Examiners' Report/
Lead Examiner Feedback

January 2018

BTEC Level 3 Nationals in Applied Science / Forensic and Criminal Investigation
Unit 1: Principles and Applications of Science I (31617H)

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January 2018
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**Grade Boundaries**

**What is a grade boundary?**
A grade boundary is where we set the level of achievement required to obtain a certain grade for the externally assessed unit. We set grade boundaries for each grade, at Distinction, Merit, Pass and Near Pass.

**Setting grade boundaries**
When we set grade boundaries, we look at the performance of every learner who took the external assessment. When we can see the full picture of performance, our experts are then able to decide where best to place the grade boundaries – this means that they decide what the lowest possible mark is for a particular grade.

When our experts set the grade boundaries, they make sure that learners receive grades which reflect their ability. Awarding grade boundaries is conducted to ensure learners achieve the grade they deserve to achieve, irrespective of variation in the external assessment.

**Variations in external assessments**
Each external assessment we set asks different questions and may assess different parts of the unit content outlined in the specification. It would be unfair to learners if we set the same grade boundaries for each assessment, because then it would not take accessibility into account.

Grade boundaries for this, and all other papers, are on the website via this link:
http://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

**Unit 1: Principles and Applications of Science I (31617H)**

| Grade | Unclassified | Level 3 | | | |
|---|---|---|---|---|---|
| | | N | P | M | D |
| Boundary Mark | 0 | 9 | 19 | 37 | 56 |

# Introduction

This unit covers some of the key science concepts in biology, chemistry and physics. Further key science concepts are considered in Unit 5: Principles and Applications of Science II.

Scientists and technicians working in science and science-related organisations must have a good understanding of core science concepts. A strong grasp of these concepts will enable you to use and apply this knowledge and understanding in vocational contexts when studying other units within this specification.
The topic areas covered in this unit include: animal and plant cells; tissues; atomic structure and bonding; chemical and physical properties of substances related to their uses; waves and their application in communications.

In addition, there was 30 minutes added to the time of the 1801 paper since the 1706 series.

# Individual Questions

**Biology**
**SECTION A: STRUCTURE AND FUNCTIONS OF CELLS AND TISSUES**

**General comments**

It was clear that the learners had made use of the Sample Assessment Material and 1706 paper as an improvement in exam technique and knowledge was evident. However assessors still need to ensure that learners are fully prepared for the exam, especially in relation to reading the question carefully, giving on topic responses and not repeating the stem of the question in their response as credit cannot be given for this. Key definitions, such as the definition of the term organ, the conversion between units and plant cell specialisations seem to be weak, as did leaners' familiarity with the structure and function of organelles. Scientific knowledge was lacking in some questions and only the stronger learners were able to apply their scientific knowledge and make connections, particularly in questions 1b and 4b. Learners should also be taught that when they have answered the question to reread their response to ensure that the question set has been addressed in the answer they have given and that they have used appropriate scientific knowledge and vocabulary.

**Question 1a**

This question was poorly answered with knowledge on specialised plant cells appearing to be a weakness. Where learners did score marks on this question it tended to be for "thin cell wall", however knowledge and understanding of structure and function of cell membrane and cell wall was limited.
The presence & function of the mitochondria was also a common response.
This is an example of a response which was awarded 2 marks.

(a) The plant root hair cell has a large surface area.
The large surface area increases the rate of absorption of water and ions from the soil.

State **two** other ways the structure of the plant root hair cell supports the absorption of water and ions from the soil.

(2)

1. Has lots of mitochondria to use as energy for the absorbtion of water or minerals
2. Thin cell wall which means there is a shorter distance for water to leave the plant

Many learners repeated information from the stem of the question and commented on surface area.
This is an example of a response which was awarded no marks.

(a) The plant root hair cell has a large surface area.
The large surface area increases the rate of absorption of water and ions from the soil.

State **two** other ways the structure of the plant root hair cell supports the absorption of water and ions from the soil.

(2)

1 It is thin, which creates a short diffusion path allowing water to be diffuse in quickly.

2 Has long end allows for absorbtion from a greater range distance to occur as the hair is long it covers

Learners tended to identify that the important structures are the vacuole and the cell wall but didn't include the correct scientific reasoning. Responses tended to focus on structure and support rather than absorption. There were also many improper references to vacuoles, mentioning its ability to store water rather than how it supports absorption.

**Question 1b**

Learners generally scored well here. The majority understood that the roots are underground and have no access to light. Fewer linked this to an inability to photosynthesise.
This is an example of a response which was awarded 2 marks.

(b) Explain why plant root hair cells do not contain chloroplasts.

(2)

The root hair cells are in the roots which are under the soil. As they are under the soil, no light can reach them therefore the chloroplast would not be able to absorb light for photosynthesis

Many correctly discussed role of chloroplast but without linking to the root hair and so not answering within the context of the question to show their understanding of the specialisations of the root hair cell.
This is an example of a response which was awarded no marks.

(b) Explain why plant root hair cells do not contain chloroplasts.

(2)

Chloroplasts are needed for photosynthesis

Some learners confused chloroplasts with mitochondria.

**Question 2a**

It was clear when learners had limited knowledge of cell ultrastructure and could not name ribosomes – many provided weak descriptions of bumpy surfaces, etc. This is an example of a response which was awarded 1 mark.

(a) State **one** structural difference between rough ER and smooth ER.

**(1)**

Rough ER has ribosommes attached to its outer membrane.

A lot of candidates stated one rough and the other smooth.
This is an example of a response which was awarded no marks.

(a) State **one** structural difference between rough ER and smooth ER.

**(1)**

rough er has a rough structure where as smooth er is more of a smooth structure.

There was also some confusion between ribosomes and mitochondria with many learners thinking rough ER has many mitochondria attached or referenced protecting the nucleus.

**Question 2b**

Generally well answered. Many candidates actually managed to include all 3 marking points in their answers. Synthesising/producing proteins most common correct answer. 'Packaging' proteins was usually seen rather than 'formation of vesicles'
This is an example of a response which was awarded 2 marks.

(b) Give **two** functions of rough ER.

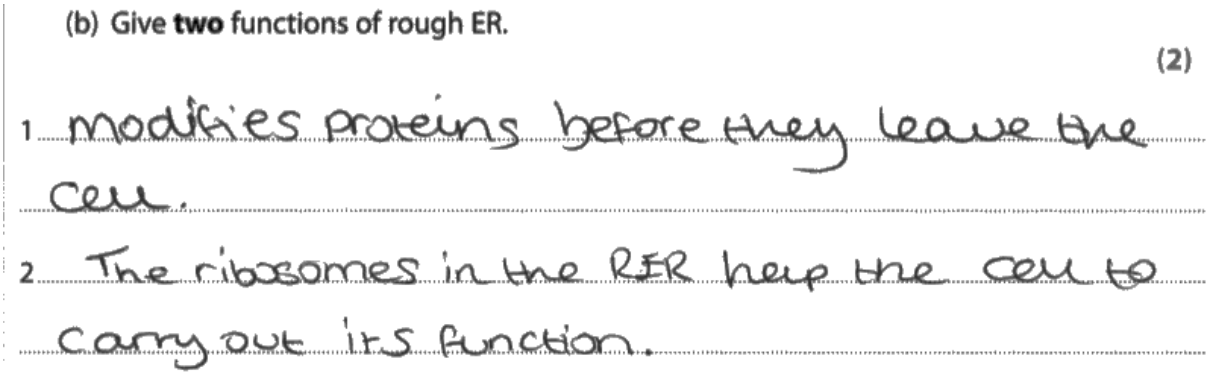
**(2)**

1 New proteins are synthesised in the rough ER

2 Rough ER transports newly synthesised proteins to the golgie apparatus

Incorrect responses usually related to lipid production or transport, with occasional references to functions relating to energy. A few gave modifying proteins – confusing this with the functions of the Golgi.

This is an example of a response which was awarded no marks.



(b) Give **two** functions of rough ER.

**(2)**

1 modifies proteins before they leave the cell.

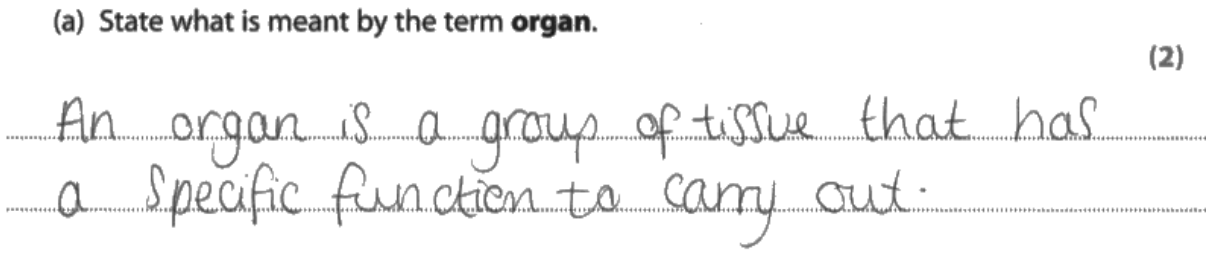
2 The ribosomes in the RER help the cell to carry out its function.

A number of candidates seemed to confuse the terms "protein synthesis" and "photosynthesis" as the latter was seen in several responses.

**Question 3a**

Many learners were able to clearly define the level of organisation of the organ in terms of several tissues combined to perform a specific function. Some restricted their answers to examples of organs or organ function without precise definition.

This is an example of a response which was awarded 2 marks.



(a) State what is meant by the term **organ**.

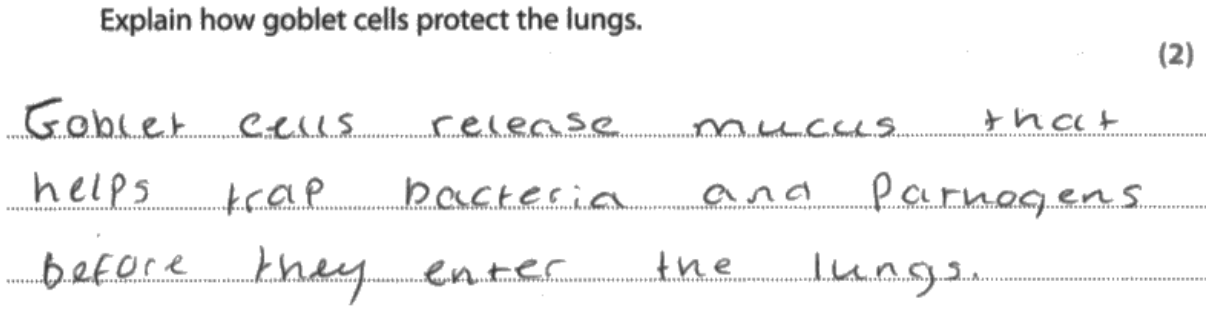
**(2)**

An organ is a group of tissue that has a specific function to carry out.

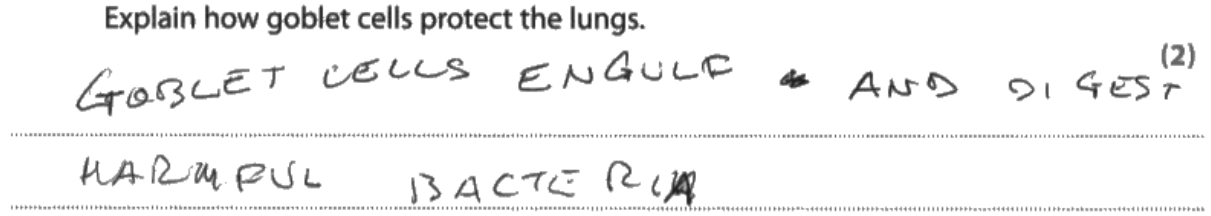
A few mistakenly provided the definition of a tissue.

**Question 3b**

A high proportion of learners stated that goblet cells secrete mucus. Only some then went on to mention mucus' role in trapping various particulates in order to score 2 marks.
This is an example of a response which was awarded 2 marks.




There were not many references to pathogens, the learners mainly writing about trapping dust or particles
There were some candidates who seemed to think that the goblet cells trapped the mucus rather than releasing it.
There were responses indicating confusion with the role of cilia, with many references to the wafting of mucus rather than production. Some candidates referred to the trapping of 'diseases'. There were also clear mix ups with white blood cells, where the student describes the engulfing of pathogens.
This is an example of a response which was awarded no marks.




**Question 3c**

Unfortunately there was much repetition of the stem in the responses to this question. However, most learners gave a response for one or two marks. Quite a few learners identified thickening and scarring but could only receive 1 mark as these were equivalent marking points. A number of learners referenced the reduction in surface area for gaseous exchange, but the weaker responses tended to refer to getting air/oxygen to the lungs, rather than gas exchange or diffusion of oxygen into the blood.

Linking of points to give a good explanation that covered at least 4 marking points was seen in the best answers.

This is an example of a response which was awarded 4 marks.

Describe how damage to the alveoli in the lungs leads to emphysema.

(4)

Damage to the alveoli via smoking or other factors can cause tar to build up over the alveoli. The alveoli can also experience swelling/inflammation. ~~which~~ Swelling/inflammation makes the thin membrane of the alveoli bigger/longer, thus increasing the diffusion pathway. An increase in diffusion pathway because of damaged alveoli causes the rate of diffusion to increase, making oxygen uptake harder. Scar tissue, tar, or inflammation all cause the membrane of the alveoli to increase, making it lose its elasticity and making diffusion ~~harder~~ into the blood harder.

**(Total for Question 3 = 8 marks)**

Some learners focused on pathogens and/ or fixated on the build-up of mucus in the lungs rather than referring to the alveoli, possibly due to the previous question. Also a number of responses suggested that emphysema is a bacterial infection.
Several candidates referenced veins and arteries narrowing, suggesting confusion with atherosclerosis.
Some learners were able to specify cells or lining, but on the whole there was very little understanding of the structures of the tissues in the alveoli.

This is an example of a response which was awarded no marks.

Describe how damage to the alveoli in the lungs leads to emphysema.

(4)

The alveoli ~~makes sure can hold~~ have pockets ~~to hold the oxygen~~ that are filled up by oxygen so when they are damaged, they can no longer hold as much oxygen in them. This causes shortness of breath due to them not being able to stretch out as much.

This answer was often preceded by an explanation of how smoking related to development of emphysema, rather than focusing on the damage to the alveoli walls.

This is an example of a response which was awarded 1 mark, for the effect of the damage to the alveoli on diffusion.

Describe how damage to the alveoli in the lungs leads to emphysema.

(4)

Smoking causes you to have a build up of tars in your lungs. This can cause damage to the lungs and increase the dissicultty of dissusion, meaing you have a lack of oxygen.

**Question 4a**

Some good answers were seen where learners confidently carried out the correct conversion and subsequent calculation.

This is an example of a response which was awarded 2 marks.

(a) Calculate how many times larger the egg cell is compared to the sperm cell head.

Show your working.

Sperm cell ∴ 4μm = 0.001mm × 4 = 0.004mm (2)

egg cell = 0.1mm.

∴ 0.1mm / 0.004mm = 25

25 times.

Some performed a correct conversion and then calculated the difference in size instead of the ratio or tried to use the equation to calculate magnification. Therefore it is valuable to show working out as the learner was credited with a mark for the conversation.

This is an example of a response which was awarded 1 mark.

**4** The width of a sperm cell head was measured as 4 μm.

The width of an egg cell was measured as 0.1 mm.

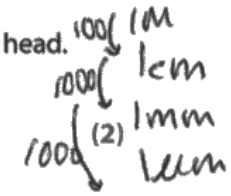
(a) Calculate how many times larger the egg cell is compared to the sperm cell head.

Show your working.

0.1 × 1000 = 100μm


head 4μm


Egg 100μm = 96 0.1mm / 100μm



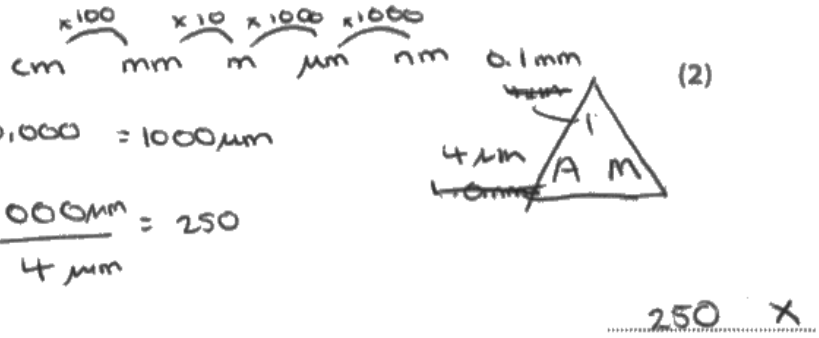

96μm

A few were unable to calculate a correct conversion and hence created a power of ten error although the method was correct.

This is an example of a response which was awarded 1 mark.

(a) Calculate how many times larger the egg cell is compared to the sperm cell head.

Show your working.




**Question 4b**

There were plenty of responses linking the mitochondria to ATP or respiration. Why this source of energy was required was less clear and so the vast majority of learners only scored 1 out of the possible 2.
Growth and cell division seen most frequently given for the second marking point, but all other clear valid uses of the energy were credited.
This is an example of a response which was awarded 2 marks.

Explain why an egg cell contains large amounts of mitochondria.

(2)

Because when it is fertilized it needs to be able to use the ATP from the mitochondria as energy for growth and division.

There were also many incorrect references to sperm cells, showing that the learners hadn't read the question carefully, and references to energy required for the movement of the egg, suggesting that the learner had confused the function of the egg with the function of the sperm.

This is an example of a response which was awarded 1 mark, for the comment "for energy".

**Explain why an egg cell contains large amounts of mitochondria.**

**(2)**

for energy So it can have maximum energy to travel and attach to Sperm.

Some learners gave a very vague use of the energy, such as for fertilisation, 'staying alive' or, occasionally, movement of the egg or sperm, and could not be credited as it was insufficient for a level 3 response.

This is an example of a response which was awarded 1 mark for the comment "it needs a lot of energy" but no further marks were awarded as the response "to produce a baby" is too vague.

**Explain why an egg cell contains large amounts of mitochondria.**

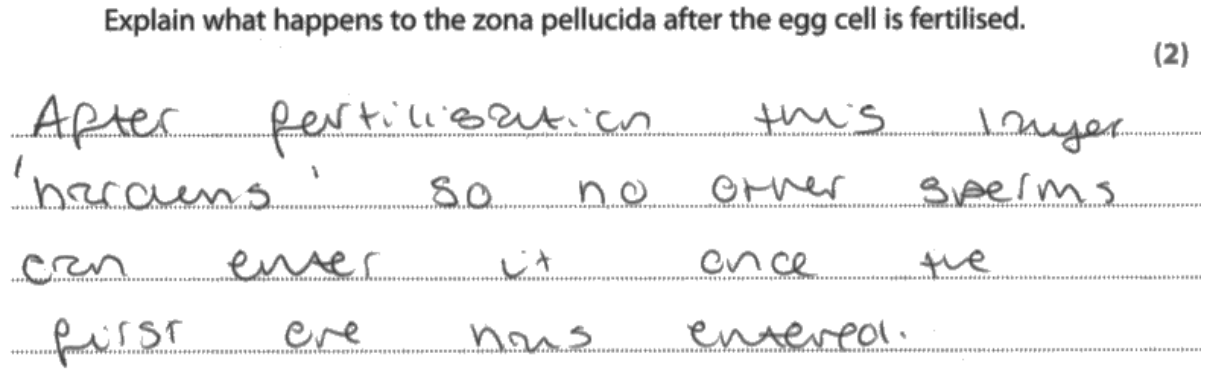
**(2)**

An Egg cell contains large amounds of mitochondria because it needs A lot of Energy ~~to~~ for to produce a baby.

**Question 4c**

This question was either answered very well or very poorly. Several good answers were seen where learners clearly understood the role of the zona pellucida immediately after fertilisation.

This is an example of a response which was awarded 2 marks.

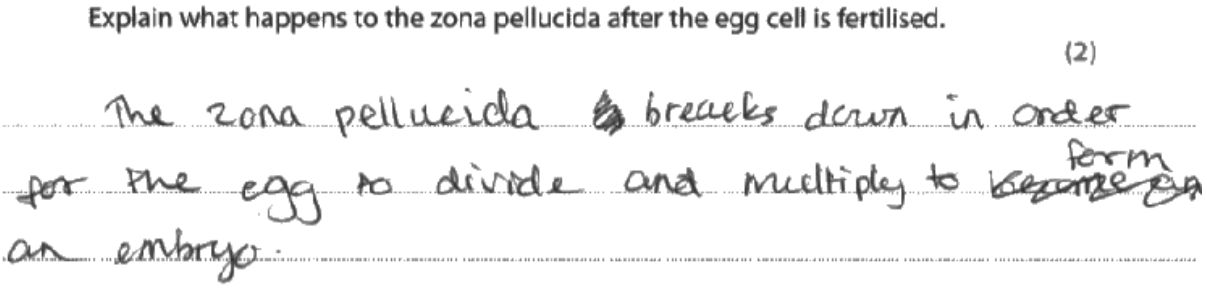

Explain what happens to the zona pellucida after the egg cell is fertilised.

(2)

After fertilisation this layer 'hardens' so no other sperms can enter it once the first one has entered.

Many suggested that the zona pellucida becomes the amniotic sac or the placenta. A large number of candidates thought the zona pellucida expanded in size to accommodate the embryo or it breaks down and provides nutrients for the embryo.

This is an example of a response which was awarded no marks.

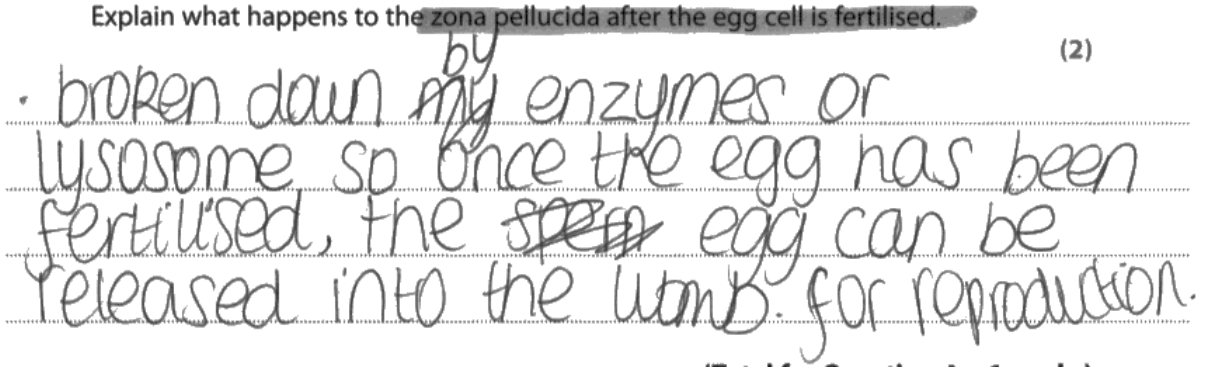

Explain what happens to the zona pellucida after the egg cell is fertilised.

(2)

The zona pellucida breaks down in order for the egg to divide and multiply to form an embryo.

A few responses were seen where candidates had failed to read the question and described the role during fertilisation rather than after.

This is an example of a response which was awarded no marks.


Explain what happens to the zona pellucida after the egg cell is fertilised.

(2)

• broken down by enzymes or lysosome so once the egg has been fertilised, the egg can be released into the womb for reproduction.

**Question 5a**

The first marking point was well understood and most candidates were able to give the role as increasing the speed of the impulse or the role of insulating the axon. It was pleasing to note that learners seemed to understand the process of saltatory conduction or could talk about the impulse jumping from node to node of Ranvier.

Speed of conduction was often twinned with insulation but only 1 mark could be awarded.

This is an example of a response which was awarded 2 marks.

**5** (a) Explain the role of myelin in the conduction of nerve impulses in myelinated axons.

**(2)**

Myelin is covered in a fatty layer which insulates electrical impulses through the axon. This helps the impuse travel faster as myelinated axons contain nodes of ranvier which help impulse jump to increase speed.

Weaker answers here tended to suggest that the myelin 'protects' the axon, which was too vague to credit. Some indicated that the impulse travelled through the myelin. Some could not be credited with the second marking point as their response was too vague or inaccurate about where the impulse was jumping – axon to axon, rather than along the axon, or over the nodes rather than from node to node.

This is an example of a response which was awarded no marks.

**5** (a) Explain the role of myelin in the conduction of nerve impulses in myelinated axons.

**(2)**

myelin helps the nerve impulses ~~nerve~~ move in the myelinated axons as the myelin conects the axons

**Question 5b**

Most learners scored this mark, but some were a little confused by the negative number and gave an incorrect answer of 40.

**Question 5c**

A high proportion of learners tackled this question which was good to see. Many centres have obviously taught this well.

This is an example of a response which was awarded level 3, 6 marks.

(c) Explain the changes in membrane potential between points A, B and C on the graph, with reference to changes in membrane permeability of:

- sodium ions
- potassium ions.

(6)

At point A, the axon is at resting potential which is -70mV. This is when the charge inside the axon is more negative than the charge outside the axon. The sodium channels in the axon open and let in sodium ions inside the axon from outside, which makes the axon become depolarised as the charge in the membrane potential is now more positive at +30 (point B on the graph). After this, the sodium channels close and potassium channels open which allows potassium ions to leave the axon; This is known as repolarisation (the membrane potential goes back to -70mV). If too many ions leave, then the membrane potential becomes too negative which is known as hyperpolarisation. At point C on the graph, the membrane potential goes back to -70mV; its resting potential.

The majority of candidates were able to demonstrate some knowledge and understanding. The majority of learners could recall the terms depolarisation, repolarisation and hyperpolarisation, but sometimes in the wrong context.
Most learners knew something about changes in axon permeability in relation to changes in axon potential difference.

However, alongside some good biological knowledge and understanding, there were some slips with many learners becoming confused, not least with Na+ and K+ ions moving the wrong way at the wrong time. Sometimes the K+ changed to K- to help explain a change in polarity. Some students tried to introduce the reactivity of the ions into their explanations. The weakest answers, where an attempt had been made, were ones where the entire answer was a description of the graph without any relevant content. Some took the graph as showing changes in membrane permeability rather than potential. Several candidates were under the impression that the permeability of ions changes, rather than the permeability of the membranes. The role of the sodium/potassium pump was often confused with diffusion, something that was talked about in the ratio of 3:2. Of those learners who described the sodium potassium pump, many got 3K and 2Na as opposed to 3Na and 2K and some had the ions travelling in the wrong direction. Some just described the graph and offered no explanation at all.

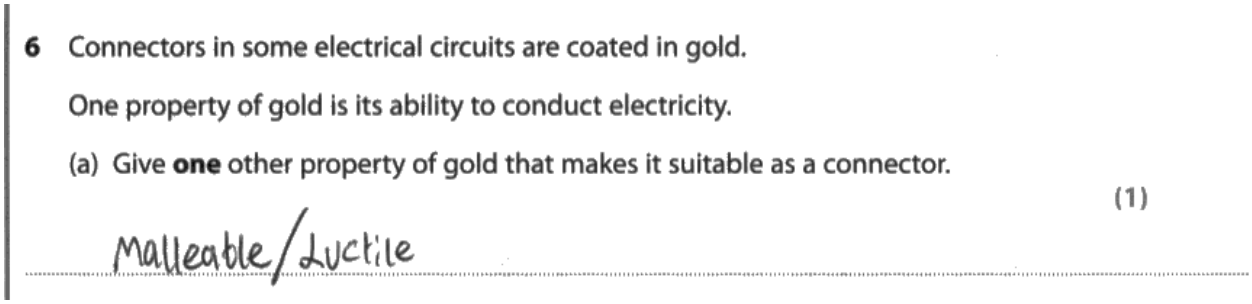
## Chemistry
## SECTION B: PERIODICITY AND PROPERTIES OF ELEMENTS

**General comments**:
This was the second sitting for this exam. Learners seemed to be better prepared than in the previous session and it was clear that revision had taken place.

Exam technique is still lacking from some learners - it is important that they are taught to read the question carefully and check that they answer the question posed, not a question that is assumed. In some cases, answers to the previous session's questions were repeated for a completely different question. Whilst this showed that learners are clearly using the sample assessment materials and post papers to revise from, it also shows that they are not interacting with the questions appropriately and applying their knowledge. Learners should be taught the importance of showing their working in calculation based questions.

In question 6a, the majority of learners were able to give one property of gold that makes it suitable as a connector in an electrical circuit.

Most gained a mark for stating that gold was malleable or ductile.



**6** Connectors in some electrical circuits are coated in gold.

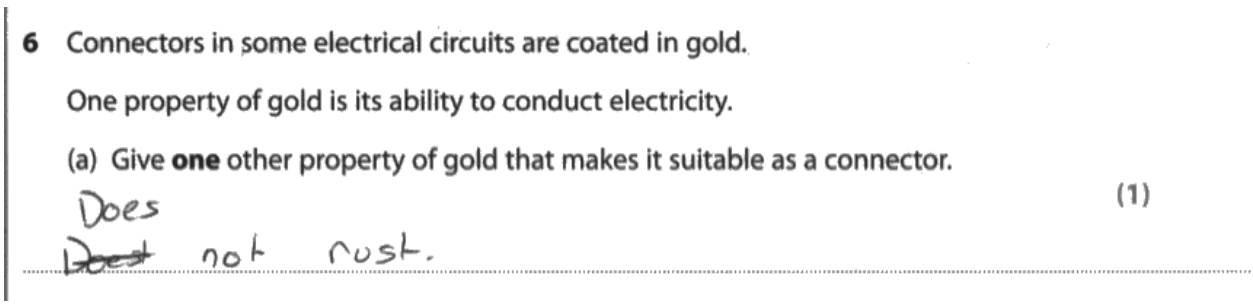
One property of gold is its ability to conduct electricity.

(a) Give **one** other property of gold that makes it suitable as a connector.

**(1)**

malleable/ductile

Fewer gave the answer that gold was unreactive. In some cases, learners stated that gold does not rust rather than gold was unreactive. Learners should understand that rust is a term that is reserved for the oxidation of iron rather than all metals and therefore credit was not awarded for answers involving rust.



**6** Connectors in some electrical circuits are coated in gold.

One property of gold is its ability to conduct electricity.

(a) Give **one** other property of gold that makes it suitable as a connector.

**(1)**

Does not rust.

Some learners did not score the mark as they did not read the question carefully and stated why metals such as gold conduct electricity instead of giving another property of gold.

**6** Connectors in some electrical circuits are coated in gold.

One property of gold is its ability to conduct electricity.

(a) Give **one** other property of gold that makes it suitable as a connector.

**(1)**

Free electrons

In question 6b, many learners were able to explain fully how gold conducts electricity to gain the three marks available.

(b) Explain how gold conducts electricity.

**(3)**

Its metallic structure allows gold to conduct electricity. The metallic structure is a lattice of positive ions surrounded by free-flowing delocalised electrons. These electrons carry the charge of electricity.

**(Total for Question 6 = 4 marks)**

The majority of learners knew that the metallic structure contains delocalised electrons, and that these electrons move. However, in some cases the learners did not add the extra detail to explain that it is the electrons that carry the charge in order to gain the third mark.

(b) Explain how gold conducts electricity.

(3)

delocalised electrons are free to move around it in a sea of electrons, this makes the metal positive.

A minority of learners stated that ions moved to carry charge - this was ignored and did not gain credit.

In question 7a, the majority of learners were able to use their periodic table to find the masses of the three elements present in ethanol and then use these to calculate the relative molecular mass for the molecule.

**7** The table shows some data about three compounds.

| compound | formula | relative molecular mass | boiling point (°C) |
|---|---|---|---|
| water | $H_2O$ | 18 | 100 |
| methanol | $CH_3OH$ | 32 | 65 |
| ethanol | $C_2H_5OH$ | | 79 |

(a) Calculate the relative molecular mass for ethanol.

Show your working.

(2)

C = 12 x 2 = 24
H = 1 x 5 = 5
O = 16 x 1 = 16
H = 1 x 1 = 1

24 + 16 + 5 + 1 = 46

Relative molecular mass = 46

It is very important that learners show their working. In some cases, learners did not find the atomic masses correctly, but were able to multiply by the correct multiples to gain one mark.

**7** The table shows some data about three compounds.

| compound | formula | relative molecular mass | boiling point (°C) |
|---|---|---|---|
| water | $H_2O$ | 18 | 100 |
| methanol | $CH_3OH$ | 32 | 65 |
| ethanol | $C_2H_5OH$ | 26 | 79 |

(a) Calculate the relative molecular mass for ethanol.

Show your working.


C = 6
H = 1
O = 8

(6×2) + (1×5) + 8 + 1 = 26

(2)

Relative molecular mass = 26

In other cases, learners were able to find the correct masses but did not multiply by the correct multiples and so gained just 1 mark. Marks could be awarded in both of the cases as working was shown, but if the incorrect answers of 26 or 136 were given with no working, then these marks could not have been awarded.

**7** The table shows some data about three compounds.

| compound | formula | relative molecular mass | boiling point (°C) |
|---|---|---|---|
| water | $H_2O$ | 18 | 100 |
| methanol | $CH_3OH$ | 32 | 65 |
| ethanol | $C_2H_5OH$ | | 79 |

(a) Calculate the relative molecular mass for ethanol.

Show your working.

C = 12
O = 16
H = 1

C × 2 = 24
H × 6 = 96
O × 1 = 16
= 136

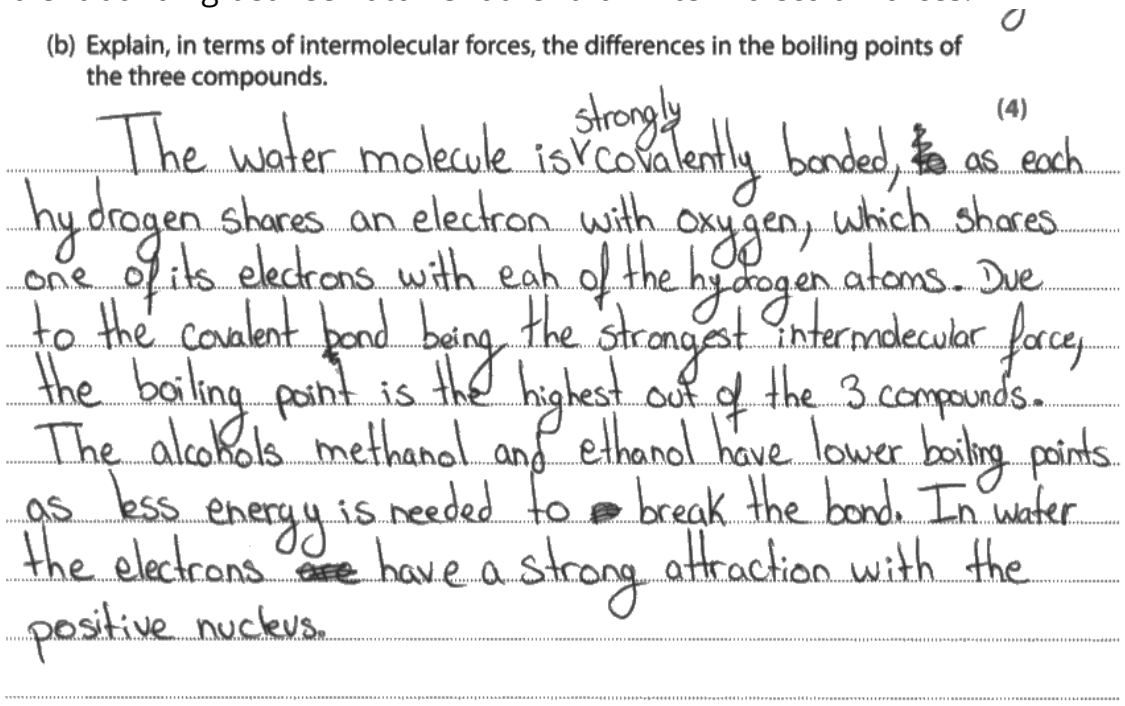
(2)

Relative molecular mass = 136

Learners found question 7b quite difficult. Only a small percentage of learners scored the full four marks available and were able to explain in terms of the intermolecular forces present the differences in the boiling points of water,

methanol and ethanol. Some very good explanations were seen that scored the full marks.

Learners that did not perform as well in this question, often referred to the covalent bonding between atoms rather than intermolecular forces.



(b) Explain, in terms of intermolecular forces, the differences in the boiling points of the three compounds.

(4)

The water molecule is strongly covalently bonded, as each hydrogen shares an electron with oxygen, which shares one of its electrons with eah of the hydrogen atoms. Due to the covalent bond being the strongest intermolecular force, the boiling point is the highest out of the 3 compounds. The alcohols methanol and ethanol have lower boiling points as less energy is needed to break the bond. In water the electrons have a strong attraction with the positive nucleus.

A fair proportion of learners knew that hydrogen bonding is the strongest intermolecular force or Van der Waals the weakest to gain a mark but were unable to take this any further to gain further credit.

(b) Explain, in terms of intermolecular forces, the differences in the boiling points of the three compounds.

(4)

london forces are the weakest intermolecular force.

water has the highest boiling point and is a covalent bond

Both methanol and ethanol are hydrogen bonds.

In question 8a, many learners were able to use the information in the stem of the question to write the balanced equation for the reaction of potassium bromide with silver nitrate.

If learners gave state symbols, they were ignored whether correct or not.

**8** (a) Silver bromide, AgBr, is an important chemical in the manufacture of photographic film.

Potassium bromide reacts with silver nitrate, $AgNO_3$, to form silver bromide.

Write the balanced equation for the reaction of potassium bromide with silver nitrate.

(2)

$KBr_{(s)} + AgNO_{3(aq)} \rightarrow AgBr_{(s)} + KNO_{3(aq)}$

Some learners wrote word equations. Learners should be taught that if a balanced equation is asked for then word equations will not be accepted.

**8** (a) Silver bromide, AgBr, is an important chemical in the manufacture of photographic film.

Potassium bromide reacts with silver nitrate, $AgNO_3$, to form silver bromide.

Write the balanced equation for the reaction of potassium bromide with silver nitrate.

(2)

potassium bromide + silver nitrate → silver bromide + potassium nitrate

A common error was to not to include the potassium nitrate on the right hand side of the equation, therefore scoring just 1 mark for the left hand side of the

equation. Learners should be taught to check that the equation balances once written.

**8** (a) Silver bromide, AgBr, is an important chemical in the manufacture of photographic film.

Potassium bromide reacts with silver nitrate, $AgNO_3$, to form silver bromide.

Write the balanced equation for the reaction of potassium bromide with silver nitrate.

**(2)**

KBr + $AgNO_3$ → AgBr

In question 8b, the majority of learners found it very hard to recall the correct definition of an ionic bond.
Just a small percentage of learners were able to recall the correct definition, as in this case, to score the mark.

(b) Silver bromide and potassium bromide both contain strong ionic bonds.

State what is meant by the term **ionic bond**.

**(1)**

Ionic bond means ~~bon~~ the electrostatic attraction between posative and negative ions.

A common error seen was where learners had tried to describe how ions are formed rather than stating what is meant by the term ionic bond.

(b) Silver bromide and potassium bromide both contain strong ionic bonds.

State what is meant by the term **ionic bond**.

**(1)**

Ionic bond is which an atom agains one or more electrons and donates to Other element.

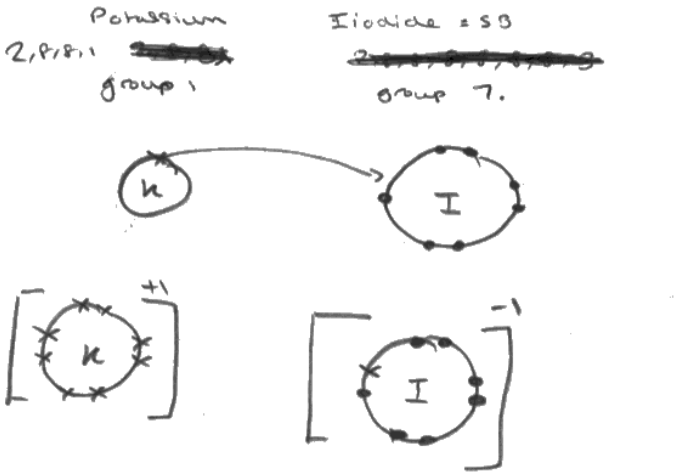
In question 8ci, the majority of learners were able to draw a dot-and-cross diagram to show the bonding in potassium iodide.

(c) Potassium iodide, KI, is another ionic compound.

(i) Draw a dot and cross diagram to show the bonding in **potassium iodide**.

Show the outer electrons only.

**(3)**




in cases where learners lost marks, it was often because they had the charge on the ions the wrong way around or if they forgot to add the charge on the ions completely.

(c) Potassium iodide, KI, is another ionic compound.

(i) Draw a dot and cross diagram to show the bonding in **potassium iodide**.

Show the outer electrons only.

**(3)**

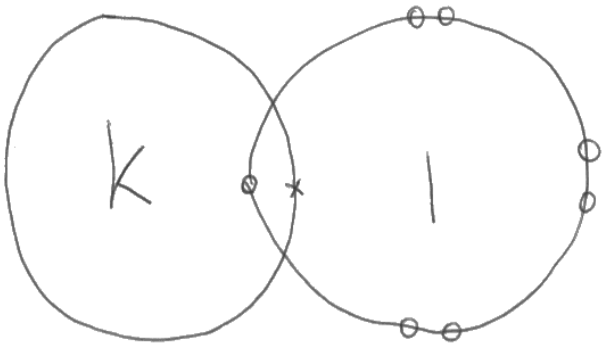

A minority of learners had drawn a covalent rather than an ionic bond and so scored a maximum of 1 mark.

(c) Potassium iodide, KI, is another ionic compound.

(i) Draw a dot and cross diagram to show the bonding in **potassium iodide**.

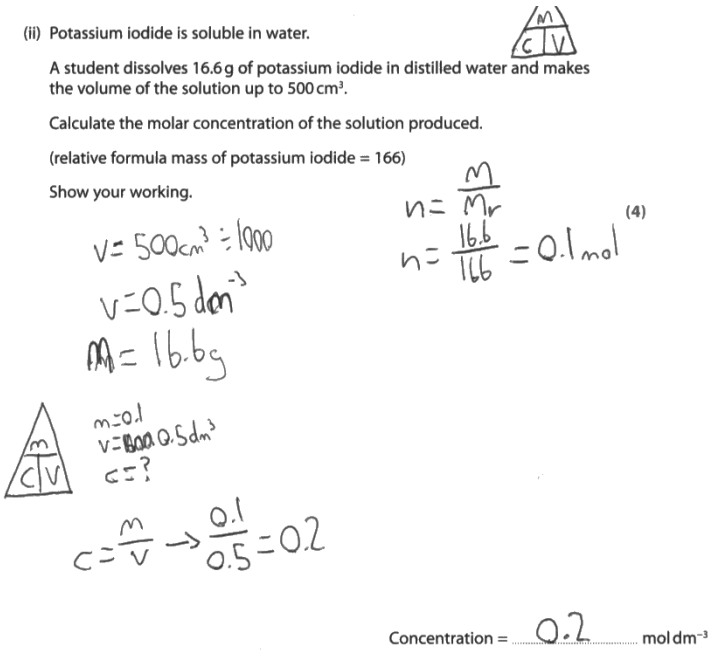
Show the outer electrons only.

**(3)**



In question 8 part cii, a good proportion of learners were able to calculate the molar concentration of the potassium iodide solution.

In the best responses seen, the answer was set out clearly and showed how the learner had calculated the concentration to score all four marks available.


(ii) Potassium iodide is soluble in water.

A student dissolves 16.6 g of potassium iodide in distilled water and makes the volume of the solution up to 500 $cm^3$.

Calculate the molar concentration of the solution produced.

(relative formula mass of potassium iodide = 166)

Show your working.

(4)

$V = 500 cm^3 \div 1000$

$V = 0.5 dm^{-3}$

$m = 16.6g$

$m = 0.1$

$V = 0.5 dm^3$

$c = ?$

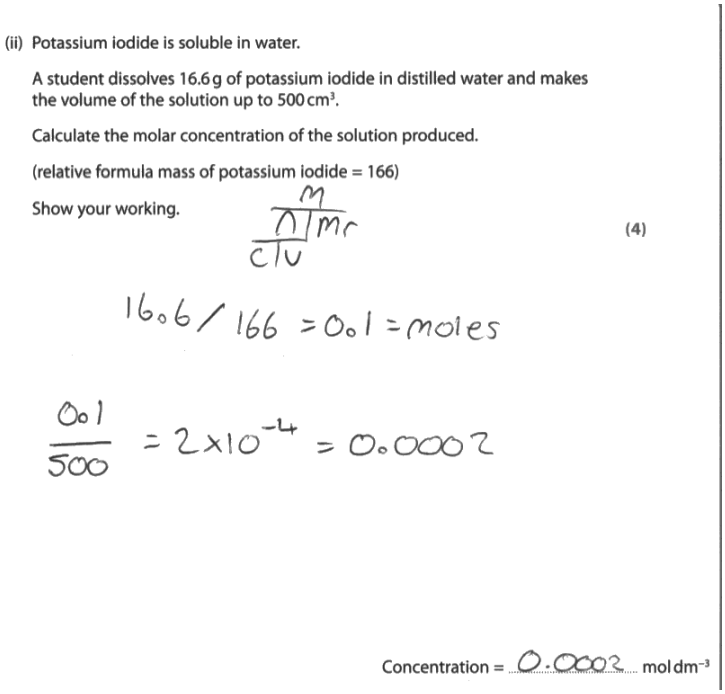
$c = \frac{n}{V} \rightarrow \frac{0.1}{0.5} = 0.2$

$n = \frac{m}{M_r}$

$n = \frac{16.6}{166} = 0.1 mol$

Concentration = 0.2 mol $dm^{-3}$

In some cases, learners lost a mark because they did not convert the volume correctly and therefore scored three rather than four marks.


(ii) Potassium iodide is soluble in water.

A student dissolves 16.6 g of potassium iodide in distilled water and makes the volume of the solution up to 500 $cm^3$.

Calculate the molar concentration of the solution produced.

(relative formula mass of potassium iodide = 166)

Show your working.

(4)

16.6 / 166 = 0.1 = moles

$\frac{0.1}{500} = 2 \times 10^{-4} = 0.0002$

Concentration = 0.0002 mol $dm^{-3}$

Weaker learners were able calculate the number of moles in the solution but were not able to take this any further.

(ii) Potassium iodide is soluble in water.

A student dissolves 16.6 g of potassium iodide in distilled water and makes the volume of the solution up to 500 $cm^3$.

Calculate the molar concentration of the solution produced.

(relative formula mass of potassium iodide = 166)

Show your working.

(4)

P + I → PI

| | | | |
|---|---|---|---|
| Mass | | | 16.6g |
| Moles | | | 0.1 |
| Mr | 39.1 | 126.9 | 166 |

39.1 + 126.9 = 166


$\frac{16.6}{166} = 0.1$

Concentration = 0.1 mol $dm^{-3}$

**(Total for Question 8 = 10 marks)**

Learners found question 9bi quite difficult with few scoring the full two marks available.

(b) (i) Write an equation to show the first electron affinity of oxygen to produce the oxygen ion, $O^-$.

(2)

$O_{(g)} + e^- \rightarrow O^-_{(g)}$

Some learners knew that the oxygen atom becomes a negative ion during electron affinity but did not show that this happened in the gaseous state, omitting the state symbols and gaining a maximum of one mark.

(b) (i) Write an equation to show the first electron affinity of oxygen to produce the oxygen ion, $O^-$.

(2)

$O + e^- \rightarrow O^-$

A common error seen was where learners placed the electron on the right hand side, rather than the left hand side of the equation. Learners should be encouraged to check, in addition to number and type of atoms balancing in equations, that charges must also balance on both sides of an equation.

(b) (i) Write an equation to show the first electron affinity of oxygen to produce the oxygen ion, $O^-$.

**(2)**

$O(g) \longrightarrow O^- + e^-$

Learners also found question 9b part ii difficult with only the best being able to complete the electronic configuration for the oxygen ion.

(ii) Complete the electronic configuration for an oxygen ion, $O^-$.

**(1)**

1s 2 2s 2 2p 5

Common errors included, learners not reading the question carefully and giving the electronic configuration of either the O atom or of an $O^{2-}$ ion.

(ii) Complete the electronic configuration for an oxygen ion, $O^-$.

**(1)**

1s 2 2s 2 2p 6

Another common error was where learners thought that the minus sign represented a loss of an electron rather than a gain of an electron.

(ii) Complete the electronic configuration for an oxygen ion, $O^-$.

**(1)**

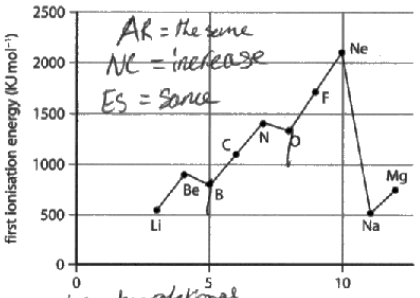
1s 2 2s 2 2p 3

The last question on the chemistry section is a six mark extended answer question with a levels based marking scheme. It was pleasing to see that the majority of learners interacted with this question well and were able to gain credit.

With this said, only the better responses scored full marks for being able to explain the trends in first ionisation energy shown in the graph in terms of energy levels and in terms of s and p orbitals.

In this first example, the learner has given a good explanation of the trends shown in the graph to gain the full six marks available.

(c) The graph shows the first ionisation energies of the elements lithium to magnesium.




Atomic radius
Nuclear charge
Electron shielding
Orbitals – repel counter rotational repulsion

Explain the trends in first ionisation energy from lithium to magnesium, with reference to:

- energy levels
- s and p orbitals.

(6)

There are four factors that affect the first ionisation energy of an element; atomic radius, nuclear charge, electron shielding and the position of electrons in orbitals. Lithium to Neon has a very similar atomic radius. The further away an electron is the less attraction it feels from the nucleus, therefore atomic radius isn't a big factor in period 2. Electron shielding is when extra shells of electrons block some of the nuclear charge. But in period 2 there are no new shells, therefore there is no effect. Nuclear charge increases across the period. This increases the attraction between the nucleus and outer electron. This is the cause for the overall increasing ionisation energy between Lithium and neon. There are dips at boron and oxygen. This is due to the position of electrons in sub-shells and orbitals. Boron has its outer electron alone in the 2p subshell. The cause for the dip is that, being alone in a higher energy sub-shell makes it easy to be removed - decreasing the ionisation energy. The outer electron in oxygen is moving in the opposite direction to the other three electrons in the 2p sub-shell.

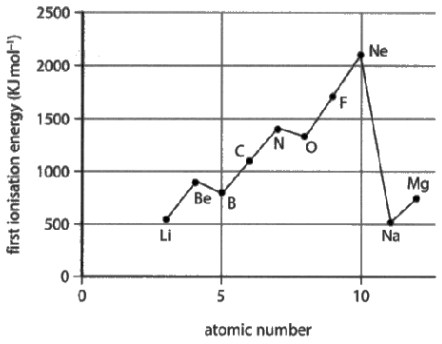
2p oxygen

This electron is easier to remove as counter rotational repulsion between it and the other electrons lowers the ionisation energy. The cause for the dramatic drop at sodium is due to atomic radius and electron shielding. From period 2 to 3, a new shell is started. This greatly increases atomic radius and electrons shielding, reducing the attraction from the nucleus

**(Total for Question 9 = 10 marks)**

In this example, the learner has given a good explanation for the general increase in ionisation energy. They then note the drop from N to O and explain this sufficiently. They note the drop of Ne to Na and the rise from Na to Mg. However, their explanation for Ne to Na is incorrect and explanation for the drop from Na to Mg is weak. The answer demonstrates some good knowledge, however, but due to the poor links in places and errors on the second page, the learner gained a mark of 4 in Level 2.

(c) The graph shows the first ionisation energies of the elements lithium to magnesium.




Explain the trends in first ionisation energy from lithium to magnesium, with reference to:

- energy levels
- s and p orbitals.

(6)

General trend is that 1st ionisation energy increases across the periodic table because more protons are added therefore it can attach more electrons, however the shielding stay the same.

from Li to Be the ionisation energy increases as it goes across the period, however there a drop from Be to B, this is because the ~~energy levels of~~ B and the $2s^2$ B orbitals are slightly further away from the nucleus, this causes a drop from Be to B

from B to N it kept increasing as normal, however there is a drop again from N to O, this is because $2p^4$ orbital are repulsion each other, as we can see in here [1↑] this two are ~~so it's easier to remove the e from, this is why there's a drop from B to N~~ so they repulse each other making it easier to remove the e from, this is why the drop from B to N.

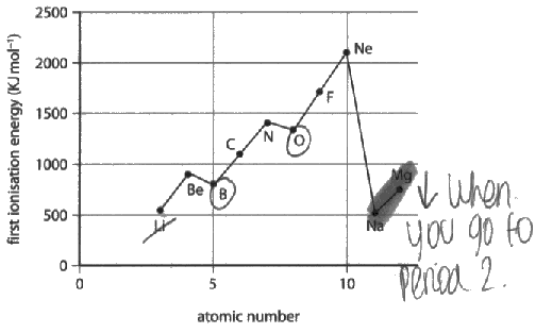
After Ne the ionisation goes down the group, (Na) as it does the 1st ionisation energy decreases, because there are more ~~energy levels~~ than energy levels which it makes it easier for the nucleus to attract each an electron. As the nucleus is ~~still~~ attracts

~~Finally~~ finally from Na to Mg the ionisation energy increases again because as many from left to right in periodic table.

**(Total for Question 9 = 10 marks)**

In this final example, the learner goes through picking elements to discuss. They describe lithium as having 2 energy levels and having s orbitals. They show an understanding that carbon has a higher ionisation energy and that it has p orbitals. They go on to state that Ne has a full outer shell and has p orbitals, spotted the decrease for sodium and knows that this is back to an s orbital. There is no understanding shown for the reason for the drop at boron and oxygen. It is clear that the learner has some idea about the patterns but not an in depth understanding and is awarded a mark of 2 in Level 1.

(c) The graph shows the first ionisation energies of the elements lithium to magnesium.




↓ when you go to Period 2.

Explain the trends in first ionisation energy from lithium to magnesium, with reference to:

- energy levels
- s and p orbitals.

(6)

① Lithium has a first ionisation energy of 5506 kJmol⁻¹ because it only has 2 energy levels and is in the s orbitals.
② If you pick another element in period 2 such as Carbon, that has 4 electrons in its outer shell, the first ionisation energy has increased to 1100 kJmol⁻¹ by having more ~~energy lev~~ electrons (same energy level) and being in p orbitals.
③ The highest ionisation energy is neon with 2100 kJmol⁻¹, and neon is in group 8/0 so has a full outer shell and 2 energy levels and in the p orbital.
④ Then, it starts to decrease when you get to sodium, which is in period 2 and has 1 electron on the outer shell + 2 energy levels in s orbital.
⑤ the only elements that dont follow this trend are oxygen and boron, this may mean that they are anomalies

SO, elements with the higher first ionisation energy (KJmol⁻¹) tend to ~~be~~ have more electrons in their outer shell and further away from the nucleus.

Also, the elements with a lower first ionisation energy tend to have fewer electrons in their outer shell and closer to the nucleus and in groups 1-3.

**(Total for Question 9 = 10 marks)**

## Physics

## SECTION C: WAVES IN COMMUNICATION

Lead Examiners Report

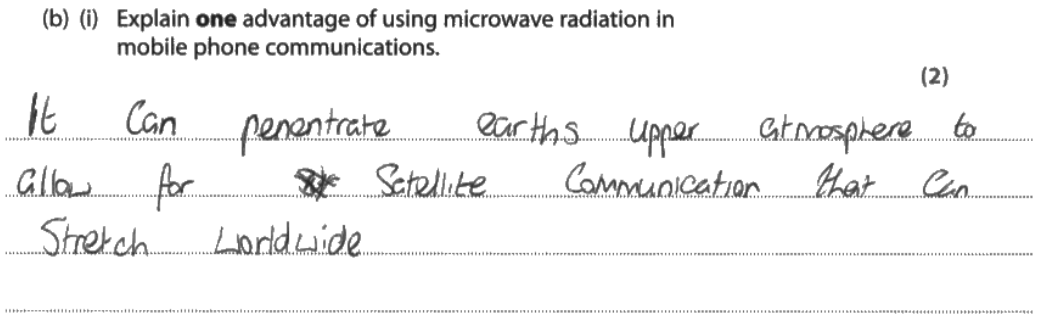
Learners found parts of this section of the paper quite challenging but most were able to attempt all questions showing that all the topics had been covered in the teaching. Learners showed an improvement in examination technique by generally allowing sufficient time to attempt all the questions in this last section of the paper. However, the theory of diffraction gratings was not well understood and the concepts of superposition, path difference and phase difference were rarely linked to wavelength or frequency. Learners must also take note of the command words used for a question. A question that requires an explanation will not get full marks if only a description is given or a number of statements are made.
Although the ability to use mathematical expressions correctly has improved learners still need to be have more practice at rearrangement of equations and must know how to deal with a square root, sin and $\sin^{-1}$. Generally, learners were able to select the correct equation to use for a calculation but some were unable to substitute correctly because the meaning of the symbols used in the equations was not known.

Question10

( a) This question although very straightforward was only answered correctly by about half the learners showing that many learners to not know the order of frequencies groupings in the electromagnetic spectrum. This is something that it is useful to learn.

(b)(i) Learners were in many cases able to give an acceptable advantage for the use of microwaves in mobile phone communication but were unable to follow this up with a linked explanation.

The following answer was awarded two marks because the advantage given was linked to a relevant explanation.


(b) (i) Explain **one** advantage of using microwave radiation in mobile phone communications.

(2)

It Can penentrate earths upper atmosphere to allow for Satellite Communication that Can Stretch Worldwide

Most answers were only awarded one mark

(b) (i) Explain **one** advantage of using microwave radiation in mobile phone communications.

(2)

It transfers a clear signal, because it has a high frequency

This answer correctly identifies a clear signal acceptable for less interference but does not give the correct reason. High frequency is the reason for the signal being able to carry a large amount of information.

The answer below gives two correct statements but can only be awarded one mark as the question requires an explanation.

(b) (i) Explain **one** advantage of using microwave radiation in mobile phone communications.

(2)

They have a longer range ~~that~~ and they don't lose any of the quality of the information.

(b)(ii) Learners found it more difficult to give a disadvantage of the use of microwaves in mobile phone communication. The most common type of incorrect answers was 'it is bad for your health' or 'it causes cancer'. References to health were ignored.

This answer gives the disadvantage as signal disruption and explains why this occurs, gaining both marks.

(ii) Explain **one** disadvantage of using microwave radiation in mobile phone communications.

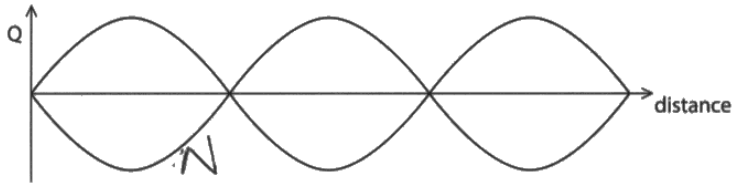
(2)

It cant diffract round hills or mountains so can often lead to phones with little or no signal and it cant pass through these big structures, or go around them.

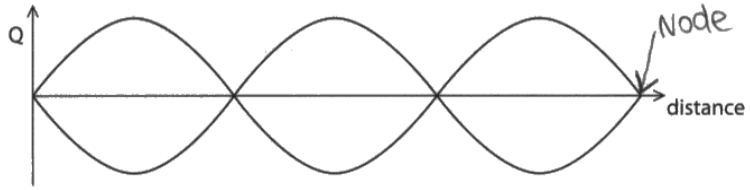
Q11

(a)(i) Only a few learners gave the correct answer of 'displacement' for Q the vertical axis shown on the diagram. The most common incorrect answer was 'amplitude' which is a specific measurement of the maximum displacement of the wave from its mean position.

(a)(ii) Most learners were able to label the position of the node in the diagram. A mark was lost when the position of the node was not clearly indicated as in the example below




The position of the node should be clearly indicated as in the following example



(b) This calculation required a square root to be removed by squaring both sides of the equation and then the equation had to be rearranged to find the tension in the string.
Learners could gain one compensatory mark for selecting the correct equation if no other mark could be awarded.
The example below shows the compensatory mark awarded as the substitution is incorrect. The learners has substituted the speed of the wave v as the tension T

(b) A guitar string is tuned by changing the tension.

The speed of a wave in the string is 16.2 m s$^{-1}$.

The mass per unit length of the string is 0.3 kg m$^{-1}$.

Calculate the tension in the string.

Show your working.

$0.3\ kgm^{-1} \times 1000 = 300$ grams. (4)

$$V = \sqrt{\frac{T}{\mu}}$$

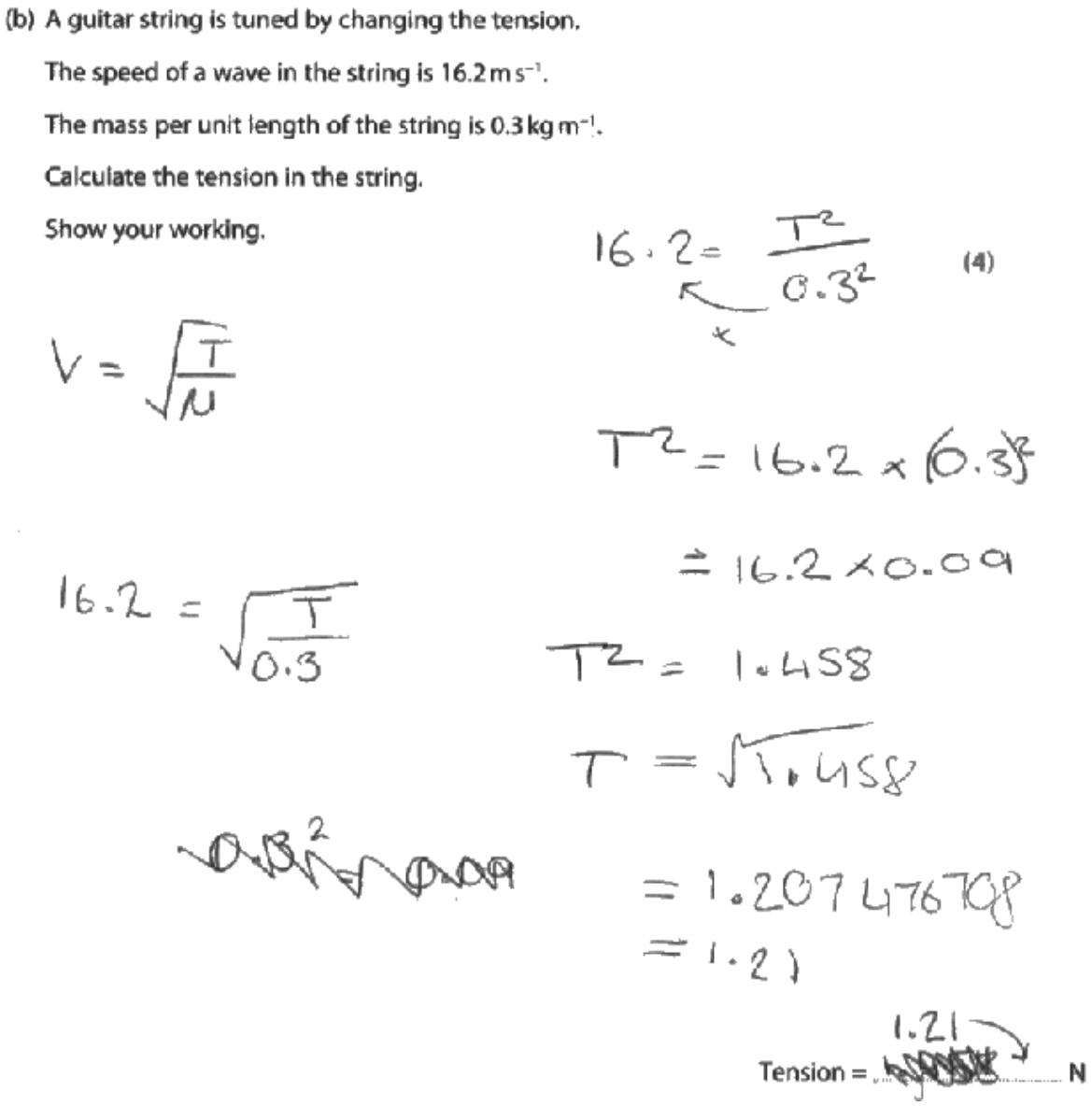
$$V = \sqrt{\frac{16.2}{0.3}}$$

$$V = 3\sqrt{6}$$

$$V = 7.35 (3SF)$$

Tension = ..... N

The second example shows two marks awarded. The substitution is correct, but the learner has not removed the square root properly to give 16.2 squared. However, the rearrangement from this error is correct and 2 marks are awarded.



(b) A guitar string is tuned by changing the tension.

The speed of a wave in the string is 16.2 m s$^{-1}$.

The mass per unit length of the string is 0.3 kg m$^{-1}$.

Calculate the tension in the string.

Show your working.

$16.2 = \frac{T^2}{0.3^2}$ (4)

$V = \sqrt{\frac{T}{\mu}}$

$T^2 = 16.2 \times 0.3^2$

$= 16.2 \times 0.09$

$16.2 = \sqrt{\frac{T}{0.3}}$

$T^2 = 1.458$

$T = \sqrt{1.458}$

$0.3^2 = 0.09$

$= 1.207476708$

$= 1.21$

1.21

Tension = ..... N

The third example shows three marks awarded

(4)

$v = \sqrt{\frac{t}{\mu}}$ $\quad v^2 = \frac{t}{\mu}$ $\quad v^2\mu = t$

$v = 16.2 ms^{-1}$ $\quad 16.2^2 \times 0.3 = 4.86$

$\mu = 0.3 kg ms^{-1}$

Tension = 4.86 N

In this case it is an error in the evaluation $16.2^2$ x 0.3 would give the correct answer but the learner has not squared 16.2 when evaluating.

The following example again also shows three marks awarded the error is in the power of ten the answer should be 78.7 N but the mass per unit length has been written as 3 instead of 0.3

$$v = \sqrt{\frac{T}{\mu}}$$

$$v^2 = \frac{T}{\mu}$$

$$v^2\mu = T$$

$$T = v^2\mu$$

$$T = (16.2)^2(0.3)$$

$$= 787.32\ N$$

$$= 787.3\ N \text{ (rounded 1 d.p.)}$$

Tension = 787.32 N

**(Total for Question 11 = 6 marks)**

About 20% of learners completed the calculation correctly as in the example below.

[4]

$$V = \sqrt{\frac{T}{\mu}} \qquad 16.2 = \sqrt{\frac{T}{0.3}}$$

~~$T = 16.2 \times 0.3 = 4.86^2 = 23.6$ N~~

$$v^2 = \frac{T}{\mu}$$

$$\frac{T}{v^2} = \mu$$

$$T = v^2 \times \mu \longrightarrow \text{~~$T = 16.2^2$~~}$$

$$16.2^2 \times 0.3 = 78.7$$

~~$\sqrt{\frac{78.7}{0.3}} = 16.2$~~

Tension = 78.7 N

Question 12

(a) More than half the learners recognised one complete wavelength and were able to read the correct value of 600nm from the graph.

(b) The majority of learners were not able explain why the central line of the pattern produced when sunlight is passed through a diffraction grating is a bright white line. The most common errors was either to assume that the light passed straight through the diffraction grating or that the colours combined.
The response given below gains one mark for the idea of constructive interference being responsible for the bright white line being produced.

(i) Explain why the central white line is bright.

(2)

The Central White line is White because Construction interference is occurring and the wave are overlaying over other.

The second answer gains two marks. The first mark for recognising that the waves are in phase and the second for the mention of constructive interference.

(i) Explain why the central white line is bright.

(2)

This point is called a maxima - the light waves at this point have met in phase and have created Constructive interference. The bright area is the Suposition of the two waves. (two waves added together)

(b)(ii) Explaining why the diffraction grating produced a pattern of coloured bands when sunlight was passed through it proved to be very challenging for learners. Three or four marks were rarely awarded. Learners that gained one mark noted that the different colours in sunlight were of different wavelengths/frequencies.
An example of this is given below, the mention of different refractive indices is ignored.

(ii) Explain why the diffraction grating produces a pattern of coloured bands.

(4)

A diffraction grating produces a pattern of coloured bands because light is made up of different colours with different wavelengths a diffraction grating ~~splits~~ splits these different colours as ~~the~~ they pass through this, is because they have different refractive indexes because of their different wavelengths.

The learners that gained two marks noted the different wavelength and also that the amount of diffraction or direction changed depended on the wavelength as seen in the example below.

(ii) Explain why the diffraction grating produces a pattern of coloured bands.

(4)

The diffraction grating produces a pattern of coloured bands because each diferent color of light has a diferent wavelength and frequency, this means that each color is deyected diferently, for example red light has the ~~greatest~~ longest wavelength so is deyected the most that of green and blue light have smaller wavelengths and are deyected less; this results in ~~the~~ separated bands of light.

Learners rarely gained marks for considering that the correct path difference could produce constructive superposition and therefore a bright line, of a particular colour, on the screen.

The example below gains three marks, the first two are awarded for the colours having different wavelengths and for the angle of diffraction being proportional to the wavelength. The third mark is given for a good attempt at explaining the dark regions as destructive interference and the bright lines as constructive interference. However, as there is no mention of path difference the fourth mark is not awarded.

(ii) Explain why the diffraction grating produces a pattern of coloured bands.

(4)

Because light has many different bright waves with different wavelengths. When the light is diffracted, the light is diffracted into fringes at each order the angle increases because the angle is proportional to the wavelength, as the angle increases the wavelength increases which is why different colours are formed at each order, so at a lower order there is a low wavelength e.g blue and at a higher order there is high wavelength eg red * where there is destructive superposition where there is no light and there is constructive interference where there is maximum energy where each bright each maximum energy is called an order

Question 13

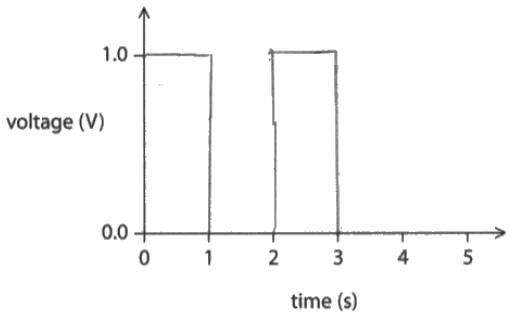
(a) Learners found this question surprisingly difficult. A digital pulse having two values, 1v and zero volts, was required as show below.
Both marks were awarded if the signal started at a different point or continued with extra pulses.

**13** A digital signal has a value of 1.0V when it is on and 0.0V when it is off.

The digital signal changes every second.

(a) Draw a digital signal corresponding to 1 0 1 0

(2)

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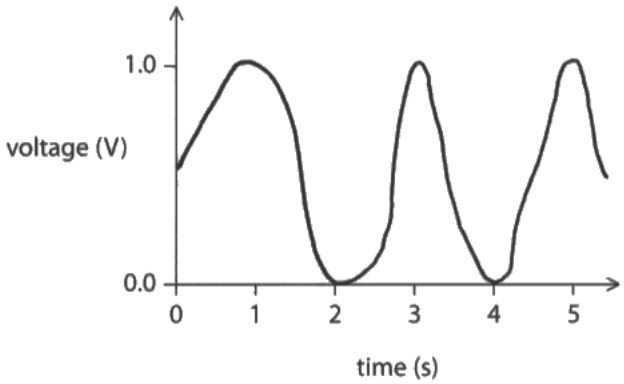
Signals which continuously varied with time as shown below were not given credit.

(a) Draw a digital signal corresponding to 1 0 1 0

**(2)**




(b) This multiple choice question also proved difficult as learners did not know the processing needed to change an analogue signal to a digital signal required the analogue signal to be sampled.

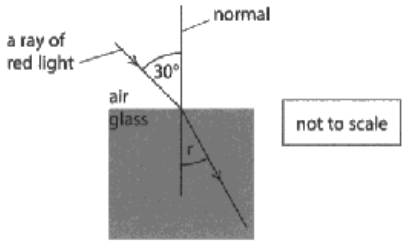
(c) The calculation caused problems because it required the use of sin and $\sin^{-1}$ and the equation used needed to be rearranged. A compensatory mark was given for selecting the correct equation if no other mark could be awarded.
The example below shows the compensatory mark being awarded.

(c) An optical fibre is made of glass.

The speed of red light in air is $3.0 \times 10^8 \text{ m s}^{-1}$.

The speed of red light in the glass is $2.0 \times 10^8 \text{ m s}^{-1}$.

A ray of red light enters the glass from the air with an angle of incidence of 30°.




Calculate the angle of refraction, r, of the red light in the glass.

Show your working.

(3)

$n = \frac{c}{v} = \frac{\sin i}{\sin r}$ $\sin c = \frac{1}{n}$

Angle of incidence = 30°

$\frac{\sin 30}{1} = 0.5$

Angle of refraction = 2 °

One mark could also be awarded for the correct substitution without the equation being shown.

To gain two marks the equation had to be rearranged to show a value could be obtained for

sin r

In the example below 0.3 (recurring ) is the correct evaluation for sin r but the learners have been unable to convert this to the angle r using $\sin^{-1}$ on the calculator

Calculate the angle of refraction, r, of the red light in the glass.

Show your working.

(3)

refractive index = $n = \frac{c}{v} = \frac{\sin i}{\sin r}$ ≈25.

Critical angle = $\sin c = \frac{1}{n}$

$\frac{2.0 \times 10^8}{3.0 \times 10^8} = 0.\dot{6}$

$0.\dot{6} \times \sin 30 = 0.\dot{3}$

$\frac{1}{0.3^*} = \sin 2$

Angle of refraction = .....

A completely correct calculation gaining three marks is shown below.

Calculate the angle of refraction, r, of the red light in the glass.

Show your working.

(3)

$n = \frac{c}{v} = \frac{\sin(i)}{\sin(r)}$

$n \times \sin(r) = \sin(i)$

$\sin(r) = \frac{\sin(i)}{n} = \frac{\sin(30)}{\left(\frac{3.0 \times 10^8}{2.0 \times 10^8}\right)} = 0.\overline{3}$

$r = \sin^{-1}(0.\overline{3}) \approx 19.471^\circ$

Angle of refraction = $19.471^\circ \approx 19.5^\circ$

13c This is a level based question requiring learners to 'explain the strengths and weakness of using optical fibres to supply broadband to homes' The mark scheme is

generic but gives the indicative content and because learners are asked for an explanation the indicative content links the strength or weakness to the explanation.
The example below is awarded a level 1. Correct information is given but there is no link to a reason. The use of broadband being 'faster or quicker ' is accepted as equivalent to ' higher rate of information transfer' but correct terminology would be preferable. 'clearer signals' are acceptable as less susceptible to noise.

(d) Explain the strengths and weaknesses of using optical fibres to supply broadband to homes.
(6)

A strength of using optical fibers to supply broadband in a house would be that they transmit information quicker. Another strength would be that the signals being sent are very clear.

To achieve level 2 the learner must give a strength or weakness and give an associated reason.
In the example below the learner has given some strengths and linked 'little loss of energy' to total internal 'refraction' instead of reflection but this error in ignored when considering the work as a whole. The weakness that the optical fibre can break is not linked to a viable reason.

(d) Explain the strengths and weaknesses of using optical fibres to supply broadband to homes.

(6)

Optical fibres are good as the light uses total internal reflection within them, which means that none or very little light energy is lost. However, if an optical fibre breaks, it is ~~very~~ very expensive to fix or replace.

Optical fibres can deliver information very quickly and clear. However, if there is just one optical fibre, the quality of the picture given may not be as clear.

When there are multiple optical fibres, the information in each fibre may arrive at different times. However, the difference in time could be miniscule.

To achieve level 3 the learner must give a strength and weakness with a reason

The example below is level 3 the response is set out clearly. The use of headings or bullet points will in no way disadvantage the learner.

The first point gives a strength and a reason. The second strength refers to wires rather than fibres and the third to energy rather than information. Neither of these are credit worthy. The weakness that the fibres can be easily broken is correct and the reasoning for this that the fibres are 'delicate' is taken as equivalent to fragile and is sufficient to take this response as a whole into level 3.

(d) Explain the strengths and weaknesses of using optical fibres to supply broadband to homes.

(6)

Strengths

-> Less energy is wasted as all is internally reflected (total internal reflection).

-> Thin wires does not take much room up

-> More energy would reach and less would be wasted on the way.

-> Good protection with cladding

-> Transfer energy much faster through the fibres

Weakness

-> Expensive to set up

-> Very delicate as they are small fibres inside the wire

-> Can break easily

To improve responses in the physics section of the paper learners should:-

- Note the command word used for questions
- Link explanations to statements
- Learn how frequencies and wavelengths are grouped in the electro-magnetic spectrum
- Learn the meanings of symbols used in equations
- Always start a calculation by giving the equation to be used
- Learn to use calculators to give values of sin and $\sin^{-1}$
- Practice rearranging equations.
- Become familiar with the ideas of superposition of waves
- Be able to use ideas of path difference and phase difference for waves.

# Summary

- This includes LE recommendations, e.g. Based on their performance on this paper, learners should: (then include between five and ten bullet points)
- If appropriate, refer and link to the specification and/or sample assessment materials (SAMs) located on the BTEC Nationals qualification webpage located here