[3220/239] 1987

SCOTTISH CERTIFICATE OF EDUCATION

PHYSICS

Higher Grade—PAPER I

Wednesday, 6th May—9.30 a.m. to 11.00 a.m.

READ CAREFULLY

1. **Check that the answer sheet provided is for Physics Higher I.**
2. **Fill in the details required on the answer sheet.**
3. **In this paper QUESTIONS 1–32 are answered by indicating the choice A, B, C, D or E by a stroke made in INK in the appropriate place in the answer sheet—see the sample question below.**
4. **Each of QUESTIONS 33–40 consists of a problem with a numerical answer. Insert the answer in INK in the space provided on the answer sheet—see the sample question below. Note that the units to be used are already filled in.**
5. **For each question there is only ONE correct answer.**
6. **Use the approximation $g = 10\,m\,s^{-2}$ or $g = 10\,N\,kg^{-1}$.**
7. **Reference may be made to the booklets of Mathematical Tables and Science Data provided (1982 editions).**
8. **Rough working, if required, should be done only on this question paper, or on the rough working sheet provided—NOT on the answer sheet.**

SAMPLE QUESTION FOR QUESTIONS 1–32

The momentum of a body is the product of

A mass and velocity squared

B mass and velocity

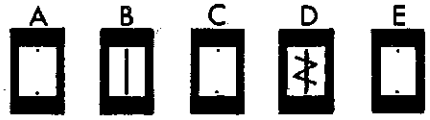
C mass and acceleration

D force and velocity

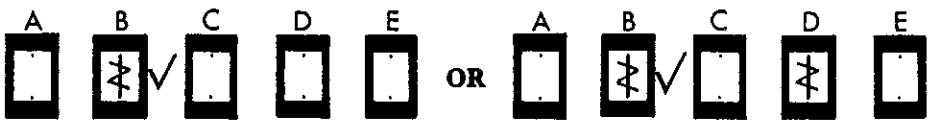
E force and displacement.

The correct answer is B—mass and velocity. A **heavy** vertical line should be drawn joining the two dots in the appropriate box in the column headed B as shown in the example below.

If after you have recorded your answer you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer D to an answer B, your answer sheet would look like this:



If you want to change back to an answer which has already been scored out, you should enter a tick (√) to the RIGHT of the box of your choice, thus:



SAMPLE QUESTION FOR QUESTIONS 33–40

What force is required to give an acceleration of $4\,m\,s^{-2}$ to a mass of 4 kg?

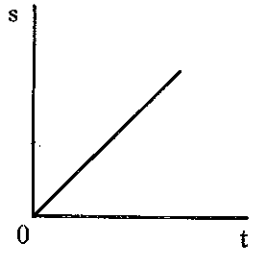
The correct answer is 16 N. The response should be as shown:

16	N

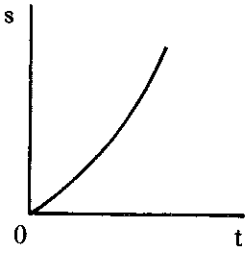
UCP 3220/239 6/3/20560

1. A car is accelerating uniformly in a straight line. Which of the following displacement–time graphs could represent its motion?

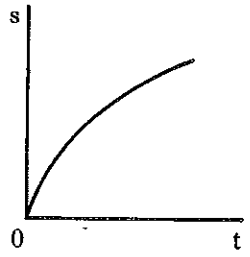
A



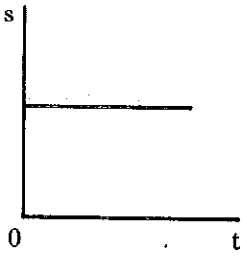
B



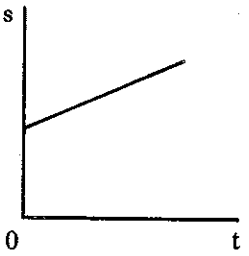
C



D



E



2. The acceleration due to gravity is $10\,m\,s^{-2}$ on Earth and $26\,m\,s^{-2}$ on another planet. On Earth, a ball released from rest takes 0·5 s to drop through a certain height.

Assuming that the resistance of the atmospheres can be neglected in both cases, the time for the ball to drop from rest through the same height on the other planet would be

A $0{\cdot}5 \times \frac{10}{26}$ s

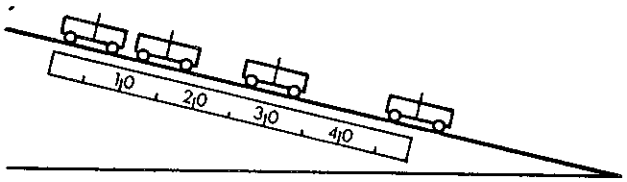
B $0{\cdot}5 \times \frac{26}{10}$ s

C $0{\cdot}5 \times \sqrt{\frac{10}{26}}$ s

D $0{\cdot}5 \times \sqrt{\frac{26}{10}}$ s

E $0{\cdot}5 \times \left(\frac{10}{26}\right)^2$ s .

3. The diagram represents a stroboscope photograph of a trolley, taken while the trolley was running down a slope.



A half-metre stick was used to show the distances and the frequency of the stroboscope was set at 5·0 Hz.

What was the acceleration of the trolley in $m\,s^{-2}$?

A 0·20

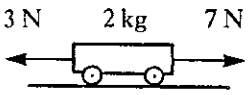
B 1·0

C 1·25

D 25

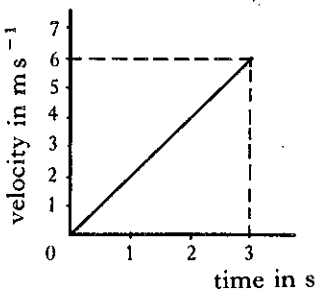
E 125

4. The forces shown below act on the trolley of mass 2 kg which is originally at rest on a level surface.

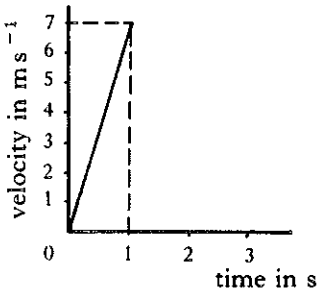


The velocity–time graph for the trolley is

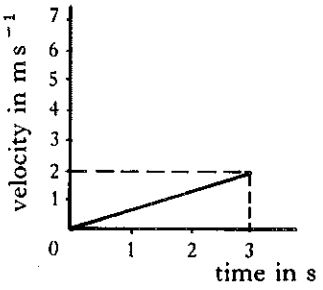
A



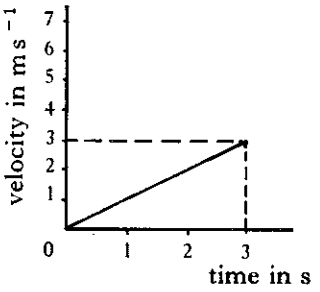
B



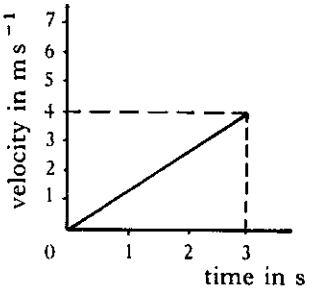
C



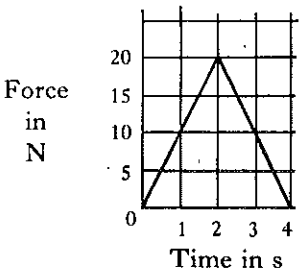
D



E



5. An object of mass 2 kg, initially at rest, is acted upon by the changing force shown on the graph.



What is the change in momentum produced by the force?

A $80\,kg\,m\,s^{-1}$

B $40\,kg\,m\,s^{-1}$

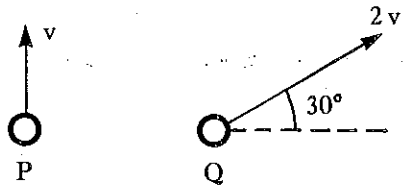
C $20\,kg\,m\,s^{-1}$

D $10\,kg\,m\,s^{-1}$

E $5\,kg\,m\,s^{-1}$

[Turn over

6. Ball P is projected vertically upwards with a velocity v, while an identical ball Q is projected at the same time with velocity 2v at an angle of 30° to the horizontal.



In the absence of air resistance, which of the following statements is/are true?

I P and Q will hit the ground at the same instant.

II The vertical deceleration of P is greater than that of Q.

III P will rise to a greater vertical height than Q.

A I only

B I and III only

C II only

D II and III only

E I, II and III

7. Two vehicles moving along a linear air track collide with each other. After impact, they stick together and continue to move along the track.

Which of the following statements is/are correct?

I The collision is inelastic.

II The total change in momentum is zero.

III The total change in kinetic energy is zero.

A None of these

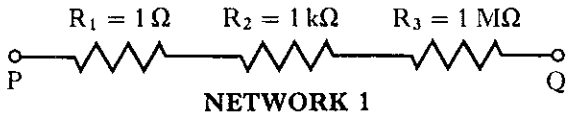
B I only

C II only

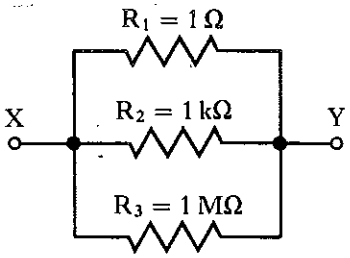
D I and II only

E I, II and III

8. Resistors R_1, R_2 and R_3 can be connected to form the two networks shown in the diagram.



NETWORK 1



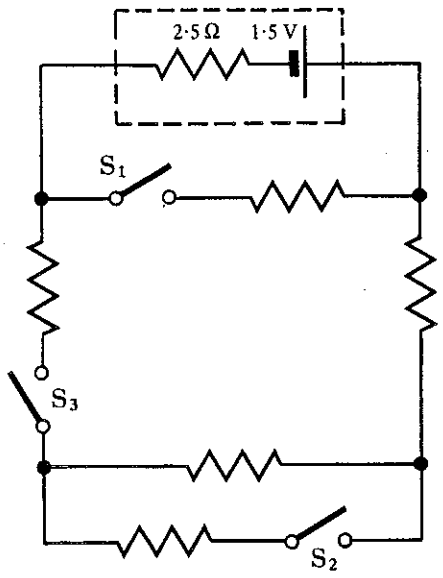
NETWORK 2

The total resistances between the terminals P and Q, of network 1, and X and Y, of network 2, are mainly decided by the value of **one** resistor in each network.

These dominant resistors are

	In Network 1	*In Network 2*
A	R_1	R_1
B	R_1	R_3
C	R_2	R_2
D	R_3	R_1
E	R_3	R_3

9. The circuit below contains a cell which has an e.m.f. of 1·5 V and an internal resistance of 2·5 Ω. It also includes five 1 Ω resistors and three switches S1, S2 and S3.



Which of the switches should be closed to obtain the maximum transfer of power to the external resistance network?

A S1 only

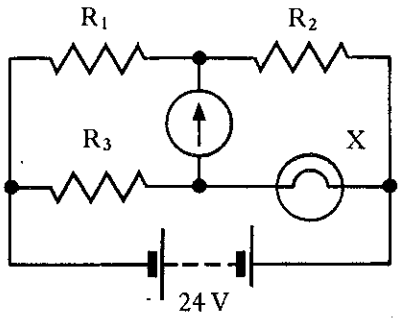
B S1 and S2 only

C S1 and S3 only

D S2 and S3 only

E S1, S2 and S3

10. Bulb X in the circuit below has a rating 12 V; 24 W and is operating under these conditions. R_1 and R_2 are of equal resistance.



For balance in this Wheatstone Bridge arrangement, R_3 must have a value of

A 2 Ω

B 6 Ω

C 12 Ω

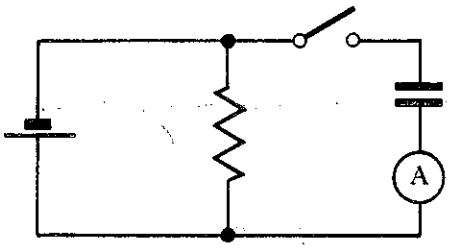
D 24 Ω

E 48 Ω.

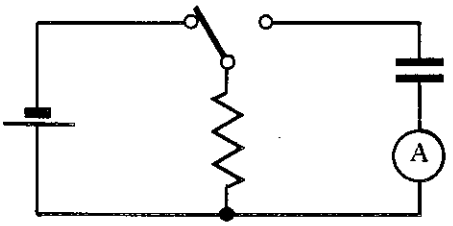
[Turn over

11. Which of the following circuits would be used in an experiment to illustrate the charging and discharging of a capacitor in a d.c. circuit? Ⓐ is a suitable centre–zero ammeter.

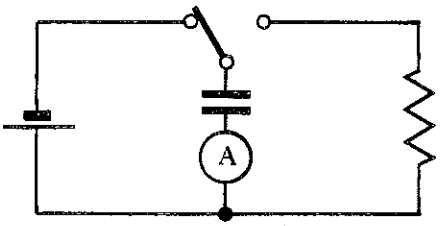
A



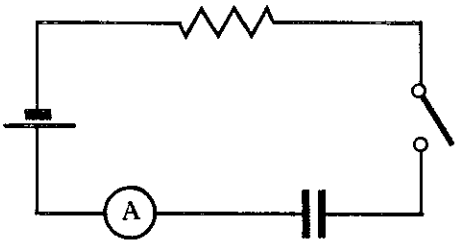
B



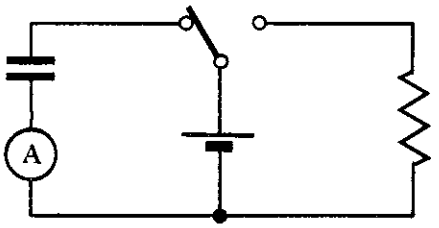
C



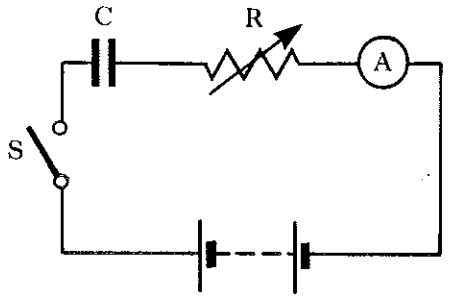
D



E



12. A capacitor is connected in series with a variable resistor, a sensitive ammeter, a switch and a battery, as shown.



After the switch is closed, the variable resistor R is reduced at a rate which ensures that the capacitor C has a constant charging current of $2{\cdot}0 \times 10^{-5}$ A for a time of 30 s. During this time, the p.d. across the capacitor rises from 0 V to 12 V.

What is the capacitance of the capacitor?

A $2{\cdot}0 \times 10^{-4}$ F

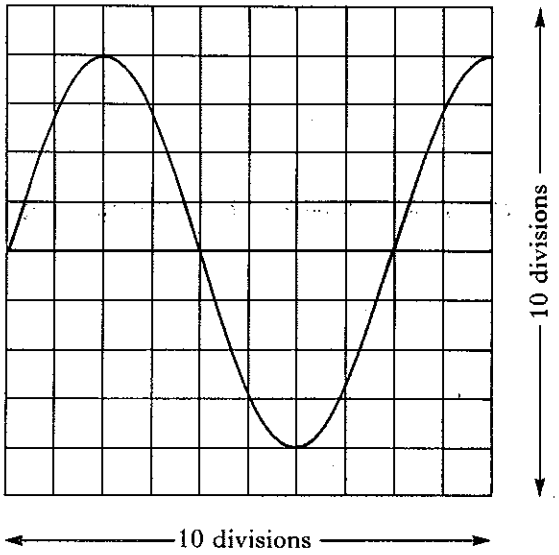
B $2{\cdot}4 \times 10^{-4}$ F

C $5{\cdot}0 \times 10^{-5}$ F

D $8{\cdot}0 \times 10^{-6}$ F

E $1{\cdot}7 \times 10^{-6}$ F

13. When a 12 V, 50 Hz a.c. supply is connected to an oscilloscope the following trace is obtained.



The time base control of the oscilloscope is set to move the spot across the screen at

A 1 division per 1/600 th of a second

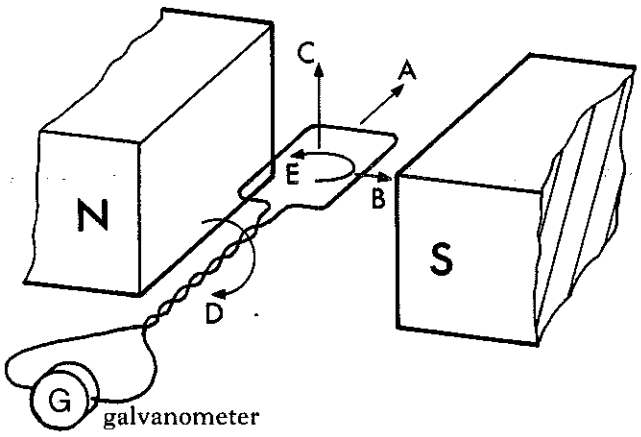
B 1 division per 1/500 th of a second

C 1 division per 1/400 th of a second

D 1 division per 1/200 th of a second

E 1 division per 1/50 th of a second.

14. A flat loop of wire lies, as shown, in the uniform field between the poles of a large magnet with its plane parallel to the field direction.



Which one of the small movements shown by arrows A to E would produce a deflection on the galvanometer G?

A Moving the coil horizontally at right angles to the field direction

B Moving the coil along the field direction

C Moving the coil vertically at right angles to the field direction

D Turning the coil about the horizontal axis as shown

E Turning the coil about the vertical axis as shown

15. An immersion heater is used to heat water in an insulated container. An a.c. supply and a d.c. supply are available which produce the same rate of heating from the heater.

If the a.c. supply has a peak value of 10 V, then the p.d. of the d.c. supply must be

A 5 V

B $\frac{10}{\sqrt{2}}$ V

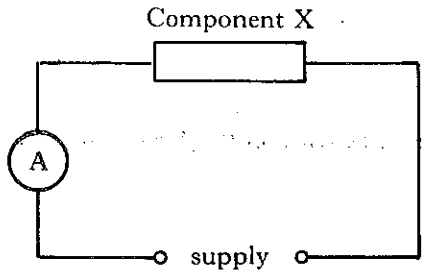
C 10 V

D $10\sqrt{2}$ V

E 20 V.

[Turn over

16. A circuit is set up consisting of component X, an electrical supply which can be set to provide either d.c. or a.c., and an appropriate ammeter.



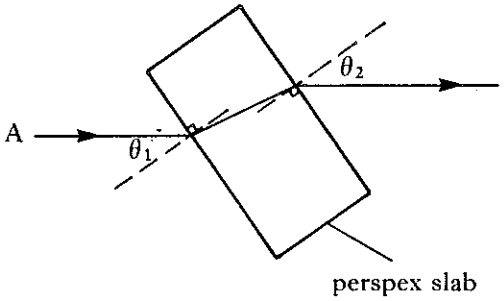
Component X is either a resistor R, a capacitor C or an inductor L. The sensitive ammeter shows that there is no current in the circuit. Which of the following entries in the table is correct?

	Type of Supply	*Component X*
A	d.c.	C
B	d.c.	L
C	a.c.	R
D	a.c.	C
E	a.c.	L

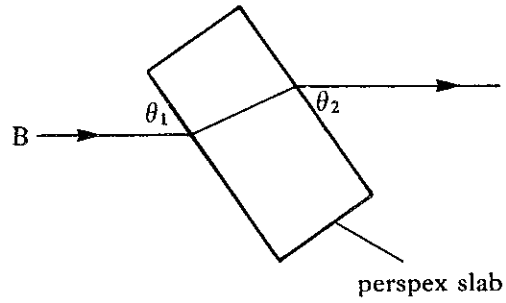
17. When light undergoes a change in direction as it travels from one medium into another, the ratio $\frac{\sin\theta_1}{\sin\theta_2}$ is a constant, where θ_1 and θ_2 are angles related to the direction of the light.

Which of the following diagrams shows both the apparatus required and the angles which should be measured to confirm the above relationship?

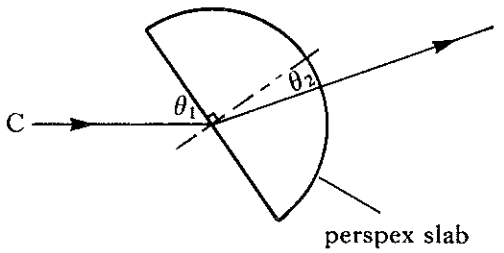
A



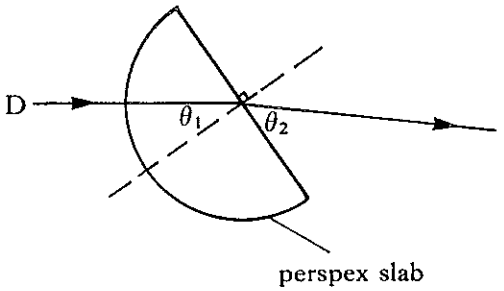
B



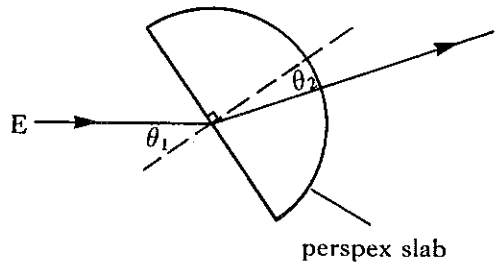
C



D

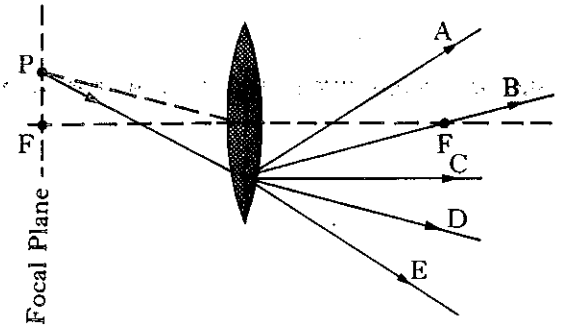


E

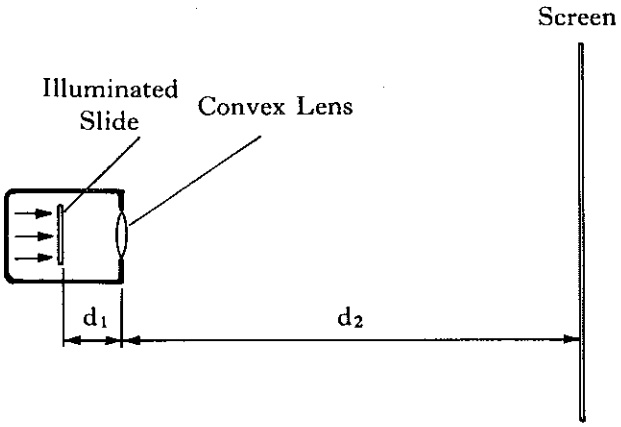


18. P is a point object in the focal plane of a converging lens. A ray of light from P enters the lens as shown. F marks the principal focal points.

Which line shows the correct direction of this ray on leaving the lens?



19. The slide projector shown in the diagram below produces a sharp image which does not completely fill the screen.



Which adjustments should be made to distances d_1 and d_2 to produce a sharp image which does fill the screen?

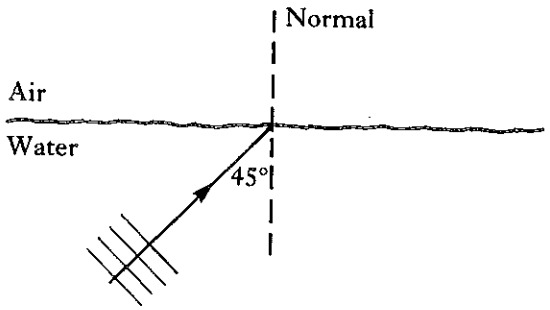
	Distance d_1	*Distance d_2*
A	decrease	increase
B	increase	increase
C	leave unchanged	increase
D	decrease	decrease
E	increase	decrease

[Turn over

20. Which one of the following sets of results has been obtained from an experiment to investigate the variation of intensity with distance from a point source of light?

	Distance	*10 cm*	*15 cm*	*20 cm*	*25 cm*	*30 cm*	*35 cm*	*40 cm*
A	Intensity (units)	256	171	128	102	85	73	64
B	Intensity (units)	256	384	512	640	768	896	1024
C	Intensity (units)	256	384	512	640	512	384	256
D	Intensity (units)	256	171	128	102	128	171	256
E	Intensity (units)	256	114	64	41	28	21	16

21. In water, sound waves travel $4\frac{1}{2}$ times **faster** than they do in air. Sound waves from an undersea earthquake strike the surface of the water at 45° to the normal.



What will happen to the sound waves?

A They will emerge at 9° to the normal.

B They will emerge at 45° to the normal.

C They will emerge at 81° to the normal.

D They will emerge at 90° to the normal.

E They will be totally internally reflected at 45° to the normal.

22. Light of frequency 5×10^{14} Hz passes from air into glass of refractive index 1·5. The speed of light in air is $3 \times 10^8 \text{ m s}^{-1}$.

What is the wavelength of this light **in the glass?**

A 4×10^{-7} m

B 6×10^{-7} m

C 9×10^{-7} m

D 1×10^{23} m

E $1{\cdot}5 \times 10^{23}$ m

23. A rain drop of mass m hits the ground with a speed v. If 25% of its energy is retained by the drop and the specific heat capacity of the rain-water is c, what is the rise in temperature of the drop?

A $\frac{mv^2}{4c}$

B $\frac{v^2}{4mc}$

C $\frac{v^2}{8gc}$

D $\frac{mg}{4c}$

E $\frac{v^2}{8c}$

24. A group of pupils gave the following statements about the simple kinetic theory of gases.

Which statement is false?

A The collisions between the molecules are elastic.

B The molecules have a constant deceleration between collisions.

C The molecules move in a random fashion.

D The volume occupied by the molecules is very small.

E The average kinetic energy is proportional to the Kelvin temperature.

25. Four molecules of a gas are moving parallel to the same axis with velocities of $+4$ units, $+2$ units, -2 units and -4 units. Their r.m.s. speed is

A zero

B $\sqrt{\frac{12}{4}}$ units

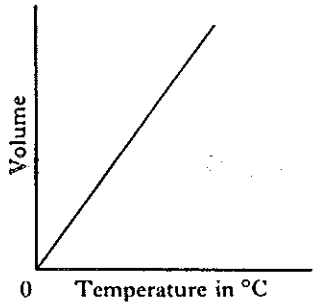
C $\frac{12}{4}$ units

D $\frac{\sqrt{40}}{4}$ units

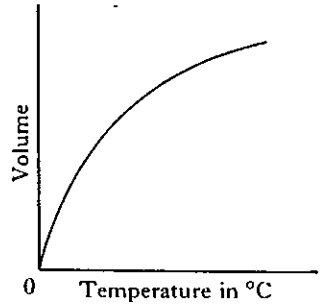
E $\sqrt{\frac{40}{4}}$ units.

26. Which of the following graphs shows the relationship between the volume of an enclosed mass of ideal gas and its temperature when the pressure is kept constant?

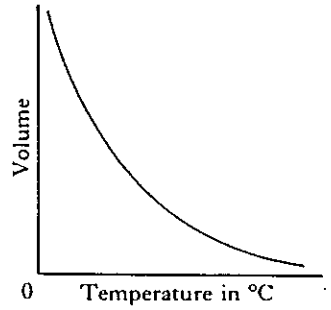
A



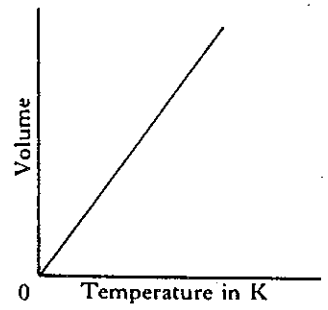
B



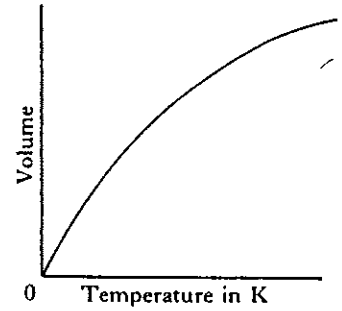
C



D

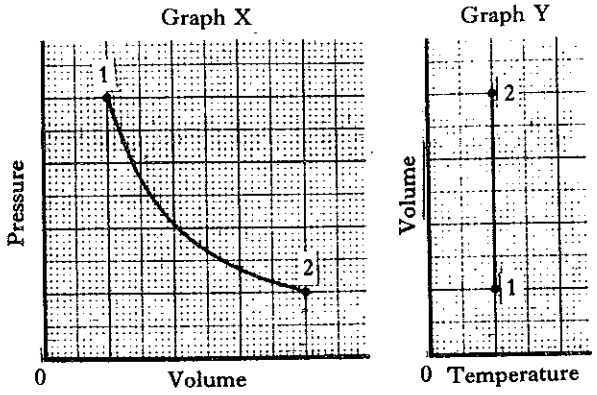


E



[Turn over

27. Graphs X and Y show the pressure, volume and temperature of a fixed mass of gas during an experiment in which the gas starts with the conditions shown at point 1 and undergoes changes to the conditions shown at point 2.



Which of the following statements is/are correct?

I The gas expands according to Boyle's Law.

II The gas is compressed at constant temperature.

III The pressure decreases at constant temperature.

A I only

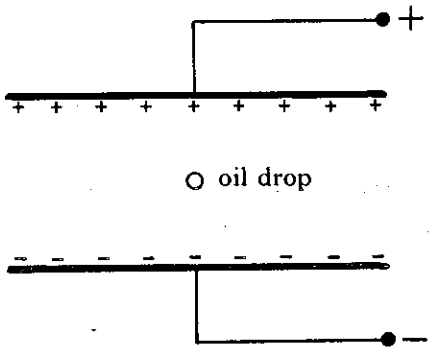
B III only

C I and II only

D I and III only

E II and III only

28. In Millikan's experiment, oil drops are observed between horizontal charged plates as shown below.



When an oil drop is observed to be motionless, it can be deduced that

A no electrostatic forces are acting on the drop

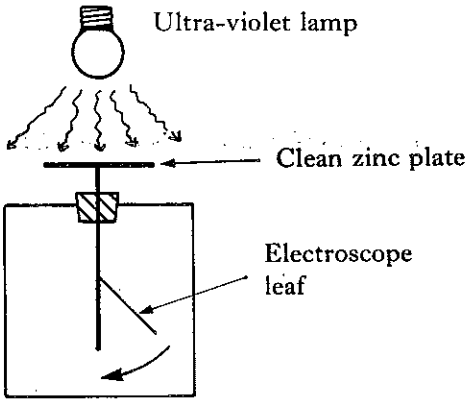
B the drop has a positive charge equal to the positive charge on the top plate

C the drop has a negative charge equal to the negative charge on the lower plate

D the weight of the drop is balanced by the upward force of air resistance on the drop

E the weight of the drop is balanced by the upward electrostatic force due to the charged plates.

29. When an ultra-violet lamp is held above a charged electroscope, which has a clean zinc plate fitted as its cap, the leaf drops gradually towards zero.

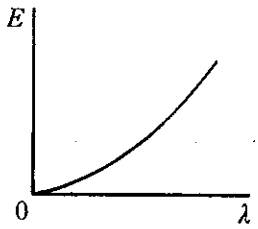


Which of the following correctly describes the effects of moving the lamp closer to the cap of the electroscope?

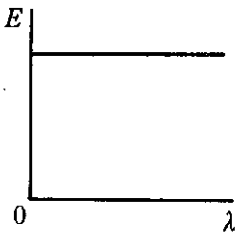
	Effect on photons reaching the plate	*Effect on rate of fall of electroscope leaf*
A	photons each have more energy	falls faster
B	no change	no change
C	more photons per second	no change
D	more photons per second	falls faster
E	photons each have more energy	no change

30. Which one of the following graphs correctly shows the relationship between the wavelength λ and the energy E of photons of electromagnetic radiation?

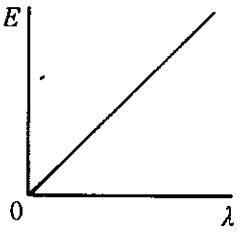
A



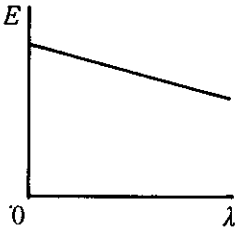
B



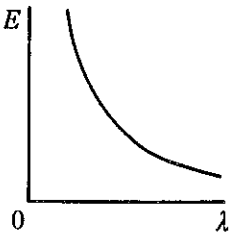
C



D

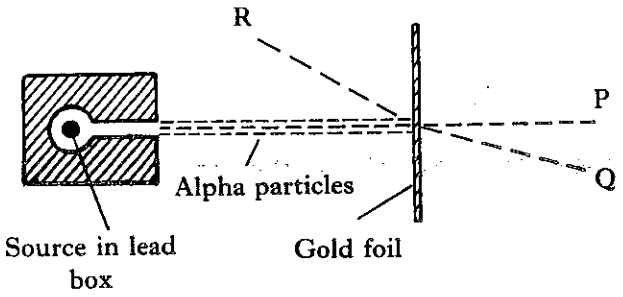


E



[Turn over

31. In a famous experiment performed by Geiger and Marsden in 1908, alpha particles were fired at a very thin gold foil, as shown below.



What could happen to the alpha particles after reaching the foil?

I They could pass through undeflected like P.

II They could pass through deflected like Q.

III They could bounce back like R.

Which of the above statements is/are correct?

A I only

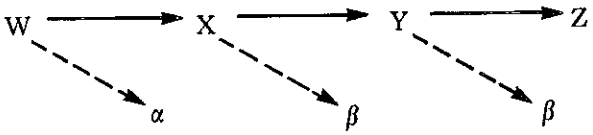
B II only

C III only

D I and II only

E I, II and III

32. The diagram represents a series of radioactive changes in which nucleus W forms nucleus X which then forms nucleus Y and finally nucleus Z.



Which one of the following gives the total change of mass number and of nuclear charge?

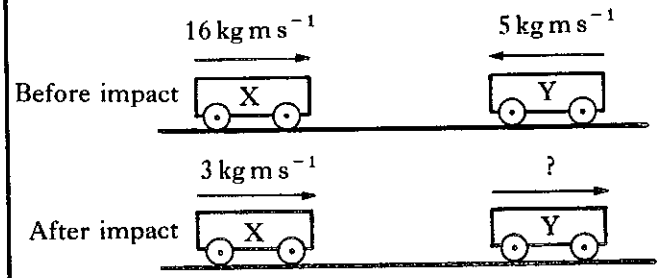
	Change of mass number from W to Z	*Change of nuclear charge from W to Z*
A	−2	+1
B	−2	0
C	−2	−1
D	−4	+1
E	−4	0

Each of Questions 33–40 consists of a problem with a numerical answer.

33. A ball is projected horizontally with a velocity of $30\,m\,s^{-1}$ from the top of a high tower.

After what time will its velocity be in the direction 45° to the horizontal, if air resistance can be neglected?

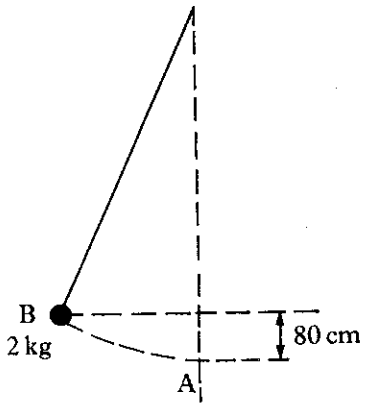
34. The diagram shows a collision between two trolleys X and Y. The momentum of trolley X before and after collision, and the momentum of Y before the collision are as indicated.



Both trolleys are travelling to the right after they collide.

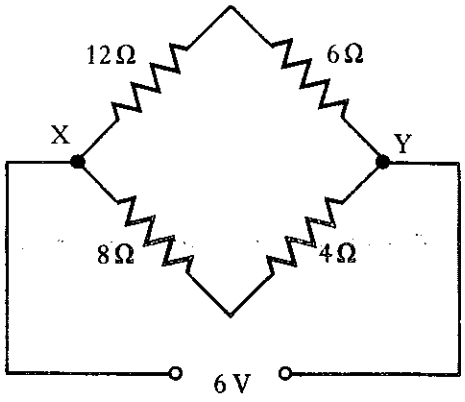
What is the momentum of trolley Y after the collision?

35. In the diagram shown below, the pendulum bob, of mass 2 kg, is released from position B, 80 cm above the lowest position of the bob at A.



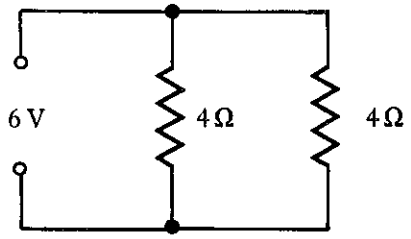
Assuming no air resistance, what is the speed of the bob when it reaches A?

36. Four resistors are connected to a 6 V supply as shown.



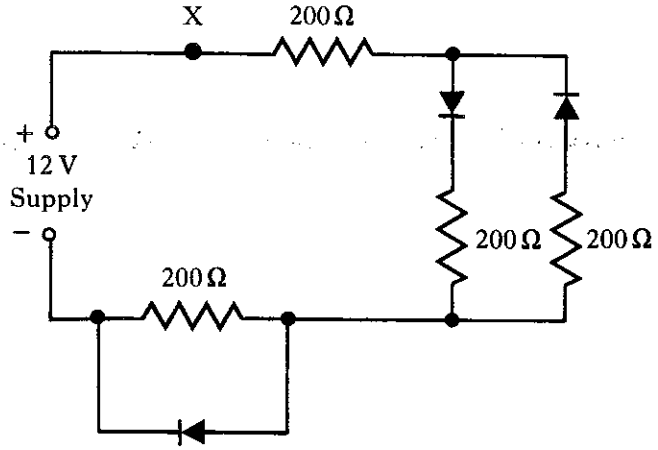
What is the potential difference between points X and Y?

37. The circuit below shows two 4 Ω resistors in parallel across a 6 V constant voltage supply.



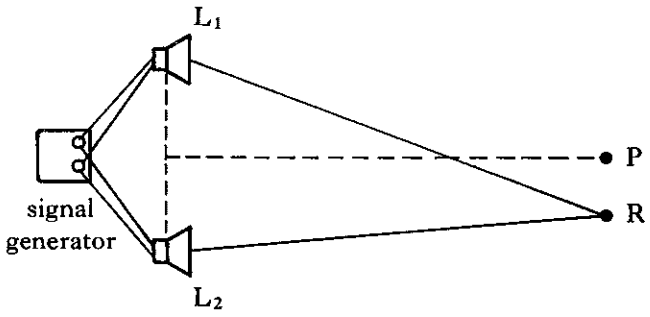
Calculate the total power developed in this circuit.

38. In the following circuit, the diodes have negligible resistance when connected one way round and infinite resistance when connected the other way round.



What is the current in the circuit at point X?

39. L_1 and L_2 are loudspeakers connected to an uncalibrated signal generator. A sound interference pattern is produced.

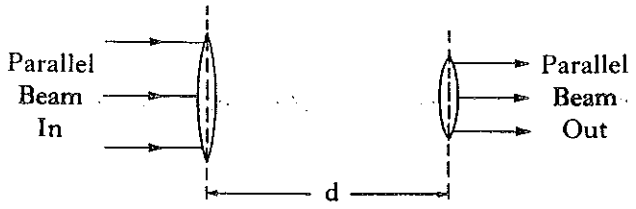


At P, equidistant from L_1 and L_2, a microphone registers a maximum. The next maximum is registered at R, where distances L_1 R = 4·6 m and L_2 R = 4·3 m.

If the speed of sound in air is 330 m s^{-1}, what is the frequency of the note emitted by the loudspeakers?

[Turn over

40. A parallel beam of light falls on a converging lens of focal length 25 cm. Another converging lens, of focal length 10 cm, is positioned so that the light emerging from it is also in a parallel beam.



What is the value of distance d?

[END OF QUESTION PAPER]