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BTEC

Examiners' Report
Lead Examiner Feedback

January 2021

Pearson BTEC Nationals
In Applied Science (31617H)
Unit 1: Principles and Applications of Science I

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Introduction

Biology

Structure and functions of cells and tissues.

Medical professionals need to understand the structure and workings of cells. They build on this knowledge to understand how the body stays healthy as well as the symptoms and causes of some diseases. This allows them to diagnose and treat illnesses. The study of bacterial prokaryotic cells gives an understanding of how some other diseases are caused and can be treated.

Introduction to the Overall Performance of the Unit

Structure and functions of cells and tissues.

There was evidence that time management during the exam is improving with more learners attempting all questions. Exam technique and the understanding of the command verbs is continuing to improve. It is beneficial for learners to appreciate the requirement of each of the command verbs so that they can target their response and provide appropriate credit worthy answers. Explain is the command verb which seems least understood. Learners' explanations require a justification/ exemplification of a point. The answer must contain some element of reasoning/justification – this can include mathematical explanations. Centres need to fully prepare learners for the exam by practising exam technique, especially in relation to reading the question carefully and not repeating the stem of the question. Learners should also be taught that when they have answered the question to reread their response in order 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. Learners should show that they understand the relationship between the structure and function of cells and tissues. Learners still struggle to recall definitions and find it difficult to provide links between different related aspects of the specification.

Introduction

Chemistry

This was the seventh sitting of the level 3 Applied Science Unit 1 Chemistry section and the fourth time the paper has been sat separately to the other disciplines that makes up the unit. It is pleasing to see that learners are still accessing the paper well with few blank spaces seen and learners achieving the full range of marks across the whole of the paper.

Introduction to the Overall Performance of the Unit

Learners that were successful this year were able use scientific vocabulary and terminology and were able to apply their knowledge of Chemistry to different situations and contexts. They were able to perform calculations in an unknown scenario, those that did well structured their working well to come to the correct answer. Learners that performed well also were able to draw diagrams that were labelled accurately using the correct technical language.

To improve further, centres should ensure that learners are aware of the difference between key terms such as property and use, chemical and physical properties. They should also be aware of the difference in command words such as give, state, describe and explain and how these types of questions should be approached.

Introduction

Physics

The examination was set to allow learners to show their knowledge and understanding of waves in the context of communication and to use their knowledge to interpret and analyse the use of waves in different applications.

Introduction to the Overall Performance of the Unit

The majority of learners have shown improvement in mathematical skills, most now show substitution into a simple equation and give an evaluation. More complex equations requiring rearrangement and functions such as square roots are still found to be challenging but most learners followed the procedure of showing substitution, attempting a rearrangement and evaluating and could therefore gain marks.
Although learners are very familiar with the quantities used to describe transverse waves and may recognise a longitudinal wave when shown on a 'slinky' they are less familiar with the longitudinal wave shown as a series of compressions and rarefactions and were less likely to be unable to identify a wavelength for a longitudinal wave. Learners were generally able to recognise total internal reflection shown in an optical fibre but need to improve their understanding of the purpose and effect of adding cladding to the fibres. Also, the way apparatus was used to produce a stationary wave on a wire was not well understood although there was frequent reference to the wave being reflected at the fixed end.
Learners need to appreciate the need to know the order of the waves in the electromagnetic spectrum in terms of increasing frequency and to realise the relationship between frequency and wavelength, so that the same order applies to decreasing wavelength. There is also some confusion between the properties of the different electromagnetic waves used for communication and the use of terms such as 'multiplexing' need to be clearly understood. The diffraction grating and its use in producing an emission spectrum using the light from a sodium lamp was much better understood and a significant number of learners were able to explain this in terms of constructive and destructive interference. However, some learners misunderstood the

question and described how light of different wavelengths was produced by the lamp rather than how the diffraction grating produced the emission spectrum.

Individual Questions

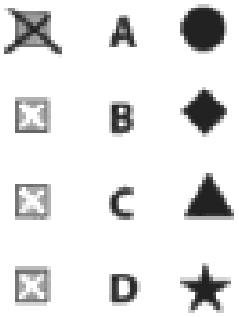
Biology

Q1(a)(i)

This was a 1mark multiple choice question, which required the learners to recall the parts of the ECG trace.

This response was awarded 1 mark.

(a) (i) Identify the P-wave in Figure 1.



Q1(a)(ii)

This was a 1 mark question. Very few identified QRS, but many were able to mention sinus wave to obtain the mark. A commonly observed incorrect response was hyperpolarisation.

This response was awarded 0 marks. This is a very common incorrect response.

(ii) Name the ECG complex that ⬟ represents in Figure 1.

(1)

~~depolarisation~~ repolarisation

This response was awarded 1 mark.
The mark can just be awarded as the learner has clearly made an attempt at spelling depolarisation. Depolarisation is an acceptable response and we do not have to include ventricular to award the mark. Their attempt at spelling does not give another related word and so can be accepted. We can also accept contraction and systole without ventricular.

(ii) Name the ECG complex that ⬟ represents in Figure 1.

(1)

Depolarisation.

Q01(b)(i)

This was a 1 mark multiple choice question assessing the learners knowledge about the names of tissues.
This response was awarded 1 mark.

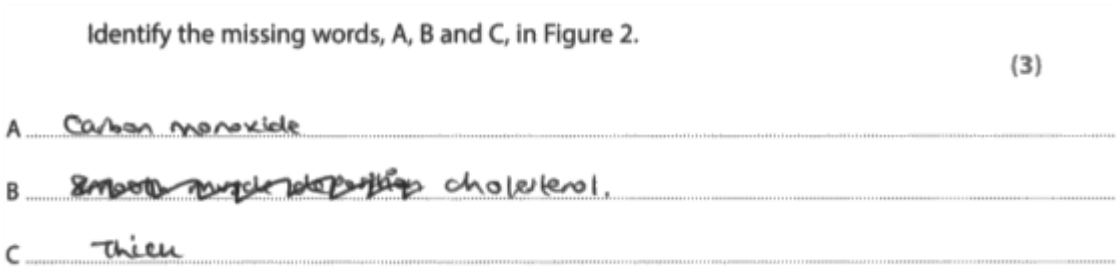
(i) Identify the type of tissue that forms the lining of the inside of arteries.

- ☒ **A** connective
- ☒ **B** endothelial
- ☒ **C** muscular
- ☒ **D** nervous

Q1(b)(ii)

This was a 3 mark question. Many learners provided the correct answers, but in the incorrect order. The most common marking point awarded was for C, however many learners lost a mark by answering ‘clotted’. There was some confusion between ‘atheroma’ and ‘atherosclerosis’.

This response was awarded 0 marks.
Incorrect missing words have been given for all 3. Unfortunately, the learner has given a correct response for A in space for B - this is a common mistake! For C the learner has stated thick - and so is not awarded a mark. The statement for C states "reduced blood flow because the inside of the artery becomes....C...." and so the statement is referring to the lumen not the artery wall. The artery wall could become thicker without reducing blood flow and so we have to ignore "thick".


Identify the missing words, A, B and C, in Figure 2.

(3)

A Carbon monoxide

B ~~Smooth muscle~~ cholesterol.

C Thicn

This response was awarded 2 marks. Marks are awarded for correct responses for B and C. For A we can ignore reference to fats (this is too vague). For B plaque is the correct response - we can accept phonetic spellings and singular or plural. For C any word which clearly implies that the lumen (the inside of the artery we are referring to in the question as blood flow is reduced) can be accepted as "other relevant response" and so blocked can be awarded a mark.


(3)

A ~~Fatty fo~~ fat

B ~~blockages~~ Plaque

C blocked

This response was awarded 3 marks. An acceptable missing word is given for A, B and C. For B plaques is the correct response but can accept "fatty deposits".


A Cholesterol

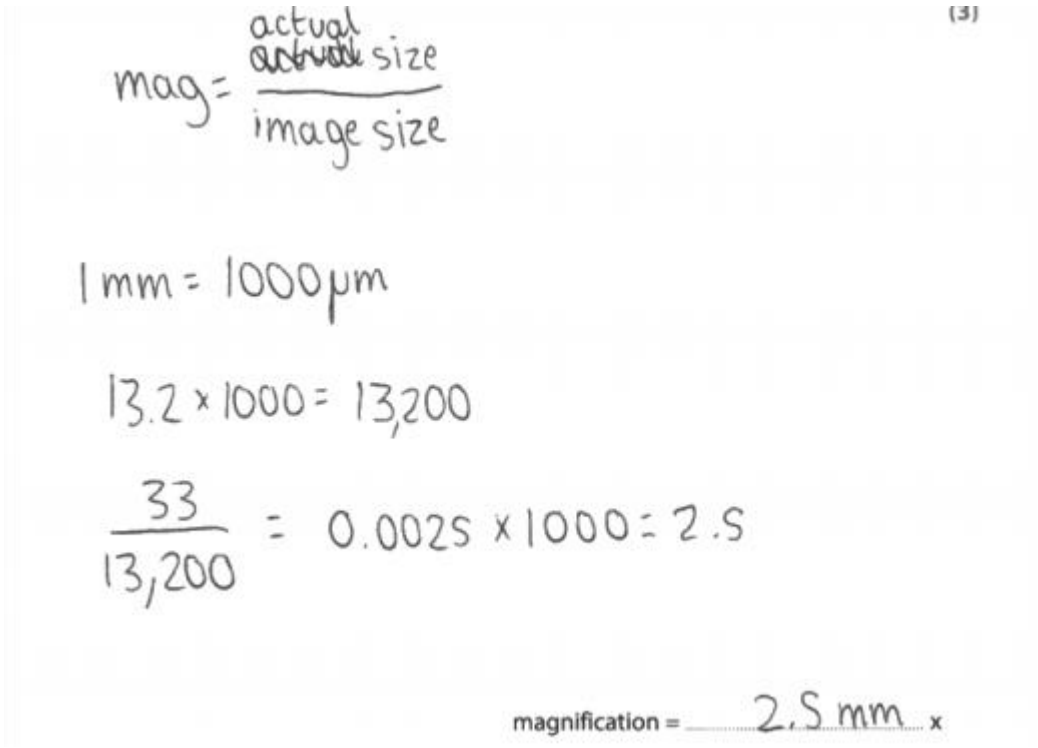
B fatty deposits

C Blocked

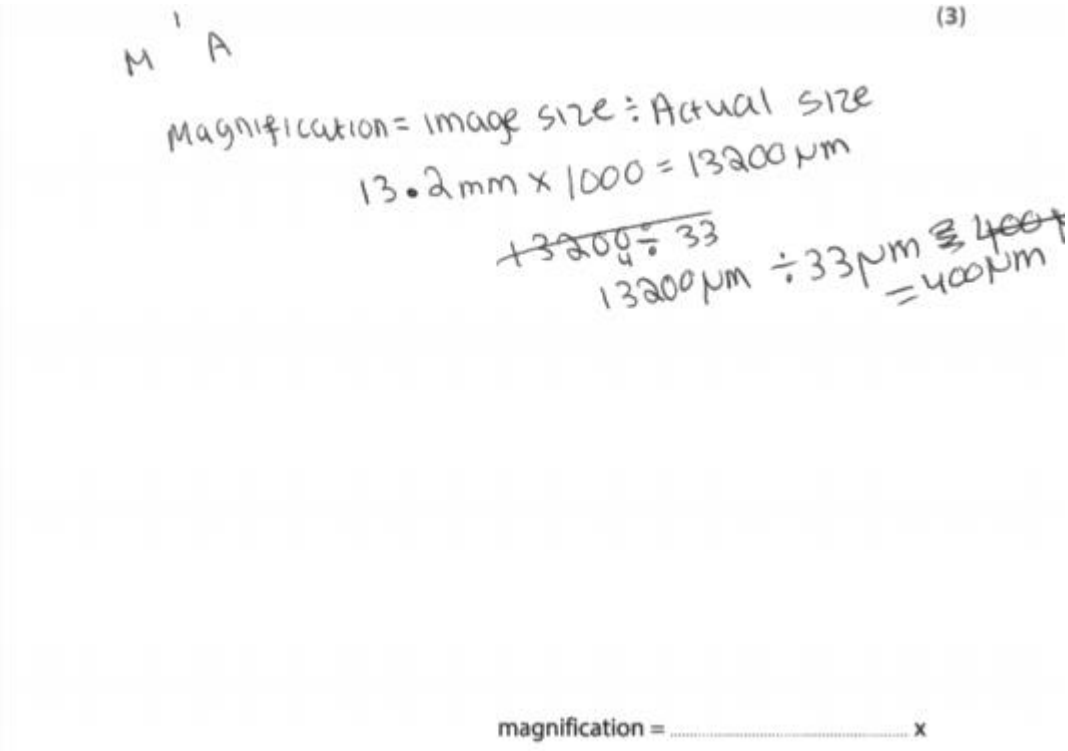
Q2(a)

This was a 3 mark question.
The conversion mark was rarely awarded, leading many learners to get 2 marks for an incorrect answer. Most learners recalled the equation and applied it well to obtain partial credit even if they failed to provide the correct answer.

This response was awarded 1 Mark.
The learner has correctly calculated the conversion and so 1 mark can be awarded. However, they later reverse the conversion by multiplying by 1000 - and so this mark does not get given. Unfortunately, the learner has inverted the division - but their evaluation is correct and so 1 mark can be awarded overall. When the response isn't 400 or a 4 to the power of ten POT error response then the working has to be investigated to see if marks can be awarded.



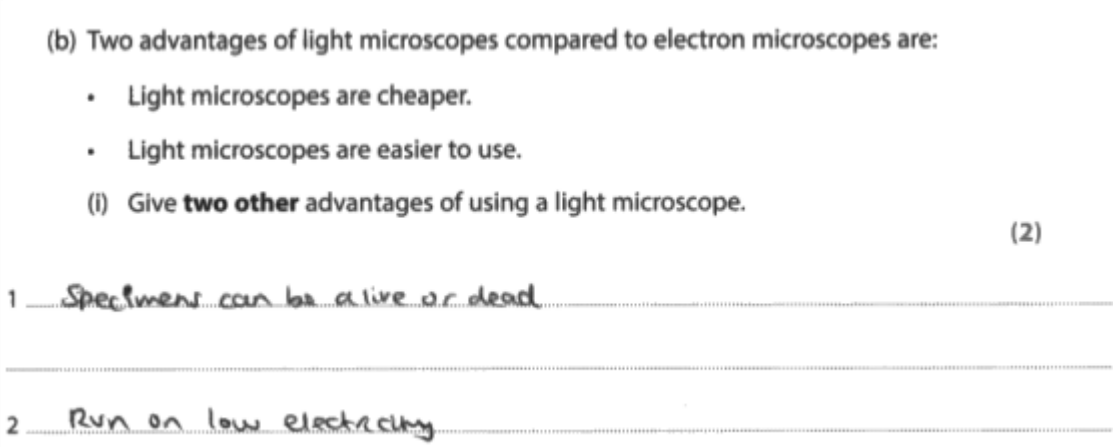
This response was awarded 3 marks.
With no answer on the response line the 400 at the end of the learners working is accepted and so 3 marks can be awarded. The unit is given at the end of the response line and as there is not a mark allocated for the recall of the unit the unit that the learner has provided can be ignored.



Q2(b)(i)

This was a 2 mark question.
Most marks were awarded for mp1 and mp2, occasionally mp7, but unfortunately the other marking points were rarely seen. The majority of learners were able to obtain at least 1 out of the 2 marking points. Common correct responses included the ideas about observing live specimens, no specialist training required, and portability.
Common mistakes came from a lack of detail, for example, giving an answer of “easier” or “small” with no reference to portability, and so repeating the points given in the stem.

This response was awarded 1 mark.
The response on line 1 is creditworthy for MP1 and so 1 mark is awarded.
The "run on low electricity" is a common response and is a little too vague to be creditworthy.



(b) Two advantages of light microscopes compared to electron microscopes are:

- Light microscopes are cheaper.
- Light microscopes are easier to use.

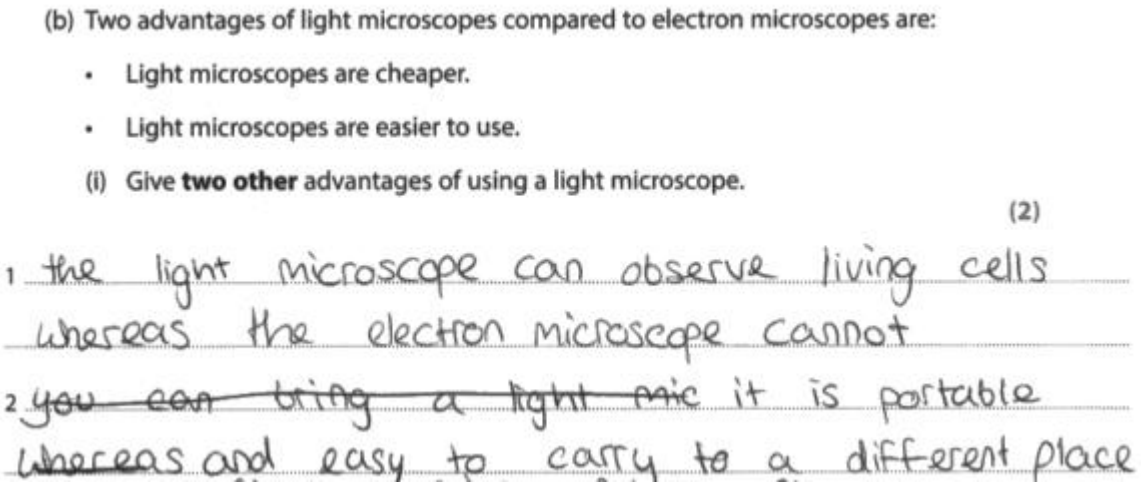
(i) Give **two other** advantages of using a light microscope.

(2)

1 Specimens can be alive or dead

2 Run on low electricity

This response was awarded 2 marks.
The learner has given 2 creditworthy responses and so scores maximum marks - the light microscope can be used to observe living cells and is portable.



(b) Two advantages of light microscopes compared to electron microscopes are:

- Light microscopes are cheaper.
- Light microscopes are easier to use.

(i) Give **two other** advantages of using a light microscope.

(2)

1 the light microscope can observe living cells whereas the electron microscope cannot

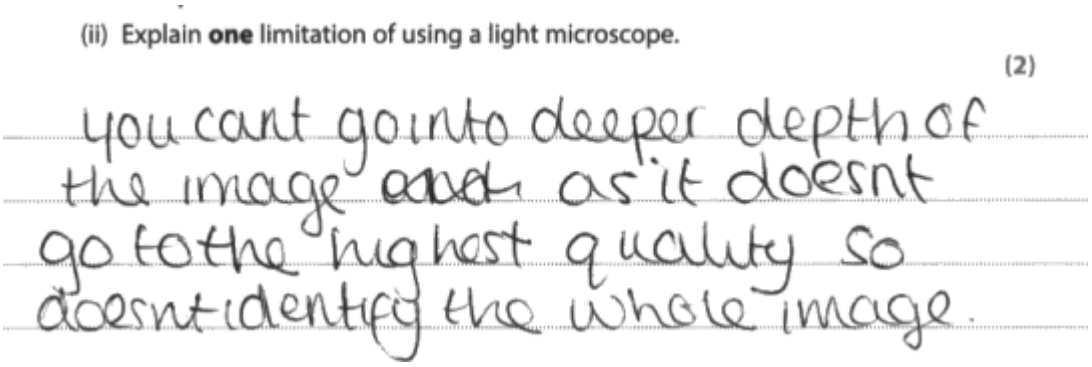
2 ~~you can bring a light mic~~ it is portable whereas and easy to carry to a different place

Q2(b)(ii)

This was a 2 mark question. Most learners obtained one or more of MP1, MP2 or MP3, but the other marking points were rarely seen. Many learners were able to identify that light microscopes have lower magnification (often referred to as 'zoom') and link this to resolution.

The scientific language used was weak. There were almost no mentions of "resolving power", wavelength or depth of field.

This response was awarded 1 mark.
This idea is rarely seen and sits outside the identification points surrounding magnification and resolution limitations on the mark scheme. The learner has given MP5 as their identification point and so can be credited with one mark. Unfortunately, the expansion given with this identification point should refer to the diffraction of light and so the learner's comment does not identify the whole image and is not sufficient for the second mark in the pair.


(ii) Explain **one** limitation of using a light microscope.

(2)

you cant go into deeper depth of the image and as it doesnt go to the highest quality so doesnt identify the whole image.

This response was awarded 2 marks.
The learner has used wavelength of light MP4 as the identification point of their explanation - this marking point is not seen often. They have given a linked expansion point - that less detail (MP3) is seen as a result of the greater wavelength of light. The learner's wording of "less detail to be seen" is just sufficient for MP3.

(ii) Explain ~~one~~ limitation of using a light microscope.

[2]

Wavelength is a limiting factor of light microscopes. They have a greater wavelength than electron microscopes which as a result allows less detail to be seen.

Q3(a)

This was a 1 mark question. This was a basic recall question, and most learners were able to give a correct response.

This response was awarded 0 marks.

myofiliament nucleus.

This response was awarded 1 mark.

(1)

myosin

Q3(b)

This was a 1 mark multiple choice question and was difficult. The learner was required to demonstrate a detailed understanding of organelles to select the correct pair.
This response was awarded 1 mark.

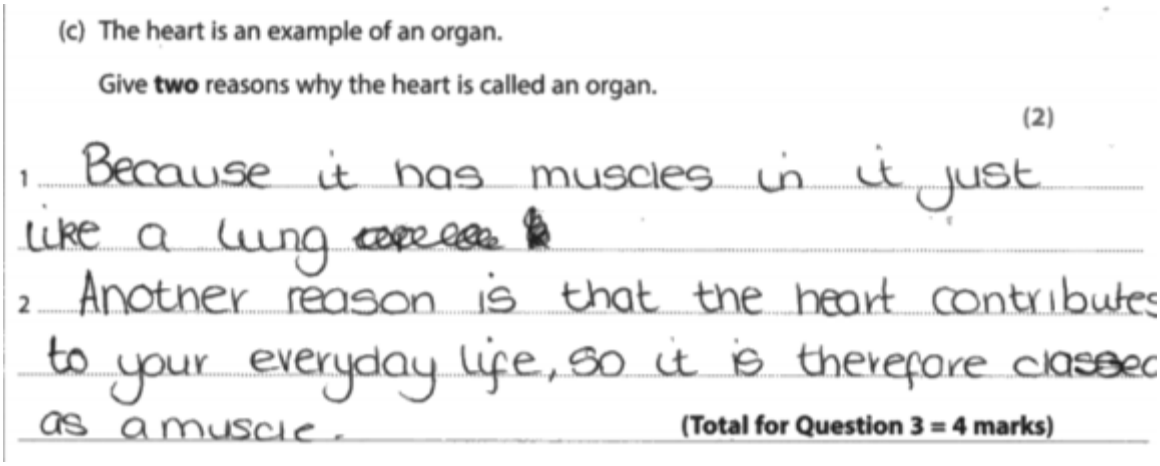
Identify the pair of organelles that both have a double membrane.

- ☒ **A** mitochondrion and lysosome
- ☒ **B** mitochondrion and ribosome
- ☑ **C** nucleus and mitochondrion
- ☒ **D** nucleus and ribosome

Q3(c)

This was a 2 mark question.
The second marking point was seen most commonly, mainly through some variation of “pumps blood around the body”. Some were able to gain the second mark for the idea that the heart is an organ as it is a “collection of tissues”, although it was clear that the learners only had a very general idea, and the scientific language was very weak. Common mistakes for this question arose from a lack of detail, for example, ‘we need it to function’.

This response was awarded 1 mark.
Basically, we are looking for 2 parts to the response - they do not have to be on the numbered lines - both marks could be achieved from 1 statement, but the numbers have been given as scaffolding. Here MP1 has been awarded as the learner has given a named tissue (muscle) and as this is plural, we can give benefit of the doubt that this is sufficient for made up of different tissues. Unfortunately, MP2 - about having a specific function - is too vague for a level 3 definition. Contributing to everyday life, allowing survival, being part of the body, etc are too vague for the function and so the second mark cannot be awarded.



(c) The heart is an example of an organ.

Give **two** reasons why the heart is called an organ.

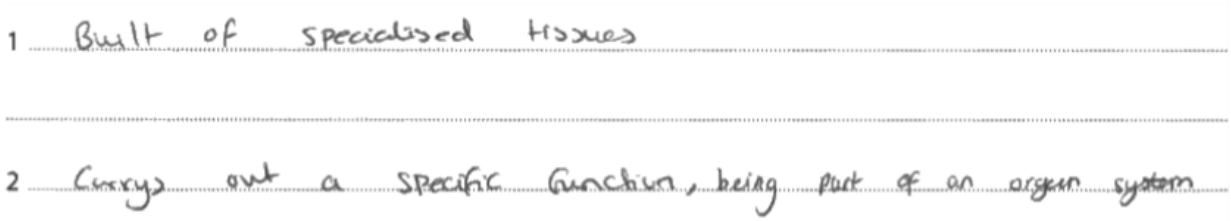
(2)

1 Because it has muscles in it just like a lung

2 Another reason is that the heart contributes to your everyday life, so it is therefore classed as a muscle.

(Total for Question 3 = 4 marks)

This response was awarded 2 marks.
The learner has given both marking points (and in fact has given 3 correct responses) and so maximum marks can be awarded for this question.



Q4(a)

This was a 1 mark question. This was a recall question with at least half of the learners giving the correct response. Where an incorrect response was given it was usually potassium or calcium.

This response was awarded 0 marks.

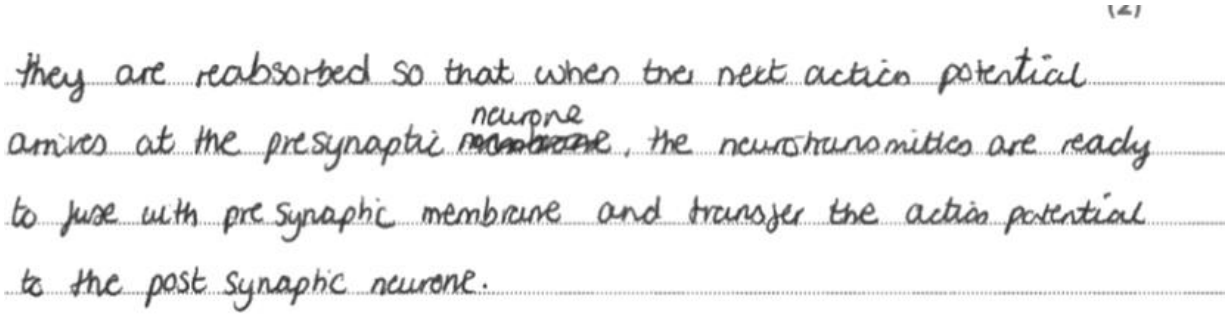
This response was awarded 1 mark.

Q4(b)

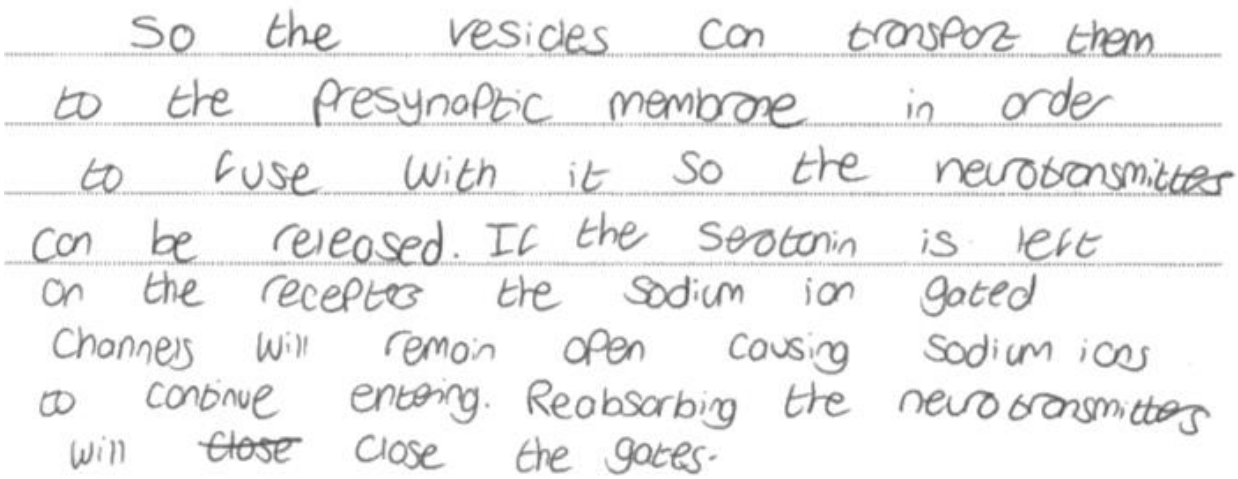
This was a 2 mark question. This question was poorly answered overall. The most common marking point was for an idea of re-synthesis or 'repeat' in relation to serotonin, although the scientific language used was once again poor. There was some reference to the regulation of action potentials by stronger learners.

Key terminology such as receptors, depolarisation or action potential were rarely seen, and many answers showed a lot of confusion and lack of understanding.

This response was awarded 1 mark. This response is describing, in some detail, further action potentials and so MP4 - enables the process to repeat - can be awarded. This is a quite common idea within the responses but is worded in a variety of ways.



This response was awarded 2 marks.
The learner's first comment about vesicles can be ignored. Their reference to receptors is sufficient for MP1. They then describe that if serotonin is left depolarisation will continue (through a description) and so that is sufficient for MP2.

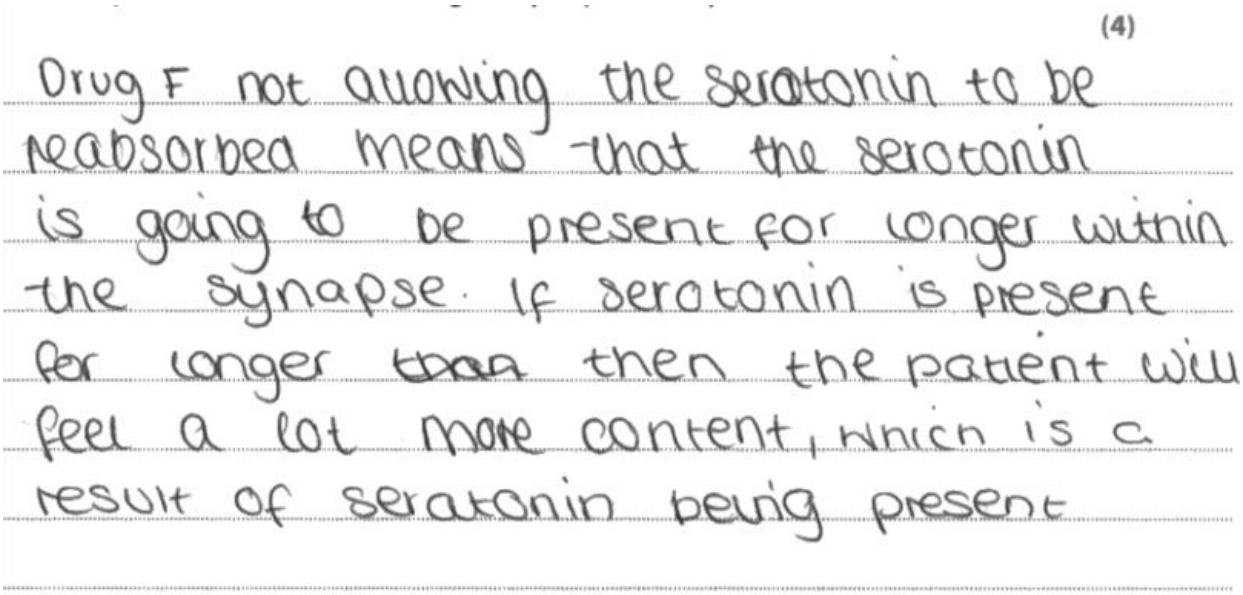

So the vesicles can transport them to the presynaptic membrane in order to fuse with it so the neurotransmitters can be released. If the serotonin is left on the receptor the sodium ion gated channels will remain open causing sodium ions to continue entering. Reabsorbing the neurotransmitters will ~~close~~ close the gates.

Q4(c)

This was a 4 mark question.
This question was also answered poorly with a lot of confusion and poor comprehension of the topic. Most of the creditworthy answers received marks for MPs 6 & 7. Very few learners managed to obtain any of the other available marking points and scientific language was again poor.

There was a common misconception that drug F would increase serotonin levels and thus, make the person happier.

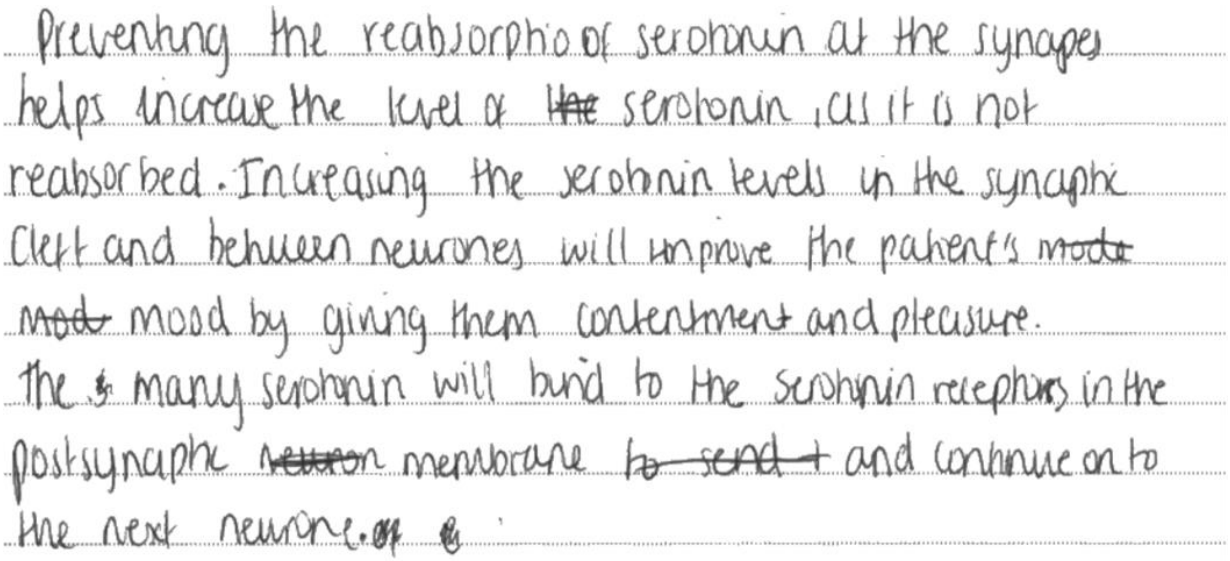
This response was awarded 1 mark.
The learner has stated the serotonin is going to be present for longer within the synapse this is too vague. For MP1 the detail of staying in the cleft, in the gap of the synapse or between the neurones would be sufficient, but synapse alone is too vague. However, the serotonin is linked to feeling more content - which is sufficient for MP7.



(4)

Drug F not allowing the serotonin to be reabsorbed means that the serotonin is going to be present for longer within the synapse. If serotonin is present for longer then the patient will feel a lot more content, which is a result of serotonin being present

This response was awarded 4 marks.
The learner has given MP1 with their statement that there will be increased serotonin level in the synaptic cleft - they have linked this to the outcome of the drug - a feeling of contentment and pleasure (MP7). The learner then adds more detail that serotonin will bind to the receptors (MP2) in the postsynaptic membrane (MP3). “On the postsynaptic membrane” is an additional mark as this provides extra detail. The "continue on to the next neurone" is not sufficient alone for MP4, but this learner has already been awarded maximum marks for the question.

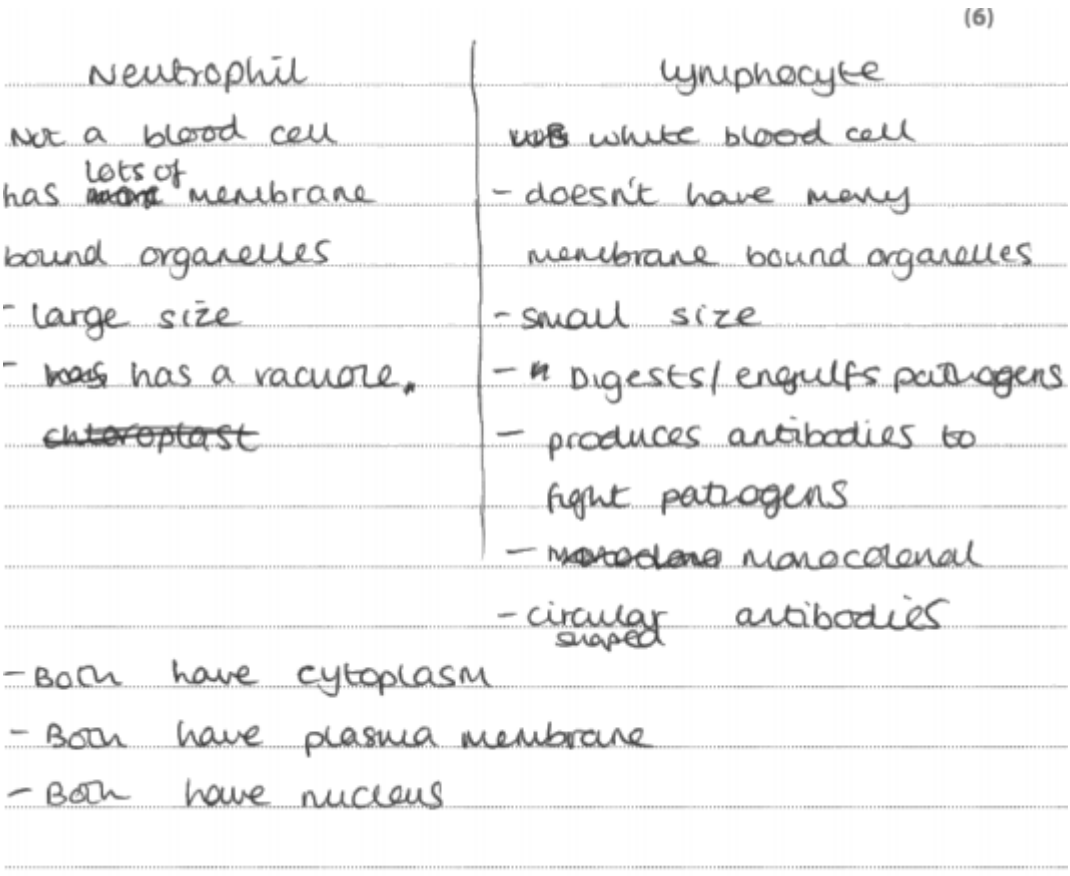

Preventing the reabsorption of serotonin at the synapses helps increase the level of ~~the~~ serotonin, as it is not reabsorbed. Increasing the serotonin levels in the synaptic cleft and between neurones will improve the patient's ~~mood~~ mood by giving them contentment and pleasure. The ~~s~~ many serotonin will bind to the serotonin receptors in the postsynaptic ~~neuron~~ membrane ~~to send~~ and continue on to the next neurone.

Q5

This was a 6 mark extended open response question.
On the whole, learners were clearly more comfortable discussing neutrophils rather than lymphocytes, the structure and function of which were rarely mentioned Some learners showed a poor understanding of the function and structure of each cell. Those learners who were able to provide creditworthy answers obtained marks for noting the similarities in structure and function of the cells.

A common misconception seen several times described one cell as eukaryotic and the other as prokaryotic.

This response was awarded 2 marks.
Responses in tables or spider diagrams or any layout is acceptable.
Unfortunately, there are a number of incorrect statements in the learner's comparison table neutrophil being large and the lymphocyte is a correct difference. The organelles listed as "they both have" after the table are correct. On balance, with the other statements being incorrect and so 2 marks have been awarded.

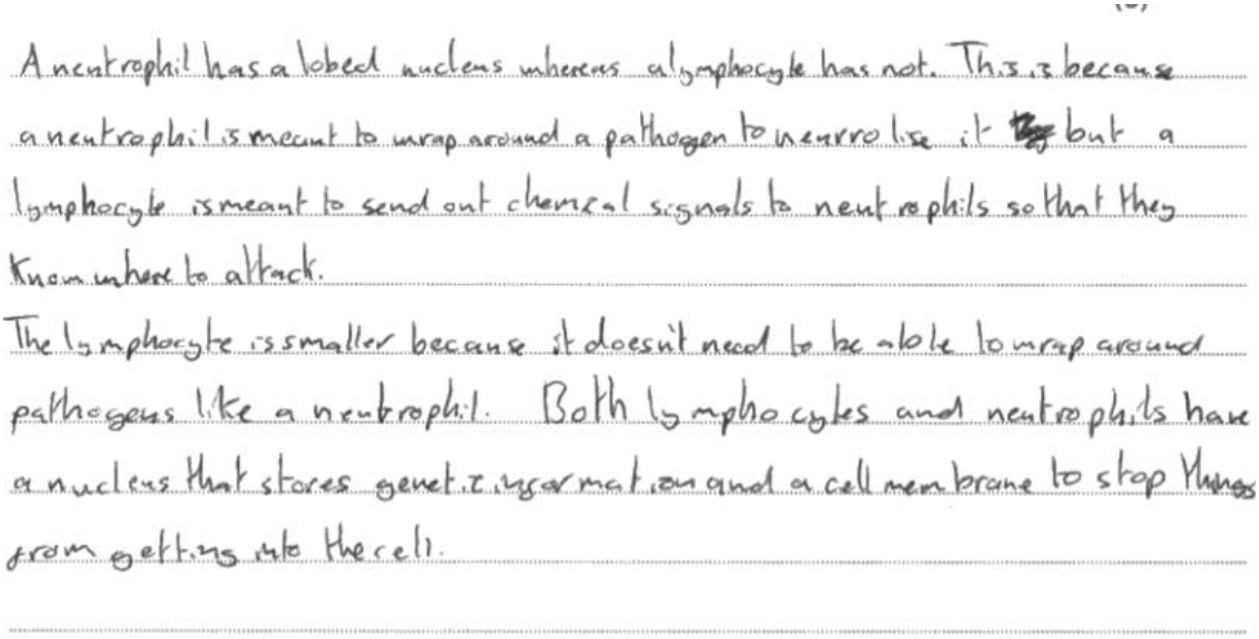


(6)

Neutrophil	Lymphocyte
Not a blood cell	~~not~~ white blood cell
has lots of membrane bound organelles	- doesn't have many membrane bound organelles
- large size	- small size
- ~~has~~ has a vacuole, ~~chloroplast~~	- Digests/ engulfs pathogens
	- produces antibodies to fight pathogens
	- ~~Monoclonal~~ monoclonal
	- circular shaped antibodies

- Both have cytoplasm
- Both have plasma membrane
- Both have nucleus

This response was awarded 4 marks.
The learner has given several correct statements - the neutrophil has a lobed nucleus, the neutrophil "wraps around a pathogen", a lymphocyte sends out chemical signals, the lymphocyte is smaller. However, the lines of argument are incomplete with some detail omitted - such as reference to antibodies, types of lymphocytes, lysosomes in neutrophils... Similarities of both have a nucleus and a cell membrane have been given. They have hinted that both are involved in defence against pathogens but have not said they are both white blood cells. On balance this is a borderline level 2/ level 3 response with 4 marks awarded.


A neutrophil has a lobed nucleus whereas a lymphocyte has not. This is because a neutrophil is meant to wrap around a pathogen to neutralise it but a lymphocyte is meant to send out chemical signals to neutrophils so that they know where to attack.

The lymphocyte is smaller because it doesn't need to be able to wrap around pathogens like a neutrophil. Both lymphocytes and neutrophils have a nucleus that stores genetic information and a cell membrane to stop things from getting into the cell.

The response below was awarded 5 marks.
The learner has given a number of correct statements. Ideally there would be similarities and differences for a level 3 response, but they don't have to be equally balanced (e.g. 5 differences and 1 similarity could still be a level 3 response). There are attempts to link structure to function - again a level 3 style response. The learner has covered the majority of the indicative content - they do not have to cover it all and they may have other relevant responses which are creditworthy. However, there are some incorrect statements which means 6 marks would not be awarded.

- neutrophil and lymphocytes are both types of white blood cells
- two types of lymphocytes - B lymphocytes and T lymphocytes
there is only one neutrophil
- ~~neutrophil white blood cells are used to target phoge pathogens~~
- neutrophil and lymphocytes are used to target pathogens that enter the body
- neutrophil has a lobed nucleus because it is needed to make more of that neutrophil. Whereas lymphocytes have antigens around them so they are able to attract the pathogen as they are complementary and fight the pathogen.
- neutrophils are used to fight bacteria that have not yet entered into the blood stream and so the lobed nucleus makes more of them so that it ~~woes~~ can kill the ~~bacteria~~ pathogens. lymphocytes are used to target ~~bacteria~~ pathogens that have entered the blood stream. B lymphocytes are used first and the T lymphocytes are used after.

- lymphocytes memorise the pathogen that was is the body, so when it appear again it is ready to attack. ~~Neutrophils only attack once.~~
- lymphocytes have lysosome which is used to break down the pathogen and remove the digested pathogens.

Summary

Based on their performance on this paper, learners should:

- Understand the demand of the command verbs, especially the difference between describe and explain
- Be familiar with and recognise the ultrastructure and function of organelles in the following cells: prokaryote cells (bacterial cells), eukaryotic cells (plant and animal cells) and eukaryotic cells (plant-cell specific)
- Revise key definitions with level 3 detail, such as organ, synapse, neurotransmitter, etc.
- Show their working out for all calculations to ensure marks can be given for the stages within the calculation even if the final answer is incorrect
- Use the additional guidance to understand the depth and breadth of the specification

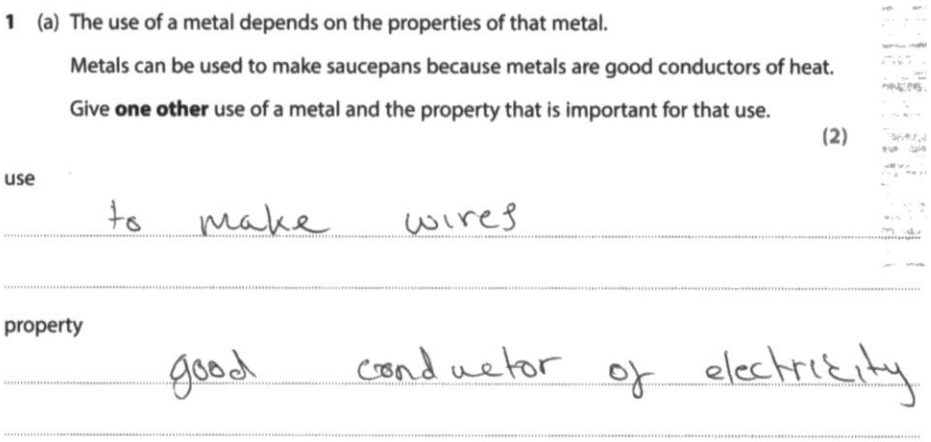
The specification and/or sample assessment materials (SAMs) located on the BTEC First qualification webpage located here.

Individual Questions

Chemistry

The first question on the paper, Q1(a), gave learners an example of a use of a metal and the property of a metal that would be required for that use. Learners were then asked to give another use along with the property of a metal that would be important for that use.

In general learners performed well, with many stating that metal is used for wires or cabling and that this use was possible as metals are able to conduct electricity, as in this example, or that metals were ductile.



1 (a) The use of a metal depends on the properties of that metal.

Metals can be used to make saucepans because metals are good conductors of heat.

Give **one other** use of a metal and the property that is important for that use.

(2)

use

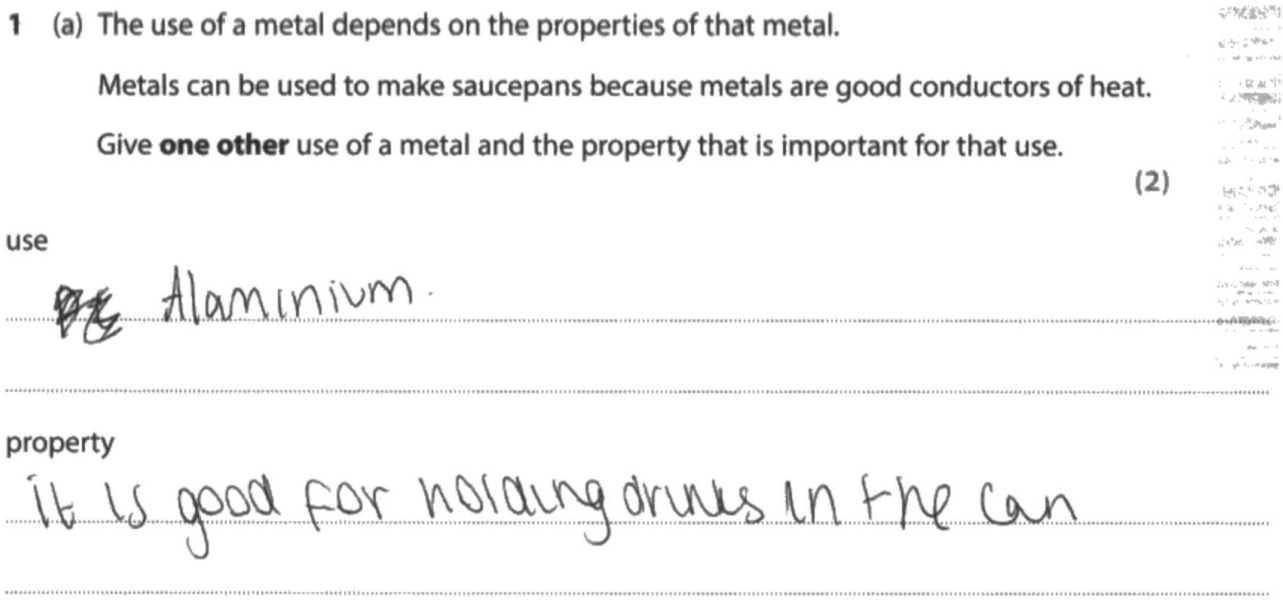
to make wires

property

good conductor of electricity

Where learners did not score full marks, it was often as they did not read the question and simply named a metal rather than gave a use or gave two properties or two uses.

This example scored 1 mark for the use.



1 (a) The use of a metal depends on the properties of that metal.

Metals can be used to make saucepans because metals are good conductors of heat.

Give **one other** use of a metal and the property that is important for that use.

(2)

use

Aluminium.

property

It is good for holding drinks in the can

Some learners tried to explain a property, rather than just give another use and property. Whilst this was ignored, whether correct or not, and did not affect the mark awarded for the use or property, this will have cost the learners time during the exam. Learners should be taught what is expected from different command words and the difference between simply stating or giving an answer rather than explaining their answer.

Part (b)(i) of question 1 asked learners to complete the arrangement of electrons in an aluminium atom. The majority were able to complete

this correctly to gain the mark. Answers that used a full arrow or a half arrow were both allowed as in these examples.

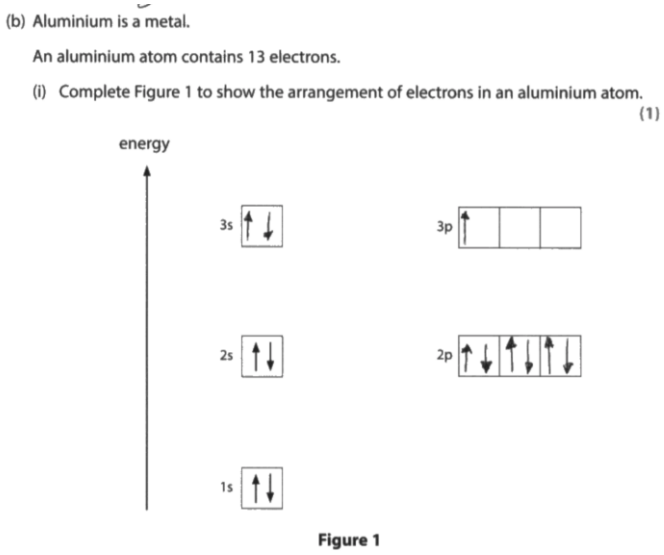


Figure 1

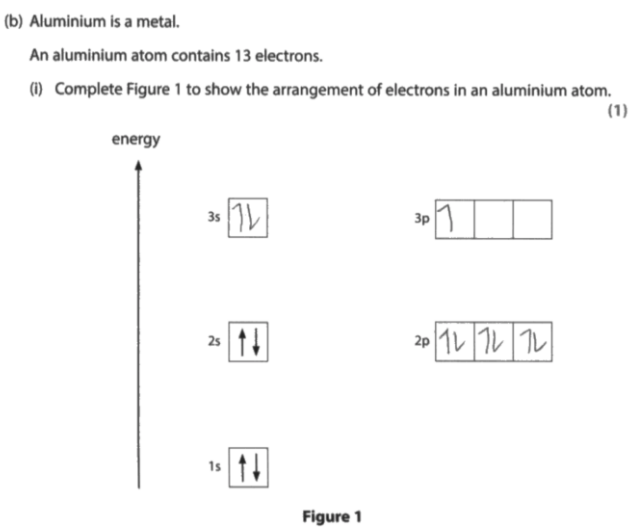


Figure 1

In cases where the learner did not gain the mark, it was often because they did not understand that the electrons paired up in the 3s orbital before filling the 3p orbital as in this example.

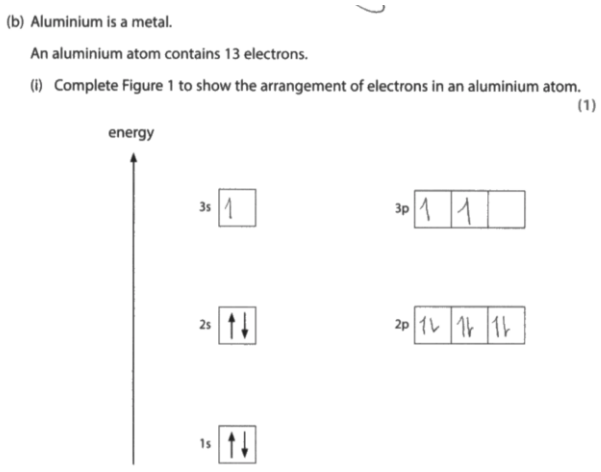


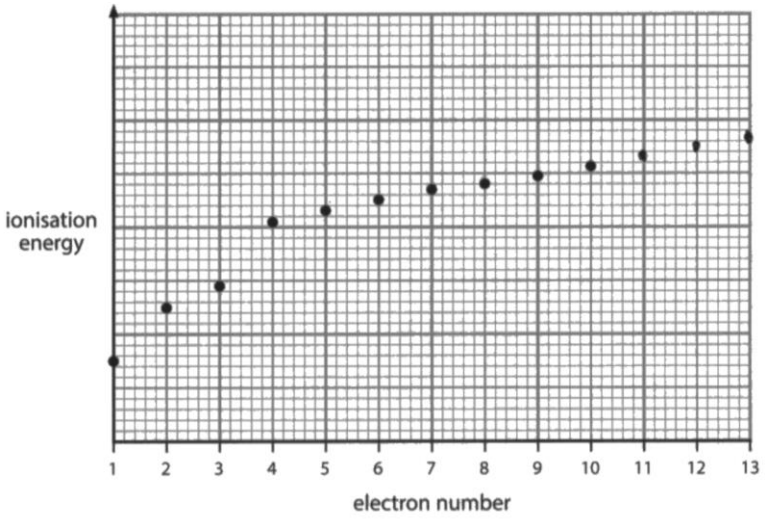
Figure 1

Part (ii) of question 1(b) asked learners to plot the last three ionisation energies of aluminium.
The majority of learners were able to score at least one mark for showing an understanding that removing successive electrons would show an increase in ionisation energy. As in this example.

(ii) Figure 2 shows a graph of the first 10 ionisation energies of aluminium.

Add **three** more points to the graph to show the ionisation energies for electron numbers 11, 12 and 13.

(2)

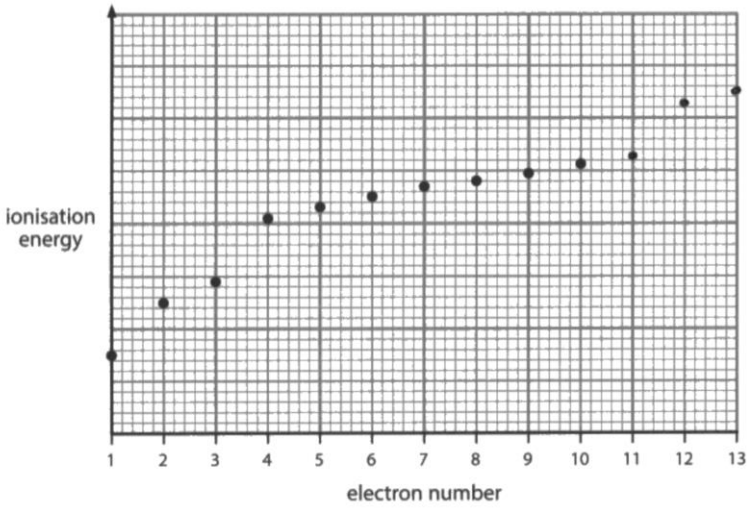


Few however knew that there should be a further 'jump' in ionisation between electrons 11 and 12 to score the second mark as in this example that scored both marks available.

(ii) Figure 2 shows a graph of the first 10 ionisation energies of aluminium.

Add **three** more points to the graph to show the ionisation energies for electron numbers 11, 12 and 13.

(2)



Question 2(a) focused on sodium sulfate. Learners found it quite difficult to give a use of sodium sulfate with many learners stating that it was

'salt'. Some learners gave very vague uses such as for chemical reactions or used in school. These were not accepted.

(b) Give **one** use of sodium sulfate.

for chemical reactions.

(b) Give **one** use of sodium sulfate.

used in science experiments at school.

Where learners did score it was often for stating that sodium sulfate is used in cleaning products or detergents.

(b) Give **one** use of sodium sulfate.

(1)

Sodium sulfate can be used in cleaning products.

(b) Give **one** use of sodium sulfate.

(1)

~~used for water systems~~ used as a detergent

Part (c)(i) of question 2 focused on the formation of the sodium ion. The majority of learners were able to state that sodium loses an electron to form the ion to gain the mark. Other synonyms were also accepted in place of losing.

(c) Sodium sulfate contains sodium ions (Na^+) and sulfate ions (SO_4^{2-}).

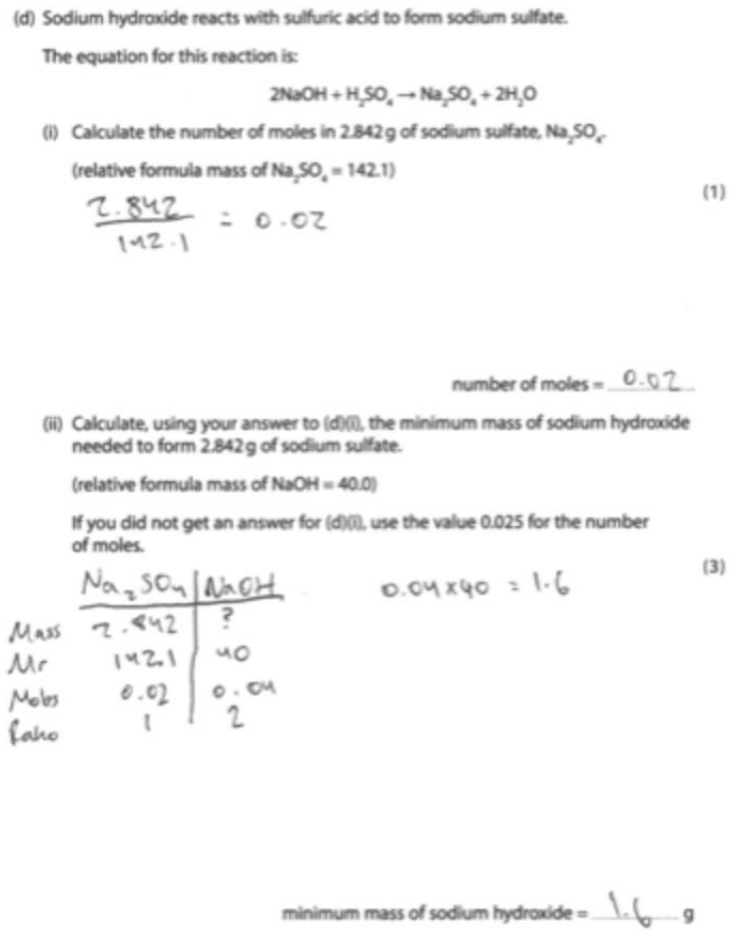
(i) Complete Sentence 1.

(1)

The sodium atom (Na) becomes the sodium ion (Na^+) by losing an electron.

Sentence 1

In was pleasing to see that in question 2(d)(i) the vast majority of learners were able to correctly calculate the number of moles of sodium sulfate to gain the mark. Of those many were able to carry this answer forward and use it to calculate the minimum mass of sodium sulfate to gain all three marks. These answers were often well presented with clear working shown.



(d) Sodium hydroxide reacts with sulfuric acid to form sodium sulfate.

The equation for this reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(i) Calculate the number of moles in 2.842 g of sodium sulfate, Na_2SO_4.

(relative formula mass of Na_2SO_4 = 142.1)

(1)

$\frac{2.842}{142.1} = 0.02$

number of moles = 0.02

(ii) Calculate, using your answer to (d)(i), the minimum mass of sodium hydroxide needed to form 2.842 g of sodium sulfate.

(relative formula mass of NaOH = 40.0)

If you did not get an answer for (d)(i), use the value 0.025 for the number of moles.

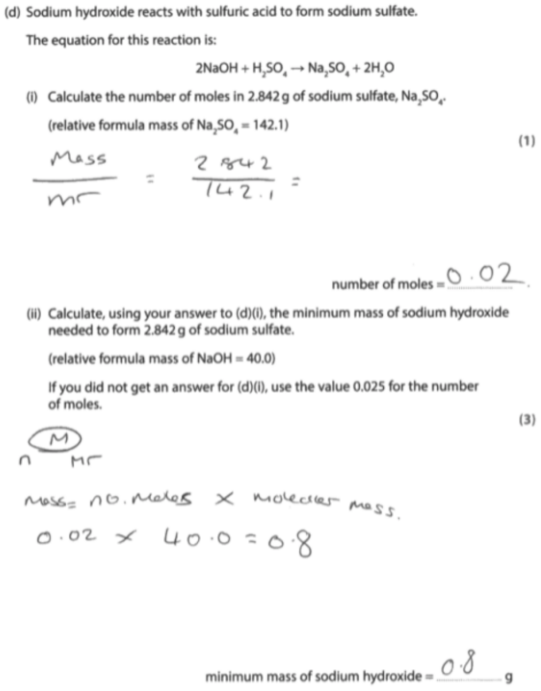
(3)

	Na_2SO_4	NaOH
Mass	2.842	?
Mr	142.1	40
Moles	0.02	0.04
Ratio	1	2

$0.04 \times 40 = 1.6$

minimum mass of sodium hydroxide = 1.6 g

A large proportion scored two rather than three marks however as they forgot to multiply their answer to (d)(i) by 2 to obtain the number of moles of sodium hydroxide and so came to an answer of 0.8 rather than 1.6, as in this example.



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(relative formula mass of Na_2SO_4 = 142.1)

(1)

Mass / mr = 2.842 / 142.1 =

number of moles = 0.02

(ii) Calculate, using your answer to (d)(i), the minimum mass of sodium hydroxide needed to form 2.842 g of sodium sulfate.

(relative formula mass of NaOH = 40.0)

If you did not get an answer for (d)(i), use the value 0.025 for the number of moles.

(3)

M

n mr

Mass = no. moles × molecular mass.

0.02 × 40.0 = 0.8

minimum mass of sodium hydroxide = 0.8 g

Learners that did not get an answer or got an answer that they were not happy with for (d)(i) and therefore used the given value of 0.025 rather than their answer from (d)(i). As in this example. The learner did not multiply the number of moles by two, but they still gained mark points two and three for calculating the mass of sodium hydroxide and the evaluation.

(d) Sodium hydroxide reacts with sulfuric acid to form sodium sulfate.

The equation for this reaction is:

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

(i) Calculate the number of moles in 2.842 g of sodium sulfate, Na_2SO_4.

(relative formula mass of Na_2SO_4 = 142.1)

(1)

2.842 x 142.1 = 403.8482

number of moles = _____

(ii) Calculate, using your answer to (d)(i), the minimum mass of sodium hydroxide needed to form 2.842 g of sodium sulfate.

(relative formula mass of NaOH = 40.0)

If you did not get an answer for (d)(i), use the value 0.025 for the number of moles.

(3)

0.025 x40 = 1

minimum mass of sodium hydroxide = 1 g

Question 3 focused on simple covalent molecules. Part (a) gave learners an example of a physical property of simple covalent molecules and asked learners to give two further physical properties.
In some cases, learners did not read the question carefully and gave properties of metals rather than simple covalent molecules and gave properties such as malleable and good conductor of electricity.

3 (a) Simple covalent molecules have low boiling points.

State **two other** physical properties of simple covalent molecules.

(2)

property 1

Malleable can be shaped into or the layers will slide over one another.

property 2

Ductile.

Again, some learners tried to explain why the molecules had the properties rather than just stating the properties. Whilst the learner did gain the two marks available for the properties, time could have been lost in the exam.

3 (a) Simple covalent molecules have low boiling points.

State **two other** physical properties of simple covalent molecules.

(2)

property 1

Doesn't conduct electricity because of no delocalised electoons.

property 2

Low melting point because of weak intermolecular forces of attraction.

Part (b) asked learners to complete the balanced equation for the reaction between hydrogen and fluorine, including state symbols. Whilst the majority of learners were able to score at least one mark, many learners found this difficult with different learners finding different aspects of the equation difficult.

Some learners lost marks as they did not know what was meant by the term state symbol and either tried to add a further number or wrote the state in the gap rather than giving the symbol. Another common error was to write the word fluorine rather than giving the symbol.
In this example, the learner scored just 1 mark for the addition of 2 to balance the equation.

(b) Hydrogen (H_2) is a simple covalent molecule.

Hydrogen reacts with fluorine to form hydrogen fluoride gas (HF).

Complete the balanced equation, including state symbols for the reaction.

(3)

H_2 (gas) + 2 fluoride (g) → 2 HF (g)

Another very common error seen was where learners did not recall that fluorine is diatomic and wrote 2F rather F2, as in this example which scored 2 marks for the state symbol and the addition of 2 to balance the equation.

(b) Hydrogen (H_2) is a simple covalent molecule.

Hydrogen reacts with fluorine to form hydrogen fluoride gas (HF).

Complete the balanced equation, including state symbols for the reaction.

(3)

H_2 (g) + 2 F (g) → 2 HF (g)

Question 3(c) asked learners to describe how a hydrogen bond forms between two hydrogen fluoride molecules. Learners found this very difficult with a large proportion not scoring on this question. A large proportion of learners did not read the question carefully and tried to describe how the covalent bond is formed between the fluorine and hydrogen atoms rather than the hydrogen bonds between the molecules and so scored no marks, as in this example.

(c) There are hydrogen bonds between hydrogen fluoride molecules.

Describe how a hydrogen bond forms between two hydrogen fluoride molecules.

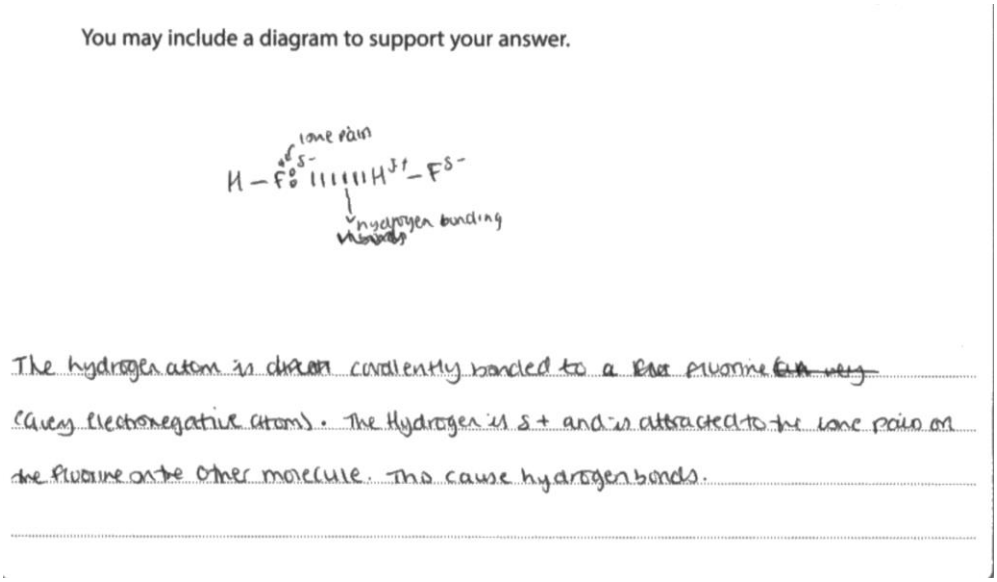
(2)

You may include a diagram to support your answer.

Because the hydrogen looses an electon to Complete the outter most shell of Flouride

Learners that read the question carefully and understood the concept of hydrogen bonding, often omitted to include the lone pairs in their explanation. Often the most effective answers used fully labelled diagrams. In this example both marks could have been awarded from the diagram or the words given. Centres should ensure that their learners are taught to label any diagrams drawn accurately with the

correct scientific language, as in this example which scored both marks available.


You may include a diagram to support your answer.

The hydrogen atom is ~~chosen~~ covalently bonded to a ~~the~~ fluorine ~~atom very~~ (very electronegative atom). The Hydrogen is δ+ and is attracted to the lone pairs on the fluorine on the other molecule. This cause hydrogen bonds.

Learners also found part (d) of question 3 difficult. However, a good proportion of learners scored at least one mark for correctly identifying that the boiling point increases, though some had trouble interpreting the negative axis for the boiling point and had the misconception that due to the negative boiling points, it was decreasing.

Those that spotted the trend often were able to explain that this was due to stronger intermolecular forces, very few however specified that Van der Waals forces were present, and fewer still understood that this was due to the increase in the number of electrons.

A significant number of learners lost marks as they were ambiguous when referring to breaking intermolecular forces. Whilst breaking intermolecular bonds would be an allowable alternative, if the learner simply describes breaking bonds then this would not be creditworthy. Learners should be taught to be clear with their explanations and descriptions, taking care with the use of the correct technical language to ensure their answer is correct and does not contradict.

In this example, the learner shows an understanding that the boiling point increases so gains one mark. Whilst they make some reference to the amount of energy required to break the bonds, as they have not specified the bonds between molecules or intermolecular bonds then this mark could not be awarded.

(d) Figure 3 shows a graph of the boiling points of hydrogen chloride, hydrogen bromide and hydrogen iodide.

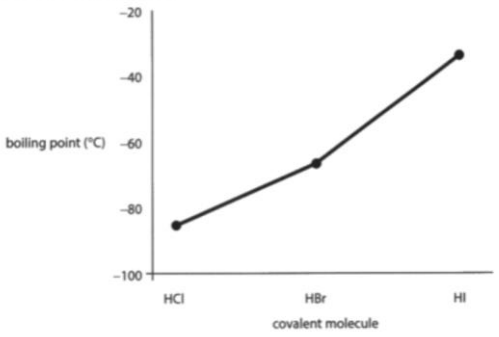


Figure 3

Explain, in terms of intermolecular forces, the change in boiling point from hydrogen chloride to hydrogen iodide.

(3)

As the bonds are stronger in hydrogen bromide and hydrogen iodide the boiling point increases because it will take more energy to break the bonds.

(Total for Question 3 = 10 marks)

In this example, the learner has correctly interpreted the graph and states that the boiling point increased from HCl to HI which gains the first marking point. They start to explain that this is due to the intermolecular forces getting stronger to gain the last marking point, but unfortunately, they have not made reference to the increasing number of electrons to gain a third mark.

(d) Figure 3 shows a graph of the boiling points of hydrogen chloride, hydrogen bromide and hydrogen iodide.

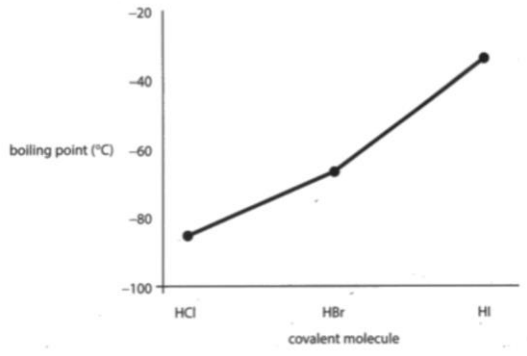


Figure 3

Explain, in terms of intermolecular forces, the change in boiling point from hydrogen chloride to hydrogen iodide.

(3)

Hydrogen chloride has weaker intermolecular forces than hydrogen iodide, making ~~to~~ it have a lower boiling point. The boiling point increase from Hydrogen chloride to hydrogen iodide so the intermolecular forces also get stronger.

(Total for Question 3 = 10 marks)

This last example gained the full three marks available.

(d) Figure 3 shows a graph of the boiling points of hydrogen chloride, hydrogen bromide and hydrogen iodide.

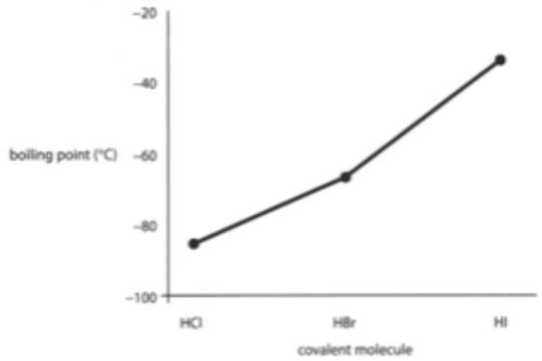


Figure 3

Explain, in terms of intermolecular forces, the change in boiling point from hydrogen chloride to hydrogen iodide.

(3)

The boiling points from HCl to HI increase because of

- more electrons
- stronger intermolecular forces will form
- Taking more energy to break the forces

(Total for Question 3 = 10 marks)

The last question on the paper, question 4, was the six-mark levelled, open response question. Learners were given the bond lengths and bond strengths of three covalent bonds and asked to discuss the relative strength of the bonds.

In general learners performed well in this question with the majority being able to give an adequate interpretation of the data with some coherence and structure to score a mark in level 1 as in this example.

4 Table 1 shows the bond lengths and bond energies of three covalent bonds.

covalent bond	bond length (nm)	bond energy (kJ mol^{-1})
C=C	0.134	612
C–C	0.154	347
C–Br	0.194	285

Table 1

Discuss the relative strength of the **three** covalent bonds.

You should use the information in Table 1 to support your answer.

(6)

bond C=C is the strongest out of 3 bonds because it has the shortest bond length and the most bond energy, where bond C–Br is the weakest because it's the longest bond out of 3 and has the least amount of bond energy.

At level 2, learners were able interpret the data well, with links to relevant ideas, which was structured in a logical way. This example gained a mark of 4 in level 2, the learner has discussed why the double bond is the strongest, referring to the sigma and pi bonds. They have given the trend in the data but unfortunately, the explanation of why C-Br has a longer bond length and lower bond energy was not creditworthy.

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C=C	0.134	612
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C–Br	0.194	285

Table 1

Discuss the relative strength of the **three** covalent bonds.

You should use the information in Table 1 to support your answer.

(6)

C=C has a higher bond energy as it contains a double bond, a sigma and Pi bond. This gives it the highest bonde energy as these double bonds require a great amount of energy in order to break, as they are very strong and will require a great amount of energy in order to break them, although they have the shortest bond length in comparison to the two others and the C=C will require double the amount of energy of C–C bond. The C–C bond has the lowest bond energy because the C–C isn't very electronegative. The C–Br bond isn't very electronegative as they don't tend to readily form bonds, giving it the lowest bond energy as C isn't really electronegative with Bromine. Carbon isn't really electronegative in general, it isn't δ+ or δ− whereas Bromine is more δ−, thus giving it the lowest bond energy as a result.

At level 3, learners were able to give a comprehensive interpretation of the data, with consistent application of relevant evidence with a coherent, logical and well-developed structure.

This answer gained a mark of 6 in level 3.

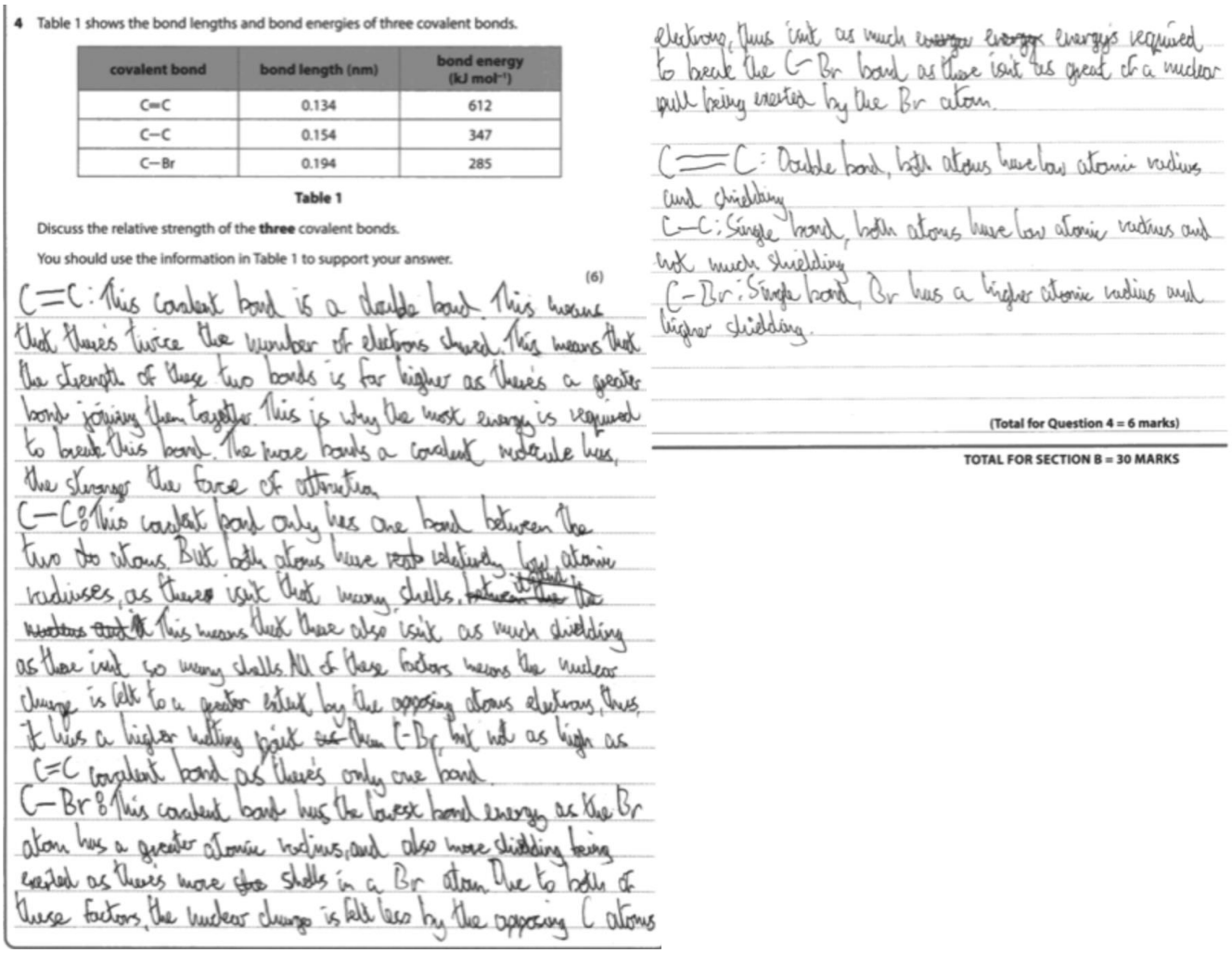

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Table 1

Discuss the relative strength of the **three** covalent bonds.

You should use the information in Table 1 to support your answer.

(6)

C=C: This covalent bond is a double bond. This means that there's twice the number of electrons shared. This means that the strength of these two bonds is far higher as there's a greater bond joining them together. This is why the most energy is required to break this bond. The more bonds a covalent molecule has, the stronger the force of attraction.

C–C: This covalent bond only has one bond between the two C atoms. But both atoms have relatively low atomic radiuses, as there isn't that many shells, ~~between the nucleus and~~ This means that there also isn't as much shielding as there isn't so many shells. All of these factors means the nuclear charge is felt to a greater extent by the opposing atoms electrons, thus it has a higher melting point ~~than~~ than C–Br, but not as high as C=C covalent bond as there's only one bond.

C–Br: This covalent bond has the lowest bond energy as the Br atom has a greater atomic radius, and also more shielding being created as there's more ~~the~~ shells in a Br atom. Due to both of these factors, the nuclear charge is felt less by the opposing C atoms electrons, thus isn't as much ~~energy~~ energy required to break the C–Br bond as there isn't as great of a nuclear pull being exerted by the Br atom.

C=C: Double bond, both atoms have low atomic radius and shielding

C–C: Single bond, both atoms have low atomic radius and not much shielding

C–Br: Single bond, Br has a higher atomic radius and higher shielding.

(Total for Question 4 = 6 marks)

TOTAL FOR SECTION B = 30 MARKS

Summary

Chemistry

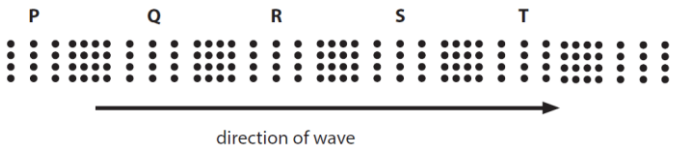
Based on their performance on this paper, leaners should:

- Be aware of the difference between key terms such as property and use and chemical and physical properties
- Practice balancing equations including the use of state symbols
- Ensure that they understand the difference between intramolecular and intermolecular forces
- Use the additional guidance to understand the depth and breadth of the specification
- Understand what is required from different command words such as give, state, describe and explain and how these types of questions should be approached
- Practice exam technique, making sure they concentrate on reading the question carefully and checking that the answer that they give, answers the question set and not a question that they think is there

Individual Questions

Physics

Q1a(i) and 1a(ii) The representation of the longitudinal wave was not as familiar to learners as the longitudinal wave shown on a slinky, but almost half of the learners were able to identify the wavelength as PQ.



The fact that the wave is made up of compression and rarefactions (P,Q,R, S and T) presented some learners with difficult in competing the sentence in the question. 'rarefraction' was often written instead of 'rarefaction' but this was allowed as a phonetic error.

Q1b(i) Almost all learners were able to read the answer from the graph as 6.8 minutes although some converted the 0.8 minutes to 48 seconds. This was acceptable but learners should note the units required in the answer line and give answers which correspond with that.

Q1b(ii) The majority of learners showed the substitution and were able to evaluate correctly as shown below. Learners should note the units given in the answer line and check that these are the units given in the question, so no conversion is required.

(ii) The transverse wave travels 6000 km in a time of 1010 s.

Calculate the speed of the transverse wave in km s^{-1}.

(2)

Use the equation:

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

Show your working.

$$\text{speed} = \frac{6000}{1010} = 5.94$$

speed of transverse wave = 5.94 km s^{-1}

Q2a

Most frequently learners were only to gain one mark from this question either for knowing the wire had to be plucked or made to vibrate in some way or for realising that the wave produced is reflected at the fixed end of the wire. The example below is one of the few answers that gained three marks.

2 Figure 3 shows a stationary wave on a wire.

Figure 3

(a) Describe **how** the stationary wave is produced on the wire.

(3)

The wire is stretched from 2 key points so it is taught. Then the wire is pulled and released and the waves are created and the force vibrates throughout the wire causing it to wave.

Q2b

The same diagram of the wave was used for the number of nodes to be identified about half of the learners were able to identify five nodes. Q2c the majority of learners were able to gain some marks of this calculation by substituting into the equation, attempting a rearrangement and giving an evaluation. The example below shows a correct evaluation where the algebra to complete the rearrangement is completed correctly, the values are substituted, and the evaluation is correct.

(c) The speed (v) of the wave on the wire is 60.1 m s^{-1}.

The mass per unit length (μ) of the wire is 0.0056 kg m^{-1}.

Calculate the tension (T) in the wire.

(4)

Use the equation:

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

Show your working.

$V = \sqrt{\frac{T}{U}}$ $(60.1)^2 \times 0.0056 = 20.2$

$V^2 = \frac{T}{U}$

$V^2 U = T$

tension in the wire = 20.2 N

Learners were able to gain marks for this calculation by showing their working and calculating a value for the tension in the wire. This allows the examiner to award marks for the work that has been done. The example below shows three marks awarded although the final evaluation is incorrect. Three marks are awarded because it can be seen that the substitution is correct, the learner has not been able to manage the square root but does attempt a correct rearrangement and has then evaluated correctly using their values. It is only possible to award three marks because the working is shown, an incorrect evaluation with no working shown will not be awarded a mark.

(c) The speed (v) of the wave on the wire is 60.1 m s^{-1}.

The mass per unit length (μ) of the wire is 0.0056 kg m^{-1}.

Calculate the tension (T) in the wire.

(4)

Use the equation:

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

Show your working.

$60.1 = \sqrt{\frac{T}{0.0056}}$

$60.1 \times 0.0056 = 0.33656$

$60.1 = \sqrt{0.33656}$

$60.1 \times 0.0056 = 0.33656$

tension in the wire = 0.34 N

Q3a

To select the correct answer for this question it was necessary for learners to know the order of the electromagnetic spectrum and to know that radio waves have the lowest frequency.

Q3b

Only about a quarter of learners were able to give two features of Bluetooth© signals. Some learners misunderstood the question and gave features of Bluetooth© devices rather than the features of the signals that are produced. The example below gains one mark for stating that the signal can pass through walls. No other mark is awarded as the second statement refers to a Bluetooth© device and not the signal.

(b) Bluetooth© devices use short wavelength, high frequency radio signals.

Give **two other** features of Bluetooth© signals.

(2)

1 They can travel through walls. Are really quick. ~~as they jump~~

2 Can also connect to other bluetooth devices.

The most common correct answers are given in the second example which gains two marks as both statements refer to the signal.

(b) Bluetooth© devices use short wavelength, high frequency radio signals.

Give **two other** features of Bluetooth© signals.

(2)

1 ~~high~~ Can penetrate through obstacles

2 travel up to 10 meters.

Q3c

Analysis of the diagram and the information given would provide the first mark as stating that the radio waves could not reach the high orbit satellite was sufficient for this mark. However, it was necessary to know that radio waves do not pass through the ionosphere to gain the second mark. A correct answer gaining both marks is given in the example below.

(c) Figure 4 shows the positions of two satellites in orbit around the Earth.

Low Earth orbit satellites orbit about 400 km above the Earth.

High Earth orbit satellites orbit about 36 000 km above the Earth.

The region of ionosphere is about 1000 km above the Earth.

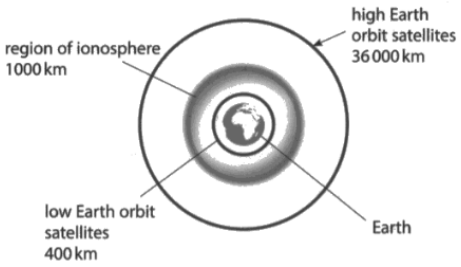


Figure 4 - not to scale

Explain why radio waves can be used for low Earth orbit satellite communication but cannot be used for high Earth orbit satellite communication.

(2)

Because low earth orbit satellites are below the region of ionosphere. The region of ionosphere blocks the radiowaves and stops them from getting through and reaching high earth orbit satellites.

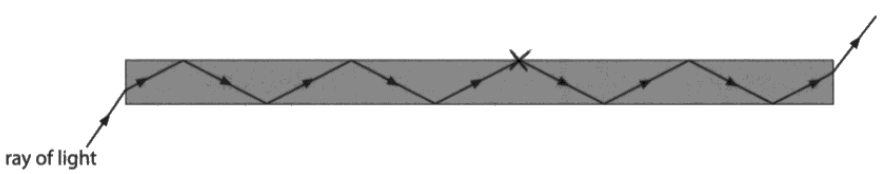
Q4a

The majority of learners were able to indicate the position of total internal reflection of light in an optical fibre. One possible correct position is shown in the example below.

4 Figure 5 shows a ray of light entering, travelling through and leaving an optical fibre.

(a) Add **one** X to Figure 5 to show **one** point of total internal reflection.

(1)



Q4b

Although the majority of learners could identify the point of total internal reflection in the first diagram they were unable to link this to the second diagram (below) which shows many less points of reflection and a much larger critical angle due to the optical fibre having cladding. Since there are many less points of total internal reflection then the cladding reduces the loss of energy of the ray of light as it passes through the optical fibre. This example shows a correct answer gaining three marks.

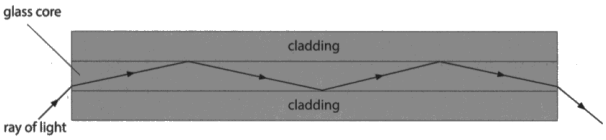


Figure 6

Explain how the cladding affects the loss of energy from the ray of light travelling along the optical fibre.

(3)

Cladding is less dense than the core. Cladding therefore increases the critical angle so there are fewer reflections. Less energy from the ray of light is lost.

Q4c

A large number of learners did not understand the meaning of multiplexing as the sending of many signals or frequencies at the same time. However, a few learners were able to gain a mark by realising that it is the use of multiplexing that gives faster broadband speeds. The answer shown below gained two marks.

(c) Explain why broadband uses multiplexing to send data through fibre optic cables.

(2)

They use multiplexing because it allows a lot more channels of data to be sent at once, meaning that a lot more data can be sent quicker over a period of time.

Q5

This extended response produced the full range of marks with some learners able to demonstrate good knowledge and understanding and present their answer explaining the production of emission spectra in a clear, coherent and logical form. Some learners gave detail of the electron energy levels in the sodium atom, however as this was not relevant to the question it was not credited.

Level 1

The examples shown below are level 1 responses. This response shows some knowledge of the process but there are no linkages although there is some structure and coherence. In the first example the main evidence is in the diagram which shows waves spreading out as they pass through the slits of the diffraction grating. Learners should be encouraged to add to diagrams and include labels as this can often be easier than trying to describe a process. The second example of a level 1 response does not add to the diagram but does refer to the diffraction grating splitting the ray of light into colours. The references to the differences in speed are ignored and both of these examples gain 2 marks.

Examples of level 1 responses:

5 Diffraction gratings can be used to produce emission spectra.

Figure 7 shows some apparatus used to produce an emission spectrum.

Figure 7 – not to scale

Light from the sodium lamp passes through the diffraction grating.

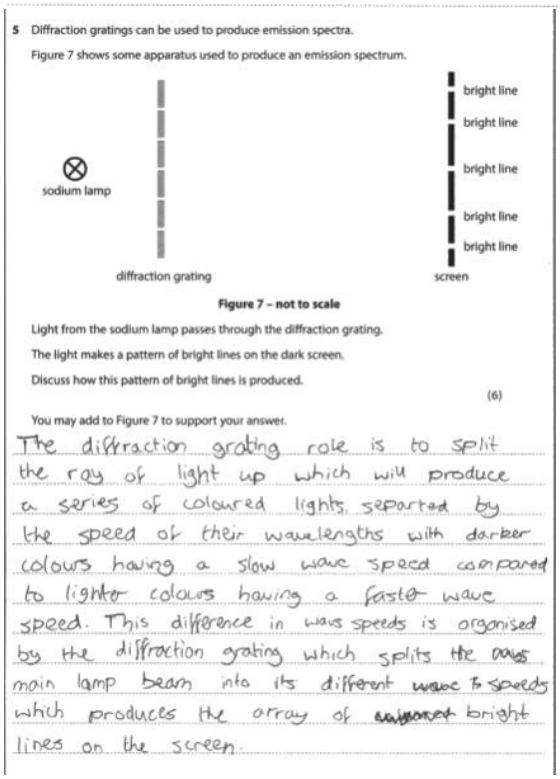
The light makes a pattern of bright lines on the dark screen.

Discuss how this pattern of bright lines is produced.

(6)

You may add to Figure 7 to support your answer.

The diffraction grating breaks up the light from the sodium lamp. That then creates a pattern on the dark screen from the way the light is broken up by the diffraction grating was larger, the patterns on the dark screen would have been larger.



5 Diffraction gratings can be used to produce emission spectra.

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Light from the sodium lamp passes through the diffraction grating.

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Discuss how this pattern of bright lines is produced.

(6)

You may add to Figure 7 to support your answer.

The diffraction grating role is to split the ray of light up which will produce a series of coloured lights, separated by the speed of their wavelengths with darker colours having a slow wave speed compared to lighter colours having a faster wave speed. This difference in wave speeds is organised by the diffraction grating which splits the rays main lamp beam into its different wave speeds which produces the array of coloured bright lines on the screen.

Level 2

The examples shown below are level 2 responses. To gain a level 2 mark the learner needed to link some relevant scientific facts and present a coherent and logical discussion. In the first example at this level the spreading out of waves on passing through the diffraction grating is shown on the diagram and the learner discusses constructive and destructive interference as the cause of the bright and dark regions of the emission spectrum. In the second example there are no additions to the diagram, but it is given that the light coming from the diffraction grating is coherent and the bright and dark regions of the emission spectrum are linked to constructive and destructive interference.

Examples of level 2 responses:

5 Diffraction gratings can be used to produce emission spectra.

Figure 7 shows some apparatus used to produce an emission spectrum.

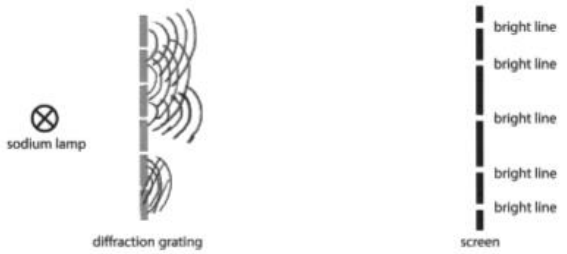


Figure 7 – not to scale

Light from the sodium lamp passes through the diffraction grating.

The light makes a pattern of bright lines on the dark screen.

Discuss how this pattern of bright lines is produced.

(6)

You may add to Figure 7 to support your answer.

The patterns of bright lines is produced because the spaces in the diffraction grating ~~please~~ is the same size over length as the rays of light that get through producing constructive interference and all the waves that not on the same length as each other are screened out and do not produce any energy which is destructive interference

5 Diffraction gratings can be used to produce emission spectra.

Figure 7 shows some apparatus used to produce an emission spectrum.

Figure 7 – not to scale

Light from the sodium lamp passes through the diffraction grating.

The light makes a pattern of bright lines on the dark screen.

Discuss how this pattern of bright lines is produced.

(6)

You may add to Figure 7 to support your answer.

This pattern of light is produced through constructive and destructive interference. The sodium lamp is emitting coherent light, this means same wavelength and frequency and at a fixed phase difference. The slits in diffraction grating cause the light to interfer. Bright spots on the screen is where constructive interference is taking place, where there is out of light on the screen is where destructive interference has taken place. The center bright spot will be the brightest

Level 3

The examples shown below are level 3 responses. To gain level 3 learners need to show that they understand the whole process of the production of the emission spectrum and can present a clear logical discussion of the process. In the first example the spreading out of the waves passing through the diffraction grating is shown on the diagram although it is not clear which part of the pattern of waves shown that the labels are referring to. This is then linked to the areas of light being due to constructive interference and the dark areas being due to destructive interference. What is meant by constructive and destructive interference is then explained. In the second example there is no addition to the diagram but the learner states that the 'waves are bent by the diffraction grating'. The discussion then links constructive and destructive interference to the light and dark regions and explains the interference without the use of a diagram.

Examples of Level 3 responses:

5 Diffraction gratings can be used to produce emission spectra.

Figure 7 shows some apparatus used to produce an emission spectrum.

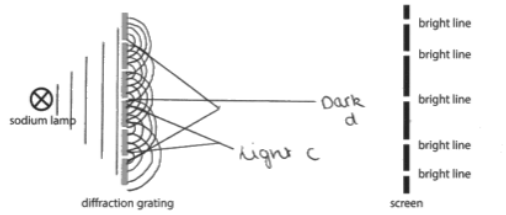


Figure 7 – not to scale

Light from the sodium lamp passes through the diffraction grating.

The light makes a pattern of bright lines on the dark screen.

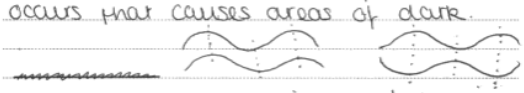
Discuss how this pattern of bright lines is produced.

(6)

You may add to Figure 7 to support your answer.

constructive destructive

The light passes through the diffraction grating and produces areas of light and dark. Where the areas of light overlap, it causes constructive interference where brighter light is produced. Where the waves are not in sinc or do not over lap, destructive interference occurs that causes areas of dark.



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5 Diffraction gratings can be used to produce emission spectra.

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Light from the sodium lamp passes through the diffraction grating.

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Discuss how this pattern of bright lines is produced.

(6)

You may add to Figure 7 to support your answer.

The pattern is created through many steps. The waves being produced from the lamp are caused to bend by the gaps in the diffraction grating. When waves intersect with waves from other gaps they create destructive and constructive interference. Destructive interference is when the trough of a wave lines up with the crest, this causes the light wave to cancel out. This means no light will shine in these areas. Constructive interference is when the crest of two waves intersect, this causes the wave to double in amplitude. This would

Areas where peaks and troughs are in sinc is where constructive interference occurs when one is positive and at the same time the other is negative this causes destructive interference.

leave a bright light. The areas of constructive interference line up and create a bright line on the screen.

Summary

To improve their mark for this paper learners should:

- always show working for calculation
- practice squaring of equations to remove the problem of the square root
- check the units used in the answer line and provide the answer in that unit
- use the information given in diagrams
- add to diagrams, add labels to diagrams or draw diagrams to help with explanations
- learn the order of the waves in the electromagnetic spectrum
- learn how the frequency changes with the order of waves on the electromagnetic spectrum
- learn the meaning of multiplexing
- read the questions carefully and actually answer the question

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