External Assessment Report 2014

Subject(s)	Physics
Level(s)	Higher (Traditional)

The statistics used in this report are prior to the outcome of any Post Results Services requests

This report provides information on the performance of candidates which it is hoped will be useful to teachers/lecturers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding. It would be helpful to read this report in conjunction with the published question papers and marking instructions for the examination.

Comments on candidate performance

General comments

There has been an increase in the number of candidates sitting the examination paper for the traditional Higher Physics course this year. This is despite the fact that there are also more centres presenting candidates for the revised Higher examination (available for the third year in this examination diet). The total number of candidates sitting Higher Physics this year (traditional plus revised) is approximately 10 300 candidates.

Markers believe that this year's paper provided good accessibility for 'C' grade candidates and also included appropriate questions to provide good discrimination for those performing at 'A' and 'B'. Although every question was correctly answered by at least a proportion of the candidates, as a whole the examination was found to be more demanding this year. The cut-off scores for the grade boundaries have been reduced a little to reflect this increased difficulty and to ensure that this year's candidates are not disadvantaged.

Markers continue to report that candidates are better at answering questions which involve numerical calculations and that they are poorer in their attempts to answer those questions requiring descriptions and explanations.

There are again some signs that areas of weakness which have been highlighted in previous external assessment reports have been answered to a better standard this year. However, many issues highlighted in recent external assessment reports have still not improved significantly.

Areas in which candidates performed well

The multiple choice section of the examination was found to be reasonably straightforward by many candidates, with questions 2, 15, 16 and 19 being answered particularly well (at least 80% of candidates choosing the correct answers).

Question 21:

This question was designed to provide a straightforward start to Section B and, in general, candidates answered it well.

Part (a) required candidates to calculate the mean of a series of measurements of the distance fallen by a ruler and also to work out the uncertainty in the distance measurement. Most candidates were able to carry out these calculations correctly. However, there were many candidates who failed to give units for one or both of their answers (in this case 'm' for metres).

In part (b), having been asked to calculate the time for the ruler to fall this distance, it was disappointing that many candidates used the relationship *distance = speed x time*. They did not appear to understand that, because the ruler was accelerating, they should have used an appropriate equation of motion (such as $s = ut + ½at^2$).

It was further disappointing to see that many of those candidates who did quote an appropriate equation of motion then substituted a value of '$-9.8\ m\ s^{-2}$' but used a positive value for '*s*'. This was a costly mistake. Obviously it is equally valid to use either a positive or a negative value for '*g*' but, in this question, it is essential that both '*s*' and '*a*' (ie '*g*') have the same sign as each other at the substitution stage.

A few candidates used 'secs' for their units of time. This is not the correct abbreviation for 'seconds' in the SI system and so is treated by markers as a unit error.

Question 23:

In part (b)(ii), many candidates carried out a correct calculation using conservation of momentum to find the speed of the dart before it collided with the wooden block.

Question 24:

In part (a)(i), many candidates carried out a correct calculation using the gas law relationship to find the new pressure of the air at the reduced volume. As the temperature remains constant for this part, it was correct to quote $P_1V_1 = P_2V_2$ as the starting relationship. Some decided to give $P_1V_1/T_1 = P_2V_2/T_2$. There is no problem with that, but a significant number then went wrong by substituting the temperature in degrees Celsius. Although this value appears on both sides of the equation, and so cancels out, the substitution in Celsius is wrong Physics and so loses marks.

In part (a)(ii), the calculation of density was very well done.
In part (a)(iii), many answers using the kinetic model to explain the effects on pressure of reducing volume were very good. Weaknesses in other answers will be described in the next section of this report.

Question 25:

Part (a)(i), determining the *e.m.f.* of the battery from the intercept on the voltage axis of the given graph, was very well done.

Part (a)(ii), determining the internal resistance of the battery from the given voltage/current graph, was well done. In a similar question in last year's examination many candidates wrongly started their answers by saying that '*r* = gradient' (instead of '*r* = - gradient'). This mistake was made less often this year.

Part (a)(iii), determining the short circuit current of the battery, was quite well done.

Question 26:

In part (a), candidates were asked to sketch a graph of the current against time for the capacitor being charged. This required them to calculate the maximum starting current from $V_{supply}/resistance$ (some made a prefix error here by not knowing or not noticing that the resistance was given in kΩ). They then needed to draw and label the axes as well as the origin before drawing an appropriate curve starting from the maximum value of current on the vertical axis down to finish on the horizontal axis. There were many ways that marks could be lost but, on the whole, this question was answered well. There are indications that candidates are following the advice given in recent external assessment reports and taking more care in their presentation of sketch graphs.

Question 27:

In part (a)(i), most candidates were able to use the oscilloscope trace and the Y-gain setting to determine the peak voltage.

In part (a)(ii), many were also good at converting between peak and r.m.s. values.

Question 28:

In part (a), a high proportion of candidates were able to use the grating formula and the given information to calculate the angle for the third order maximum.

In part (b)(ii), many candidates were able to argue correctly that covering one of the gaps causes the strength of the signal at K to increase as destructive interference no longer occurs.

Question 29:

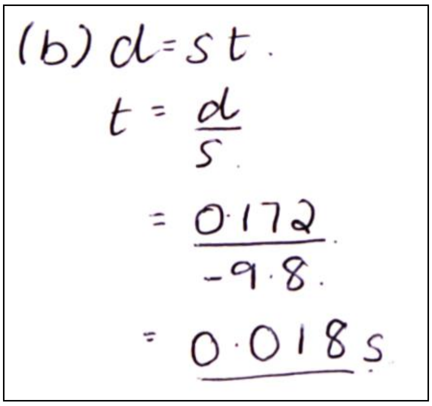
Part (a) required candidates to use Snell's law to calculate the critical angle. This calculation was done very well. Some candidates were unable to get the required value of refractive index from the given graph. This appeared to be due to them making errors reading the scale(s).

Question 30:

The calculations in part (a) {ie the maximum E_k of a photoelectron and its maximum velocity} were both done well.

Examples of candidate answers

Q21(b): example 1:

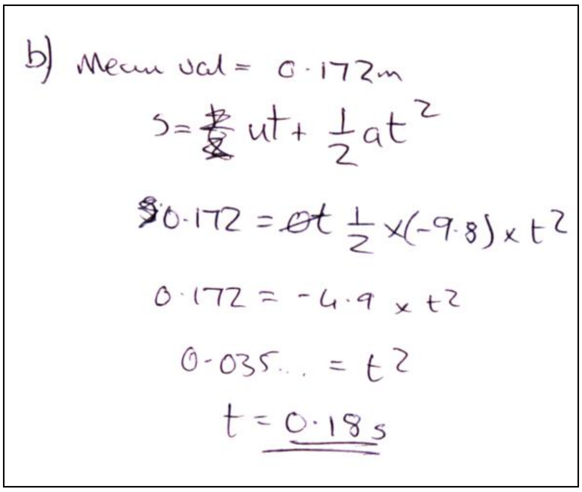


Comment: This is an example of a candidate who is demonstrating a number of weakness in his/her knowledge and understanding of physics:

- it is wrong to use the simple distance, speed and time relationship when an object is accelerating
- the candidate has substituted the value of acceleration for 'speed'
- the negative value has been 'ignored' in the subsequent calculation

No marks can be awarded for this answer.

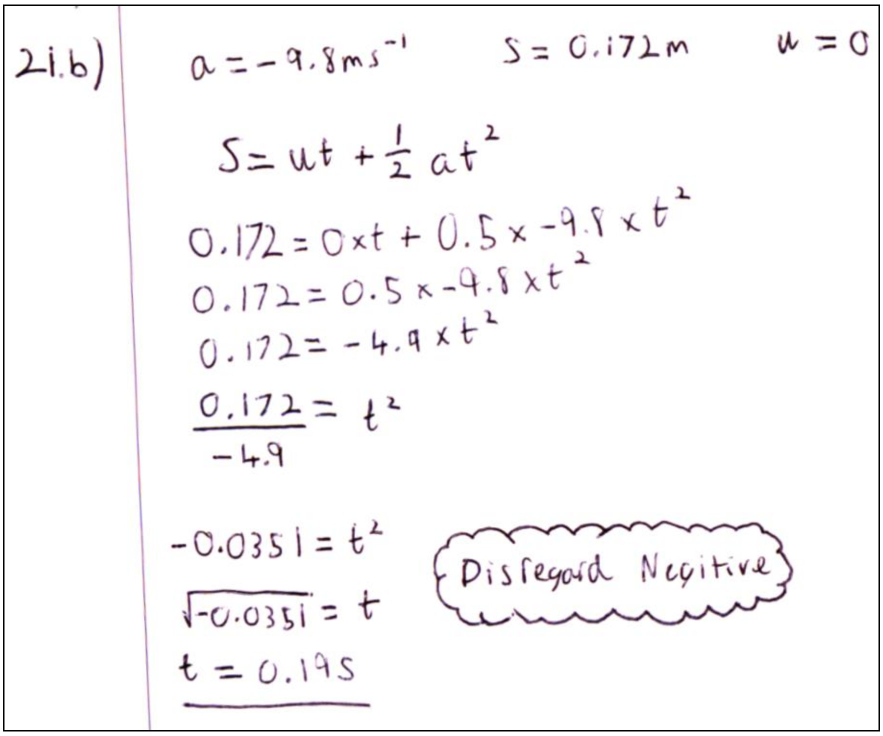
Q21(b): example 2:



Comment: This candidate has chosen the correct formula but has gone wrong at the substitution stage. As both the acceleration, *a*, and the displacement, *s*, are in the same direction, they should have the same sign as each other (ie both positive or both negative).

This answer can be awarded only the ½ mark for selecting an appropriate relationship.

Q21(b): example 3:


21.b)

$a = -9.8 ms^{-1}$ $S = 0.172 m$ $u = 0$

$S = ut + \frac{1}{2}at^2$

$0.172 = 0 \times t + 0.5 \times -9.8 \times t^2$

$0.172 = 0.5 \times -9.8 \times t^2$

$0.172 = -4.9 \times t^2$

$\frac{0.172}{-4.9} = t^2$

$-0.0351 = t^2$ Disregard Negitive

$\sqrt{-0.0351} = t$

$t = 0.19 s$

Comment: This candidate has made the same mistake as in example 2 (ie *a* and *s* should have the same sign as each other at the substitution stage).

It is irrelevant that the candidate has recognised that there is a problem with the negative sign and has even written 'Disregard Negitive' (wrong spelling was disregarded) – this is wrong physics and the answer can be awarded only the ½ mark for selecting an appropriate relationship.

Areas which candidates found demanding

In the multiple-choice section of the examination, there was only one question that was answered correctly by less than half of the candidates (question 5 [49%] – almost as many candidates chose distractor 'B' as their answer). This question is about pressure exerted by a box on the surface on which it rests.

Question 22 – This question uses the context of a parascender being pulled by a powerboat to probe candidates' understanding of vectors and the relationship between force and motion.

Candidates did not answer this question well. Part (b), which required candidates to explain the motion of the parascender in terms of the forces acting was particularly poorly answered.

Specific areas of weakness in the answers from candidates were:

Part (a)(i):

- Very few candidates could define the *resultant of a number of forces* as the single, overall force which causes the same effect (eg acceleration) as when all the forces are acting.
- Many candidates 'talked' about getting the resultant by adding the forces, but did not make it clear that this must be carried out as a vector sum.
- A significant number of candidates thought they were being asked to explain what a resultant force of 0 N means.

Part (a)(ii):

- Very few candidates made a good attempt at drawing a scale diagram of the forces acting on the parascender.
- Many did not seem to realise that the three forces acting (1200 N, weight and the parasail's force) should be added as vectors to give the resultant of zero given in the question, ie having drawn the 1200 N and weight to scale and in the correct relative directions, the third force should be drawn back to the origin to complete the triangle.
- Of those who remembered to give a direction, many tried to quote it as a three-figure bearing. This is not appropriate in this question, as the force exerted by the parasail should be quoted relative to the horizontal (or vertical). North is neither defined nor relevant in this question.
- Many attempted to use the cosine rule. This is a perfectly valid and acceptable way to answer this question, but candidates must realise that the cosine and sine formulas are not provided. There were many examples of candidates writing down a wrong formula – no marks can be awarded when the starting relationship is incorrect. Candidates who wish to use this method must memorise the relevant formulas before sitting the examination.

Part (b):

- This part of the question told candidates that the parascender releases the rope and initially rises higher. They were asked to 'explain, in terms of forces, why the parascender rises'. An acceptable answer should explain that, as there is no longer a downward component of force from the rope, the upward vertical component of the force from the parasail is greater than the weight of the parascender. This causes a (brief) resultant upward force and consequent upward acceleration. Candidates' answers frequently showed little understanding of the combination of forces and the relationship with acceleration. Few showed that they understood the need to consider just the vertical components of forces in order to explain behaviour in the vertical direction.

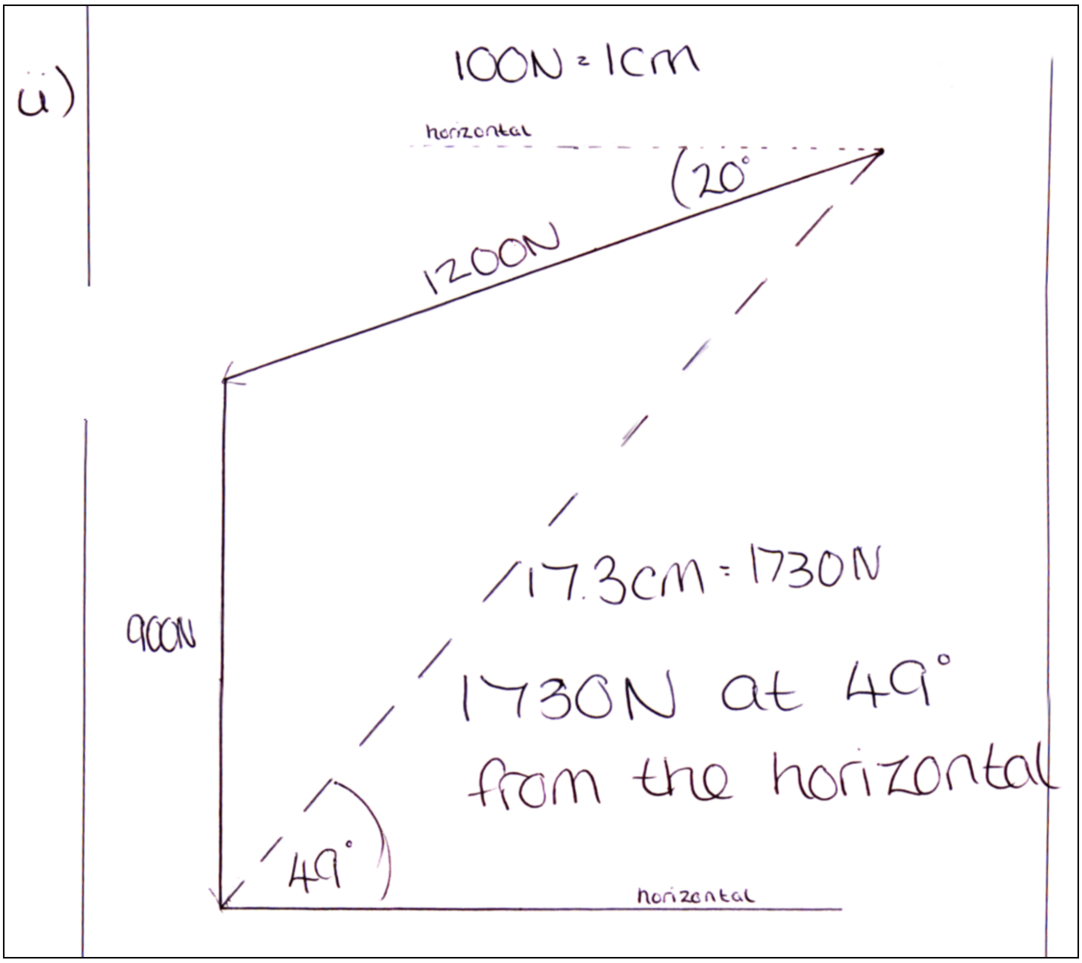
Examples of candidates' answers to question 22:

1. For part (a)(i):

22 (a) i) The resultant of a number of forces means the difference between the forces acting in different ~~dif~~ directions of the object

Comment: This is an example of one of the many answers seen by markers that did not explain what *resultant force* means. This candidate may well have had useful information in their head, but there was nothing worth marks in their written answer.

2. For part (a)(ii):



Comment: This answer has been included because it is one of the few correct answers seen by markers!

The candidate has stated, and correctly used, an appropriate scale. The combination of the vectors has been clearly shown and the answer is clearly stated as a magnitude and direction.

It was disappointing that so few good attempts were made.

3. For part (b):

> (b) Releasing the rope causes the force exerted from the parasail to increase, therefore pulling more on the parascender and causing them to rise. The unbalanced force increases.

Comment: The force exerted by the parasail does not increase. This candidate has not appreciated that releasing the rope removes the 1200 N force that it had been exerting on the parascender. The vertical component of that 1200 N force had combined with the weight to balance the upward vertical component of the force by the parasail.

4. For part (b):

> b. the force of tension is released and the parascender rises for an instant because the force on him is greater than the force of friction. Also for an instant gravity is not acting upon him so he momentarily rises.

Comment: This answer is one of the many seen by markers that demonstrate very poor understanding by many candidates of forces and their effects on motion.

It is unclear what this candidate believes is the 'force on him' that is 'greater than the force of friction'. It is in fact the forces of friction (or drag) that are causing the unbalanced force upwards.

It is worrying that a candidate sitting the Higher Physics examination believes that 'for an instant gravity is not acting upon him'.

5. For part (b):

> b. Force acting upon the parasail increases when the rope is released causing parascender to rise higher.

Comment: This is another answer that demonstrates very poor understanding (shown by many candidates) of forces and their effects on motion.

Question 23: This question aims to provide candidates with opportunities to show their knowledge and understanding of the conservation of linear momentum. It also tests their abilities to use the conservation of energy and momentum in the analysis of interactions between objects.

This question was more poorly answered than had been expected.

Specific areas of weakness in the answers from candidates were:

Part (a):

- Few candidates set out their answer to show the total momentum before, the total momentum after and then to equate these two quantities.
- Many candidates wrongly thought that by showing that the magnitude of the momentum of X after the explosion was equal to the magnitude of the momentum of Y after the explosion they had then proved the conservation of momentum.
- Some candidates did not appear to appreciate the vector nature of velocity (and consequently the vector nature of momentum).
- Some candidates did not show that they had multiplied the mass (of X) by its velocity to get the momentum (of X). This is a 'show' question and the value of the momentum should not just 'appear'.

Part (b)(i):

- This is a 'Show' question and the candidate must start by writing the relevant formulas ($E_k = ½ mv^2$ and $E_p = mgh$ in this case) and then substitute the relevant given data. It is not acceptable to start with just numbers in the answer to this type of question.
- The final line of the candidate's answer must state the value that they were asked to show – in this case 1·7 m s^{-1} (not 1·72 m s^{-1}).

Part (b)(ii):

- It was disappointing that many candidates attempted to use an energy calculation (rather than conservation of momentum) to work out the velocity of the dart before its collision with the wooden block.

Part (b)(iii):

- When the dart bounces off the wooden block, it then has a negative momentum. By the conservation of (linear) momentum, the block must now have a greater momentum than in the first 'collision'. This means that its change in momentum is greater, its velocity is greater and so the height reached is greater. It was disappointing that few candidates made any reference to momentum as they attempted to explain why the block swings higher when the dart bounces off.

Examples of candidates' answers to question 23:

1. For part (a):

23a. X $p = mv$
$= 0.7 \times 0.51$
$= 0.357\ kgms^{-1}$

Y $p = mv$
$= 0.3 \times 1.19$
$= 0.357\ kgms^{-1}$

this shows that momentum is conserved.

Comment: This candidate has only shown that, after the explosion, the magnitude of the momentum of object X is equal to the magnitude of the momentum of object Y. This is not sufficient to prove the conservation of momentum.

It is still necessary to combine their momenta **as vectors** to get a total momentum of zero and also show that this is the same as the total momentum before the explosion.

2. For part (b)(iii):

(iii) It is hit with the same force, as v is the same, however as the dart does not stick, the overall mass is lighter. The same force of impact but on a lighter mass will cause the block to swing higher.

iii) The block swings to a greater vertical height because the same energy is transferred by the dart to a smaller mass. So, since $E_K = 1/2\ mv^2$, and m decreases, v must increase, allowing the block to rise higher.

Comment: Many answers like those above started with wrong assumptions such as the block experiences the same force as before or the block receives the same energy as before.

3. For part (b)(iii):

> • as mom before = mom after, when the dart bounces that creates a negative momentum which means that the block will have a greater momentum and as mass stays the same, velocity will increase so it will swing higher

Comment: This candidate has communicated some correct physics related to the situation. The vector nature of momentum is mentioned – although it would have been better to have been more precise and state that ‘the momentum of the dart is negative after the collision’. It is not quite correct that the ‘mass stays the same’ (compared to the first collision) – the small change in mass does not, however, change the fact that the velocity of the block increases.

Question 24 – This question tests candidates’ knowledge of kinetic theory and the gas laws in the context of an experimental set-up where a syringe of trapped air is held in a water bath.

Parts (a)(i) and (a)(ii) were well done. Both of these involved candidates performing straightforward calculations.

Parts (a)(iii) and (b) were poorly answered.

Specific areas of weakness in the answers from candidates were:

Part (a)(i): (Calculation of the new value of pressure when the volume is decreased.)

- Some candidates used $P_1V_1/T_1 = P_2V_2/T_1$ and substituted the temperature value in Celsius.

Part (a)(ii): (Calculation of the density of the trapped air, given the mass and volume.)

- Some candidates did not appear to know that the SI unit of density is kilograms per cubic metre (kg m^{-3}).

Part (a)(iii): (This part requires candidates to use the kinetic model to explain what happens to the pressure of the gas when the volume is decreased.)

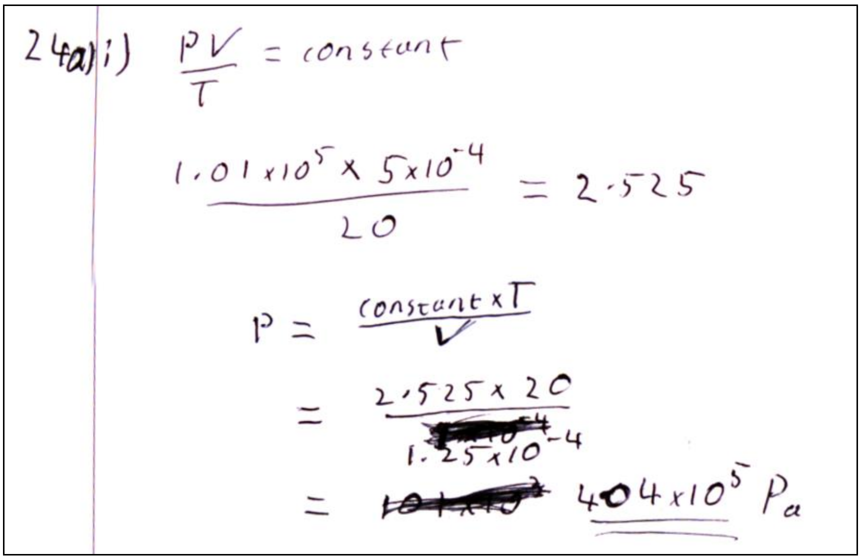
- Some candidates failed to say that pressure is due to moving gas molecules colliding with the walls of the syringe. This is the fundamental starting point for a kinetic theory explanation.
- Despite being told in the question that the temperature remains constant, some candidates stated that the molecules were moving faster and others said that individual collisions of the molecules with the walls were harder. Both of these mistakes indicate that those candidates do not have a correct understanding of the kinetic model.
- The question asks for a description of how the pressure of the gas is affected by decreasing the volume. Candidates who failed to conclude that the pressure increases could not be awarded marks.
- Many candidates provided incomplete answers such as ‘*more collisions*’ rather than ‘*more collisions per second*’ or ‘*more frequent collisions*’.
- Candidates should use **words** to express the terms ’increasing’ and ‘decreasing’. There are still a few candidates using up (↑) and down (↓) arrows in their descriptions. Markers have repeatedly said that this is not acceptable in examination answers.

Part (b): (This part requires candidates to explain what happens to the density of the trapped air when its temperature is increased. Many who gave good answers for the calculation in part (a)(ii) showed little understanding of density in this part.)

- Candidates should have stated ‘the density does not change’ and given the reason as ‘neither the mass nor volume have changed’. Some, however, failed to give any explanation – had they not read the question carefully? The practice of reading the question again immediately after writing their answer would help to avoid such errors.
- Other candidates said that ‘density does not depend on temperature’ – this is neither an explanation, nor necessarily correct.

Examples of candidates’ answers to question 24:

1. For part(a)(i):


24a) i) $\frac{PV}{T}$ = constant

$\frac{1.01\times10^5 \times 5\times10^{-4}}{20} = 2.525$

$P = \frac{\text{constant} \times T}{V}$

$= \frac{2.525 \times 20}{1.25\times10^{-4}}$

$= 4.04\times10^5$ Pa

Comment: This candidate has produced the 'correct' answer, but has used wrong physics in the process. The full gas law has been used but the temperature has been substituted in Celsius, not kelvin units.

This answer can only be awarded the ½ mark for selecting the appropriate relationship.

2. For part (a)(i):

(a) (i)

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{(1.01\times10^{5})\times(5\times10^{-4})}{293} = \frac{P_2\times(1.25\times10^{-4})}{293}$$

$$0.17 = \frac{P_2\times(1.25\times10^{-4})}{293}$$

$$P_2 = 3.98\times10^{5}\ \text{Pa}$$

Comment: This candidate has also included temperature values but has correctly changed to kelvin units. However, from line two to line three, the calculation for the left hand side has been rounded to two significant figures. This has resulted in the final answer being inaccurate to the three significant figures that the candidate has quoted.

3. For part (a)(i):

24 a(i)

$$\frac{P_1}{V_1} = \frac{P_2}{V_2} \Rightarrow \frac{1.01\times10^{5}}{5.00\times10^{-4}} = \frac{P_2}{1.25\times10^{-4}}$$

$$= 25250\ \text{Pa} \Rightarrow 2.52\times10^{4}\ \text{Pa}.$$

Comment: This candidate has 'made up' a formula. Given the availability of the list of the relationships in the data booklet and the many opportunities to become familiar with this list throughout the course, this should not happen in the examination. Obviously, no marks can be awarded.

4. For part (a)(ii):

ii) $\rho = \frac{m}{V}$

$= \frac{1{,}45 \times 10^{-3}}{1{,}25 \times 10^{-4}}$

$= 11 \cdot 6\ kgm^{3}$

Comment: This candidate has answered correctly until the final line where the units of density are wrong.

5. For part (a)(ii):

ii $\rho = ?$

$P = 404\,000\ Pa$

$V = 1 \cdot 25 \times 10^{-4}\ m^3$

$m = 1 \cdot 4 \times 10^{-3}\ kg$

$\rho = \frac{m}{V}$

$= \frac{1 \cdot 4 \times 10^{-3}}{1 \cdot 25 \times 10^{-4}}$

$= 11 \cdot 2\ kg\ m^{-3}$

Comment: This candidate has selected the correct relationship but has gone wrong at the substitution stage. The question paper gives the value of the mass as $1{\cdot}45 \times 10^{-3}$ kg. This candidate has made a costly error by using $m = 1{\cdot}4 \times 10^{-3}$.

This answer can only be awarded the ½ mark for selecting the appropriate relationship.

6. For part (a)(ii):

(ii) $\rho = \frac{m}{V} = \frac{1 \cdot 45 \times 10^{-3}}{1 \cdot 24 \times 10^{-4}} = 11 \cdot 7\ kgm^{-3}$

Comment: Like the previous example, this candidate has selected the correct relationship but has gone wrong at the substitution stage. The question paper gives the value of the volume as $1{\cdot}25 \times 10^{-4}\ m^3$. This candidate has made a costly error by using $V = 1{\cdot}24 \times 10^{-4}$.

This answer can only be awarded the ½ mark for selecting the appropriate relationship.

7. For part (a)(ii):

> (ii) density = $\frac{\text{pressure}}{\text{volume}}$
>
> $= \frac{4.04 \times 10^5}{1.25 \times 10^{-4}}$
>
> $= 32.32 \times 10^8$ Pa/m^3

Comment: This is another example of a candidate 'making up' a formula. Given the availability of the list of the relationships in the data booklet and the many opportunities to become familiar with this list throughout the course, this should not happen in the examination. Obviously, no marks can be awarded.

8. For part (a)(iii):

> (iii) Volume ↓ ∴ Spacing of particles ↓
>
> ∴ ↑ the number of collisions within the walls and
>
> ↑ force of collisions within the walls
>
> ∴ ↑ Pressure.

Comment: This candidate has used arrows in a written description. For many years, in external assessment reports, it has been made clear that this is not an acceptable method of communication in a Physics examination. The answer is also weak in that it does not explicitly enough state that the pressure exerted by the gas is due to the molecular collisions with the container walls (what does 'within the walls' mean?). The answer also implies that the force of individual collisions increases.

9. For part (b):

> (b) The density increases because heat allows the particles to move with a larger velocity making more collisions therefore more dense

Comment: This answer is completely wrong and shows that the candidate has no understanding of the meaning of the term *density*.

10. For part (b):

(iii) The kinetic energy of each collision remains constant. However the number of collisions ↑ due to the decrease in available space.
number of collisions ↑ therefore total pressure ↑ exerted on the sides ↑

Comment: This candidate has not described the basic kinetic model to explain why a gas exerts a pressure, ie that the gas molecules are constantly moving and colliding with the container walls. This exerts a force (and hence a pressure) on the container walls. The answer does mention ‘collisions’, but it does not say what is/are colliding, nor what they are colliding with. This answer also inappropriately uses arrows, rather than words, in attempting to describe what happens.

Question 25 – This question is about *e.m.f.*, internal resistance and the combination of resistances in the context of a technician testing a car battery.

Part (a) was moderately well done, but part (b) was answered very poorly.

Specific areas of weakness in the answers from candidates were:

Part (a)(i):

- The *e.m.f.* is equal to the intercept on the vertical axis when the given graph line is extrapolated. This answer is 12·0 V, but some candidates gave an answer of 10·0 V, seemingly thinking that the *e.m.f.* is the value at the end of the graph line without extrapolating it to the voltage axis. Other candidates gave an answer of 14·0 V, which appears to have been chosen because it is the highest labelled value on the vertical axis.

Part (a)(ii):

- Some candidates calculated the internal resistance using $E = V + Ir$, using their value of *e.m.f.* from part (a)(i) and values for V and I taken from the graph. Those who used this method generally did very well.
- Other candidates attempted to use the gradient of the given graph. Those who used this method did not perform so well. A significant proportion of candidates did not realise that the internal resistance is equal to the negative of the gradient of the graph. Saying ‘r = gradient of graph’ is the same as starting an answer with a wrong formula.

Part (a)(iii):

- When a supply is short circuited, the resulting current can be calculated from E/r. Although this relationship is not provided, it is expected that candidates will be familiar with using Ohm's law and be able to substitute E for 'V' and r for 'R'.

Part (b): (Candidates were asked to explain why the headlamp becomes dimmer when the starter motor is operated. It was expected that this is an everyday context commonly used by teachers to illustrate the effects of internal resistance. Candidates' responses did not indicate that this is the case.)

- Many candidates thought that it was sufficient to state that, because the headlamp and starter motor are in parallel, the current splits. They appeared to believe that the total current was the same as before and seemed unaware that the supply provides a greater current when the motor is switched on.
- It was concerning to find many candidates stating that the parallel connection means that the supply voltage splits between the two components. This is a very basic error in the understanding of parallel circuitry.
- Markers saw numerous examples of the misuse of physics terminology, for example candidates saying 'voltage through' and/or 'current across'.

Examples of candidates' answers to question 25(b):

1.

b)	in a parallel circuit, current is split across branches, so rather than the lamp recieving all of the current, when the switch is closed, ~~some is given to~~ it is split across the lamp and motor, resulting in a dimmer lamp.

Comment: Although current does split in a parallel connection, this is not the reason for the headlamp being dimmer. When the starter motor is operated, the total current from the battery is greater than before and so an answer would need to go much further to explain why the current in the headlamp is less than before.

2.

25 b)	Since the headlamp and motor are connected in parallel, the voltage across both must be shared even as the current stays constant across both, so the headlamp only gets a fraction of the ~~output~~ terminal p.d., hence it gets dimmer.

Comment: The candidate is wrong to state that 'the voltage … must be shared' as voltage is divided across components that are connected in series, not in parallel. The candidate is also wrong in thinking that the current 'stays constant' – connecting another component in parallel reduces the total circuit resistance and so increases the overall current from the battery.

3.

b)	When the switth is open all the ~~same~~ volts ~~are~~ (except lost volts) are going through the bulb but when the switth is closed then some volts are going to the motor so less volts across the bulb the dimmer it is.

Comment: This answer uses some inappropriate terminology. Potential difference (or voltage) should be described as being 'across' components – it does not 'move' anywhere or 'go through' anything.

Question 26 – This question is about factors involved in the charging of a capacitor.

No part of this question was well done.

Parts (b) and (d) were answered particularly poorly.

Specific areas of weakness in the answers from candidates were:

Part (a): (Candidates were asked to sketch a graph of charging current against time.)

During charging of the capacitor, the graph of the current should decrease from its maximum initial value and gradually curve down and 'flatten off' on the time axis. Some candidates lost marks because their graphs were poorly drawn. It is pleasing to report that the common problems listed in recent external assessment reports were seen less frequently this year.

However, although less frequent, the following errors were still seen by markers this year:

- unlabelled axes
- unlabelled origin
- freehand lines curving the wrong way
- carelessly drawn freehand lines which did not stay at a steady level
- the graph line flattening out above (or below) the 0 A value
- the value of '0·75' shown, but no units given anywhere on the current axis
- a gap between the start of the graph line and the current axis

- Some candidates produced two **conflicting** answers to this question – one in their booklet and another on separate graph paper. Markers need to be clear which version the candidate wishes to be marked. Candidates should delete any draft answer(s).
- Some candidates made errors calculating the initial current. This was sometimes due to them making errors with the prefix in the value of '12 kΩ' for the series resistance.

Part (b): (Candidates were asked to explain why there is a current in the circuit during the charging process.)

An ideal answer should explain that electrons are repelled from the negative terminal of the battery and flow to one of the plates of the capacitor. At the same time, electrons are attracted off the other plate of the capacitor and move towards the positive terminal of the battery. This flow of electrons in the wiring is the charging current.

- Many candidates thought that there is a current in the insulator between the plates of the capacitor and they tried to explain why that occurs.
- Some candidates thought that the forces driving the flow of charge were due to the polarity of the capacitor's plates rather than the *e.m.f.* of the battery.
- Some candidates said that there was current due to using an a.c. supply (even though the circuit diagram clearly shows a battery).

Part (c): (Calculate the charge on the capacitor given the current in the resistor.)

- Many candidates calculated the p.d. across the resistor and then used this as the value of the p.d. across the capacitor. (It was necessary to subtract this value from the supply voltage.)

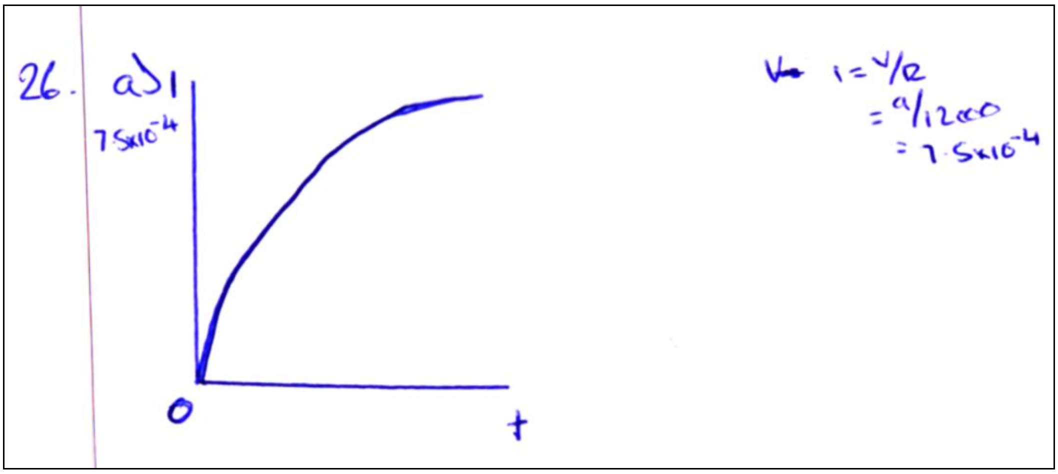
Part (d): (The capacitor is discharged. It is then charged again using a higher value of series resistance. How does the increase in resistance affect the maximum p.d. and current?)

- Many candidates did not appear to know that the maximum p.d. across the capacitor is only affected by the supply voltage.
- Many candidates did not appear to know that the maximum charging current is determined by the supply voltage divided by the series resistance.
- Although the question clearly says 'Explain what effect …', many candidates merely stated the effect(s) and made no attempt at any explanation. Again, re-reading the question might help reduce this type of error.

Examples of candidates' answers to question 26:

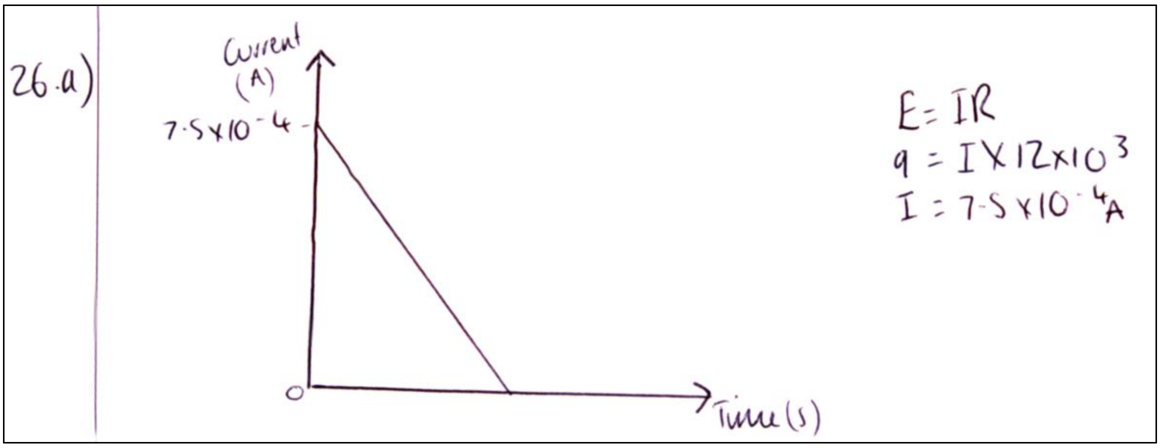
For part (a):

1.



Comment: This candidate has calculated the correct value of current, but the graph shows that they do not understand that this is the maximum current at the start of the charging process and that the charging current should then decrease from this value. No marks can be awarded.

2.



Comment: This candidate has calculated the correct value of the maximum current and has realised that it decreases from this value during the charging process. However, the candidate has drawn a straight line graph rather than the correct shape of a curve down to the horizontal axis.

One wonders whether this candidate has participated in experiments on the charging and discharging of capacitors, where results clearly show that the changes in current are not linear.

For part (b):

1.

A ~~Because as the capact capacitor charges, electrons 'stack' up at one plate~~
Because as the capicitor is charging, not all the electrons can pass through the 'isolator at once and flow in that part of the circuit, causing a current.

Comment: This answer makes it clear that the candidate has little understanding of what is happening during the charging of a capacitor.

2.

b AC ~~cur~~ current is being used in the experiment. As AC is always constantly changing direction ~~so~~ it is not blocked by the insulator in the ~~cap~~ capacitor,

Comment: The examination question clearly shows that the power supply in this circuit is a battery. Why would a candidate for the Higher Physics examination believe that a battery provides an alternating current?

3.

b) The insulater between the plates creates a resistance meaning that a current will be produced.

Comment: It is concerning that a candidate should demonstrate such poor understanding of basic facts about electricity.

For part (c):

1.

c) $V = IR$
$= 5.0 \times 10^{-4} \times 12000$
$= 6 V$

$Q = CV$
$= 2200 \times 10^{-6} \times 6$
$= 0.0132 C$

Comment: This wrong answer was seen frequently by markers. The candidate has correctly calculated a potential difference of 6 volts. However, this is the p.d. across the **resistor**, It should be then subtracted from the supply voltage (9 V) so that a value of 3 V is used in the second calculation to get the charge on the capacitor.

Question 27 – This question involves a signal generator connected to two resistors connected in series. It provides opportunities to probe candidates' abilities to deal with oscilloscope traces, calculate peak and r.m.s. values and analyse potential dividers and op-amp behaviour.

Parts (a)(i) and (a)(ii) were well done, but parts (a)(iii) and (b) were answered poorly.

Specific areas of weakness in the answers from candidates were:

Part (a)(ii):

- Many candidates did not use subscripts and so it was often not clear whether they were working with peak or r.m.s. values. This was not a problem if they worked through to a correct final answer, but, when they did not reach a correct answer, it was difficult for a marker to allocate partial marks to their working.

Part (a)(iii):

- Many candidates gave the r.m.s. voltage across the 1·0 kΩ resistor and not the r.m.s. output voltage of the signal generator.

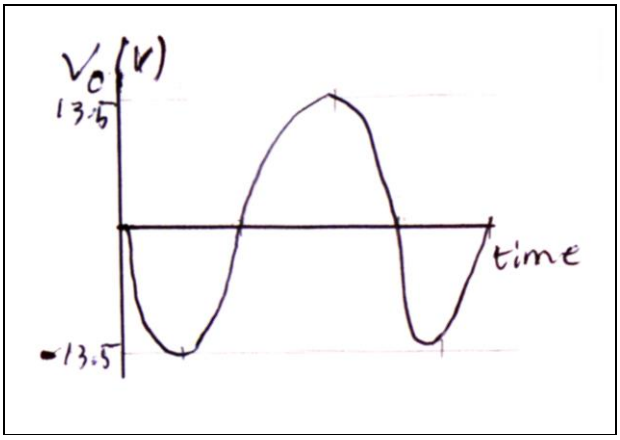
Part (b): (An op-amp, with a very large gain, is now connected across the 1·0 kΩ resistor. The candidate is asked to sketch the resulting output signal from the op-amp. Their answer should have shown that the output signal is inverted, that the op-amp goes into saturation and that, for the very high gain, the output signal is a square wave)

- A significant number of candidates failed to show inversion of the signal.
- Many candidates failed to realise that the op-amp saturates and so sketched a sine wave for the output trace.
- Of those who realised that saturation occurs, many showed a 'clipped' sine wave as the output trace.

- The given input trace showed three half cycles. For their ‘corresponding’ output trace, some candidates showed a different number of cycles. This is wrong as it would indicate a change in frequency of the output signal.

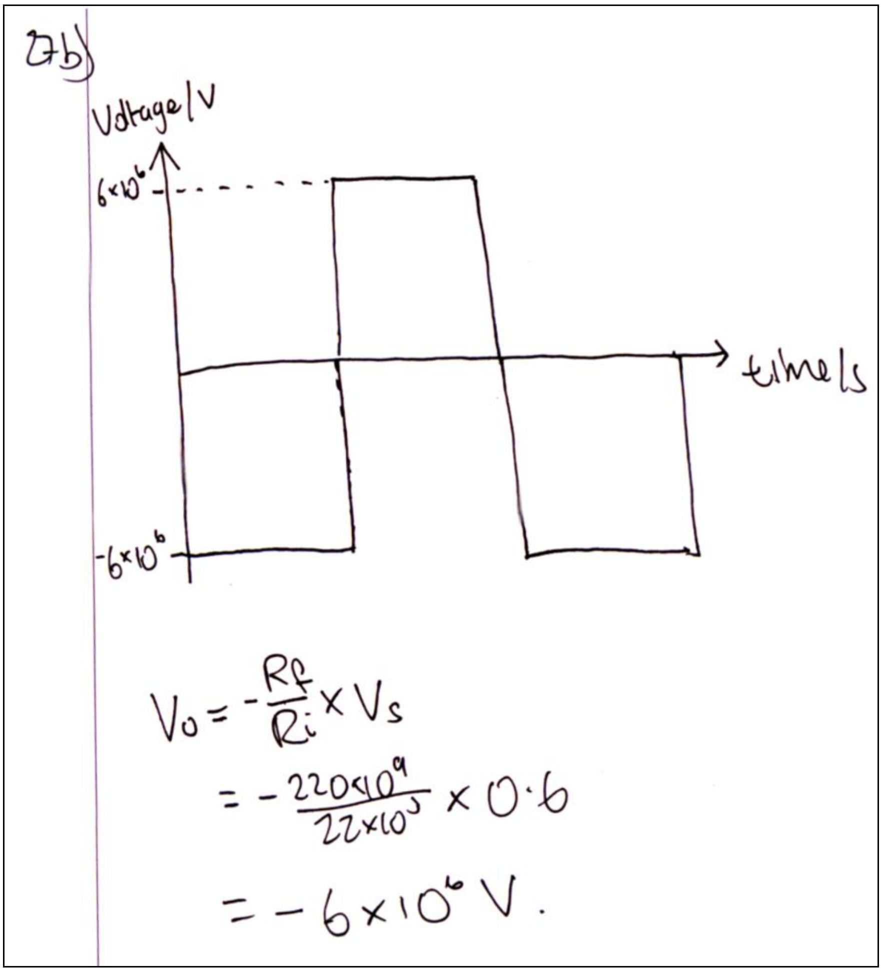
Examples of candidates’ answers to question 27(b):

1.



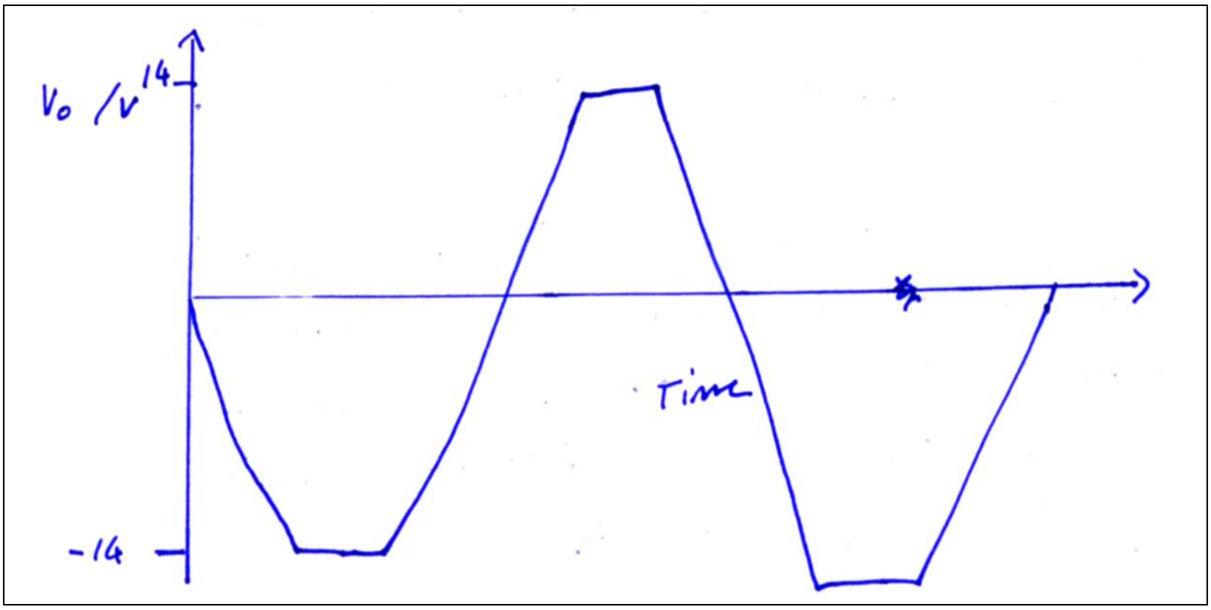
Comment: This candidate has realised that the signal is inverted and that the op-amp saturates. However, the very high gain of the circuit means that even the smallest value of input signal will produce an output voltage at ±15 V (approximately). This means that the shape of the output signal should be ‘square’.

2.



Comment: This candidate has realised that the signal is inverted and that the output is 'square' in shape. However, they have stated that the maximum value is ±6 x 10^6 volts, rather than ±15 V.

3.



Comment: This answer correctly shows inversion and that the maximum output voltage is near to the value of the supply voltage (ie ±15 V). However, it has not been realised that with such a high gain even the smallest value of input voltage will be so greatly amplified that it produces an output voltage at ±15 V (ie a ‘square’ wave output).

Question 28 – This question asks candidates about the interference patterns produced by two different experimental setups. The first uses monochromatic light incident on a grating and the second uses a source of microwaves in front of a double gap in metal plates.

Parts (a) and (b)(i) were well done, but the answers to part (b)(ii) were poorer.

Specific areas of weakness in the answers from candidates were:

Part (a):

- The wavelength of the light was given as ‘589 nm’ – some candidates did not know the meaning/value of the prefix ‘nano’.

Part (b)(i): (Candidates were given the path lengths from each gap and asked whether constructive or destructive interference occurs at point **J**. They were also told that they must justify their answer by calculation.

The most straightforward way to answer this part is to show that the path difference is 75 mm and that 2·5 wavelengths ‘fit into’ this path difference. The odd half wavelength in the path difference means that destructive interference occurs at **J**.)

- Some candidates made no attempt at a calculation. Showing an appropriate calculation was essential in order to gain any marks.
- A significant number of candidates worked out the path difference in millimetres but then divided this by the wavelength in metres (despite having been given this too in millimetres).
- A significant number of candidates did not answer as instructed by choosing ‘constructive’ or ‘destructive’. Markers quite frequently saw ‘minimum’ and even ‘deconstructive’.

Part (b)(ii): (Candidates were told that point **K** is initially a point of destructive interference. They were asked what happens to the strength of the signal detected at **K** when one of the gaps is covered with a sheet of metal. Again they were told that they must justify their answer.

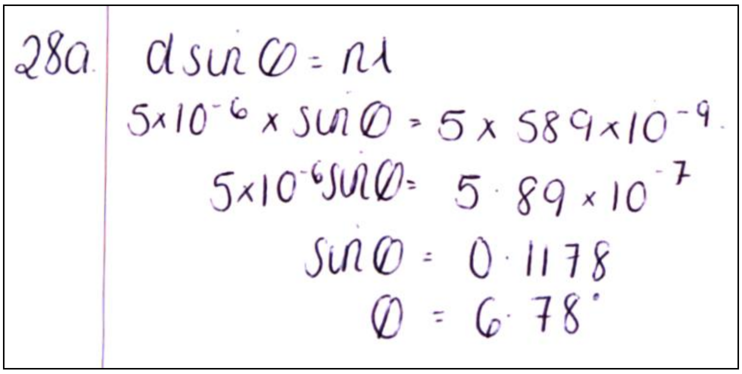
An appropriate answer should have said that, because there is now only one set of waves reaching point **K**, destructive interference no longer occurs and so the strength of the signal increases.)

- Some candidates made no attempt at a justification. Providing a justification was essential in order to gain any marks.

- Some candidates said that the signal strength increases because constructive interference now occurs at **K**, apparently being unaware that interference can only occur when two (or more) sets of waves meet and combine. This justification is wrong physics and prevents any marks being awarded.

Examples of candidates' answers to question 28:

1. For part (a):



28a. $d \sin \theta = n\lambda$

$5 \times 10^{-6} \times \sin \theta = 5 \times 589 \times 10^{-9}$

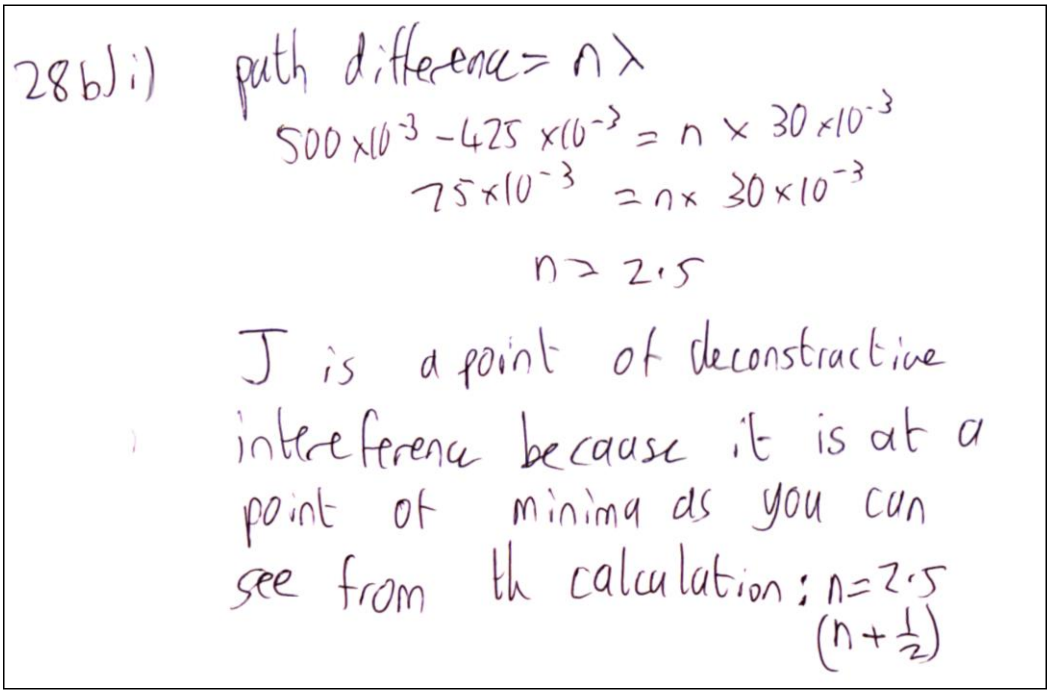
$5 \times 10^{-6} \sin \theta = 5 \cdot 89 \times 10^{-7}$

$\sin \theta = 0 \cdot 1178$

$\theta = 6 \cdot 78^{\circ}$

Comment: The question clearly states that the third order spectrum is to be considered. In the second line, the candidate has used a value of five for 'n' instead of three. This is regarded as wrong substitution and only a ½ mark can be awarded for selection of the correct relationship. (It is irrelevant that a further arithmetical error has been made in line three.)

2. For part (b)(i):



28b)i) path difference $= n\lambda$

$500 \times 10^{-3} - 425 \times 10^{-3} = n \times 30 \times 10^{-3}$

$75 \times 10^{-3} = n \times 30 \times 10^{-3}$

$n = 2 \cdot 5$

J is a point of deconstractive interference because it is at a point of minima as you can see from th calculation: $n = 2 \cdot 5$ $(n + \frac{1}{2})$

Comment: This candidate has carried out a good numerical analysis of the data, but for some unknown reason has failed to choose either of the options given by the question (ie ‘constructive’ or ‘destructive’). Instead, the candidate has used ‘deconstructive’. This word does not exist, has no meaning and cannot answer the question.

3. For part (b)(ii):

> ii) decrease, as the metal sheet is stopping some microwaves from getting through.

Comment: This is the ‘intuitive’ (but wrong) answer that is often given by someone who has little knowledge of the physics of wave behaviour. This wrong answer illustrates that the candidate does not understand what happens in destructive interference and that the signal strength increases when you prevent it from occurring.

4. For part (b)(ii):

> ii) It increases. Rather than two waves meeting out of phase from two gaps causing ~~constructive~~ destructive interference, the leave in phase from one gap meaning constructive interference which amplifies the signal.

Comment: Although this candidate has correctly stated that the strength of the signal increases, he/she has reached the conclusion using wrong physics. One gap means that there is now only one set of waves. This means that no interference can occur, not that ‘constructive interference’ occurs. For interference to occur there must be two (or more) sets of waves meeting and combining..

Question 29 – This is a short question on the refraction of light in a triangular glass prism. It also involves data handling skills, candidates being given a graph of refractive index versus wavelength for the glass prism.

Part (a) was quite well done, but the answers to part (b) were poorer.

Specific areas of weakness in the answers from candidates were:

Part (a): (Candidates were asked to calculate the angle of refraction for the ray of light as it leaves the prism.)

- There were a few candidates who used the wrong value of refractive index. They should have found that the refractive index for a wavelength of 660 nm is exactly 1·615. The wrong values for '*n*' appeared to be due to candidates making mistakes in reading the vertical scale of the graph.
- Although most candidates were able to select the Snell's law relationship, a significant number made errors at the substitution stage. The fact that the refraction is occurring as light travels from **glass into air** meant that candidates often substituted the angles the 'wrong way round'. [It is worth noting that candidates who used '$n_1 sin\theta_1 = n_2 sin\theta_2$', usually substituted correctly, worked out the correct answer and received full marks. Although that relationship is not provided in the data booklet, there is no problem with candidates using it in their answers.]
- There were a few candidates who performed inappropriate intermediate rounding when evaluating 'sin 38' and who therefore ended up with an inaccurate final answer. They should have kept the 'full' answer in their calculators in order to find $\sin^{-1}\{1{\cdot}615 \times \sin 38\}$.
- Some candidates failed to give the units for their final answer (ie degrees). It should be noted that in the future such errors will lose the full mark for the final answer under the new marking methodology in the CfE Higher.

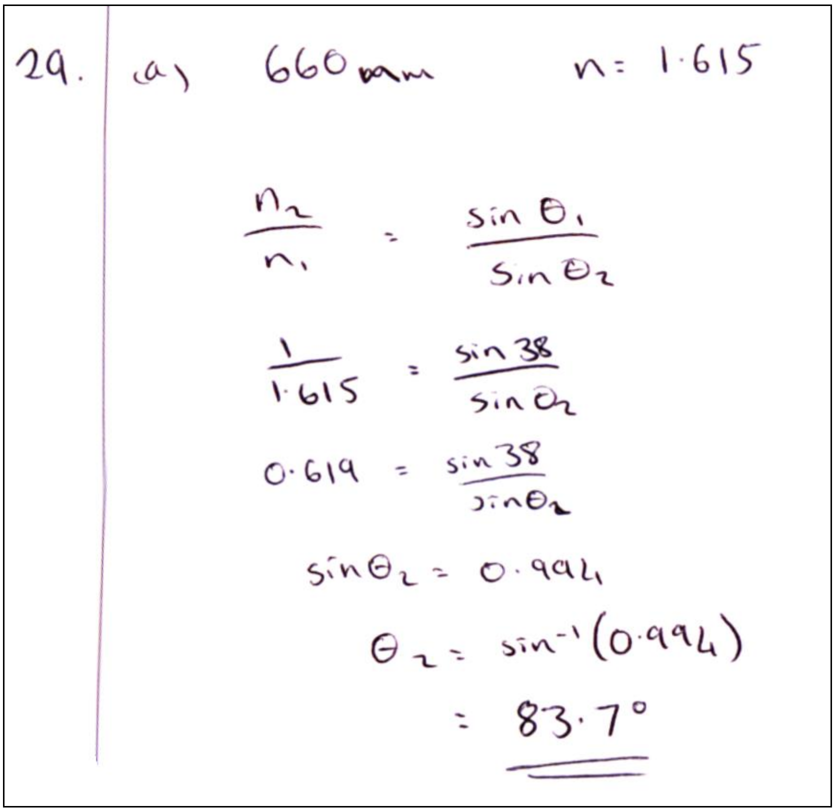
Part (b): (Candidates were told that light of shorter wavelength is now shone through the prism and asked whether its speed is less than, the same as or greater than the speed of the original ray. They were asked to justify their answer.

The correct answer required candidates to refer to the graph to realise that this shorter wavelength has a greater refractive index. As $n = v_1/v_2$, there is a greater change of speed and so the speed is less than before.)

- Many candidates quoted the wave formula ($v = f\lambda$) and stated that, because frequency remains constant on refraction, a shorter wavelength means a smaller velocity. This showed a lack of appreciation of the situation being presented in the question, where a different wavelength (and so a different frequency) was being used.

Examples of candidates' answers to question 29:

1. For part (a):


29. (a) 660 nm n: 1·615

$\frac{n_2}{n_1} = \frac{\sin\theta_1}{\sin\theta_2}$

$\frac{1}{1\cdot615} = \frac{\sin 38}{\sin\theta_2}$

$0\cdot619 = \frac{\sin 38}{\sin\theta_2}$

$\sin\theta_2 = 0\cdot994$

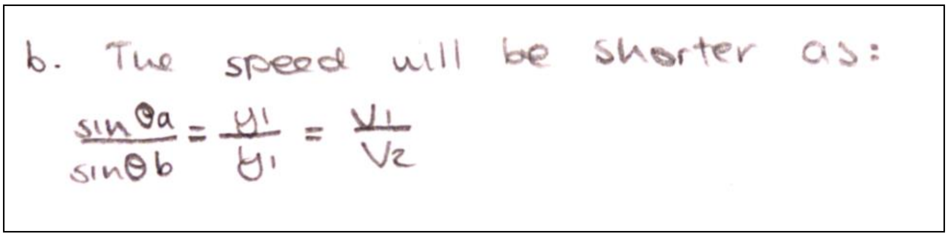
$\theta_2 = \sin^{-1}(0\cdot994)$

$= 83\cdot7°$

Comment: This candidate has chosen the correct relationship and substituted correctly. However, there are then two examples of intermediate rounding within the calculation. The value of 1/1·615 has been rounded to 0·619 (ie to three sig. figs.). In the next line, the value of sin 38/0·619 has been rounded to 0·994. The overall consequence is that the final answer is now inaccurate in the third figure (it should be 83·9^{o}).

Candidates should either retain any intermediate answer within their calculator all the way through to the final answer or they should round their intermediate answers to a greater number of significant figures so that the final answer is not affected (to the number of significant figures they wish to quote), eg keeping intermediate rounding to 5 significant figures and so using sin θ_2 = 0·99429, gives θ_2 correctly as 83·9^{o}.

2. For part (b):


b. The speed will be shorter as:

$\frac{\sin\theta a}{\sin\theta b} = \frac{y_1}{y_1} = \frac{V_1}{V_2}$

Comment: What does a ‘shorter’ speed mean?

Marks cannot be awarded when a candidate uses inappropriate terminology.

Question 30 – This question is based on an experimental arrangement to investigate the photoelectric effect.

Parts (a)(i) and (a)(ii) were well done but the responses to part (b) were poor.

Specific areas of weakness in the answers from candidates were:

Part (a)(i): (Calculation of the maximum kinetic energy of a photoelectron.)

- Many candidates correctly started their answer with $E_k = hf - hf_o$. However, some then substituted the work function of sodium in place of 'f_o' rather than for 'hf_o'. This error meant that they could only be awarded the partial marks for selecting the correct formula.

Part (a)(ii): (Calculation of the maximum velocity of a photoelectron.)

- Many candidates quoted too many significant figures in their final answer. The mass of an electron is given on the data sheet (page two of the examination paper) as $9{\cdot}11 \times 10^{-31}$ kg. This value (along with the other data provided in the question) has been given to three significant figures and so the appropriate number of sig. figs. in a candidate's answer should ideally be no greater than three also. However, markers frequently saw answers such as, 'v = 388817·34 m s^{-1}' (ie to eight sig.figs.). It appears that some candidates are confused about the difference between quoting an answer to, say, three significant figures and quoting an answer to three decimal places. It is recommended that candidates practise using scientific notation and giving the same number of significant figures in their final answer as the data in the question.
- There were also examples of rounding errors in the final answer. Ideally the answer of 388817·34 m s^{-1} should be given as $3{\cdot}89 \times 10^5$ m s^{-1}, but some gave it as $3{\cdot}88 \times 10^5$ m s^{-1} – this is incorrect rounding.

Part (b): (Candidates were asked to explain how decreasing the irradiance of the radiation affects the maximum velocity of a photoelectron.

An ideal answer would be: 'The reduction in the irradiance means that fewer photons are incident on the sodium plate every second. However, each photon has the same energy as before and, as one photon gives all its energy to one electron, each photoelectron has the same maximum velocity as before.' It is important to include this concept of one photon interacting with and releasing one electron as this is the basis of the quantum theory.)

- Although candidates were asked to 'explain', many failed to provide any attempt at an explanation.
- Some attempts at an explanation were simply statements and not explanations. For example 'the velocity of the photoelectrons is the same because irradiance does not affect velocity'. Markers were looking for the candidate to explain **why** changing the irradiance does not affect the maximum velocity of a photoelectron.

Examples of candidates' answers to question 30:

1. For part (a)(i):

a) i)

$E_k = hf - hf_0$

$E_k = (6{\cdot}63 \times 10^{-34} \times 6{\cdot}74 \times 10^{14}) - 3{\cdot}78 \times 10^{-19}$

$E_k = 4{\cdot}5 \times 10^{-19} - 3{\cdot}78 \times 10^{-19}$

$E_k = 7{\cdot}2 \times 10^{-20}$ J

Comment: This answer starts with the correct formula and is followed by correct substitutions. However, in moving from line two to line three, the candidate has rounded the answer to the calculation of (6·63 x 10^{-34} x 6·74 x 10^{14}) to 4·5 x 10^{-19} (it should be 4·46862 x 10^{-19}). This is an example of inappropriate rounding as it has caused the final answer to be inaccurate (the final answer should be 6·89 x 10^{-20} J).

2. For part (a)(ii):

~~[illegible]~~ $6{\cdot}89 \times 10^{-20}$ J

ii)

$E_k = \frac{1}{2} mv^2$

$6{\cdot}89 \times 10^{-20} = \frac{1}{2} \times 9{\cdot}11 \times 10^{-31} \times v^2$

$v^2 = 1{\cdot}5 \times 10^{11}$

$v = 387298{\cdot}3$ m/s

Comment: The candidate has correctly used their answer to part (a)(i) to find the velocity. Both the value of the energy and the mass of an electron are given to three significant figures. This should have been an indicator to the candidate about how many sig. figs. to quote in their final answer (ie three). However, the candidate has given their final answer quoted to seven significant figures. This is a mistake that markers cannot ignore.

3. For part (b):

b) It has no effect. Irradiance of the incident ~~[illegible]~~ light only determines the number of photoelectrons emitted per second and does not alter their energy. The velocity of a photoelectron is altered by the incident ~~p~~ ~~[illegible]~~ photon's frequency energy.

Comment: This answer shows some good understanding of the physics. The answer's weakness is that it does not get to the 'heart' of the quantum theory by specifically stating that one photon interacts with, and releases, one electron.

4. For part (b):

b) The irradiance of light does not affect the frequency, and therefore the energy, of its photons. Since only 1 photon at a time can attempt to free an electron, the energy given to electrons, and hence their maximum speed, is unaffected

Comment: This is a good answer!

5. For part (b):

b) This does not affect the ~~[illegible]~~ final ~~[illegible]~~ velocity as increasing the irradiance ~~only~~ ~~only~~ only increases the number of photons fired.

Comment: This answer misses out any mention of **rate**, ie the number of photons **per second** is changed when irradiance is altered.

Neither does this answer actually explain why the velocity of photoelectrons is unaffected as it does not go into the necessary detail of one photon releasing one electron.

Question 31 – This question is about electron transitions between atomic energy levels along with the associated radiations and emissions lines.

Part (a) was moderately well done, but the answers to parts (b), (c) and (d) were poor.

Specific areas of weakness in the answers from candidates were:

Part (a): (Candidates were given four energy levels for atom **Q** and asked how many lines were produced in the emission spectrum for these levels.)

- It was surprising and disappointing that only 60% of candidates could state that 6 emission lines are produced by transitions between these four energy levels.

Part (b): (Candidates were asked to consider both atoms **P** and **Q** and 'identify **the** transition that produces radiation of the lowest frequency'.

The correct answer is $\mathbf{Q}_3$ to $\mathbf{Q}_2$.)

- A significant number of candidates gave two transitions; one transition for **each** of atoms **P** and **Q**. Candidates must read questions very carefully and respond appropriately.
- Here, the use of an arrow can be accepted, ie $\mathbf{Q}_3 \longrightarrow \mathbf{Q}_2$. However, some candidates gave their answer as $\mathbf{Q}_2 \longrightarrow \mathbf{Q}_3$, which is wrong (as this means that an atom is **absorbing** energy and electrons are being raised from $\mathbf{Q}_2$ to $\mathbf{Q}_3$).
- Other candidates gave their answer as $\mathbf{Q}_3 - \mathbf{Q}_2$, which does not make clear the correct 'direction' of the transition and so cannot be awarded marks.

Part (c): (Candidates were given a table showing the three values for the energy levels for atom **P** and were asked to calculate the shortest wavelength of radiation emitted from atom **P**.

The ideal answer should find the greatest energy difference, ie *E*, between the levels $\mathbf{P}_2$ and $\mathbf{P}_0$, and then calculate the wavelength from $\lambda = hv/E$.)

- A disappointingly high number of candidates used an energy **value** from the table rather than an energy **difference** between the given values.
- The values of Planck's constant and the speed of light are given in the data sheet to three significant figures. It is therefore appropriate that the final answer is also quoted to three significant figures and that any intermediate calculations are **not** rounded off to the extent of affecting the value of this final answer. A significant number of candidates either carried out inappropriate intermediate rounding or quoted their final answer to too many sig. figs.

Part (d)(i): (Candidates were asked to explain why an emission line for atom **P** was the **same colour** as one for atom **Q**.

The ideal answer is that, because the two energy gaps are the same size, the emitted photons have the same energy and hence the same frequency.)

- Many answers were imprecise, for example making reference to the 'size between the energy levels'.
- Some answers referred to the energy 'required' by electrons for the transition rather than the energy emitted by electrons making that transition.

Part (d)(ii): (Candidates were asked to explain why an emission line for atom **P** was **brighter** than one for atom **Q**.

The ideal answer is that more electrons make the transition per second in atom **P** and so more photons are emitted per second.)

- An essential requirement for a complete answer is to make reference to the **rate** of electron transitions and/or photon emission. Many candidates failed to do this, saying only 'more electrons make that transition' or 'more photons are emitted'.

Examples of candidates' answers to question 31:

1. For part (b):

> b) Lowest freq : lowest energy.
>
> $Q_3 - Q_2$ produces lowest frequency.

Comment: This candidate has identified that a transition between energy levels Q_3 and Q_2 corresponds to the lowest amount of energy. However, an electron can go through this transition in either direction, ie Q_2 to Q_3 corresponds to the lowest amount of energy being **absorbed**, whereas Q_3 to Q_2 corresponds to the lowest amount of energy being **emitted**. An essential part of the answer is to identify the 'direction' of the transition for radiation to be produced (rather than absorbed). The dash between Q_3 and Q_2 is not sufficient to make this clear.

2. For part (d)(ii):

> ii) more transitions happen from P_2 to P_1 than from Q_2 to Q_1 so more photons are emitted from P.

Comment: This answer misses out any mention of **rate**, ie the number of photons emitted **per second** is what affects the brightness.

Other general issues:

- Many markers complained about the difficulty they had in reading the answers from some candidates due to unclear handwriting.
- A few candidates made more than one attempt at answering a question. For example, some produced two sketch graphs for question 26 part (a), one in the answer booklet and another on square-ruled paper. This causes problems when there are inconsistencies between the two answers. A marker cannot be expected only to choose the correct part(s) and ignore inconsistencies.
- Markers reported that the structure within numerical calculations was often of a poor standard and difficult to follow.

Advice to centres for preparation of future candidates

Many of the following points have already been made in the external assessment reports of the last few years. However, these points are being repeated as they cover areas which still require to be improved to ensure better success for candidates in the future.

- Candidates must read each question very carefully and ensure that their response really does answer what has been asked. Candidates should be encouraged to re-read a question immediately after writing their answer. This practice could reduce the frequency of inappropriate or incomplete answers.

- Candidates should be encouraged to present their numerical analyses in a clear and structured way – markers need to be able to follow the logic in candidates' answers.

- Candidates must attempt to write their answers legibly. If they wish to change an answer, it is usually better to rewrite the answer than to 'overwrite' the original answer.

- When a candidate makes two (or more) attempts for the same part of a question, they must score through the part(s) that they do not wish to be considered by the marker - they must not leave alternative answers for the marker.

- Candidates must be prepared to present their answers on blank paper. It should be ensured that they have had sufficient practice in presenting written paragraphs, clearly structured calculations and neat diagrams on unlined paper prior to sitting the examination paper.

- Candidates should consider using square-ruled paper for some of their answers. Answers which might be improved by using this paper include vector diagrams, sketched graphs and other diagrams such as those showing the path(s) taken by rays of light.

- Candidates should use a ruler when drawing straight lines. For example, when drawing the axes of graphs and the path(s) taken by rays of light.

- Candidates must remember to quote direction as well as magnitude when giving vector quantities as answers.

- Candidates should not use up (↑) and down (↓) arrows in their answers rather than using words. The use of arrows may be acceptable 'shorthand' when making their own notes, but candidates should not use this symbolism when attempting to communicate Physics to others – as in examination answers.

- Candidates must start their answers to 'show' questions by quoting an appropriate formula before any numbers/values are used. The substitution of numbers should then use the data given in the question without 'mental arithmetic' having been performed.

- Candidates must be aware that, in a ‘must justify’ question, no marks can be awarded if no attempt is made at a justification.

- Most candidates need more practice in writing descriptions and explanations. They need to be more careful in the detail and precision of the language used in their descriptions and explanations.

- Many candidates would benefit from spending more time learning correct technical terminology (for example, ‘*destructive interference*’, not ‘*deconstructive interference*’) and correct spelling (for example, ‘*capacitor*’, not ‘*capacitator*’). Careful study of the content statements for the course could help candidates with this issue.

- Candidates must understand that to ‘sketch’ a graph does not mean that the graph can be untidy or inaccurate. The instruction to ‘sketch’ a graph only means that **it does not have to be drawn to scale**. Care should still be taken to present these sketches as neatly as possible. For example, a ruler should be used to draw the axes and any straight sections of the graph line. The origin and axes on sketch graphs must be labelled and any important values carefully shown. It is useful to link these important values to the relevant parts of the graph line using dotted reference lines. It is wise to use a pencil when attempting to draw the graph line – any wrong line(s) can then be erased to leave a neat, clear, single line as the final answer.

- Many candidates would benefit from more practice at reading data from graphs which have been drawn with a variety of scales.

- Some candidates would benefit from further advice and practice on presenting their final answers to an appropriate number of significant figures.

- In numerical calculations, candidates should round off values only at their final answer for a part of a question. The answer(s) to any intermediate calculation(s) should not be rounded to the extent of causing inaccuracy in the final answer. This could also involve advice being given about the efficient use of handling data on a calculator.

- Candidates must ensure that they know all the prefixes required for the course and that they practise using the correct power of ten for each prefix.

Statistical information: update on Courses

Number of resulted entries in 2013	8788

Number of resulted entries in 2014	9098

Statistical information: Performance of candidates

Distribution of Course awards including grade boundaries

Distribution of Course awards	%	Cum. %	Number of candidates	Lowest mark
Maximum Mark 90				
A	27.4%	27.4%	2490	60
B	25.4%	52.8%	2311	48
C	21.6%	74.4%	1967	37
D	9.5%	83.9%	866	31
No award	16.1%	-	1464	-

General commentary on grade boundaries

- While SQA aims to set examinations and create marking instructions which will allow a competent candidate to score a minimum of 50% of the available marks (the notional C boundary) and a well prepared, very competent candidate to score at least 70% of the available marks (the notional A boundary), it is very challenging to get the standard on target every year, in every subject at every level.

- Each year SQA therefore holds a grade boundary meeting for each subject at each level where it brings together all the information available (statistical and judgemental). The Principal Assessor and SQA Qualifications Manager meet with the relevant SQA Business Manager and Statistician to discuss the evidence and make decisions. The meetings are chaired by members of the management team at SQA.

- The grade boundaries can be adjusted downwards if there is evidence that the exam is more challenging than usual, allowing the pass rate to be unaffected by this circumstance.

- The grade boundaries can be adjusted upwards if there is evidence that the exam is less challenging than usual, allowing the pass rate to be unaffected by this circumstance.

- Where standards are comparable to previous years, similar grade boundaries are maintained.

- An exam paper at a particular level in a subject in one year tends to have a marginally different set of grade boundaries from exam papers in that subject at that level in other years. This is because the particular questions and the mix of questions are different. This is also the case for exams set in centres. If SQA has already altered a boundary in a particular year in, say, Higher Chemistry this does not mean that centres should necessarily alter boundaries in their prelim exam in Higher Chemistry. The two are not that closely related as they do not contain identical questions.

- SQA's main aim is to be fair to candidates across all subjects and all levels and maintain comparable standards across the years, even as arrangements evolve and change.