{quartz} = 510/1.55$

$\mathbf{\lambda_{quartz} = 329nm}$

b.ii. As the wavelength of visible light increases the refractive index of the quartz(n_{quartz}) decreases. This means that ($1/n_{quartz}$) increases and therefore $\theta_{critical}[\sin^{-1}(1/n_{quartz})]$ also increases.

b.iii. Flint glass has a higher refractive index than crown glass for all wavelengths of light. This would result in the spectrum being projected onto a lower position on the screen. Additionally, because the difference in refractive index across the spectrum is greater with flint glass, the distance between the red end and the violet end of the spectrum, as appearing on the screen, would be greater.

11.a.i. To conserve atomic and mass number in the decay of Thorium to Palladium a beta particle(β, ${}^{0}_{-1}e$)is emitted.

a.ii. Number of neutrons(n) = mass number(A) - atomic number(Z)

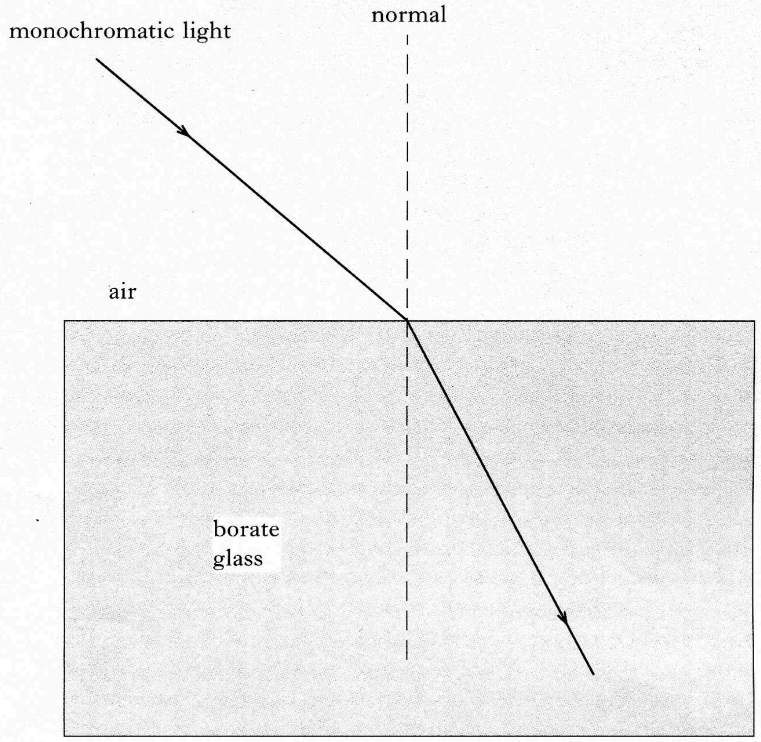
n = 238 - 92

n = 146

Marks

10. (*a*) The following diagram shows a ray of monochromatic light passing from air into a block of borate glass.

The diagram is drawn to scale.



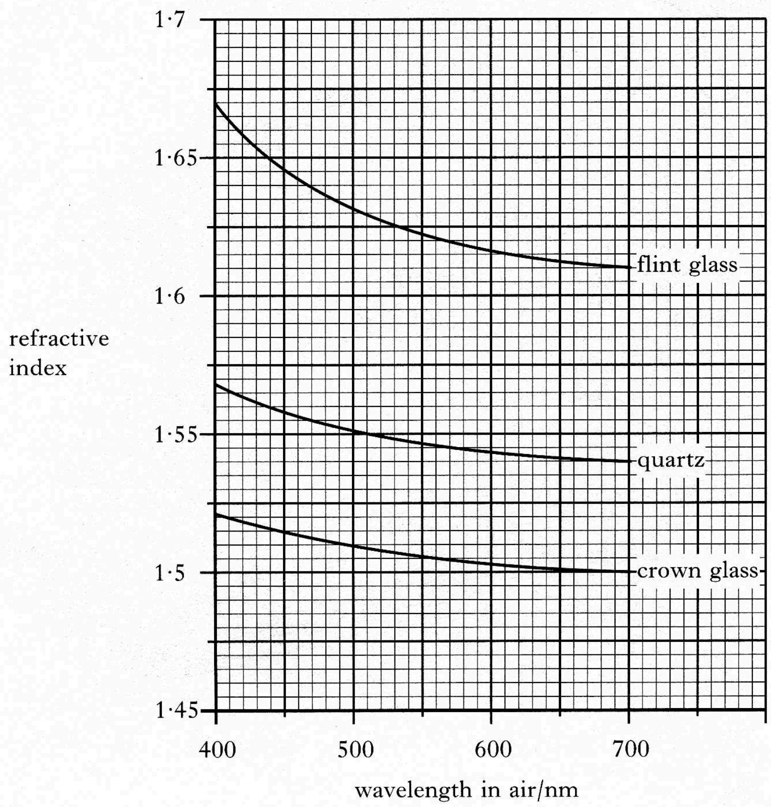
(i) Use measurements taken from the above diagram to calculate the refractive index of borate glass for this light. You will need to use a protractor.

(ii) Calculate the value of the critical angle for this light in the borate glass. **4**

Marks

10. (continued)

(*b*) The following graph shows how refractive index depends on the type of material and the wavelength in air of the light used.

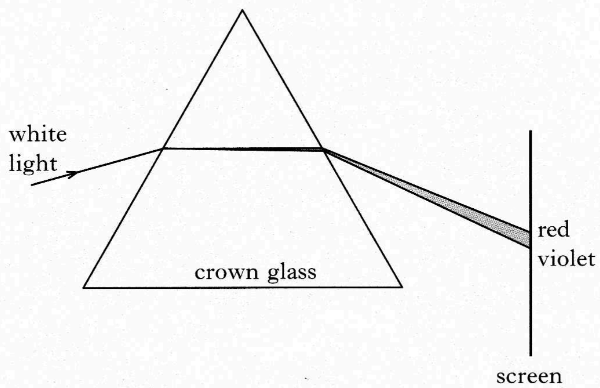


A ray of light of wavelength 510 nm in air passes into a block of quartz.

(i) Calculate the wavelength of this light in the quartz.

(ii) Explain what happens to the value of the critical angle in quartz as the wavelength of visible light increases.

(iii) A ray of white light enters a triangular prism made of crown glass, producing a visible spectrum on a screen, as shown below.



The crown glass prism is now replaced by a similar prism made from flint glass.

Describe how the visible spectrum on the screen will be different from before. **5**

(9)

 [Turn over for Question 11 on *Page fourteen*

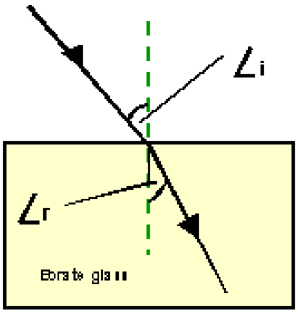
Back to Table

c.i. $E = hf$
$E = 6.63x10^{-34}x7.486x10^{13}$
$E = 4.96x10^{-20}J$

c.ii. $\Delta E_{54} = E_5 - E_4$
$\Delta E_{54} = -0.864x10^{-19}-(-1.360x10^{-19})$
$\Delta E_{54} = 4.96X10^{-20}J$

The transition between energy levels E_5 and E_4 produces the infrared photon.

10.a.i.



Angle i = 50^o
Angle r = 28^o

$n_{glass} = sin(i)/sin(r)$
$n_{glass} = sin\ 50^o/sin\ 28^o$
$n_{glass} = 0.766/0.496$
$n_{glass} = 1.63$

a.ii. $\theta_{critical} = sin^{-1}(1/n)$
$\theta_{critical} = sin^{-1}(1/1.63)$
$\theta_{critical} = sin^{-1}(0.613)$
$\theta_{critical} = 37.8^o$

b.i. $n_{quartz} = \lambda_{air}/\lambda_{quartz}$
$\lambda_{quartz} = \lambda_{air}/n_{quartz}$
$\lambda_{quartz} = 510/1.55$
$\lambda_{quartz} = 329nm$

b.ii. As the wavelength of visible light increases the refractive index of the quartz(n_{quartz}) decreases. This means that ($1/n_{quartz}$) increases and therefore $\theta_{critical}[sin^{-1}(1/n_{quartz})]$ also increases.

b.iii.Flint glass has a higher refractive index than crown glass for all wavelengths of light. This would result in the spectrum being projected onto a lower position on the screen. Additionally, because the difference in refractive index across the spectrum is greater with flint glass, the distance between the red end and the violet end of the spectrum, as appearing on the screen, would be greater.

11.a.i. To conserve atomic and mass number in the decay of Thorium to Palladium a beta particle(β, ${}^{0}_{-1}e$)is emitted.

a.ii. Number of neutrons(n) = mass number(A) - atomic number(Z)
n = 238 - 92
n = 146

Back to Table Answers

Marks

11. (*a*) The first three stages in a radioactive decay series are shown below.

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th \longrightarrow {}^{234}_{91}Pa \longrightarrow {}^{234}_{92}U$$

(i) What particle is emitted when Thorium (Th) decays to Palladium (Pa)?

(ii) How many neutrons are in the nuclide represented by $^{238}_{92}U$?

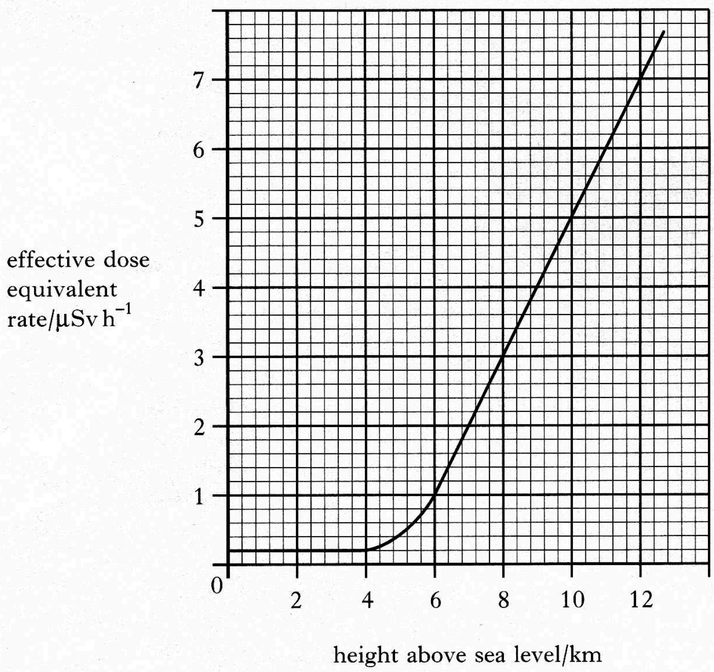
(iii) In the next stage of the above decay series, an alpha particle is emitted.

Copy and complete this stage of the radioactivity decay series shown below, giving values for a, b, c and d, and naming the element X.

$$^{234}_{92}U \longrightarrow {}^{a}_{b}X + {}^{c}_{d}\alpha$$

5

(*b*) The following graph shows how the effective dose equivalent rate due to background radiation varies with height above sea level.



(i) Name **two** sources of background radiation.

(ii) The graph shows that there is an increase in effective dose equivalent rate at altitudes greater than 4 km. Suggest a reason for this increase.

(iii) An aircraft makes a 7 hour flight at a cruising altitude of 10 km.

(A) Calculate the effective dose equivalent received by a passenger during this flight.

(B) A regular traveller makes 40 similar flights in one year and spends the rest of the year at sea level.

Calculate the effective dose equivalent of background radiation received by this traveller in that year.

8

(13)

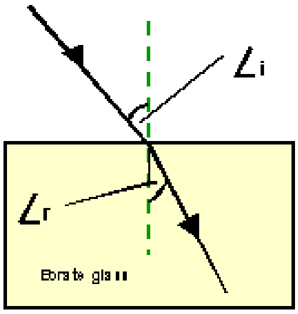
[END OF QUESTION PAPER]

c.i. $E = hf$
$E = 6.63\times10^{-34}\times7.486\times10^{13}$
$\mathbf{E = 4.96\times10^{-20}J}$

c.ii. $\Delta E_{54} = E_5-E_4$
$\Delta E_{54} = -0.864\times10^{-19}-(-1.360\times10^{-19})$
$\Delta E_{54} = 4.96\times10^{-20}J$

The transition between energy levels E_5 and E_4 produces the infrared photon.

10.a.i.



Angle i = 50^o
Angle r = 28^o

$n_{glass} = \sin(i)/\sin(r)$
$n_{glass} = \sin 50^o/\sin 28^o$
$n_{glass} = 0.766/0.496$
$n_{glass} = 1.63$

a.ii. $\theta_{critical} = \sin^{-1}(1/n)$
$\theta_{critical} = \sin^{-1}(1/1.63)$
$\theta_{critical} = \sin^{-1}(0.613)$
$\boldsymbol{\theta_{critical} = 37.8^o}$

b.i. $n_{quartz} = \lambda_{air}/\lambda_{quartz}$
$\lambda_{quartz} = \lambda_{air}/n_{quartz}$
$\lambda_{quartz} = 510/1.55$
$\boldsymbol{\lambda_{quartz} = 329nm}$

b.ii. As the wavelength of visible light increases the refractive index of the quartz(n_{quartz}) decreases. This means that $(1/n_{quartz})$ increases and therefore $\theta_{critical}[\sin^{-1}(1/n_{quartz})]$ also increases.

b.iii. Flint glass has a higher refractive index than crown glass for all wavelengths of light. This would result in the spectrum being projected onto a lower position on the screen. Additionally, because the difference in refractive index across the spectrum is greater with flint glass, the distance between the red end and the violet end of the spectrum, as appearing on the screen, would be greater.

11.a.i. To conserve atomic and mass number in the decay of Thorium to Palladium a beta particle(β, ${}^{0}_{-1}e$)is emitted.

a.ii. Number of neutrons(n) = mass number(A) - atomic number(Z)
n = 238 - 92
n = 146

Back to Table

a.iii. $^{234}_{92}U \rightarrow {}^{230}_{90}Th + {}^{4}_{2}He$

b.i. Soil and rocks containing natural radioactive isotopes, and cosmic rays, contribute to background radiation.

b.ii. The earths atmosphere absorbs cosmic radiation and reduces the effective dose equivalent rate at sea level. At heights above 4km there is less atmosphere to absorb the radiation which results in a higher dose equivalent rate at these rarefied altitudes.

b.iii.

(A)t = 7h

H/t = 5μSv/h

H = ?

H = tx5μSv/h

H = 7hx5μSv/h

H(flight) = 35μSv

(B)During 40 flights: H = 40x35μSv

H = 1400μSv (As a result of flights)

In addition to this the traveller will be exposed to sea level background radiation.
Time at sea level t_{sea} = (365x24)-(7x40) = 8480h

H(at sea level) = 8480hx0.2μSv/h

H(at sea level) = 1696μSv

H(total) = H(at sea level) + H(flight)

H(total) = 1696μSv + 1400μSv

H(total) = 3096μSv = 3.096(mSv/year)

END OF PAPER

Return to past paper index page.

1999 Paper 1 (Multiple Choice)

Back to Table

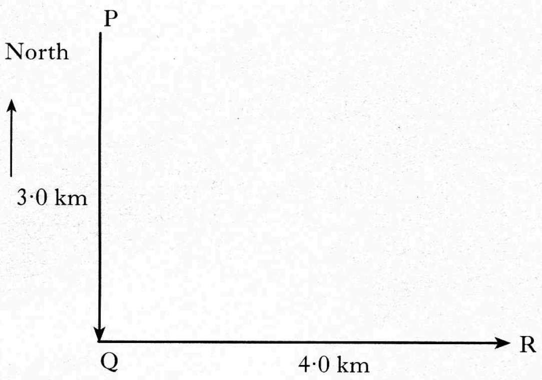
1. C	11. B	21. A
2. A	12. B	22. A
3. E	13. B	23. D
4. E	14. D	24. A
5. C	15. B	25. D
6. D	16. C	26. D
7. C	17. E	27. C
8. B	18. D	28. B
9. D	19. C	29. D
10.D	20. B	30. E

Back to Table Answers

SECTION A

Answer questions 1–30 on the answer sheet.

1. A long-distance athlete runs from point P to point Q and then jogs to point R.

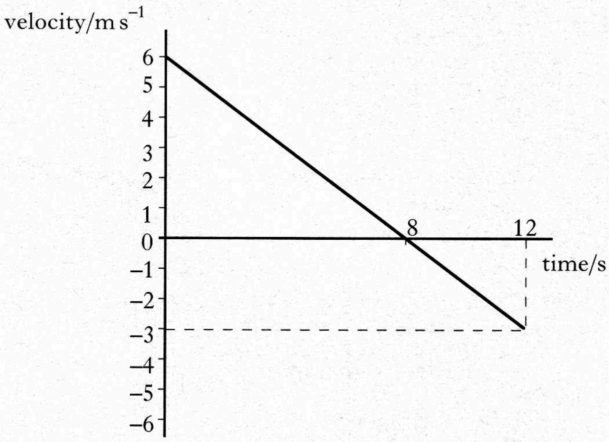


She takes 20 minutes to run from P to Q and then a further 40 minutes to jog from Q to R.

Which row in the following table correctly gives her average speed and her average velocity for the whole journey from P to R?

	Average speed	*Average velocity*
A	7·0 km h^{-1}	5·0 km h^{-1} on a bearing of 143°
B	7·0 km h^{-1}	7·0 km h^{-1} on a bearing of 127°
C	7·0 km h^{-1}	5·0 km h^{-1} on a bearing of 127°
D	5·0 km h^{-1}	7·0 km h^{-1} on a bearing of 127°
E	5·0 km h^{-1}	5·0 km h^{-1} on a bearing of 143°

2. The velocity-time graph for an object travelling along a straight line is shown below.



The displacement of the object during the first 12 seconds is

A 18 m

B 24 m

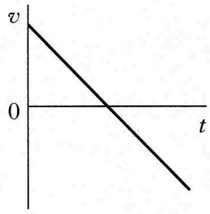
C 30 m

D 36 m

E 54 m.

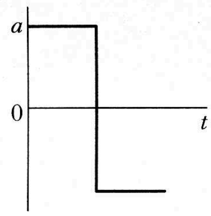
[Turn over

3. The velocity-time graph for an object travelling in a straight line is shown below.

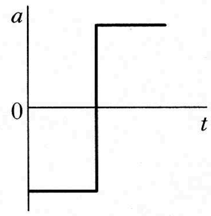


Which one of the following is the corresponding acceleration-time graph?

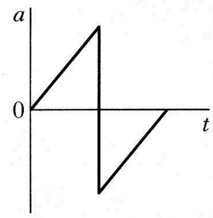
A



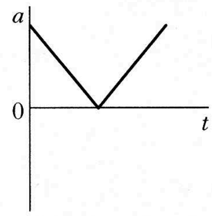
B



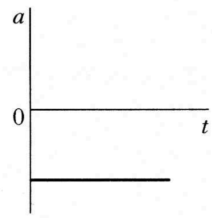
C



D



E



4. In the equation $s = ut + \frac{1}{2}at^2$ for an object moving in a straight line with a uniform acceleration "a", the term "ut" represents

A the initial velocity of the object

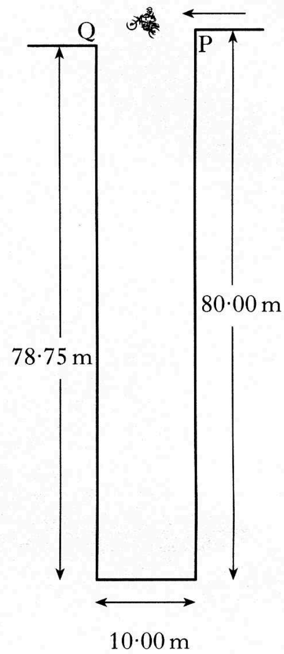
B the initial acceleration of the object

C the velocity of the object after t seconds

D the acceleration of the object after t seconds

E the displacement of the object after t seconds if the acceleration is zero.

5. A motorcycle stunt involves crossing a ravine from P to Q. The motorcycle is travelling horizontally when it leaves point P.



Neglecting air resistance and taking the acceleration due to gravity to be $10\,\text{m}\,\text{s}^{-2}$, the time taken to cross the ravine from P to Q is

A 0·125 s

B 0·25 s

C 0·5 s

D 1·0 s

E 4·0 s.

6. A crane on an oil-rig is used to raise a sunken buoy from the seabed. The weight of the buoy is 4900 N and the buoyancy force (upthrust) acting on it is 1000 N. When the buoy is being raised vertically at a constant speed, a force of 800 N acts on it due to water resistance.

What is the size of the force which the vertical cable applies to the buoy?

A 200 N

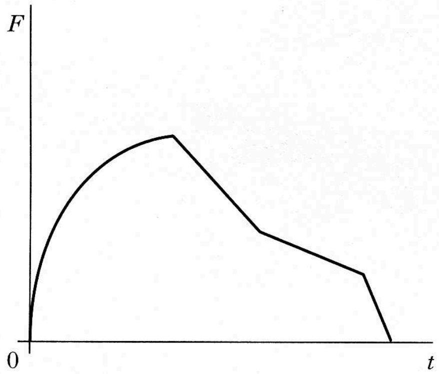
B 1800 N

C 3100 N

D 4700 N

E 6700 N

7. The graph below shows how the force, F, exerted on an object varies with time t.



The area under the graph represents the object's change of

A acceleration

B velocity

C momentum

D kinetic energy

E potential energy.

8. A spacecraft of mass 1200 kg has landed on a planet where the gravitational field strength is $5\,N\,kg^{-1}$. The spacecraft rests on three pads, each of contact area $0{\cdot}5\,m^2$. The pressure exerted by these three pads on the surface of the planet is

A $8{\cdot}0 \times 10^2$ Pa

B $4{\cdot}0 \times 10^3$ Pa

C $7{\cdot}8 \times 10^3$ Pa

D $9{\cdot}0 \times 10^3$ Pa

E $1{\cdot}2 \times 10^4$ Pa.

9. A girl wrote the following statements in her physics notebook.

I The pressure of a fixed mass of gas varies inversely as its volume, provided the temperature of the gas remains constant.

II The pressure of a fixed mass of gas varies directly as its kelvin temperature, provided the volume of the gas remains constant.

III A temperature **change** of 20 °C in a gas is the same as a temperature **change** of 293 K.

Which of the above statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

10. On a cold morning, a motorist checks the pressure of the air in one of her car tyres. It is found to be $3{\cdot}0 \times 10^5$ Pa at a temperature of 2 °C.

After a long run on a motorway, the temperature of the air in the tyre rises to 57 °C. The volume of the air in the tyre remains constant and no air escapes.

Which row in the following table gives the correct value of the final pressure of the air in the tyre and a correct statement about the final density of the air in the tyre compared to the initial density?

	Final pressure of air	*Final density of air*
A	$8{\cdot}6 \times 10^6$ Pa	greater
B	$8{\cdot}6 \times 10^6$ Pa	same
C	$8{\cdot}6 \times 10^6$ Pa	less
D	$3{\cdot}6 \times 10^5$ Pa	same
E	$3{\cdot}6 \times 10^5$ Pa	less

[Turn over

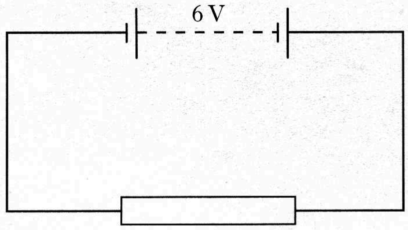
11. A pupil is given three resistors of values 2·0 Ω, 3·0 Ω and 6·0 Ω.

She is told to connect **all three** resistors together.

What are the values of the smallest possible resistance and the largest possible resistance which she could obtain by connecting all three resistors?

	Smallest resistance/Ω	*Largest resistance*/Ω
A	1·0	36·0
B	1·0	11·0
C	2·0	36·0
D	2·0	11·0
E	4·0	36·0

12. In the following circuit, the battery has an e.m.f. of 6 V and negligible internal resistance.



The energy required to move one coulomb of charge round this circuit is

A 3 J

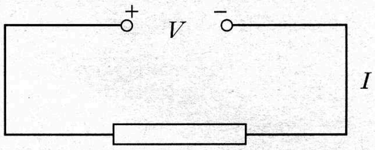
B 6 J

C 12 J

D 18 J

E 72 J.

13. When the potential difference across a heater of resistance R ohms is V volts, there is a current of I amperes in the heater.



The power of the heater, in watts, is given by

A IR

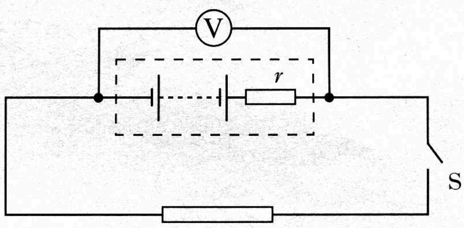
B $\frac{V^2}{R}$

C $\frac{V}{I}$

D V^2R

E IR^2.

14. A pupil sets up the following circuit to measure the internal resistance r of a battery.



The reading on the voltmeter is 12·0 V when switch S is open. The reading drops to 10·0 V when switch S is closed.

The internal resistance of the battery is

A 0·00 Ω

B 0·05 Ω

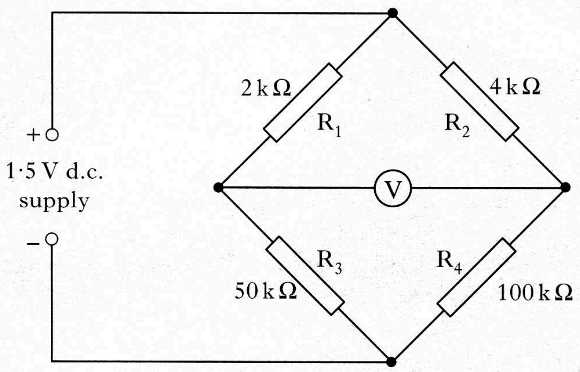
C 16·7 Ω

D 20·0 Ω

E 100·0 Ω.

Back to Table Answers

15. A balanced Wheatstone bridge circuit is set up as shown.



Which of the following changes will cause the Wheatstone bridge to be changed to an out-of-balance condition?

I Doubling the value of R_1 and doubling the value of R_2

II Doubling the value of R_1 and doubling the value of R_4

III Doubling the voltage of the supply

A I only

B II only

C I and II only

D II and III only

E I, II and III

16. An alternating voltage produces a trace on an oscilloscope screen as shown in Figure 1. The boxes on the screen measure 1 cm × 1 cm.

The time-base setting of the oscilloscope is 50 milliseconds per centimetre.

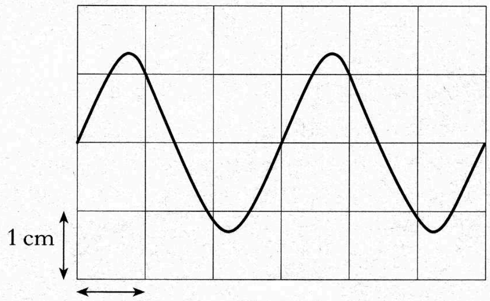


Figure 1

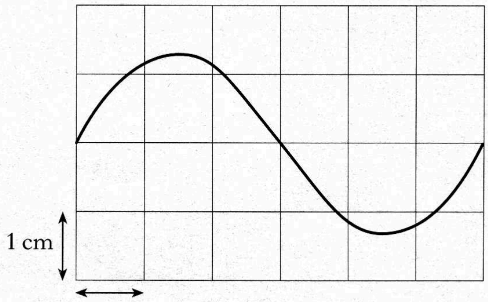


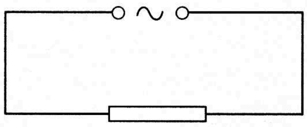
Figure 2

How should the oscilloscope controls be adjusted to change the trace on the screen to that shown in Figure 2?

	Y-amplification	*Time-base setting (in ms per cm)*
A	increased	100
B	unchanged	100
C	unchanged	25
D	increased	50
E	decreased	25

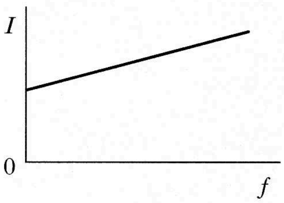
[Turn over

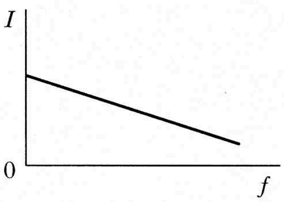
17. A resistor is connected across a signal generator, as shown below.

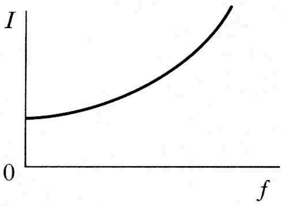


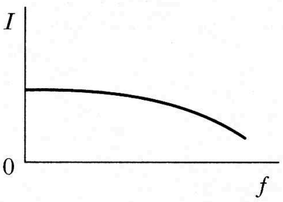
The r.m.s. voltage of the signal generator remains constant.

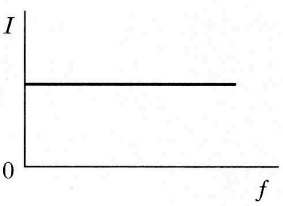
Which of the following graphs shows how the r.m.s. current I varies with frequency f in this circuit?

A


B


C


D


E


18. The farad is equivalent to the

A volt per coulomb

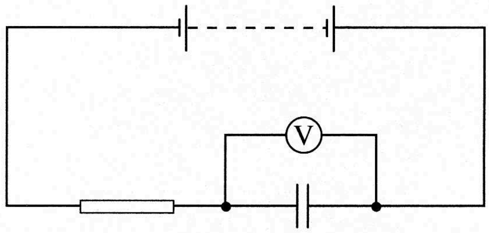
B ampere per volt

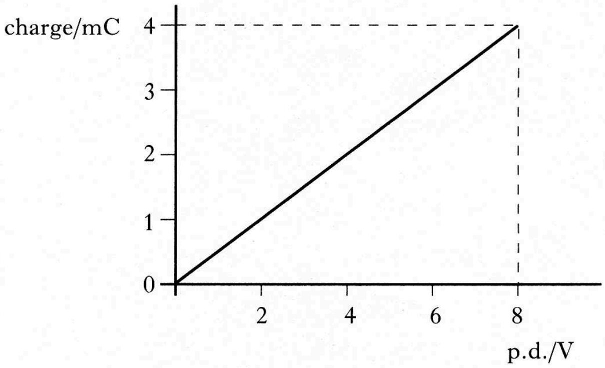
C joule per coulomb

D coulomb per volt

E coulomb per joule.

19. In the following circuit, a capacitor is being charged up from a d.c. supply. The graph shows how the charge on the capacitor depends on the p.d. across the capacitor.





The energy stored in the capacitor when the p.d. across it is 8 V is

A 0·25 mJ

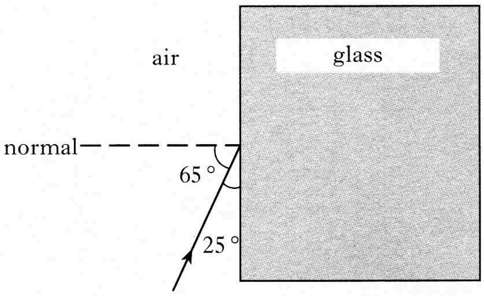
B 0·5 mJ

C 16 mJ

D 32 mJ

E 128 mJ.

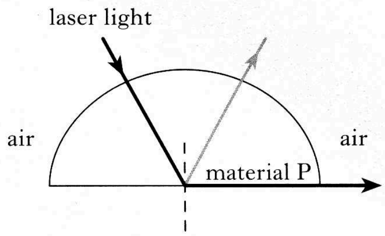
21. A ray of monochromatic light of frequency $6{\cdot}0 \times 10^{14}$ Hz in air is incident upon a block of glass of refractive index 1·5, as shown below.

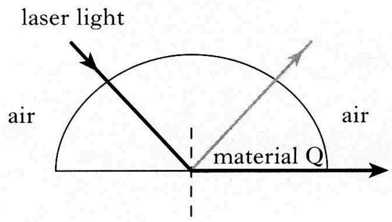


Which row in the table below gives the angle of refraction and the frequency of the light in the block of glass?

	Angle of refraction in glass	*Frequency in glass/* Hz
A	37 °	$6{\cdot}0 \times 10^{14}$
B	37 °	$4{\cdot}0 \times 10^{14}$
C	16 °	$6{\cdot}0 \times 10^{14}$
D	16 °	$4{\cdot}0 \times 10^{14}$
E	37 °	$9{\cdot}0 \times 10^{14}$

22. A student uses a beam of laser light to investigate critical angle. He uses two semicircular blocks made from different transparent materials, P and Q. In the following diagrams, the incident rays of light are shown at their critical angles.





Which of the following statements is/are true?

I Material P has a higher refractive index than material Q.

II The wavelength of the laser light is longer inside material P than inside material Q.

III The laser light travels at the same speed inside materials P and Q.

A I only

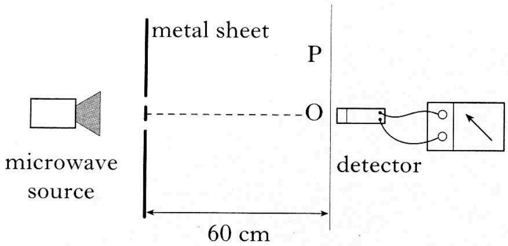
B II only

C III only

D I and II only

E I, II and III

23. Microwaves with a wavelength of 3 cm in air are sent towards two slits in a metal sheet, as shown below.



With the detector at a distance of 60 cm from the metal sheet, a position of maximum intensity is obtained at the central position O.

The detector is moved up from position O until the next maximum is obtained at position P.

A second microwave source with a different wavelength then replaces the first source. It produces its first MINIMUM at position P.

The wavelength of the second microwave source is

A 1·5 cm

B 2·5 cm

C 4·5 cm

D 6·0 cm

E 20·0 cm.

24. Which row in the following table gives the approximate wavelengths of red, green and blue light in nanometres?

	Red light/nm	*Green light*/nm	*Blue light*/nm
A	700	550	480
B	700	480	550
C	900	700	550
D	700	550	300
E	480	550	700

25. In the following passage, three words have been replaced by the letters X, Y and Z.

"The intensity of light incident on a surface is equal to the X per square metre. The intensity is Y proportional to the square of the distance from a point source of light, which means that, if the distance from the source is Z, the new intensity is a quarter of the initial value."

Which of the following gives the correct words for X, Y and Z?

	X	Y	Z
A	energy	directly	doubled
B	energy	inversely	doubled
C	power	directly	quartered
D	power	inversely	doubled
E	power	inversely	quadrupled

26. Ultraviolet radiation is incident on a zinc plate. Photoelectrons with a certain maximum kinetic energy are released from the zinc. The intensity of the ultraviolet radiation is now increased.

What happens to the maximum kinetic energy of the photoelectrons and the rate at which they are released?

	Maximum kinetic energy of the photoelectrons	*Rate at which photoelectrons are released*
A	increases	increases
B	decreases	increases
C	increases	remains the same
D	remains the same	increases
E	remains the same	remains the same

[Turn over

27. The minimum energy required to eject an electron from a certain metal is $3{\cdot}0 \times 10^{-19}$ J. Light of frequency $4{\cdot}8 \times 10^{14}$ Hz is incident on this metal.

Which of the following statements is correct?

A Electrons will not be ejected from the metal.

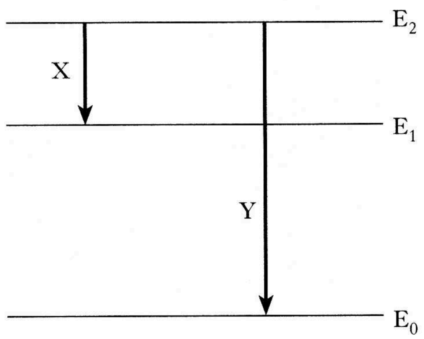
B Electrons will be ejected with 0 J of kinetic energy.

C Electrons will be ejected with $1{\cdot}8 \times 10^{-20}$ J of kinetic energy.

D Electrons will be ejected with $3{\cdot}2 \times 10^{-19}$ J of kinetic energy.

E Electrons will be ejected with $6{\cdot}2 \times 10^{-19}$ J of kinetic energy.

28. Part of the energy level diagram for a certain atom is shown below.



A student makes the following statements.

I Photons of higher frequency will be emitted during transition Y than during transition X.

II Photons of longer wavelength will be emitted during transition X than during transition Y.

III When an electron is in the lowest energy level, the atom is ionised.

Which of the above statements is/are true?

A I only

B I and II only

C I and III only

D II and III only

E I, II and III

29. In a nuclear reactor, Uranium 239 decays into nuclide X by emitting a beta particle, as shown in the following reaction.

$$^{239}_{92}\text{U} \longrightarrow \text{X} + \beta$$

Which row in the table gives the correct information about the nuclide X?

	Mass Number	*Atomic Number*
A	235	90
B	238	92
C	239	92
D	239	93
E	239	91

30. During an experiment to measure the specific heat capacity of a liquid, the relationship $V\,I\,t = c\,m\,\Delta T$ is used.

The following quantities are measured.

$V = 12{\cdot}0 \pm 0{\cdot}1$ V

$I = 4{\cdot}2 \pm 0{\cdot}1$ A

$t = 300 \pm 1$ s

$m = 500 \pm 2$ g

$\Delta T = 15 \pm 1$ °C

Which quantity will contribute the largest uncertainty to the final answer for the specific heat capacity, c?

A Voltage

B Current

C Time

D Mass

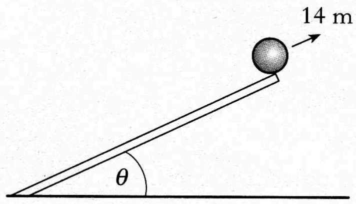
E Temperature change

SECTION B

Write your answers to questions 31 to 37 in the answer book.

Marks

31. A ball is rolled up a slope so that it is travelling at 14 m s^{-1} as it leaves the end of the slope.



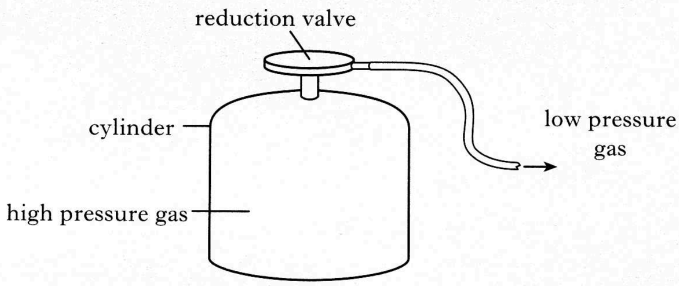
(*a*) The slope is set so that the angle to the horizontal, θ, is 30°.

Calculate the vertical component of the velocity of the ball as it leaves the slope.

(*b*) The slope is now tilted so that the angle to the horizontal, θ, is increased. The ball is rolled so that it still leaves the end of the slope at 14 m s^{-1}.

Describe and explain what happens to the maximum height reached by the ball. **3**

32. Gas is often stored in cylinders at high pressure. The pressure of the gas must be reduced by a reduction valve before the gas can be used.



The pressure of the gas in the cylinder is 20×10^5 Pa. The pressure of the gas as it leaves the reduction valve is 4×10^5 Pa.

Gas with a volume of 0·01 m^3 enters the reduction valve from the cylinder. What is the volume of this gas when it leaves the reduction valve, assuming that the temperature of the gas does not change? **2**

[Turn over

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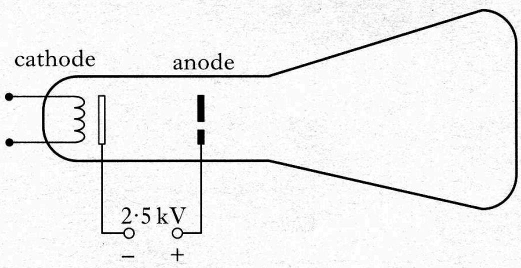
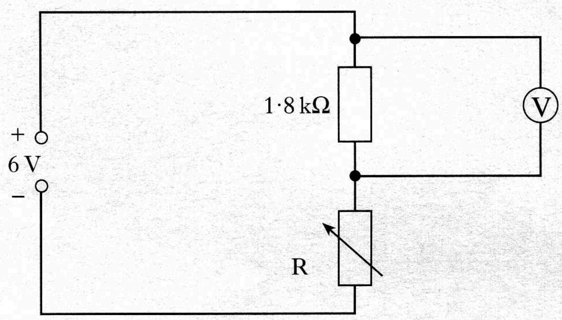
Marks

33. The diagram shows an arrangement which is used to accelerate electrons.
The potential difference between the cathode and the anode is 2·5 kV.



Assuming that the electrons start from rest at the cathode, calculate the speed of an electron just as it reaches the anode. **3**

34. A 1·8 kΩ resistor and a variable resistor, R, are connected to a 6 volt d.c. supply as shown. The supply has negligible internal resistance. A voltmeter is used to measure the potential difference across the 1·8 kΩ resistor.

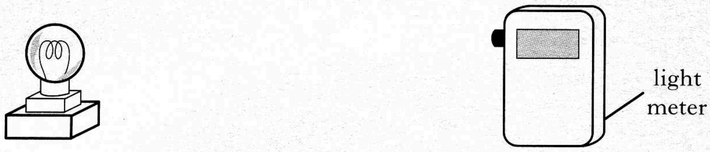


(*a*) Calculate the potential difference across the 1·8 kΩ resistor when the variable resistor, R, has a value of 1·2 kΩ.

(*b*) The resistance of the variable resistor, R, is increased. Explain why the reading on the voltmeter decreases. **3**

Marks

35. (*a*) A light meter is used to measure the intensity of light from a small lamp.



At a distance of 1·5 m from the lamp, the intensity of the light is 0·60 W m^{-2}. What is the intensity at a distance of 4·5 m from the lamp?

(*b*) At a distance of 1·5 m from a laser, the intensity of the laser light is 400 W m^{-2}.

What is the intensity of the laser light at a distance of 4·5 m from the laser? Justify your answer. **4**

36. Energy is released from stars as a result of nuclear reactions.

One of these reactions is represented by the statement given below.

$$^{14}_{7}N + ^{4}_{2}He \longrightarrow ^{18}_{9}F + \text{gamma radiation}$$

(*a*) What type of nuclear reaction is described by this statement?

(*b*) Explain why this reaction results in the release of energy. You should make reference to an equation in your explanation. **3**

37. When introducing optoelectronics to a class, a Physics teacher writes:

"One of the important factors affecting *photoelectric emission* from a metal is the *threshold frequency* for the metal".

Explain the meaning of the terms:

(*a*) photoelectric emission;

(*b*) threshold frequency. **2**

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2. **A**	12. **B**	22. **A**
3. **E**	13. **B**	23. **D**
4. **E**	14. **D**	24. **A**
5. **C**	15. **B**	25. **D**
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7. **C**	17. **E**	27. **C**
8. **B**	18. **D**	28. **B**
9. **D**	19. **C**	29. **D**
10.**D**	20. **B**	30. **E**

31. a. V(vertical)=V(resultant)xsin30
V=14xsin30
V=7(m/s)

b. The maximum height reached is calculated using:

$v^2=u^2 + 2as$

OR

$s=(v^2-u^2)/2a$

Note that it is the vertical components of motion that are being considered in this equation and that at the maximum height the vertical component of the velocity is zero, reducing the above equation to:

$s=-u^2/2a$

With increasing θ u(vertical) is increased. Thus the vertical displacement(height), calculated using the above equation, is increased.

32. Use Boyles law $P_1V_1=P_2V_2$ to solve this problem.

$P_1=20x10^5Pa$
$V_1=0.01m^3$
$P_2=4x10^5Pa$
$V_2=?$

$V_2=P_1V_1/P_2$
$V_2=20x10^5Pax0.01m^3/4x10^5Pa$
$\mathbf{V_2=0.05m^3}$

33. Energy gained by the electron in the electric field is calculated using E=qV.
The kinetic energy of the electron is calculated using $E=mv^2/2$

Equating these two equations gives:

$mv^2/2=qV$
or
$v=(2qV/m)^{1/2}$
$v=(2x1.6x10^{-19}x2500/9.11x10^{-31})^{1/2}$
$v=(8x10^{-16}/9.11x10^{-31})^{1/2}$
$v=(8.78x10^{14})^{1/2}$
$v= 29.63x10^6 m/s$

34. a. Use the potential divider voltage formula V(R1)=[R1/(R1+R2)]xV(S)for this problem.

V(R1)=Voltage across fixed resistor=1.8kΩ
V(S)=Supply Voltage=6V

V(R1)=[1.8kΩ/(1.8kΩ+1.2kΩ)]x6
V(R1)=0.6x6
V(R1)=3.6V

b. The Voltage in the circuit is divided according to the equation V(s)=V(R1)+V(variable).

When the resistance of the variable resistor is increased the voltage across it increases. This means that the voltage across the fixed resistor must decrease if the two voltages add up to equal the supply voltage.

35. a. Use the equation $I_1d_1^2=I_2d_2^2$

$I_1=0.60W/m^2$	$I_2=I_1d_1^2/d_2^2$
$d_1=1.5m$	$I_2=0.60W/m^2x(1.5m^2)^2/(4.5m^2)^2$
$I_2=$? W/m^2	**$I_2=0.067W/m^2$**
$d_2=4.5m$	

b. The light from the laser does not spread out in all directions as is the case with a standard filament bulb. This means that the intensity of the beam does not decrease with distance. The intensity at 4.5m and at 1.5m have a value of $400W/m^2$.

36. a. Two nuclei join in this nuclear reaction, therefore, it is described as a **fusion reaction**.
b. The mass of the product $^{18}{}_9F$ is less than the sum of the masses of the two reactants, $^{14}{}_7N$ and $^4{}_2H$.
This difference in mass, called the mass defect(m), is converted into energy (E). The amount of energy is calculated using the equation $E=mc^2$, where c represents the speed of light.

37. a. Photoelectric emission is used to describe the process where electrons absorb quantised energy, of a sufficient amount, from electromagnetic radiation to enable them to escape from the metal in which they are bound.
b. The threshold frequency describes the lowest frequency that the electromagnetic radiation can have to stimulate photoelectric emission.

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