BTEC

L3 Lead Examiner Report 1906

June 2019

L3 Qualification in Applied Science

Unit 5: Principles and Applications of Science II (31627H)

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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 and 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 5 (31627H)

Grade	Unclassified	Level 3			
		N	P	M	D
Boundary Mark	0	14	29	51	74

Introduction

Organ and Systems (Biology)

31627_H1B is the biology section of the externally assessed unit, unit 5. This unit, Organs and Systems, covers the cardiovascular system (B.1), the respiratory system (ventilation and gas exchange in the lungs) (B.2), the structure and functions of the urinary system (B.3), and cell transport mechanisms (B.4).

This was the fifth series of the new specification. It was the second time that learners had sat the Biology, Physics and Chemistry sections as individual papers.

The question paper followed the same format as for the previous papers and for the sample assessment material. It consisted of five questions, four of which consisted of smaller items; there were 18 items in total. These included four multiple choice items and three other single mark questions testing recall of knowledge. There were some 2, 3 and 4 mark items, each carrying a greater cognitive demand, where learners had to analyse or interpret information or apply their knowledge to a new scenario. These questions were marked using a points-based mark scheme.

The last question carried 6 marks and was marked using a levels-based approach that considered the overall quality of the response and not just the amount of correct and relevant facts presented by the learner. More detail can be found below, in the individual question section of the report.

Properties and Uses of Substances (Chemistry)

This is the fourth examination series for the Unit 5 (Principles and Applications of Science) Chemistry section A: Properties and uses of substances. The following topics were covered:

- Question 1: recalling / identifying the properties of titanium for a specified use; the extraction of titanium and comparison of production methods (A1)
- Question 2: identifying alkanes from nomenclature; combustion of alkanes (A2); exothermic processes; calculation of internal energy change (A3)
- Question 3: understanding standard enthalpy change of formation and use of these in calculation (A3); completion of an electrophilic addition mechanism for sulfuric acid with an alkene (A2); completing an equation for neutralisation using calcium hydroxide (A1)

- Question 4: recall and use of the general formula of an alkene; understanding / identifying bond lengths and bond angles; recalling stages of hybridisation (A2)
- Question 5: knowledge and understanding of the extraction and purification of alumina (A1)

Introduction to the Overall Performance of the Unit

Organs and Systems (Biology)

Many learners were well prepared, by their centres, for the examination; they read the questions carefully with due consideration of the command word used and subsequently selected relevant and appropriate information to use in their responses.

However, a significant number, for some questions, offered explanations when they had been asked for a description and vice versa. This type of confusion was seen particularly in responses to questions 1bi and 1bii. In one case, question 2 c, the majority of learners did not read the question carefully enough and did not, therefore, answer appropriately.

Some of the responses to very straightforward questions, such as naming a structure shown on a diagram, were disappointing; for example a surprising number of learners misidentified the trachea as the oesophagus. Many candidates are not able to calculate percentage change (question 4 d ii) and, whilst many could correctly interpret information shown on a graph (question 1 bi), it is clear that some learners need more practice at this particular skill.

- You can access the specification and/or sample assessment materials (SAMs) located on the BTEC First qualification webpage located here.

Properties and Uses of Substances (Chemistry)

In general, candidates performed similarly on this paper by comparison to recent series.

Areas where candidates performed well were:

- Interpretation of images and diagrams – this was mainly where images such as hip implants (Question 1) or benzene structures (Question 4) were presented and learners were able to identify a use or quality
- Question 2 – this was mainly targeted at pass level and learners were able to show that they could identify an organic compound from its name or a reaction type from the description, or explain an exothermic process
- Calculations – candidates were generally able to rearrange and substitute equations or energy cycle values to solve problems (Questions 2 and 3)

Areas where candidates did not perform as well were:

- Completion of mechanisms and equations - Question 3(c) and (d)
- Expanding upon identification points to give a sustained line of reasoning - Question 4 (a) and (b)
- Recall of specific details in extraction of substances – Question 1 and 5
- Recall of specific details in hybridisation – please see the Additional Guidance document for further details (https://qualifications.pearson.com/en/qualifications/btec-nationals/applied-science-2016.coursematerials.html#filterQuery=category:Pearson-UK:Category%2FExternal-assessments&filterQuery=category:Pearson-UK:Document-Type%2FContent-support)

Thermal Physics, Materials and Fluids (Physics)

Learners were able to access most parts of this paper and show achievement in the various topics tested.

Calculations were better answered in this paper compared to previous series which is encouraging. Many learners appear more confident in rearranging equations and substituting values into equations. However, there were still a number of learners that found rearranging equations very difficult. Learners continue to struggle with converting units. One of the key mathematical skills at this level is the ability to ensure that all quantities are in the correct unit for a calculation. In many cases a mark was lost for what was a 'power of ten error' (POT) in a calculation.

Most of the command words used in the paper were familiar to the learners, however, there still remains the issue with explain type questions, where learners fail to score full marks because of not giving both parts of an answer. In an explain question the learner needs to make an identification of a point and then give reasoning. The mark scheme for explain questions makes clear the requirements. In many cases the identification is made and then nothing else is written. It should be noted that marks for such questions are awarded as linked pairs, which the mark scheme also makes clear. It would greatly aid learners if centers spent time prior to the examination in explaining how to answer such questions.

One question asked learners to describe a process, (Q3c), in many cases learners did not produce a description in a logical order. Learners need to be clear before writing the order of events so that they make sense.

The paper identified some common misconceptions relating to air flow over wings, the process of condensation and heat pumps.

Individual Questions

Organs and Systems (Biology)

Question 1a

For this question learners were required to recall the functions of ureters and the bladder. Many gave correct responses that the ureters carry urine from kidneys to bladder but some lost the mark by giving vague references to waste or by not specifying where the urine was being carried from and to; some attempted to give the information but were incorrect. Some stated that the urine went from bladder to kidney or from kidney to anus. Some learners thought the ureters carried blood. Many correctly stated that the bladder stores urine, or that the urine passes form bladder to urethra/out of the body but many confused the functions of the bladder with that of the kidneys and talked about filtration occurring in the bladder. About one third of learners gained one mark here and a similar number gained both marks. About one third gained no marks.

This response gained 2 marks.

1 (a) Complete Table 1 to show the functions of the ureters and bladder.

(2)

organ	function
Renal arteries	Carries blood to the kidneys
Renal veins	Carries blood away from the kidneys
Ureters	Transfer the urine/waste from the kidney to the bladder.
Bladder	Holds urine until ready to release.

Table 1

Although, in the response for the function of the ureters, the learner mentions waste, which alone would not have been credited as it is too vague, they have also referred to urine, so the response is worthy.

This response gained one mark

1 (a) Complete Table 1 to show the functions of the ureters and bladder.

(2)

organ	function
Renal arteries	Carries blood to the kidneys
Renal veins	Carries blood away from the kidneys
Ureters	this is where urine is made.
Bladder	this is where the urine is kept.

Table 1

The learner has correctly stated the function of the bladder.

This response gained no marks

(a) Complete Table 1 to show the functions of the ureters and bladder.

(2)

organ	function
Renal arteries	Carries blood to the kidneys
Renal veins	Carries blood away from the kidneys
Ureters	allows ~~carries~~ the urine out
Bladder	Carries the [illegible] urine

The learner appears to have confused the two structures but had they put their responses in the appropriate boxes in the table they would have been too vague to be credited. There is no indication of where the urine goes when let out, or to where the urine is being carried.

This response gained no marks

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organ	function
Renal arteries	Carries blood to the kidneys
Renal veins	Carries blood away from the kidneys
Ureters	Squtle Sises / Secreats urea
Bladder	Stores urea

Had the learner said 'stores urine' instead of 'stores urea' for the function of the bladder, they would have gained one mark. However urea and urine are not the same.

Question 1bi

In this question learners were presented with a graph showing the rate of urine production, over a two-hour period, after drinking 1 litre of water. One line showed the results when no ADH was given and the other line showed the results with ADH injected. For 1 b i they were asked to describe the changes in rate of urine production when no ADH was injected, over the two hour period.

Good responses accurately described the trends shown, such as a slow increase for the first 15 minutes followed by a steep increase until it peaked at 16 ml minute^{-1} at 45 minutes, followed by a steady decrease to 2 ml minute^{-1} by 120 minutes (or the end of the two hour period). Such a response showed that the learner could accurately describe the trend seen on the correct line of the graph. Unfortunately some learners looked at the wrong line on the graph and described what happened when ADH was injected, thereby forfeiting the marks.

Weaker responses just indicated that the rate of urine production increased (until 45 minutes) and then went down. This gained one mark.

Many learners indicated when the urine production peaked and gained a mark if they gave data quotes of both time and volume. Many of these also gained a mark for describing either the decrease or increase correctly.

A few learners misinterpreted the command word and tried to explain why the rate of urine production was changing but such responses gained no marks as they were not answering the question.

This response gains three marks.

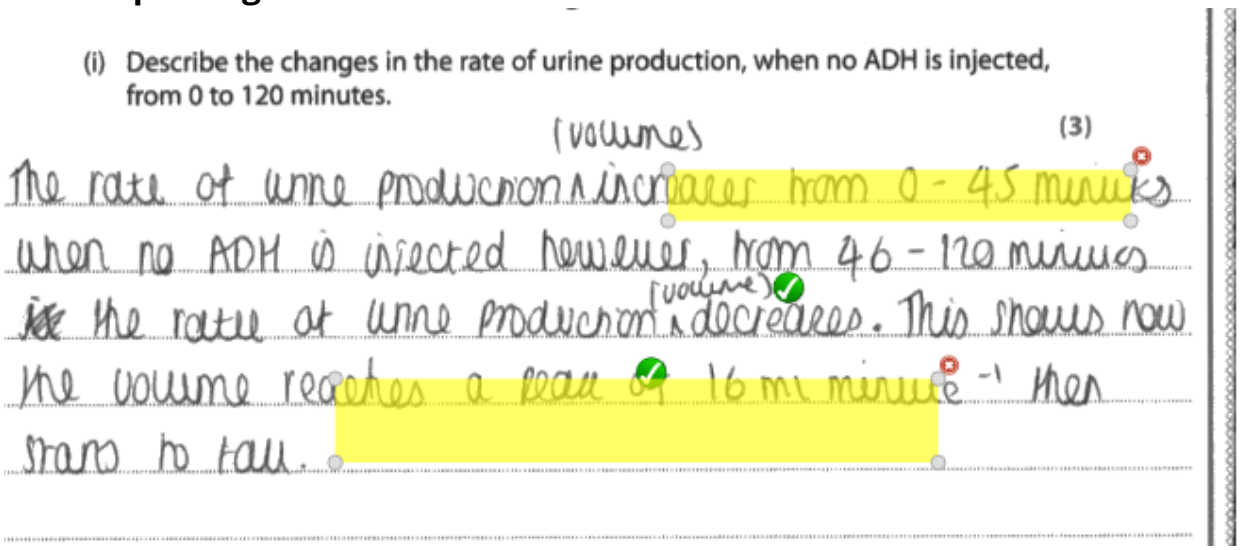
(i) Describe the changes in the rate of urine production, when no ADH is injected, from 0 to 120 minutes.

(3)

At 0 minutes the volume of urine is around 0.4 ml/min^{-1} and as the minutes increases to 46 minutes the volume of urine is 16 ml minute^{-1}. After the peak has been reached the volume of urine decreases down to 2 ml minute^{-1} at 120 minutes. The volume of urine is not very constant but changes from 0 to 120 minutes by a small amount.

It has clearly and concisely described the increase, the peak and the decrease with reference to both times and volumes of urine produced.

This response gained two marks



(i) Describe the changes in the rate of urine production, when no ADH is injected, from 0 to 120 minutes.

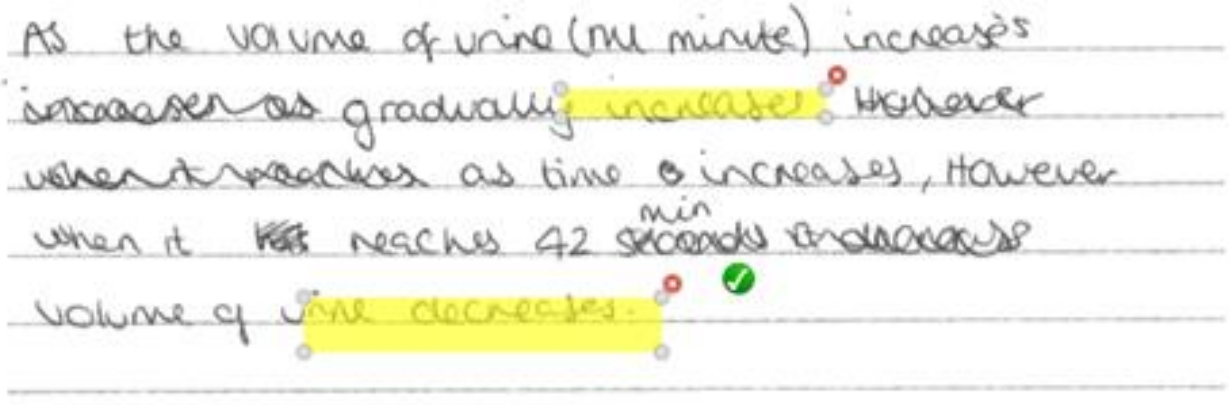
(3)

(volume)

The rate of urine production increases from 0 - 45 minutes when no ADH is injected however, from 46 - 120 minutes the rate of urine production (volume) decreases. This shows how the volume reaches a peak of 16 ml minute^{-1} then starts to fall.

The response shows that the volume peaked at 45/46 minutes at 16 ml minute^{-1} and then describes the decrease over a specified period of time.

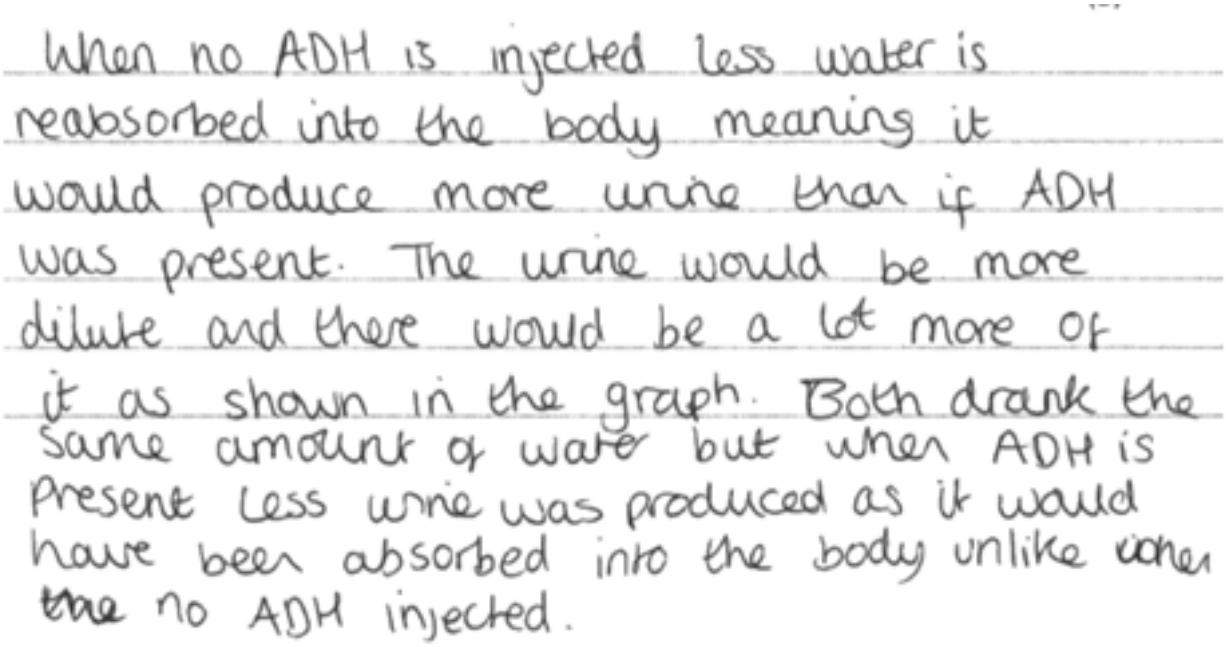
This response gained one mark



As the volume of urine (ml minute) increases increases as gradually increases However when it reaches as time increases, However when it reaches 42 min seconds decreases volume of urine decreases.

The response described the general trend of increasing and then decreasing. There was an attempt at data quotes, but just one reference to time was not enough to gain a second mark.

This response gained no marks


When no ADH is injected less water is reabsorbed into the body meaning it would produce more urine than if ADH was present. The urine would be more dilute and there would be a lot more of it as shown in the graph. Both drank the same amount of wate but when ADH is present less urie was produced as it would have been absorbed into the body unlike when the no ADH injected.

The response was offering an explanation of why something was happening – the difference between the two lines on the graph, rather than a description of what is happening for one condition.

Question 1bii

In this question learners were asked for an explanation; they were asked to explain the effect of ADH on the rate of urine production. As with most 2 mark questions asking for an explanation, one mark is for identifying the effect and the other mark is for the explanation – the reason why or how the effect happens.

Good responses indicated that the rate of urine production decreased (the identification mark) because (the expansion mark) more water was reabsorbed into the blood (in the nephron/kidneys) and some very good responses detailed how this increase in reabsorption of water in the collecting duct was brought about by ADH causing more aquaporins to be inserted into the cell membranes of cells making up the walls of the collecting duct. It was very encouraging to see that level of understanding of the action of ADH. At this level merely saying that more water is reabsorbed into the body is not enough detail; learners should indicate that the water is reabsorbed into the blood or that it is absorbed from the kidney tubules.

This response gained 2 marks

(ii) Explain the effect of ADH on the rate of urine production.

(2)

ADH lowers the rate of urine produced. It opens up pathways in the Collecting duct for water to be re adsorbed. ADH controls the rate of urine production. Urine is more concentrated and has less volume

The response gained one mark for stating that the rate of urine production is lowered and another mark for identifying that it is because water is reabsorbed from the collecting duct. We ignore the use of adsorbed instead of absorbed

This response gained one mark

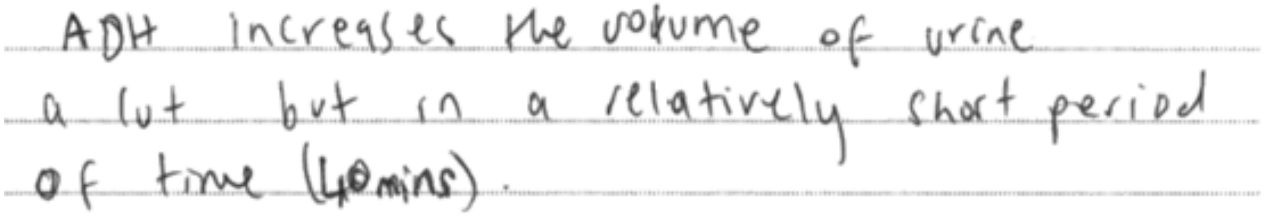
(ii) Explain the effect of ADH on the rate of urine production.

(2)

ADH slows down urine production as it absorbs the water back into the body by osmosis

The mark gained is for identifying that urine production is slowed but the reference to water being reabsorbed back into the body is not enough for the second mark. Had the learner said that it was reabsorbed into the blood (by osmosis) they would have gained the second mark.

This response gained no marks.



The learner appears to have looked at the wrong line on the graph

Question 1c

In this question learners were given some vital information in the stem, namely that the renal vein contains less oxygen than the renal artery. They were asked to state **two other** ways in which the blood in the renal vein is different from that of the renal artery. It seems that many learners misinterpreted this as being asked to describe any two differences between the blood in the renal vain and blood in the renal artery and they repeated the information in the stem of the question, which gained no marks. Some learners described differences between the structures of arteries and veins and some referred to the direction of blood flow in the two vessels. This question was quite challenging but it was expected that more learners would recognise that the blood in the renal vain would contain more carbon dioxide (picked up form respiring cells in the kidney) and less urea (as that had been filtered out by the nephrons). Many learners were not applying their knowledge of what happens in the kidney to answer this question and were merely trotting out differences between arteries and veins. More able learners also correctly indicated that the renal vein blood would contain fewer salts/ions, less water (as these would have been filtered and added to urine) and less glucose (as some would have been used for respiration in kidney cells) and be under less pressure.

This response gained two marks

(c) The blood in the renal vein contains less oxygen than the blood in the renal artery.

State **two other** ways that the blood in the renal vein is different from the blood in the renal artery.

(2)

1 The blood in the renal vein will contain less nutrients, such as glucose than the renal artery.

2 The blood in the renal vein is at a much lower pressure than the blood in the renal artery.

The response correctly identified two differences. Had the learner simply referred to nutrients in the first line, they would not have gained that mark as the term 'nutrients' is too vague. However they qualified this term with "such as glucose' and gained the mark.

This response gained two marks

1 The blood in the renal vein is under less pressure than the blood in the renal artery.

2 Blood in the renal artery is more concentrated with ions as it travels to the body cells

One mark was awarded for the reference to less pressure and the other mark was for saying that the blood in the renal artery has more ions, which is the converse of saying that blood in the renal vein has fewer ions. The phrase about travelling to body cells was ignored as it is irrelevant.

This response gained one mark

State **two other** ways that the blood in the renal vein is different from the blood in the renal artery. (2)

1 renal artery glucose

2 renal artery has more water in it

The mark awarded was for saying that the renal artery contains more water (than the renal vein). This is the converse to saying that the renal vein contains less water (than the renal artery). Reverse arguments are always accepted as long as it is clear to what the learner is referring. Had the learner simply said 'It contains more water' then they would not have gained the mark as the word 'it' is always assumed to refer to the subject of the question stem which, in this case, is the renal vein.

This response gained no marks.

(2)

1 Renal Veins are carrying deoxygenated blood, out of the body

2 The renal Veins will be carrying the Products reabsorbed by the kidneys.

The first point (ignoring the incorrect fact that veins carry blood out of the body) repeated the stem of the question and the second, whilst indicating an attempt to think about how blood is altered as it flows through kidney tubules, was too vague

Question 2a

Question 2 was all about surface area to volume ratio and movement of substances into and out of cells, section B4 of the specification.

In the first part learners were given data and asked to calculate the SA/V ratio of a columnar cell. All they had to do here was divide 1032 by 1440 and just over 90% of them did this correctly. They could express their answer as 0.716 or

round it to 0.72 or 0.7. They could put their answer in the space in the table if they did not wish to use the space provided. A few learners got the division upside down and divided volume by surface area. Some did the sum both ways and left the examiner to choose but this approach does not gain any marks.

This response gained 2 marks

	columnar cell from the lining of the bronchi	squamous cell from the wall of the glomerulus
surface area (SA) (μm^2)	1032	816
volume (V) (μm^3)	1440	80
SA/V	0.7	10.2

Table 2

The learner has carried out the calculation correctly, rounded to one decimal place and given their answer in the table.

This response gained one mark.

Show your working.

~~8 + 6 : 80~~

1032 : 1440

129 180

43 30

15

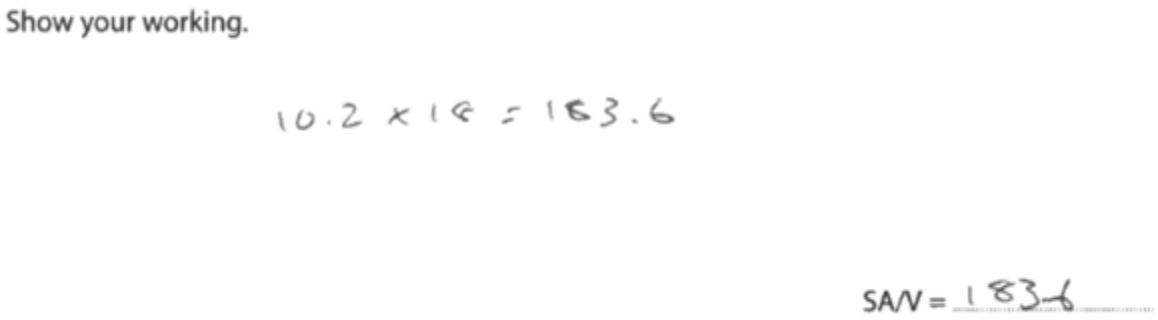
5

: 10

SA/V = 43 : 3

The learner has correctly stated that the ratio is 1032:1440, which is equivalent to 1032/1440, but has then got the division upside down and one part is a factor of 20 out.

This response gained no marks

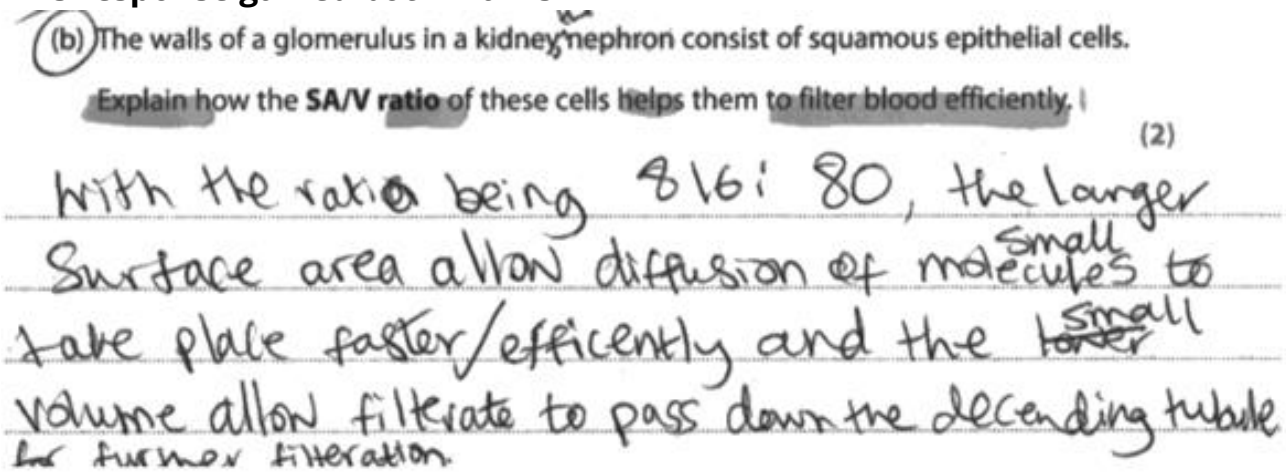


The learner has multiplied the SA/V ratio of the squamous cell by the volume of the squamous cell.

Question 2b

This question tried to get learners to apply their understanding of the concept of SA/V ratio to a situation in the body. The command word was 'explain' so we expected them to identify, from data in Table 2, that the squamous cells have a large(er) SA/V ratio and to expand the idea to indicate that therefore there is more membrane compared to cell contents for substances to pass through. Or that it is a short distance for substances to pass from the membrane to all parts of the cell or to the other side of the cell. Many of them gained the first mark and many gave the second idea by referring to a short pathway or a sort diffusion distance or that diffusion would be faster. This was credited although diffusion does not play a part in ultrafiltration in the glomerulus. However a significant few merely repeated the question and stated that the blood would be filtered more efficiently; this did not gain the second mark.

This response gained both marks


(b) The walls of a glomerulus in a kidney nephron consist of squamous epithelial cells.

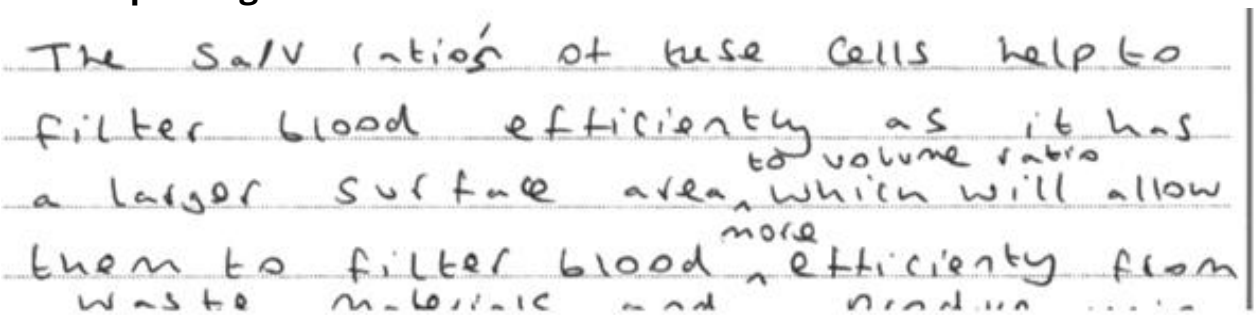
Explain how the **SA/V ratio** of these cells helps them to filter blood efficiently.

(2)

With the ratio being 8:6:80, the larger surface area allow diffusion of small molecules to take place faster/efficiently and the ~~larger~~ small volume allow filtrate to pass down the decending tubule for further filteration.

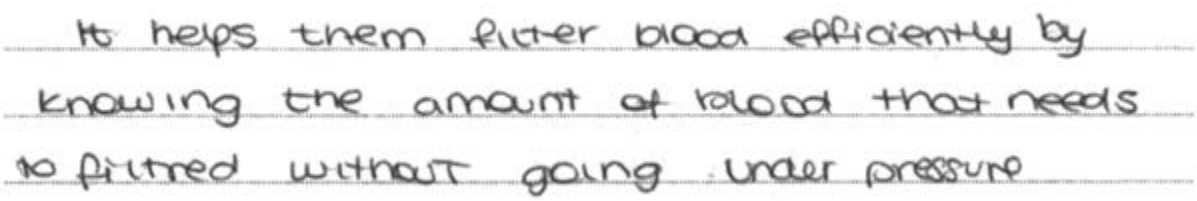
The learner gained a mark for reference to a larger surface area and a mark for reference to faster diffusion

This response gained one mark


The SA/V ratio of these cells help to filter blood efficienty as it has a larger surface area to volume ratio, which will allow them to filter blood more efficienty from waste materials and medium ...

The learner gained a mark for referring to a larger surface area to volume ratio but the rest merely repeats the question

This response gained no marks


It helps them filter blood efficiently by knowing the amount of blood that needs to filtred without going under pressure

The learner has merely repeated what is in the question.

Question 2c

This question was designed to test learners' understanding of some aspects of active transport and endocytosis. They should know that endocytosis is a form of bulk transport that takes substances into cells; it does not use protein carriers in the membrane, as the substances passing into cells is too large to pass through the membrane; instead it is enclosed in vesicles caused by invagination of the cell surface membrane. This is an active process that therefore involves (hydrolysis of) ATP. Some learners appeared to be guessing and demonstrated very little understanding but many correctly gave the direction of movement as into the cell. Unfortunately some learners did not appreciate that to say 'in the cell' or 'within the cell' has a different meaning to 'into the cell' and these responses were not credited. Many learners thought that carrier proteins in the membrane were involved and a significant number thought that ATP was not involved. This section (section B.4) of the specification is smaller in content that the other three sections but it contains valuable underpinning knowledge and concepts and will always be tested in the examination.

This response gained three marks

(c) Complete Table 3 to show the differences and similarities between active transport and endocytosis. Active transport has been completed for you.

(3)

feature	active transport	endocytosis
direction of movement	out of or into the cell	in to ~~out of~~ the cell
involves protein carriers in the membrane	yes	NO
uses ATP	yes	Yes

Table 3

All three responses are correct.

This response gained one mark

feature	active transport	endocytosis
direction of movement	out of or into the cell	into the cell
involves protein carriers in the membrane	yes	yes
uses ATP	yes	~~yes~~ No

Table 3

The learner correctly identified the direction of movement. Had the learner crossed out yes in the last row and not written anything in its place, they would have gained that mark. As it is, their second response was marked and, as it was incorrect, did not gain a mark.

This response gained no marks.

feature	active transport	endocytosis
direction of movement	out of or into the cell	or out of cell
involves protein carriers in the membrane	yes	yes
uses ATP	yes	No

Table 3

All three responses are incorrect.

Learners need to be aware than 'endo' means into and 'exo', as in 'exit', means 'out of'

Question 3ai

Question 3 was all about the lungs and associated structures and their involvement in ventilation (section B.2 of the specification). Learners were shown a diagram of the lungs and associated structures to help jog their memories.

3ai asked them to name structure X – a tube leading to the lungs. Most gave the correct name, trachea, but disappointingly there were a number of other names offered, such as oesophagus, bronchi, sternum, spleen, pharynx, thoracic cage, air goes in and out, airways and windpipe. Airways and windpipe are not incorrect terms but too vague to be credited at level 3, where we expect learners to know the names of certain structures in the body. We accept phonetic spellings but, as always, if the word is misspelt in such a way that it becomes the term for another structure, such as tracheid or tracheole, then it is not credited.

Question 3aii

This was a multiple choice question about the function of pleural fluid. Many learners knew that the function of the pleural fluid is to reduce friction. However some thought it was to remove pathogens (perhaps they are confusing it with mucus) and some confused it with surfactant and gave the response 'to prevent the alveoli collapsing'.

Question 3b

This was a straightforward one-mark question asking learners to name the muscles that caused the rib cage to move during breathing. About half of learners correctly named the intercostal muscles and some qualified with internal or external. Neither of those qualifications was required but neither detracted from the answer. However learners who gave a list, such as 'diaphragm and intercostal' lost the mark. However those that gave a list with a neutral addition, such as 'large muscles, intercostal' were credited. Some learners incorrectly gave 'diaphragm' as their answer. Others offered 'cardiac muscle' and 'cartilage muscle' as their responses.

Question 3c

This question asked learners to explain how the movements of the rib cage and diaphragm enable a person to inhale. Most knew that the ribs move up and out and that the diaphragm moves down and that these increase the volume of the thoracic (or chest) cavity, hence lowering the pressure and causing air to enter down the pressure gradient. Many also correctly referred to the lungs expanding. Some learners described the movements associated with exhaling and some incorrectly thought that increasing the volume also increased the pressure.

This response gained four marks

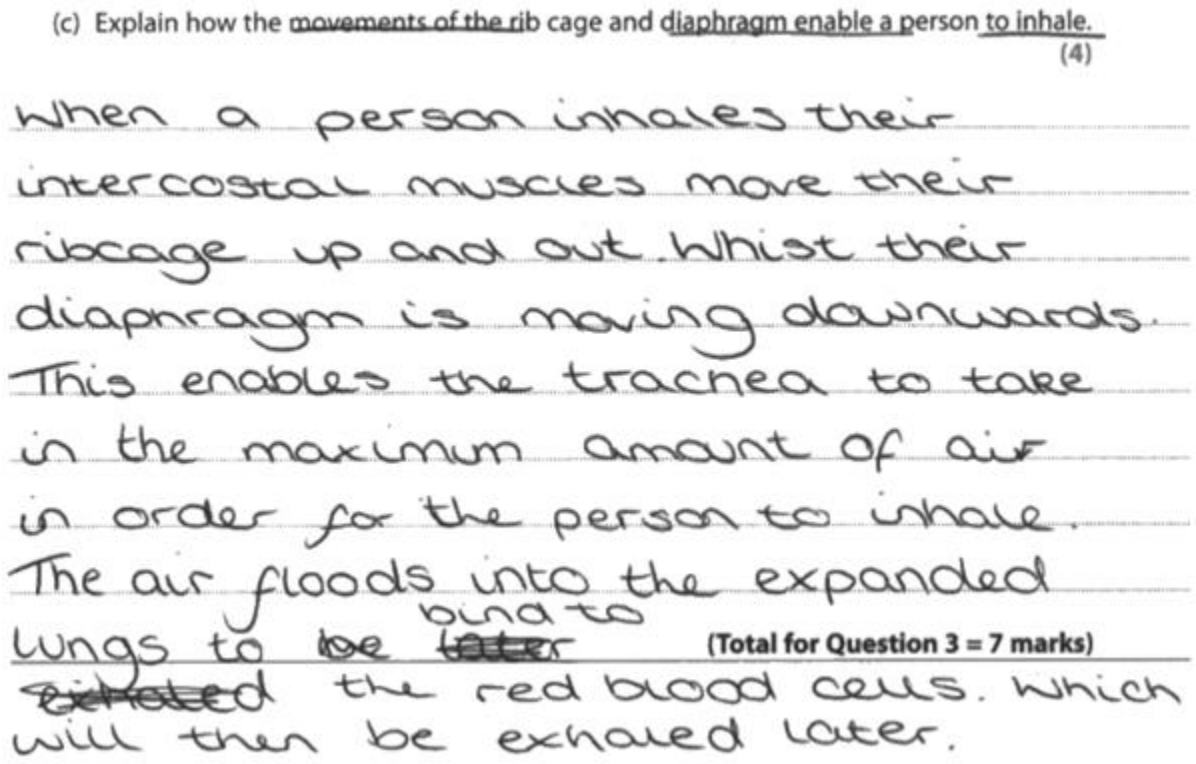
(c) Explain how the movements of the rib cage and diaphragm enable a person to inhale. (4)

The diaphragm contracts & allows the lungs to expand even further. When the diaphragm contracts, the rib cage moves outwards, giving the lungs more space Due to this, a person can inhale even deeper because their expanding lungs still have room to do so.

The learner has correctly stated that the diaphragm contracts and the rib cage moves outwards. 'Giving the lungs more space' is equivalent to increasing the

volume in the chest cavity and was credited with a mark. The reference to the expanding lungs also gained a mark.

This response gained three marks



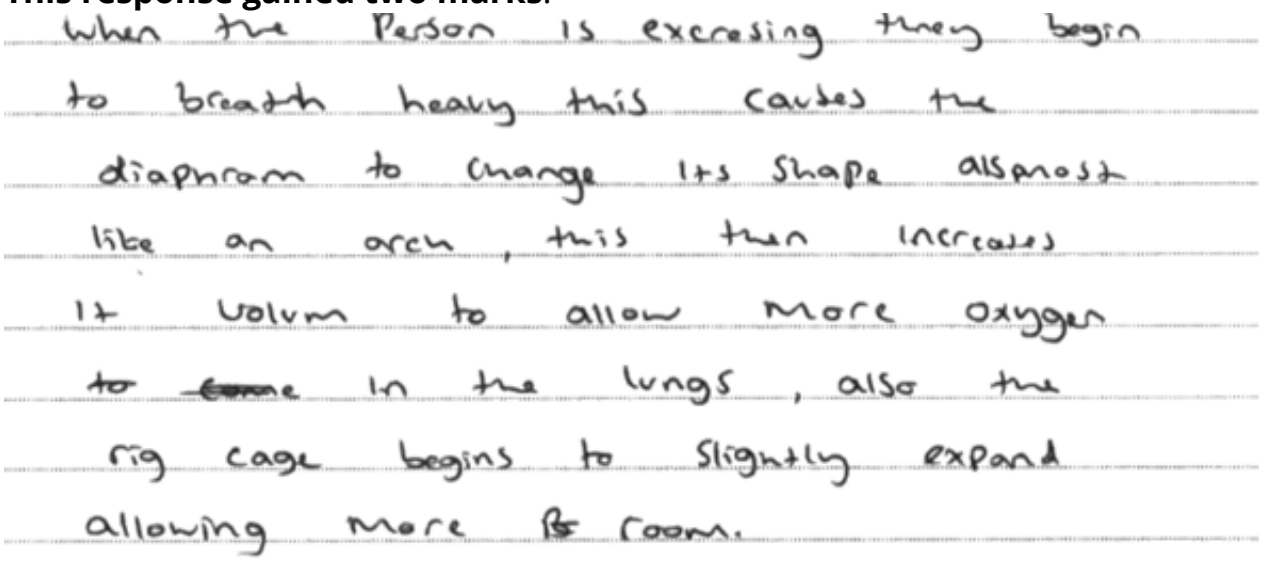
(c) Explain how the movements of the rib cage and diaphragm enable a person to inhale.
(4)

When a person inhales their intercostal muscles move their ribcage up and out. Whist their diaphragm is moving downwards. This enables the trachea to take in the maximum amount of air in order for the person to inhale. The air floods into the expanded lungs to ~~be~~ bind to ~~later~~ ~~exhaled~~ the red blood cells. which will then be exhaled later.

(Total for Question 3 = 7 marks)

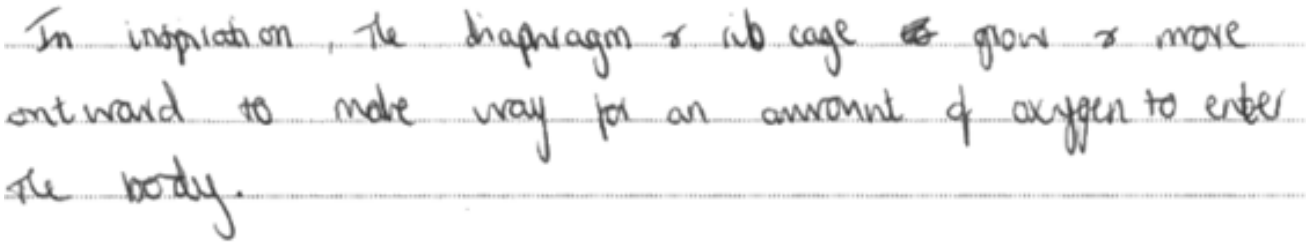
The learner gained a mark for saying that the rib cage moves up and out, one for saying the diaphragm moves downwards and one for the reference to expanded lungs. Had the learner, on the second line, stated that the intercostal muscles *contracted,* they would have achieved another mark, giving them full marks. The learner has sensibly underlined key parts of the question so that they focus on what is required in the response.

This response gained two marks.


When the Person is exercising they begin to breath heavy this causes the diaphram to change its shape almost like an arch, this then increases it volum to allow more oxygen to ~~come~~ in the lungs, also the rig cage begins to slightly expand allowing more ~~to~~ room.

The learner has incorrectly stated that the diaphragm arches but they have then said that the rib cage expands (1) and this allows more room; coupled with their earlier remark about increasing volume, that reference to increasing room has also gained a mark.

This response gained one mark


In inspiration, the diaphragm & rib cage ~~to~~ grow & move outward to make way for an amount of oxygen to enter the body.

The learner has correctly stated that the rib cage moves outwards.

Question 4a

Question 4 was about the cardiovascular system, section B.1 of the specification.

Learners were asked to identify the septum as shown on a diagram of a longitudinal section through a heart. 57% of learners correctly identified the structure and phonetic spelling was allowed, although 'sepsis' was not credited as it has another, specific meaning. Incorrect responses included captivia, semi lunar valve, cavity wall, pulmonary arteries and system.

Question 4b

This was a multiple choice question asking learners to correctly identify the types of blood in four blood vessels. Most chose the option that described the aorta and pulmonary veins as containing oxygenated blood and the venae cavae and pulmonary arteries as containing deoxygenated blood. However, a significant few incorrectly chose the option that said the pulmonary arteries carry oxygenated blood and the pulmonary veins carry deoxygenated blood.

Question 4c

Here learners were given an incomplete sentence that defined cardiac output. They then had to choose, from four options, to what the definition referred. Whilst many learners correctly identified cardiac output, quite a few said stroke volume and some said ventricular systole or heart rate.

Question 4d

This was also a multiple choice question. Learners were given a scenario and were told that a patient had a resting heart rate of 105 beats per minute and asked to identify the correct term that described this resting heart rate. Therefore they had to know that 105 bpm is faster than normal (60-80 bpm) and that tachycardia is the word used to describe a faster than normal resting heart rate. Some learners confused tachycardia with bradycardia (which is a lower than normal resting heart rate) and a surprising number chose atrial fibrillation or ventricular fibrillation.

Question 4dii

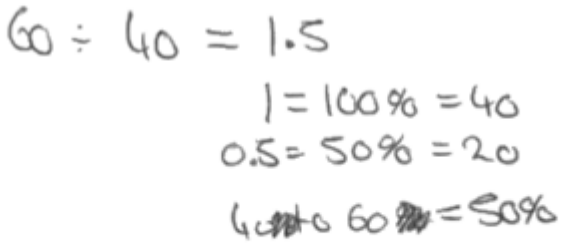
This question involved a calculation. Learners were told the initial (before treatment for congestive heart failure) and final (after treatment) stroke volume of the patient and were asked to calculate the percentage increase. Whilst about a third of learners correctly calculated this to be 50% (an increase from 40 – 60 ml) it was disappointing to see that some had no idea at all. Some learners correctly calculated the difference to be 20 ml but then used the heart rate of 105 bpm in their calculation. Some divided the difference by the final stroke volume instead of by the original; others used the alternative method of (60/40 x 100) – 100 but did not complete the calculation, arriving at a figure of 150. Some tried this method but got the division upside down. Some multiplied 60 x 40.

This response gained three marks.

(ii) After the patient received treatment for congestive heart failure, their resting stroke volume increased from 40 ml to 60 ml.

Calculate the percentage increase in this patient's stroke volume after treatment.
(3)

Show your working.



50 %

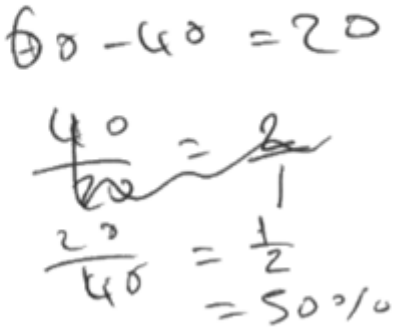
The learner has used part of a valid method in the first line. They have then seen that 20 is half of 40 and, using a common sense approach, have arrived at the correct answer. A correct response gains full marks.

This response gained three marks

(ii) After the patient received treatment for congestive heart failure, their resting stroke volume increased from 40 ml to 60 ml. (20 ml)

Calculate the percentage increase in this patient's stroke volume after treatment.
(3)

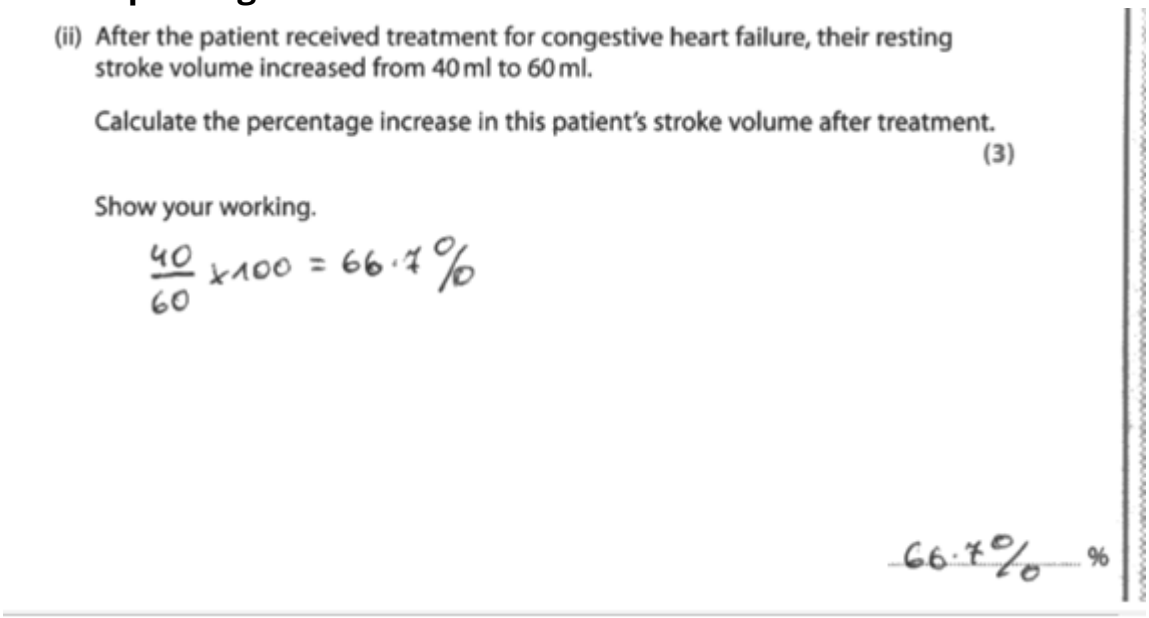
Show your working.



50 %

The learner has correctly calculated the difference and realised that as 20 is half of 40, then it is 50%.

This response gained one mark.


(ii) After the patient received treatment for congestive heart failure, their resting stroke volume increased from 40 ml to 60 ml.

Calculate the percentage increase in this patient's stroke volume after treatment.

(3)

Show your working.

$\frac{40}{60} \times 100 = 66.7\%$

66.7% %

The division is upside down but the learner has then multiplied by 100, which is one stage in the calculation, so they get an error carried forward mark. Had they then subtracted 100 (and achieved the rather bizarre, considering they were asked for the percentage increase, answer of -33.3% they would have gained 2 marks.

Question 4diii

In this question learners were told that increasing the patients' stroke volume increased their respiration enabling them to be more active. They were asked to explain how this happens.

Many learners correctly indicated that if the stroke volume increases then more blood is pumped out of the heart (at each beat). Hence more blood goes to the lungs to be oxygenated; the increased oxygen is carried to cells/muscles for more aerobic respiration, releasing more ATP for muscle contraction. More aerobic respiration also means less anaerobic respiration and therefore less lactic acid accumulation and less muscle fatigue. Some of the more able learners also correctly pointed out that with an increased stroke volume the heart rate will decrease and there will be less strain on the heart and, because more blood is being oxygenated in the lungs, the patient will not have to breathe so fast.

Many learners showed a good understanding here and also gave extra detail such as describing how more oxyhaemoglobin is made at the lungs but some forfeited marks by repeating the question and did not refer to *aerobic* respiration or to not having to rely on *anaerobic* respiration; some said ATP was made but did not indicate that *more* would be made. Some gave vague answers and said that the patient would not get tired and would be able to exercise more, which really is only repeating what they were told in the question stem.

This response gained four marks.

(iii) Increasing the patient's stroke volume increases their cellular respiration, enabling them to be more active.

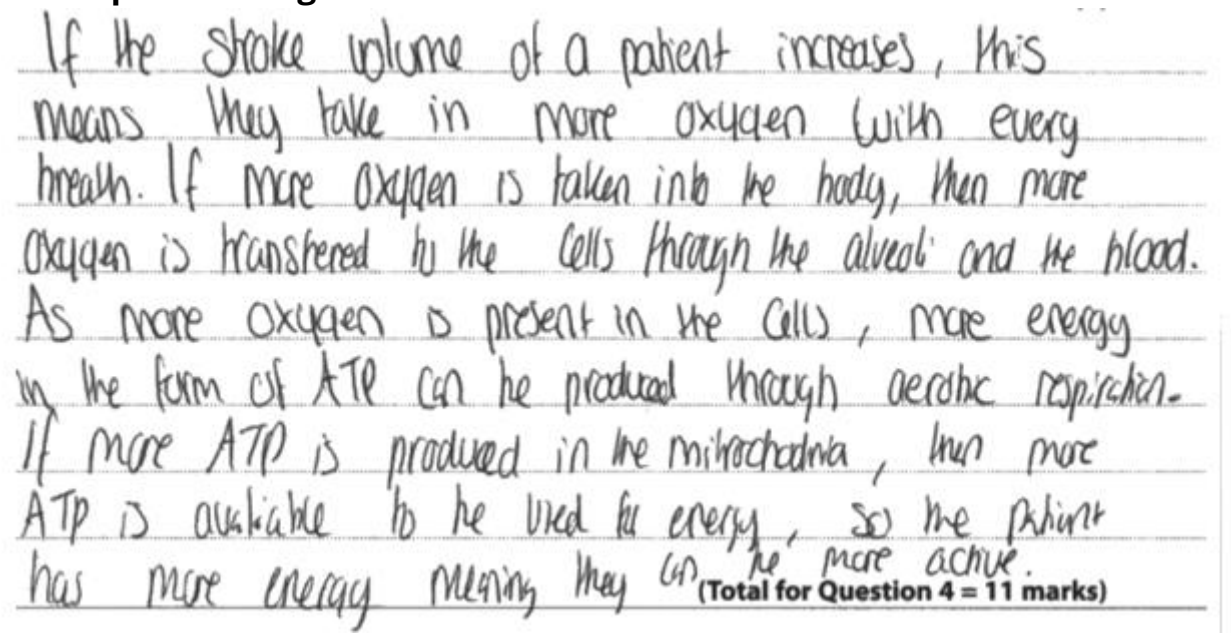
Explain why.

(4)

This is because increase in stroke volume means more oxygenated blood is pumped all round the body, this allows muscle to get more oxygen and glucose for aerobic respiration which produces ATP for the muscles to contract. This means the person is more capable of being active.

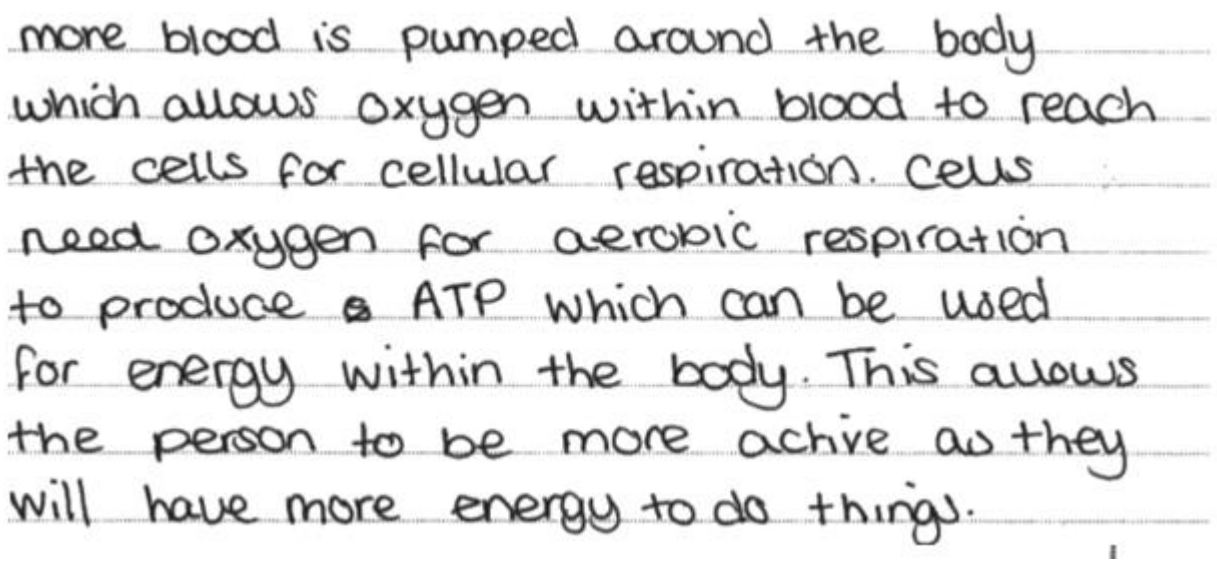
The learner has indicated that more blood is pumped around the body (1 mark) which is equivalent to more blood leaving the heart (at each beat); they have said that more oxygen is taken to muscles (1 mark) for aerobic respiration (1 mark) and although they have not said *more* ATP, they have linked it to muscle contraction so gain the mark for muscle contraction (1 mark)

This response also gained four marks.


If the stroke volume of a patient increases, this means they take in more oxygen with every breath. If more oxygen is taken into the body, then more oxygen is transfered to the cells through the alveoli and the blood. As more oxygen is present in the cells, more energy in the form of ATP can be produced through aerobic respiration. If more ATP is produced in the mitochodria, then more ATP is available to be used for energy, so the patient has more energy meaning they can be more active.
(Total for Question 4 = 11 marks)

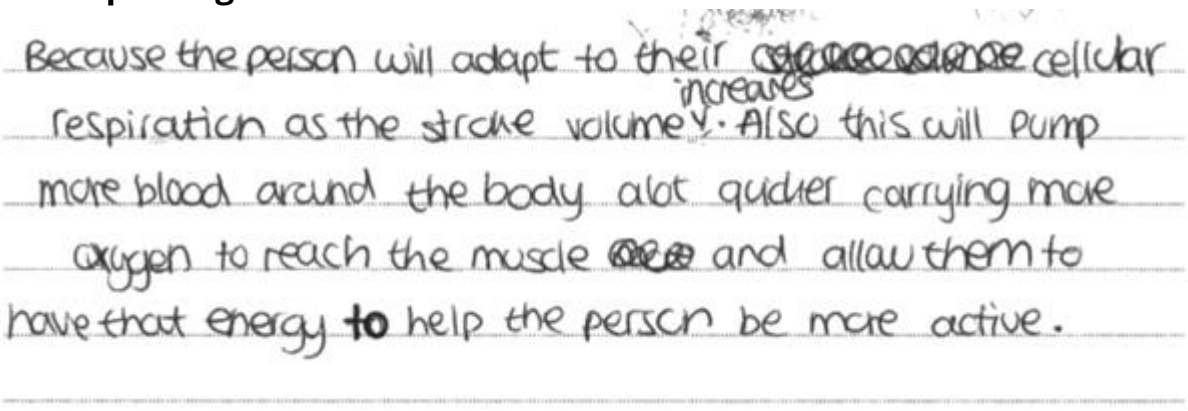
The learner has described oxygenation of the blood (1) and then stated that more oxygen is carried to cells (1) and more ATP is made (1) by aerobic respiration (1). Had they not used the word 'aerobic' they would still have obtained that mark because they have described respiration in mitochondria and because all the stages of respiration that are aerobic occur within mitochondria, this is equivalent to stating aerobic respiration. Some learners did refer to oxidative phosphorylation or the Krebs cycle and they also achieved the aerobic respiration mark.

This response gained three marks


more blood is pumped around the body which allows oxygen within blood to reach the cells for cellular respiration. Cells need oxygen for aerobic respiration to produce ATP which can be used for energy within the body. This allows the person to be more achive as they will have more energy to do things.

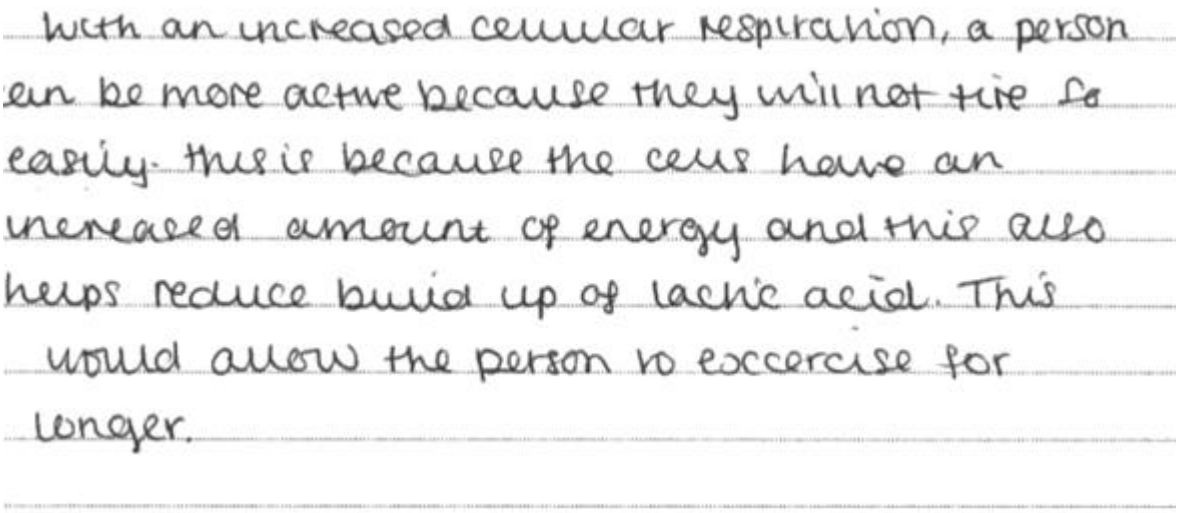
More blood being pumped is fine for a reference to an increased cardiac output (1) and as it is written ' more blood allows oxygen to reach cells' implies there is more oxygen (1) aerobic respiration gains a mark but the learner has not said *more* ATP and the last sentence just repeats the question although, had they said here 'more ATP to do things', they would have gained the mark for more ATP.

This response gained two marks


Because the person will adapt to their cellular respiration as the stroke volume increases. Also this will pump more blood around the body alot quicker carrying more oxygen to reach the muscle and allow them to have that energy to help the person be more active.

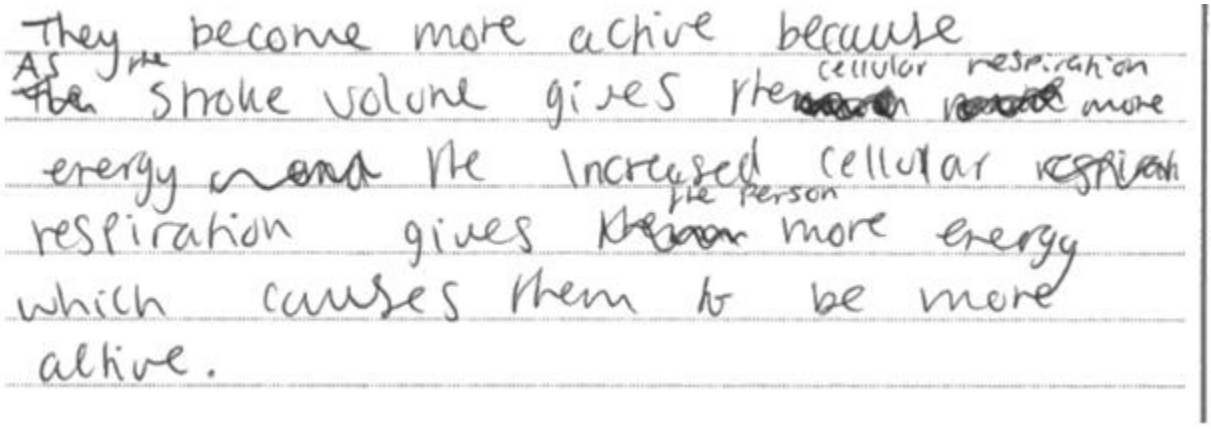
The learner gained two marks for saying that more blood being pumped and more oxygen is reaching the muscles. Had the learner simply said that blood pumps faster they would not have got the first mark as, with an increased stroke volume, there is more blood pumped at each beat and, because the heart rate will decrease, it will not be being pumped faster.

This response gained one mark



The learner starts by repeating part of the question stem. The reference to not tiring refers to the person and is not equivalent to muscles not experiencing fatigue so that does not gain a mark. More energy is too vague for the more ATP mark but the reference to reducing the build up of lactic acid is creditworthy and gains a mark.

This response gained no marks.



The response is too vague and only repeats the question

A fairly common and perennial error that learners make in the context of ATP and respiration is to say that ATP is made *for* respiration. Learners should be made aware of this inaccuracy. Although a small amount of ATP is used to 'kick start' glycolysis, unless learners specifically state this, we assume that those

making this error are not talking about that but are not understanding that respiration releases energy from organic molecules and the released energy is used to make molecules of ATP.

Question 5

This question asked learners to discuss how the structures in the lungs are adapted to enable them to carry out their function.

Good responses identified the function, namely that the lungs enable oxygen from the air to get into the blood and form oxyhaemoglobin in red blood cells, which can then transport the oxygen to other cells for respiration. At the lungs the carbon dioxide, which is toxic and would lower the blood pH, produced during respiration is passed into the air and breathed out. Hence the lungs are also organs of excretion. Good responses then discussed how the structures of the bronchi, bronchioles and alveoli enable these functions to be carried out.

Many learners discussed the roles of airways and alveoli; they correctly stated that there is no gaseous exchange from the airways but that the walls have cartilage to prevent collapse and smooth muscle to allow dilation when inhaling. They referred to the large surface area of the gaseous exchange surface, the alveoli, the close proximity of alveoli to the capillaries and the short diffusion distances due to the walls of alveoli and capillary endothelium being single a layer of flattened squamous epithelial cells.

Fewer learners referred to the blood flow in the capillaries of the lungs maintaining a steep concentration gradient between alveoli and capillaries or to the role of surfactant in preventing the collapse of alveoli and thus preventing the reduction of surface are for gaseous exchange. Some learners think that gases diffuse faster when in solution, or that gases *have* to be in solution to diffuse. This idea was disproved experimentally more than 20 years ago but, unfortunately, still persists in some student texts. Hence, learners who described this idea were not penalised but learners should be made aware that, in fact, gases diffuse *more slowly* when in solution. The surfactant made in the walls of the alveoli provides moisture in the lungs and prevents the alveoli collapsing (sticking together) which would reduce the surface area for gaseous exchange. So moisture is important for gaseous exchange but it is *not* true that gases cannot diffuse unless in solution.

Some learners also correctly referred to elastin in the walls of the alveoli allowing them to stretch and recoil. Some learners referred to the secretion of mucus by cells lining the airways and its function to trap pathogens and particles, and the

subsequent removal of the mucus by the beating of the cilia. Unfortunately some learners think that the mucus is produced in the alveoli.

Some learners included the function of the ribs to protect the delicate lungs and the function of pleural membranes to secrete pleural fluid and reduce friction. Unfortunately some learners, possibly confusing pleural fluid with mucus, mistakenly think that pleural fluid removes pathogens.

Some learners merely rewrote their responses to question 3c and hence did not really address the question as they did not refer to gaseous exchange but merely described ventilation of the lungs which, although an essential step to enable gaseous exchange, was not enough to enable those learners to reach level 2 or level 3.

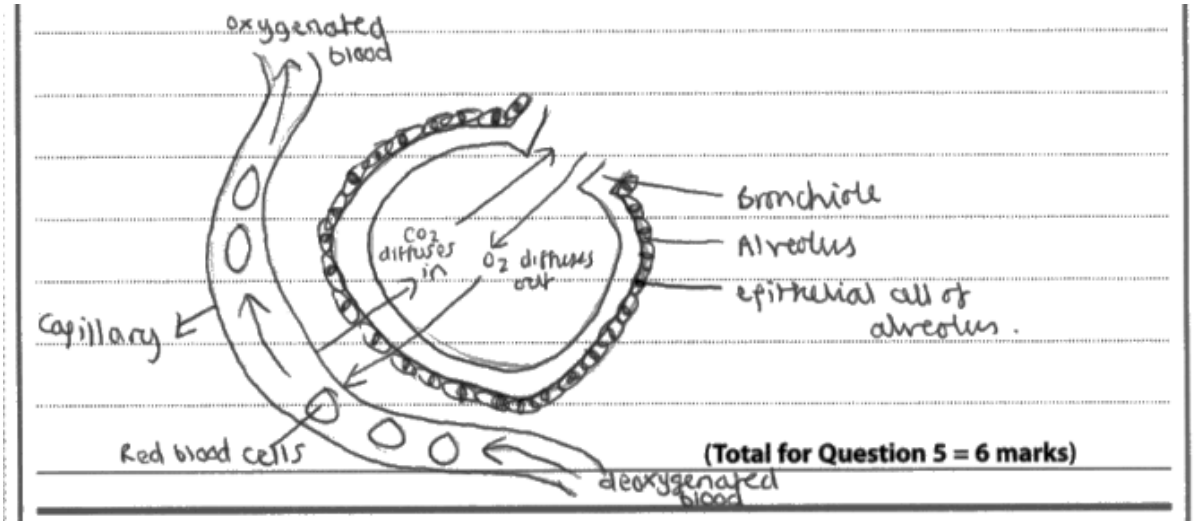
The following response is worthy of top level 3 with 6 marks

5 Discuss how the structures in the lungs are adapted to enable them to carry out their function.

You may include annotated diagrams to support your answer.

(6)

The function of the lungs is to take in oxygen and release carbon dioxide. The lungs consist of the trachea, bronchi, bronchioles, alveoli and diaphragm and intercostal muscles. The trachea consist of rings of cartilage to prevent the lungs from collapsing during breathing and to help airways open so air can flow in. The bronchi also have rings of cartilage to help the tube open during breathing. Bronchioles are narrower than bronchi but have little or no cartilage. The alveoli are tiny air sacs that are the site of gas exchange, specifically at the alveolus, due to it being one cell thick and made up of squamous epithelial cells. The alveoli allow rapid ~~diffusion~~ gas exchange as they have a large surface area with millions of alveoli providing more gas molecules to pass through, a short diffusion pathway as diffusion distance is shorter to enable rapid diffusion / exchange of gases, such as oxygen and carbon dioxide. They also have a rich capillary network and there is a layer of moisture containing surfactant, which prevents alveoli ~~lining of the alveoli walls~~ from collapsing by reducing surface tension of water and in alveoli walls.



The learner has given a lot of detail and discussed the points they have made. There is nothing inaccurate and correct technical terms are used throughout. The response is well synthesised, concise and coherent. The learner has included a diagram. This is not needed to gain full marks but relevant annotated diagrams can help the learner to achieve marks. The response has selected relevant information and shows comprehensive knowledge and understanding, with a clear coherent and logical structure.

This response reached the lower end of level 3 and gained 5 marks

5 Discuss how the structures in the lungs are adapted to enable them to carry out their function.

You may include annotated diagrams to support your answer.

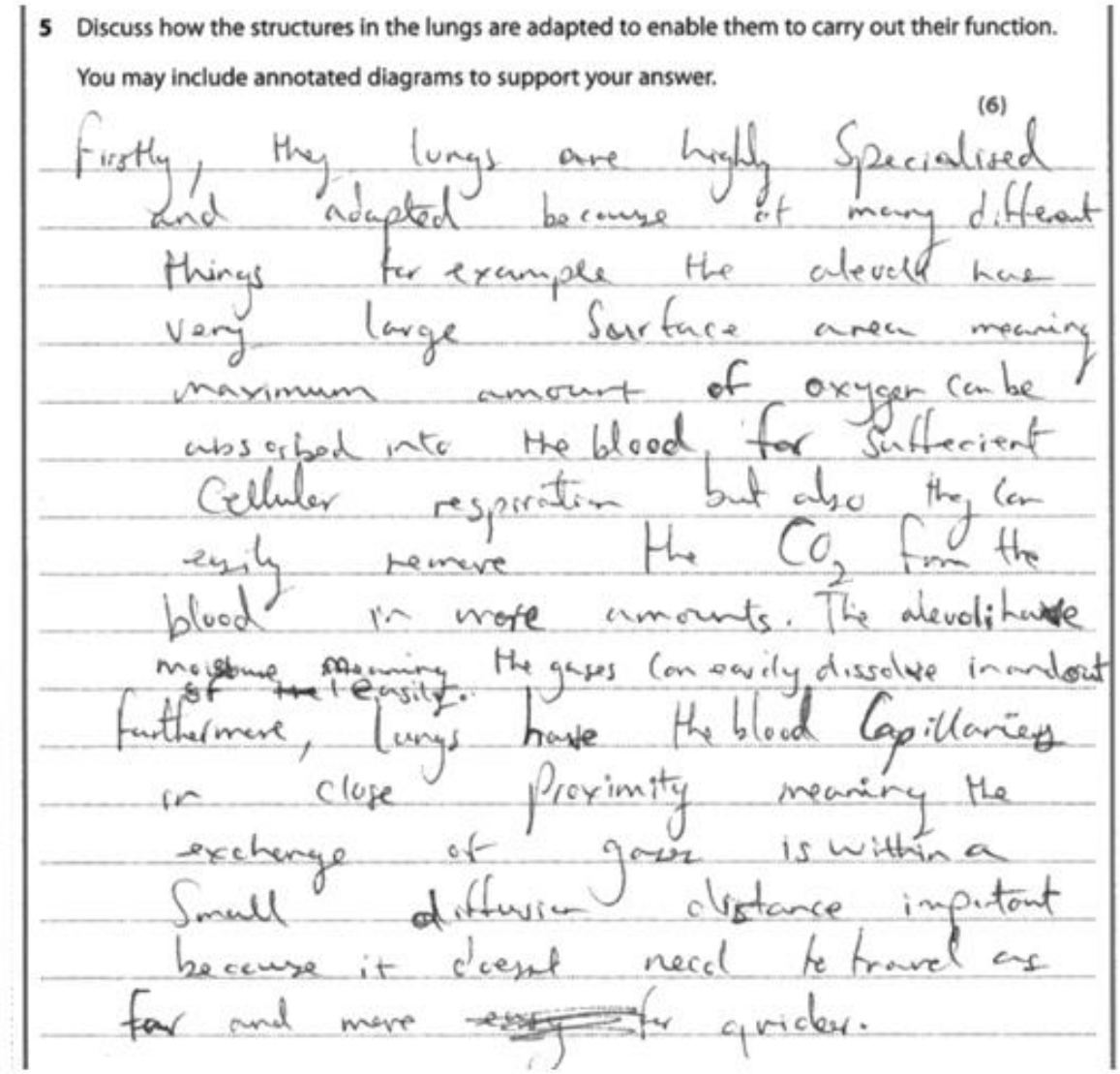
(6)

One of the structures present in the lungs are the alveoli and the alveoli walls. The alveoli walls are one cell thick structures which allow them to carry out the gaseous exchange of oxygen and carbon dioxide throughout the lungs. The rate of gaseous exchange through the alveoli is increased by the large surface area of the alveoli structures. Another structure of the lungs are the bronchi, the bronchi is adapted by containing of Columnar epithelial cells which line it. These epithelial cells have microscopic projections called cilia. Cilia are projections that support the lungs by 'sweeping' / removing any particles, the cilia also ensure that no large molecules are able to diffuse through the lungs. These cilia are usually lined with mucus, mucus is found within the lungs. When mucus is secreted, it is able to 'trap' and destroy any particles present in the lungs. Other structures of the lungs such as the pleural membranes are adapted to regulate what enters and exits the lungs such as being semi permeable (only allowing certain molecules to enter and leave) allowing smaller molecules such as oxygen and carbon dioxide to diffuse through but not other molecules e.g. nitrogen. The ribcage acts as a physical barrier which helps in protecting the lungs from any damage and the ribs hold the lungs in place and prevent lungs collapsing.

(Total for Question 5 = 6 marks)

The response gives an accurate description of how the lungs are adapted for efficient gaseous exchange. The learner has also referred to the functions of cilia and mucus. However, they are confused about the role of pleural membranes. The reference to the rib cage is accurate and relevant. Overall the response is well written and coherent. Had the learner included the correct function of the pleural membranes this response would have reached the top of level 3 and achieved 6 marks.

This response just gets into level 3 with 5 marks

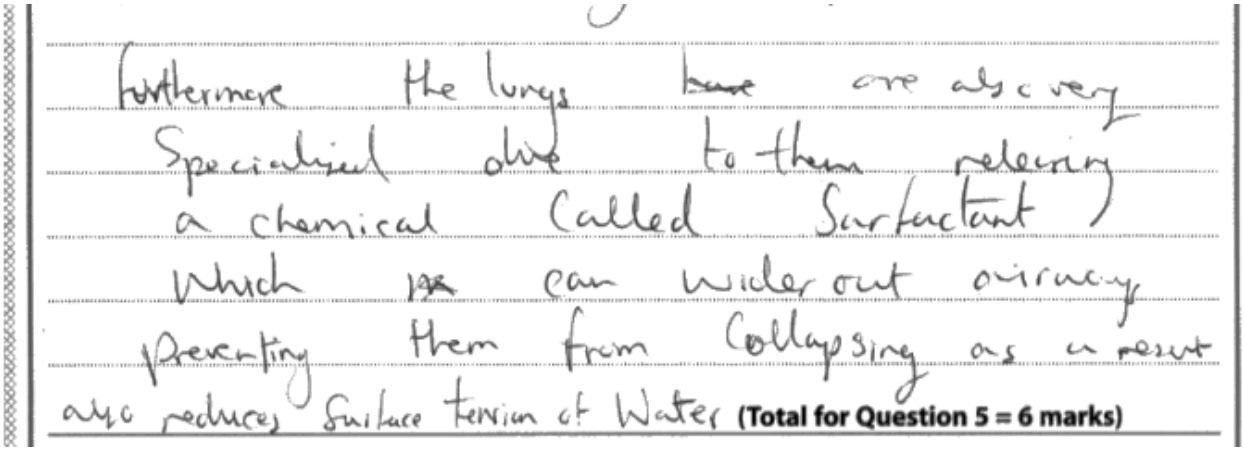


5 Discuss how the structures in the lungs are adapted to enable them to carry out their function.

You may include annotated diagrams to support your answer.

(6)

Firstly, they lungs are highly Specialised and adapted because of many different things for example the alveoli have very large Surface area meaning maximum amount of oxygen can be absorbed into the blood for Sufficient Cellular respiration but also they can easily remove the CO_2 from the blood in more amounts. The alveoli have moisture meaning the gases can easily dissolve in and out of the easily. Furthermore, lungs have the blood Capillaries in close proximity meaning the exchange of gases is within a Small diffusion distance important because it doesn't need to travel as far and more ~~easily~~ for quicker.



Furthermore the lungs have are also very Specialised due to them releasing a chemical Called Surfactant which can widen out airways preventing them from Collapsing as a result also reduces Surface tension of Water **(Total for Question 5 = 6 marks)**

The learner has included relevant information about the roles of alveoli, capillaries and surfactant. Had they included a brief mention of airways or pleural membranes then this response would have reached the top of level 3. The response is well written and coherent.

This response was placed at the top of level 3 with 4 marks

5 Discuss how the structures in the lungs are adapted to enable them to carry out their function.

You may include annotated diagrams to support your answer.

(6)

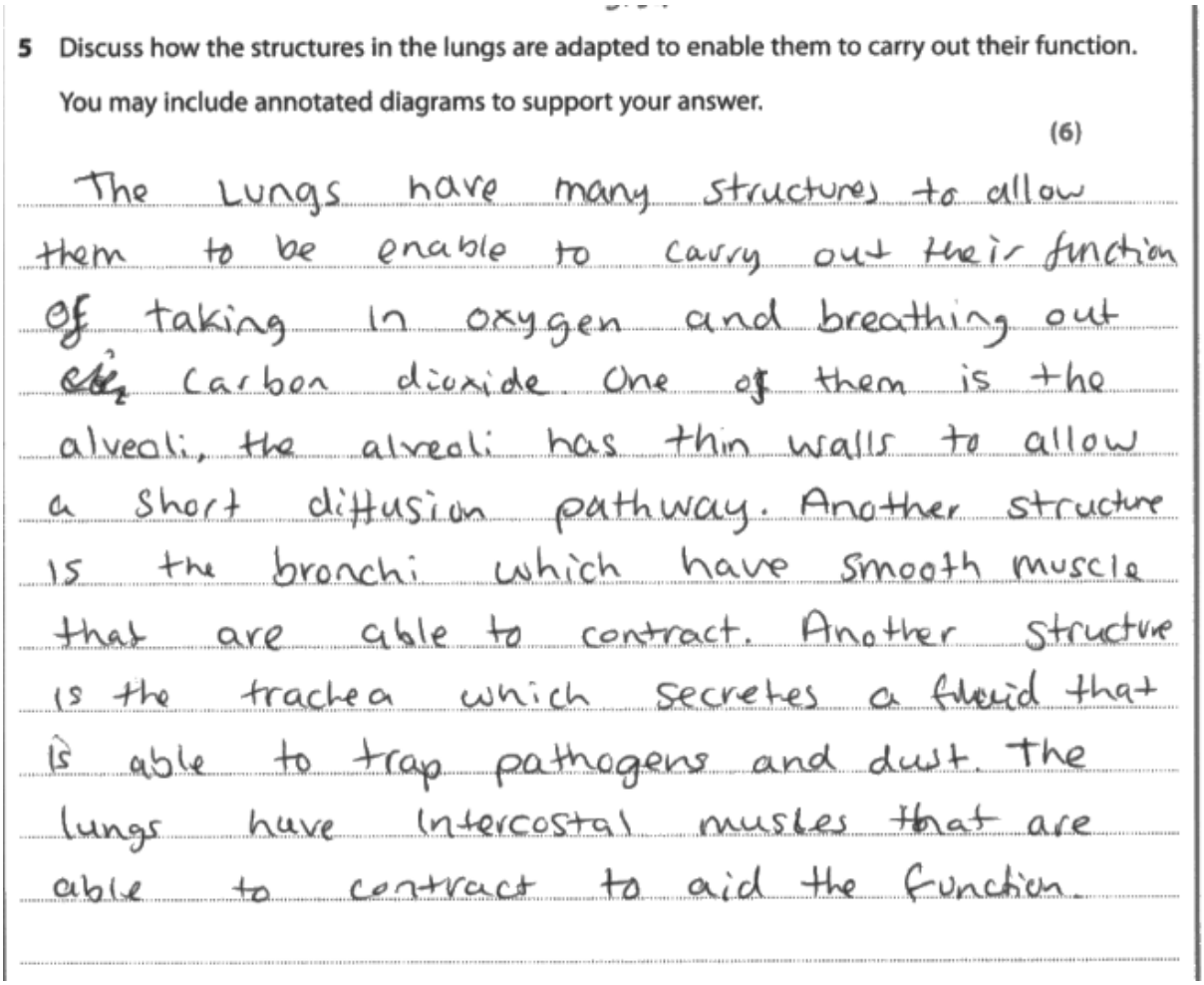
The windpipe, known as the trachea, is responsible for carrying oxygen to the lungs and carbon dioxide away from the lungs, they have C shaped cartilage, this provides structure and flexibity to the Pipe allowing it to expand when we inhale and not break when we move. Another Structure adapted to enable them to carry out their function is the Alveoli, They are small sacks found in the lungs and are responsible for gas exchange via diffusion. firstly, alveoli are made of squamous epithelial cells, which are very thin at 1 cell thick, this allows for faster diffusion of oxygen and carbon in and out of the blood in the cappilaries. The alveoli also has a dense capillary network so ~~there is more~~ this allows for more and faster diffusion as there always a blood flow. The alveoli have a larger surface area to volume ratio, so there are more areas for diffusion to happen. The alveoli have a thin layer of lubricate this is to stop the air sacs cracking when they expand.

Structures
- alveoli
- squamous
- lubrication
- SA:V
- Bronchus
- C cartilage for strength
- Trachea
- C cartilage - allows for food and flexibility.
- Hair

(Total for Question 5 = 6 marks)

The learner has given some relevant information about the trachea, alveoli and capillary network. It is quite well written and clear, although technical terms are not always used; for example surfactant rather than lubricant would have enhanced the response. The function of the surfactant given here is not really appropriate.

This response gains 3 marks



5 Discuss how the structures in the lungs are adapted to enable them to carry out their function.

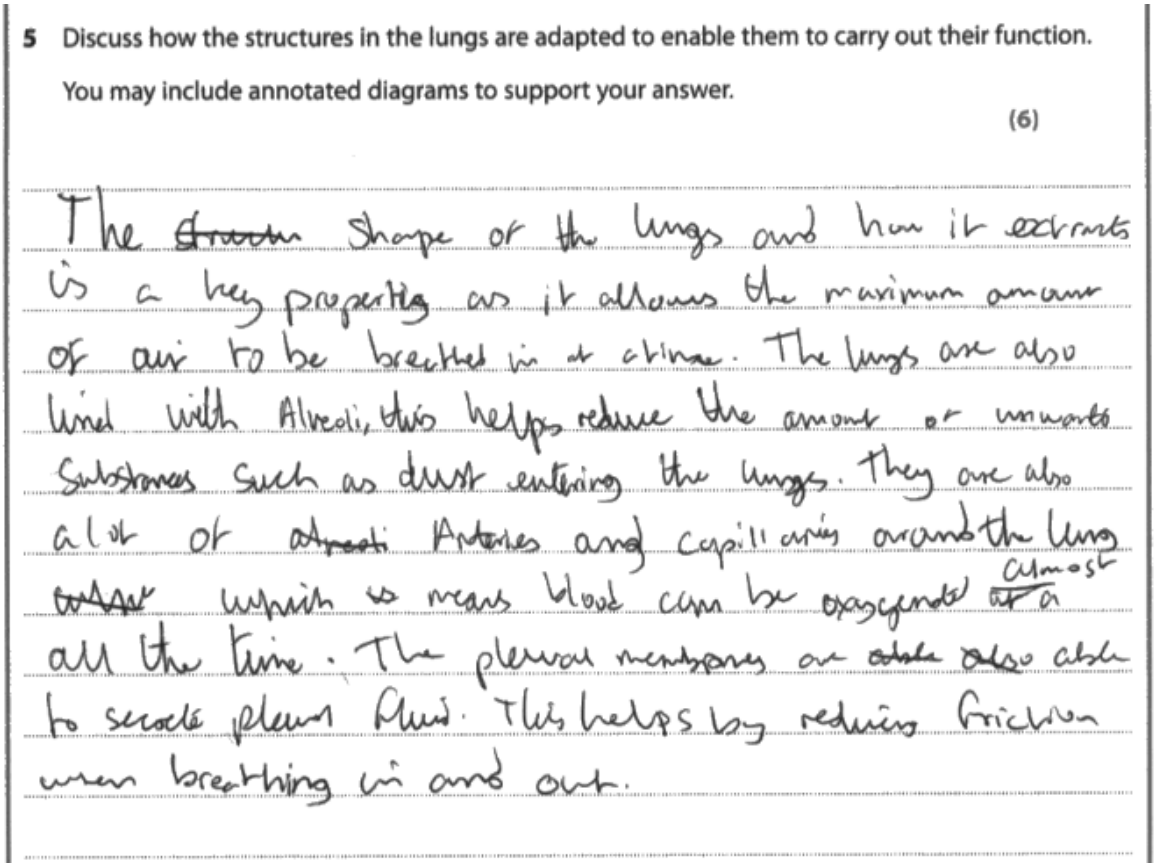
You may include annotated diagrams to support your answer.

(6)

The Lungs have many structures to allow them to be enable to carry out their function of taking in oxygen and breathing out ~~CO_2~~ carbon dioxide. One of them is the alveoli, the alveoli has thin walls to allow a short diffusion pathway. Another structure is the bronchi which have smooth muscle that are able to contract. Another structure is the trachea which secretes a fluid that is able to trap pathogens and dust. The lungs have intercostal muscles that are able to contract to aid the function.

The learner has not properly identified the function as gaseous exchange but has vaguely referred to taking in oxygen and giving out carbon dioxide. They have included some relevant ideas about large surface area and short diffusion pathway. They have also given some facts about the airways. The reference to intercostal muscles is not clear – the way it is written suggests that the learner thinks the lungs contain these muscles. It is clear and coherent and just gets into level 2. The knowledge and understanding are good and some structures are linked to their functions.

This response gained 2 marks



5 Discuss how the structures in the lungs are adapted to enable them to carry out their function.

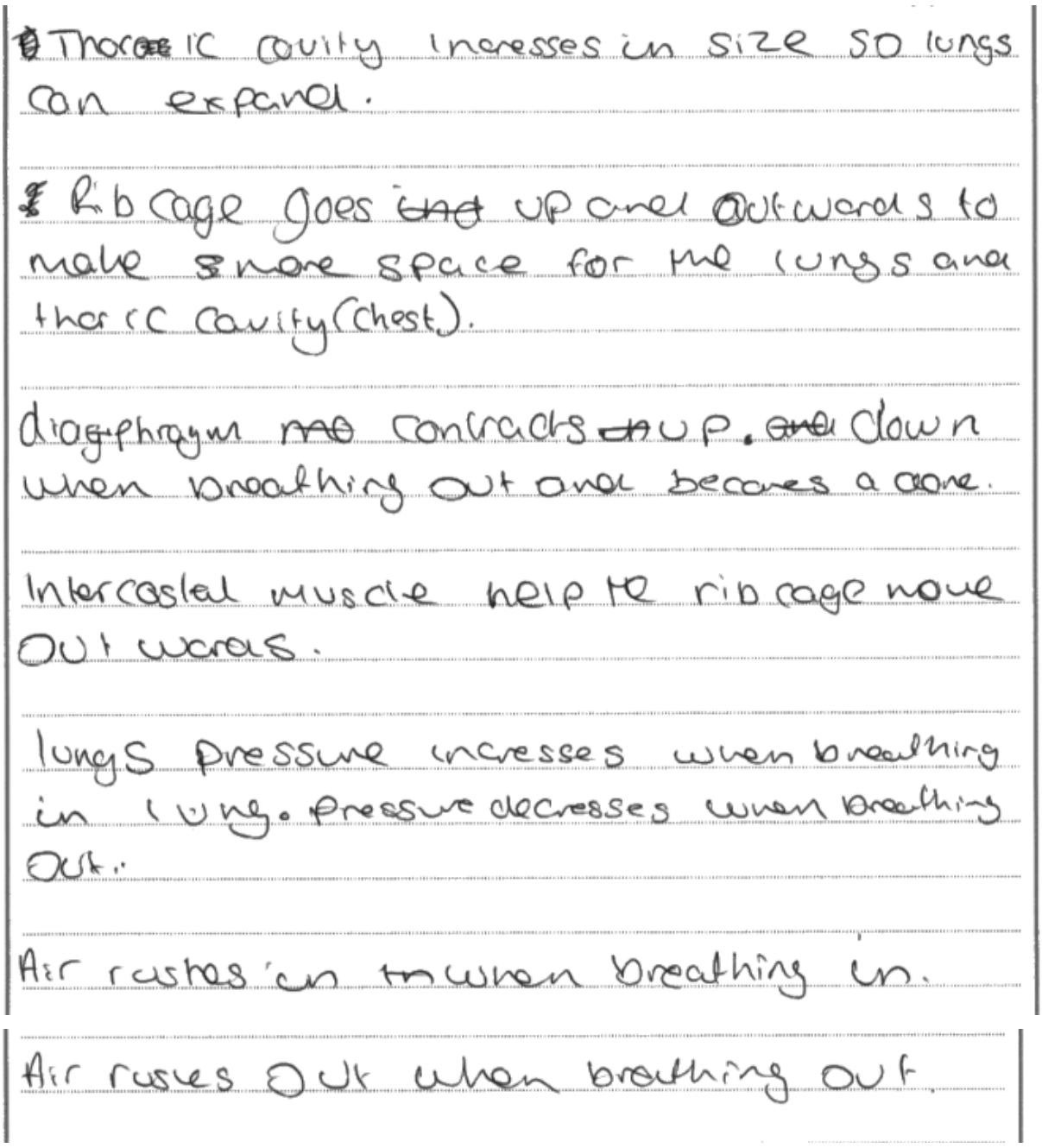
You may include annotated diagrams to support your answer.

(6)

The ~~structure~~ shape of the lungs and how it expands is a key property as it allows the maximum amount of air to be breathed in at a time. The lungs are also lined with Alveoli, this helps reduce the amount of unwanted substances such as dust entering the lungs. They are also a lot of ~~alveoli~~ Arteries and capillaries around the lung ~~tissue~~ which is means blood can be oxygenated almost ~~or~~ a all the time. The pleural membranes are ~~also able~~ also able to secrete pleural fluid. This helps by reducing friction when breathing in and out.

The learner has referred to alveoli but has not linked this to their function of gaseous exchange; instead they seem to be confusing the alveoli with mucus-secreting cells and ciliated epithelial cells lining the airways. There is a reference to blood vessels but it is not very clear – 'arteries and capillaries around the lung' is not a good description of the networks of capillaries surrounding the alveoli and there is not link to the functions of the blood vessels. There is a correct reference to pleural membranes and pleural fluid. This response is at the top of level 1 as it demonstrates adequate knowledge but the statements are rather generic and fail to link structure to function.

This response was at the bottom of level 1 and gained 1 mark



Thoracic cavity increases in size so lungs can expand.

Rib cage goes up and outwards to make more space for the lungs and thoracic cavity (chest).

diaphragm contracts up, and down when breathing out and becomes a dome.

Intercostal muscle help the rib cage move out wards.

lungs pressure increases when breathing in lung. Pressure decreases when breathing out.

Air rushes in when breathing in.

Air rushes out when breathing out.

The learner has not demonstrated that they really understand the function of the lungs. They have described breathing and so only referred to how air enters and leaves the lungs.

Properties and Uses of Substances (Chemistry)

Question 1a

A majority of candidates were able to give one other property of titanium (excluding strength) that would make it suitable for use as a hip replacement implant and a range of different responses were acceptable.

(a) Give **one** other property that makes titanium suitable for this use.

(1)

Titanium ~~does not rust~~ is light weight.

1 mark

(a) Give **one** other property that makes titanium suitable for this use.

(1)

titanium ~~doest corrode inside the body.~~ doesn't corrode, inside the body.

1 mark

However, candidates must ensure that they select a property which is relevant to the context in the photo and modify their answer appropriately. For instance, malleability is strictly only correct in the manufacture of the implant rather than in its use.

(a) Give **one** other property that makes titanium suitable for this use.

(1)

Titanium is a ductile material.

0 marks

Equally, there is an expectation that candidates will be clear and use correct terminology in their responses.

(a) Give **one** other property that makes titanium suitable for this use.

(1)

Corrosive resistant

0 marks

(a) Give **one** other property that makes titanium suitable for this use.

(1)

~~It is effecent~~. last longer.

0 marks

Question 1bi

Within this multiple choice question, the correct option was "magnesium", and was the most commonly selected answer amongst candidates. However, most candidates did not correctly select this answer, with all other options being selected. Whilst candidates would seem to be familiar with the process of titanium extraction from its ore, it is important that they understand the role of substances within the process.

Question 1bii

In common with Q1(b)(i), candidates would seem familiar with the reduction of titanium(IV) chloride to titanium, but almost half were unable to adequately explain the chemistry behind it.

There were two possible approaches to the question – either to explain that a gas in air that would react with titanium or its chloride, or to explain the relevant properties of argon.

Explain why air needs to be replaced with argon gas for this reaction.

(2)

Air contains oxygen which can react with the titanium chloride.

2 marks

Note in the above response, the candidate would need to indicate that air contained oxygen for the first mark. Candidates that did not specifically identify a gas in air that would react were limited to 1 mark.

Because the hot titatian (IV) chloride will react with the air and can cause an explosion

1 mark

Candidates were not credited for a "mix-and-match" approach. The question indicates "explain" so a point must be identified and expanded upon. In the following example, a comparison is made rather than an explanation. There is no indication that titanium or its chloride would be the reactant.

Because argon is an unreactive noble gas with no free electrons, unlike oxygen, which would react.

1 mark

Question 1biii

By contrast, this question did not necessarily require candidates to know the extraction of titanium in detail but instead to suggest two other reasons why electrolysis may be more efficient as a method. Again, just over half of candidates were able to score on this question.

Two advantages of electrolysis are that it is quicker and can be run continuously.

Give **two** other reasons why electrolysis would be a more efficient method of extraction than the Kroll process.

(2)

When using electrolysis you will get less impurities compared to the Kroll process. Also, less energy is needed in the electrolysis process.

2 marks

The most common errors made by candidates were to provide responses to the question which were not qualified (ie cheaper, easier), were vague (ie less polluting, safer) or repeated the context (ie more efficient, can be continuously run).

Its cheaper than the Kroll process due to the temperature necessity and electrolysis is also easier to set up.

0 marks

Although aspects that were relevant were frequently identified, the question did indicate some reasoning or comparison, and a small minority of candidates did not address this.

It is worth encouraging candidates to re-read through the entirety of question for information that might be relevant – throughout Q1(b), there was indication that there was more than one step in the Kroll process, that a high temperature was used and that there could be unwanted side reactions, which candidates could have used.

Question 2a

This multiple-choice question was correctly answered by about 80% of candidates. Although the responses were all skeletal formulae, most learners could either use the name (pentane) or the molecular formula (C_5H_{12}) to identify the correct structure.

Question 2bi

This question was generally answered well by candidates. Most candidates were able to identify that the description of the reaction was combustion.

Where candidates failed to score, it was occasionally the case that candidates would misidentify the reaction as addition or cracking. However, it was more often the case that candidates would refer to the reaction as being exothermic, but this process was already clearly established in the context of Q2(b).

Question 2bii

Again this question was well answered by candidates, with about 80% scoring at least 1 mark if not both. Most candidates were able to state what they understood an exothermic process to be for 1 mark and many were also able to expand on this to give the effect on the surroundings.

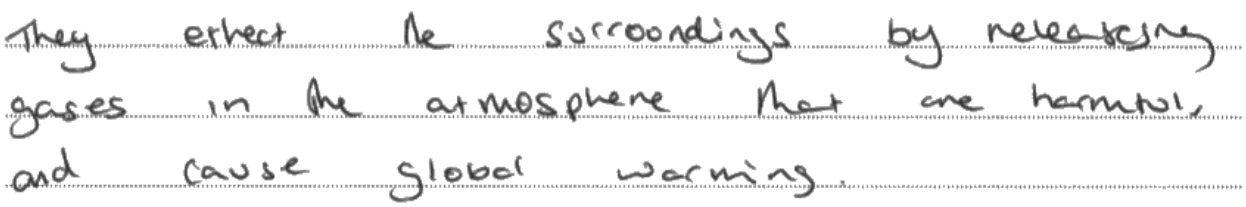
(ii) Explain how exothermic processes affect their surroundings.

(2)

Exothermic reactions give off energy to their surroundings for example, Exothermic reactions sometimes give heat energy to the surroundings make the surrounding temperature rise.

2 marks

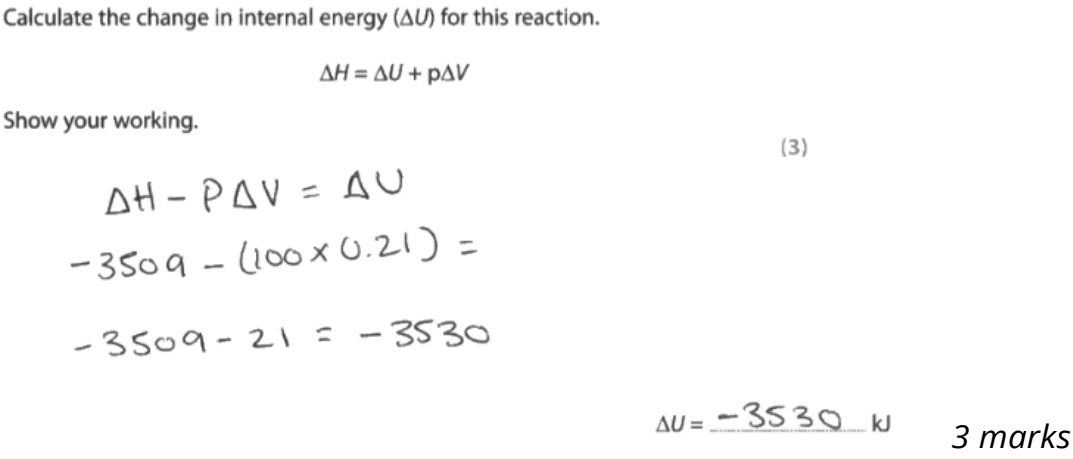
Incorrect answers tended to either be based upon descriptions of the system taking in heat energy from the surroundings or emission of waste gases / products.



0 marks

Question 2biii

This calculation based question saw almost 90% of candidates score at least 1 mark, and scoring full marks was not uncommon.



3 marks

Most learners were able to substitute into the equation provided, but the most common errors preventing full marks would tend to involve incorrect rearrangement. This would either give a correct yet positive value, or would arise from the division of ΔH by pΔV.

Change in internal Energy = $\Delta H + P\Delta V$

$= \frac{-3509kJ}{(100kPa \times 0.21m^3)}$

$= \frac{-3509kJ}{21}$

$= -167.10$

$\Delta U = -167.1$ kJ

2 marks

Responses scoring fewer than 2 marks were typically because of the aforementioned error and because the working as written did not lead to the value on the answer line.

Responses scoring no marks were generally because there was no attempt. Candidates must be encouraged to make some attempt on calculations as the probability of scoring some marks is high.

Question 3ai

This 1 mark question required candidates to give a reason why the equation shown could not be classified as showing the enthalpy change of formation of sulfur trioxide. Although a statement was sufficient, this question did target more able candidates as the definition of standard enthalpy change of formation needed to be known and applied.

Few candidates were actually able to identify that more than 1 mole of sulfur trioxide was produced or that it was not formed from its elements.

The equation for the Contact process is

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(a) (i) This equation does not show the enthalpy change of formation of sulfur trioxide.

Give **one** reason why.

(1)

it requires one mole of the substance to be produced but ~~this one~~ it has two moles of SO_3.

1 mark

They are not primed from their constituent elements in their natural state under standard conditions.

1 mark

However, a significant proportion were able to identify that the reaction was reversible and therefore was not forming the product fully or showed a complete reaction, which was a credible reason. This showed a good appreciation of how to use information from the question to answer.

The equation for the Contact process is

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

(a) (i) This equation does not show the enthalpy change of formation of sulfur trioxide.

Give **one** reason why.

(1)

The equation doesn't show ~~the~~ due to the arrows as it's a reversable reaction which is shown

1 mark

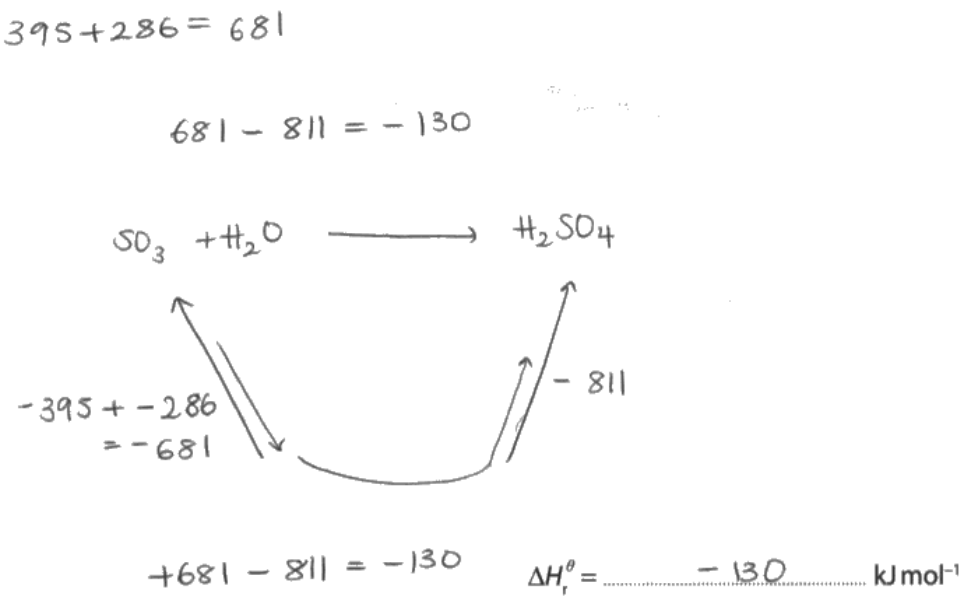
Responses that failed to score were generally because the question was not attempted or because candidates identified an aspect that was not relevant or incorrect (eg that the substances were all gases or that the enthalpy change would be zero).

Question 3aii

The correct option "vanadium(V) oxide" was the most commonly selected answer amongst candidates, with just under 50% of the cohort getting this right.

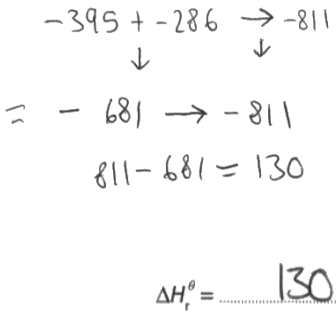
Question 3b

This calculation based question, based upon an energy cycle diagram, was conceptually more demanding than Q2(b). Only two-thirds of the candidates scored 1 mark or more, with about 20% of the cohort getting full marks.

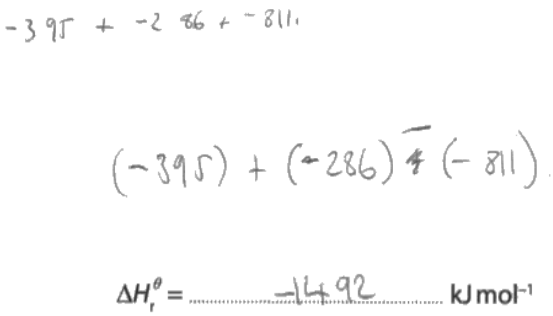


3 marks

Most candidates that did score normally achieved 2 marks. Typical reasons for this would tend to involve incorrect rearrangement, leading to a correct yet positive value, or some other incorrect combination of the values.



2 marks



2 marks

Where candidates scored less than 2 marks which were not as a result of incorrect evaluation, can be traced to poor examination strategy.

If candidates do not indicate their final answer on the answer line, there is a risk that they will not be awarded marks if it is otherwise not clearly shown within their working.

If candidates show more than one channel of working out that does not follow on, then a list is being shown which may feature incorrect as well as correct working. This will restrict what can be awarded to the candidate.

The following example highlights some of these issues.

Show your working, using the Hess energy cycle or any other method.

(3)

Σ Reactants - Σ products.

$-395 + -286 = -811$

$-811 - 681 = -130$

$-395 + -286 = -681$

$-395 + (2 \times -286)$

$-395 + -572 = -967$

$967 - -811 =$

4

$\Delta H_r^\theta =$ +156 kJ mol^{-1}

1 mark

In this response, the learner shows the correct answer in their first couple of lines of working. However, this is not the answer presented on the answer line, so full marks cannot be credited to the candidate.

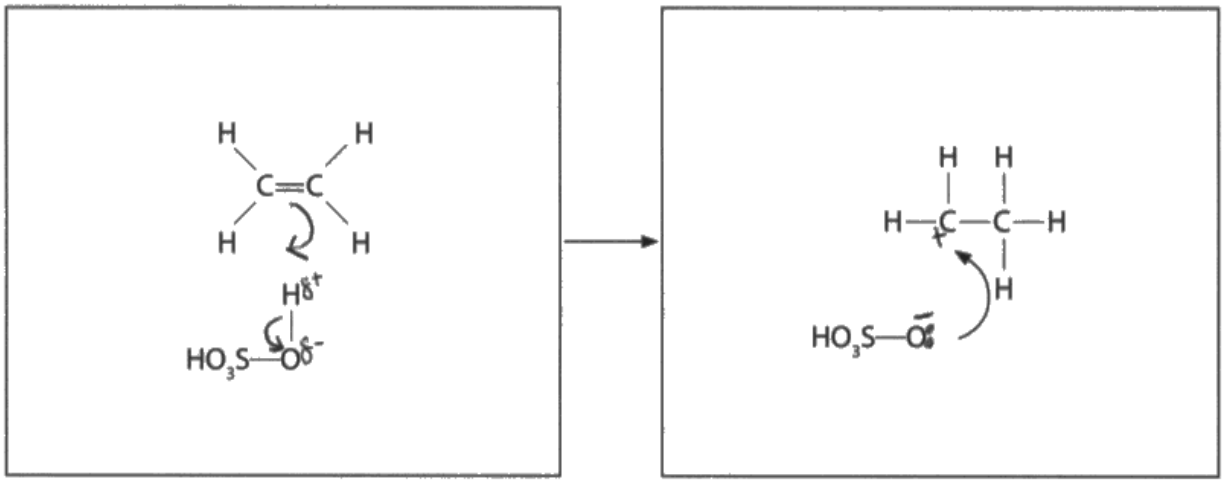
Additionally, the learner continues with their working out below the correct answer. The additional working out shows multiple attempts at the calculation and the value on the answer line is not a correct evaluation of any line of working that is observed.

The response can be credited 1 mark for the summation of enthalpy change of formation of the reactants, as seen at points on the page, for 1 mark.

Question 3c

Although operationally this question was simple (ie to draw in the missing features of the mechanism), it demanded a high level of accuracy and skill that most candidates were unable to demonstrate. Just under half of the cohort scored any marks, with less than 10% even to able complete one stage correctly. Fully correct answers were extremely rare.

The dipoles, charges, lone pairs of electrons and some of the curly arrows are not shown in Figure 3.



Step 1 **Step 2**

Q3(c)(i) 2 marks *Q3(c)(ii) 2 marks*

Candidates not scoring 4 marks in total on Q3(c) did so for a variety of reasons.

In step 1, common errors observed were:

- Omitting dipoles on the H and O atoms
- Drawing a curly arrow from sulfuric acid to the ethene molecule
- Omitting a second curly arrow on the sulfuric acid molecule
- Placing curly arrow on the wrong starting and ending positions points

In step 2, common errors observed were:

- Omitting or mixing up the positive and negative charges on the O and C atoms
- Placing the lone pair of electrons at incorrect / non-relevant positions on the molecules
- Not accurately positioning the lone pair of electrons between the O atom and the start of the curly arrow

Question 3d

Only 50% of candidates scored any marks for completing and balancing the equation for the reaction of calcium hydroxide with sulfuric acid, although a majority of this group were able to do this correctly. Although not a requirement, some candidates showed how they had arrived at their answer. Centres are

strongly advised to provide candidates with opportunities to practice their techniques for writing and balancing equations in order to prepare for this fundamental chemistry skill in examinations.

(d) Calcium hydroxide, $Ca(OH)_2$, can be used to neutralise sulfuric acid effluent from factories. The neutralisation reaction forms water, H_2O, and one other product.

Complete and balance the chemical equation for the reaction of calcium hydroxide with sulfuric acid.
(State symbols are not required.)

(2)

$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$

(Total for Question 3 = 11 marks)

Ca	1	Ca	1
O	6	O	5
H	4	H	4
S	1	S	1

2 marks

The main reason that candidates did not score full marks was because the formula of calcium sulfate was not known, or more specifically, they were unable to work out the formula of this product. Again centres are strongly advised to provide candidates with opportunities to practice their techniques for writing formulae and constructing word equations for simple equations as a starting point, such as neutralisation in this case.

calcium hydroxide + sulfuric acid → calcium sulfate + water

Question 4a

This question asked for candidates to explain the difference between a carbon-carbon double bond and a single bond, which they would need to identify in the first instance. A diagram of a suggested skeletal formula for benzene is given which

would allow candidates to deduce this if they did not recall the difference. Consequently the majority of candidates were able to identify that a double bond was shorter than a single bond (or vice versa). Candidates should always look to provide a clear identification where appropriate in short answer questions which require explanation and expansion.

A suggested skeletal formula for benzene is shown in Figure 4.

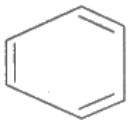


Figure 4

(a) Explain the difference in bond length between a carbon-carbon double bond and a carbon-carbon single bond.

(3)

The length of the carbon-carbon double bond are much shorter the the carbon-carbon single bonds

1 mark

Relatively few responses were able to expand why double bond were shorter. Many candidates linked this to a variety of associated topics arguments which were not relevant in this context: bond strength / energy, the number of bonds involved, alkenes / alkanes, chain length, intermolecular forces, etc. Whilst this showed familiarity with some of the consequences of the type of bonding, none of these expansions were credit-worthy or offered explanation.

carbon- carbon double bond is stronger than the carbon- carbon single bond as it is harder to break. Carbon- Carbon double bond is longer than Carbon - carbon single bond.

0 marks

(a) Explain the difference in bond length between a carbon-carbon double bond and a carbon-carbon single bond.

(3)

Double bonds are in alkenes and alkanes contain single bonds. Alkanes have a much longer chain than alkenes, which are easier to break as they are low in density. This indicates that single bonds require less energy to break.

0 marks

Responses which were able to consider the number or density of electrons between the carbon atoms and attraction to the nuclei, however, scored two or more marks. Occasionally, responses referred to the effect of additional p orbital overlap being a factor.

The carbon-carbon double bond is shorter than the carbon-carbon single bond. In a double bond, there is a sigma and pi bond σ bond C=C π bond and each bond is a pair of electrons. The pi bond electrons move in a figure of eight and overlap. In a single bond, there is only one pair of electrons. ~~and so~~

2 marks

A Carbon-carbon single bond has a longer bond length than a carbon-carbon double bond. This is because there is a greater number of electrons in the double bond so the attraction between them and the nuclei is much higher so therefore the bond length is shorter.

3 marks

Question 4b

A successful response relied upon recall of the general formula for an alkene which only about half of the cohort were able to do. Many candidates confused the general formulae for alkenes with that of alkanes.

(b) Benzene has the molecular formula C_6H_6.

Explain, in terms of the general formula for alkenes, why benzene can **not** be an alkene.

(2)

Benzene cannot be an alkene because the general formula of an alkene is C_nH_{2n+2}. Therefore if there are 6 carbons there would be 14 hydrogens and C_6H_{14} is the ~~formula~~ molecular formula of hexene not benzene.

0 marks

the general formula for alkenes is C_nH_{2n}, so the formula of Benzene being C_6H_6 does not obey the general formula. Benzene is a ~~cyclohexene~~ cycloalkene. **(2)**

1 mark

Simple statements such as "benzene / C_6H_6 does not fit the general formula C_nH_{2n}" were insufficient to score a further mark and some attempt to prove that benzene did not fit the formula was expected.

An alkene has the general formula C_nH_{2n} so if there was 6 carbons then it would be C_6H_{12} but its C_6H_6 meaning it has a formula of C_nH_n which is different so not an alkene.

2 marks

Question 4c

In common with Q4(a), a diagram of benzene was given which would allow candidates to deduce the correct bond angle if they did not recall it. The bond angle "120°" was a popular choice amongst candidates. A bond angle of 109° was also a popular choice, and was assumed to have been well learnt as part of candidate's understanding of the tetrahedral nature of carbon compounds in Unit 1. However, candidates must have a broader knowledge of this for Unit 5 to account for planar and linear shapes.

Question 4d

This question asked for a description of sp^2 hybridisation and was poorly answered by the majority of candidates. Many responses either revealed little or no knowledge of the term or struggled to provide any relevant ideas. Common misconceptions were typically around the formation of pi or sigma orbitals or electron filling rules.

(d) When carbon atoms bond with one another, their atomic orbitals are hybridised.

Carbon atoms in benzene show sp^2 hybridisation.

Describe the process of sp^2 hybridisation for a carbon atom.

(4)

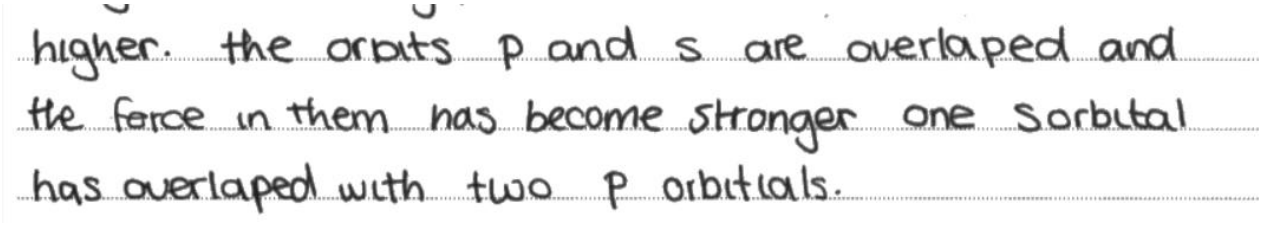
for the process of sp^2 hybridisation of a carbon atom, the 2 p orbitals overlap each other and this is known as a pi bond so an alkene hydrocarbon.

0 marks

Some learners were able to access 1 or 2 marks simply by indicating that s and p orbitals (and correct number) were mixed to form a new orbital.

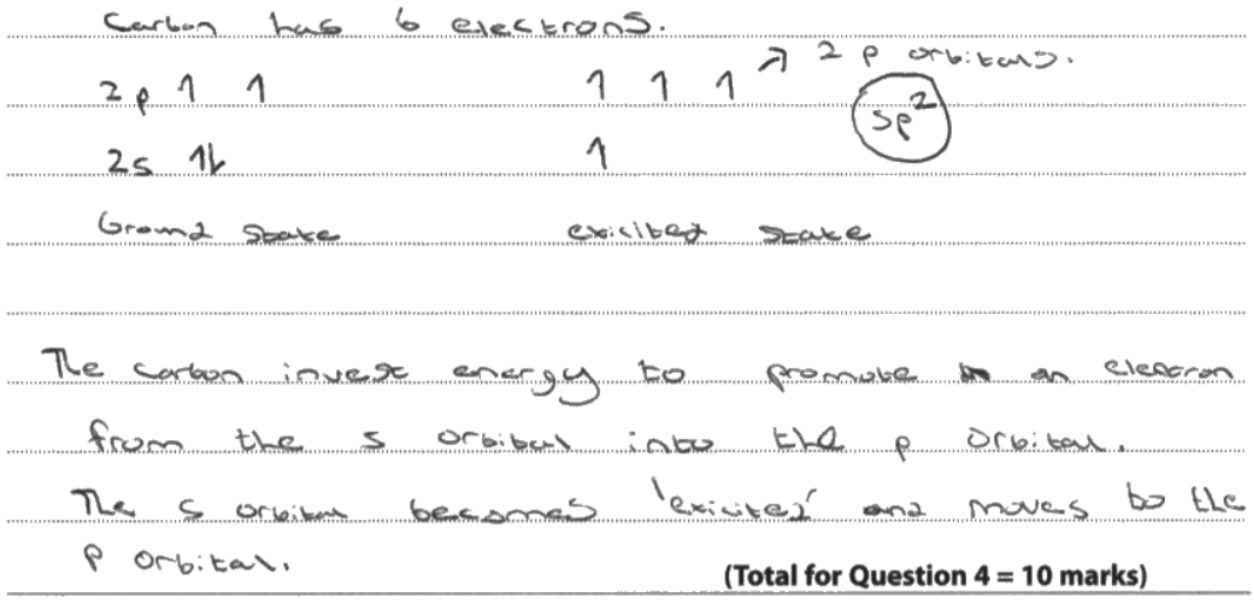
Electrons from the s orbital and the p orbitals overlap forming a sp^2 orbital

1 mark



2 marks

Better answers would go beyond simple statements to describe the arrangement of electrons or provide diagrams to convey knowledge.



2 marks

Responses that did not obtain more than a couple of marks were normally because they outlined how hybridisation took place, but not the outcomes of the process. Often the best scoring responses were those that were clearly expressed and, as required by the question, were simply descriptions rather than attempt to explain underlying principles.

In the following response, the candidate states that s and p orbitals are combined, the number of each involved, and also two relevant facts about the sp^2 hybrid orbitals formed – each contains 1 electron and that they each have the same energy.

This is when one s ~~orbital~~ orbital and 2 ~~ps~~ p orbitals come ~~together~~ together and have all the orbitals have one electron present in each orbital making ~~them~~ them have the orbitals have the same ~~same energy~~ energy.

4 marks

Question 5

The final question was a level-based question on the extraction and purification of alumina. Although many detailed attempts were seen for this question, a sizeable percentage of the candidates did not fully recall the process or mistook this for the extraction process of aluminium.

5 Alumina is aluminium oxide.

It is extracted from its ore bauxite, but must be separated from impurities that are acidic (such as silica) and basic (such as iron(III) oxide).

Explain how alumina is extracted and purified from bauxite.

You may include equations in your answer.

(6)

This is done through electrolysis where electricity is used in order to seperate compounds and impurities

0 marks

However, learners that were able to identify a couple of points that were relevant to the extraction were able to attain Level 1.

Alumina is extracted from it ore Bauxite. It is the crushed to make grains which eventually is crushed or heated to make slurry.

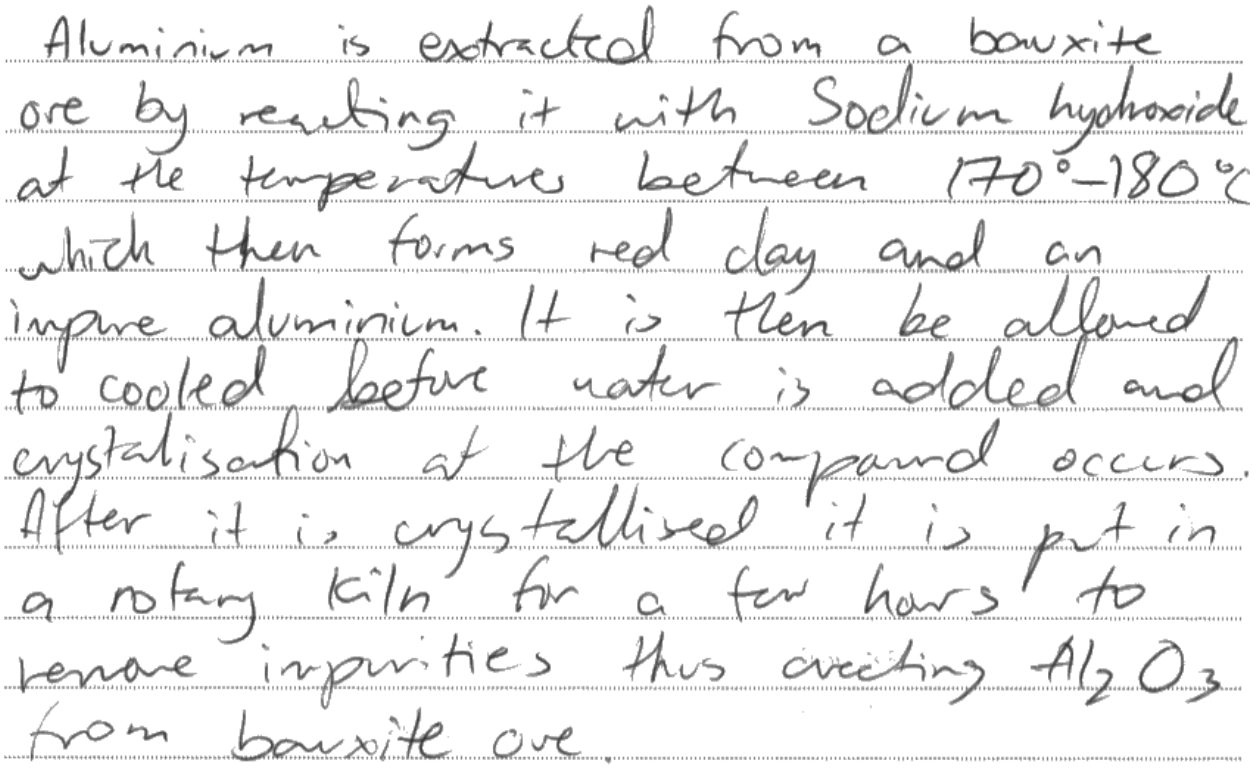
1 mark

First alumina is separated from ore with the process of flocculants and than later to remove the small impurities a process named sedimentation is used. Alumina is known for its strength and stability so high temperatures, about 1000°C and high pressure, 200 atm needs to be used in order to separate its impurities.

2 marks

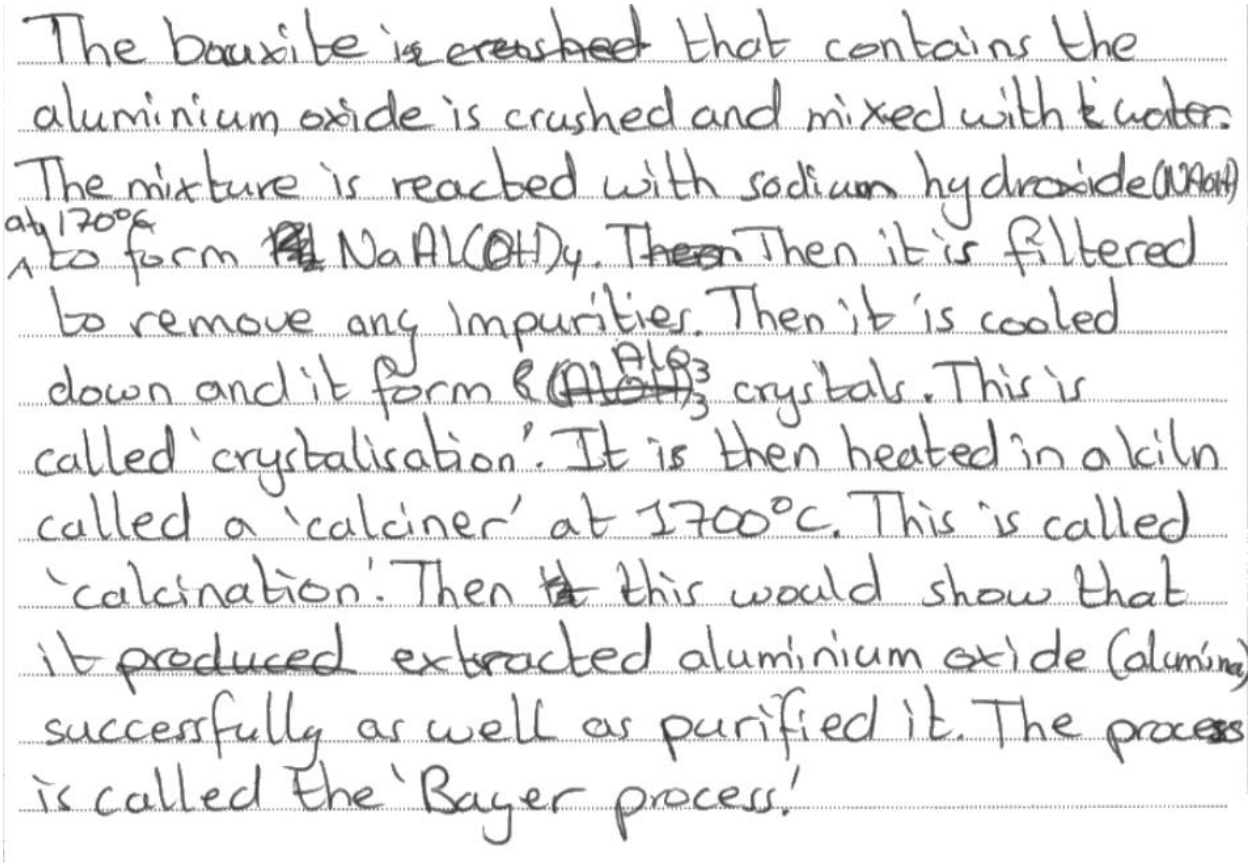
Responses that achieved level 2 moved beyond unconnected statements to a better knowledge of the process which would present the stages of extraction and purification in a logical order.

In the following example, a clear and coherent description with key details such as the use of sodium hydroxide, temperature and a rotary kiln given. However, there are aspects that are not quite correct such as the formation of impure aluminium and reasons for the stages are not explained.


Aluminium is extracted from a bauxite ore by reacting it with Sodium hydroxide at the temperatures between 170°–180°C which then forms red clay and an impure aluminium. It is then be allowed to cooled before water is added and crystalisation of the compound occurs. After it is crystallised it is put in a rotary kiln for a few hours to remove impurities thus creating Al_2O_3 from bauxite ore.

3 marks

A correct description of the full process would achieve the top of Level 2, as shown in the following example.

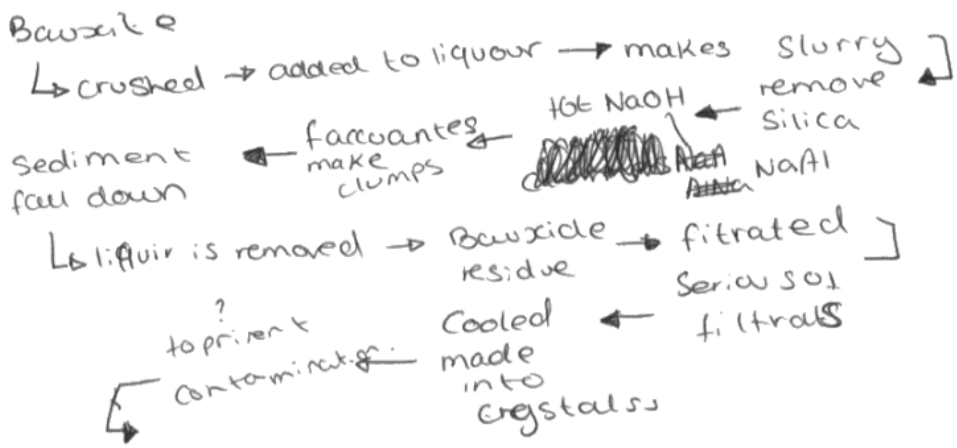

The bauxite ~~is crushed~~ that contains the aluminium oxide is crushed and mixed with ~~k~~ water. The mixture is reacted with sodium hydroxide (NaOH) at 170°C to form ~~Na~~ $NaAl(OH)_4$. ~~Then~~ Then it is filtered to remove any impurities. Then it is cooled down and it form ~~$Al(OH)_3$~~ Al_2O_3 crystals. This is called 'crystalisation'. It is then heated in a kiln called a 'calciner' at 1700°C. This is called 'calcination'. Then ~~it~~ this would show that it produced extracted aluminium oxide (alumina) successfully as well as purified it. The process is called the 'Bayer process'

4 marks

Again, whilst the response is coherent, logical and provides a good knowledge of the process, the candidate has not actually explained any of the chemistry that underpins the processes.

A number of responses would give the answer as a series of steps or bullet points for the extraction and was a suitable format. It did, however, limit the response to Level 2, however, as it did not typically show any signs of explanation.

High scoring responses were often accompanied by a plan of the process and what the candidate was going to write:



The following response is at Level 3. It correctly describes the process but goes beyond this to explain some of the chemistry, such as formulae for the product from alumina and sodium hydroxide and an equation for the decomposition of aluminium hydroxide with heat.

Alumina has the formula Al_2O_3 and it is found in bauxite, which is aluminium ore. It is extracted and purified from bauxite using the Bayer process. Firstly, you crush the bauxite (aluminium ore). Then react this with NaOH (sodium hydroxide) at 170°c to form $NaAl(OH)_4$, known as sodium tetrahydroxoaluminate. Filter out solid impurities. Allow this to crystallise, in order to form $Al(OH)_3$. Finally, heat in a rotary kiln to form Al_2O_3 (aluminium oxide).

$2Al(OH)_3 \longrightarrow Al_2O_3 + 3H_2O$

5 marks

Other aspects that could have been explained include:

- crushing the bauxite to increase its surface area
- the use of heat / pressure / large suface area to increase rate of reaction

discussion of the alumina acting as an acid when reacting with sodium hydroxide or iron(III) oxide's unreactivity because it is a base

Thermal Physics, Materials and Fluids (Physics)

Q1 was based on the ideas of Energy, Power and Efficiency in a mechanical system.

Question 1a

Asked learners to select the correct energy store. Learners were able to answer this question with little difficulty. The great majority gaining the mark.

Question 1b

Was more challenging to learners. Many learners that did not score this mark gave answer A, joule, as the unit which measures power. The correct answer was D, power.

Question 1c

This question was answered well, and many learners were able to give the idea of a loss to the surroundings or to heat etc. as identified in the mark scheme. A few learners quoted the first law of thermodynamics or wrote generally about forces.

Question 2 was based on the properties of Fluids and Fluid Flow.

Question 2a

Asked learners to explain how viscous drag is reduced in an aeroplane. The question stem gave a clear clue as to the kind of features to be considered. Many learners were able to score at least 1 mark for saying that the aeroplane was streamlined or aerodynamic, a good number were also able to give the reason. Some learners tried to reuse the stem of the question in attempting an answer. The answer was looking for a link between the aeroplane being streamlined and so able to reduce air resistance.

Question 2b

Required learners to complete an air flow diagram. Learners answered in many different ways. The aim of the question was for the learner to show what was meant by turbulent flow. A diagram similar to the one shown gave a two mark answer. Many learners chose to continue the lines separately, which was acceptable as long as there was a degree of randomness in the lines drawn.

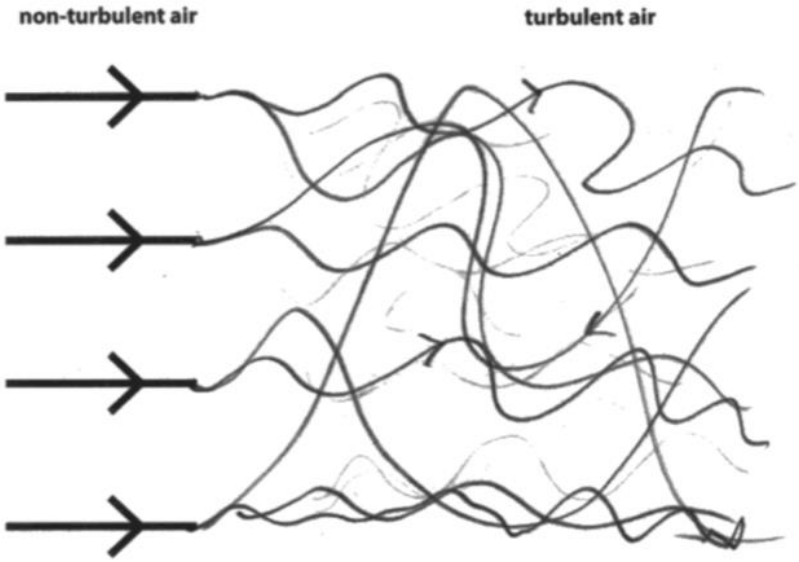


Figure 2

Question 2c

Challenged many learners. This question asked learners to explain why there is a pressure difference between the top and bottom of a wing. The answer drew upon Bernoulli's principle. A number of learners quoted the principle in answers. Some learners wrote responses that did not answer the question and explained the principle in general without reference to the situation. Other learners considered what happened to the air flow at the front of the wing compared to the back, not top to bottom. The best answers used a well labelled diagram based on figure 3 from the question in explaining their answer. An example of a 4 mark answer is given here.

(c) An aeroplane wing is shaped to allow airflow to produce an upward force.

Figure 3 shows a cross-section of an aeroplane wing.

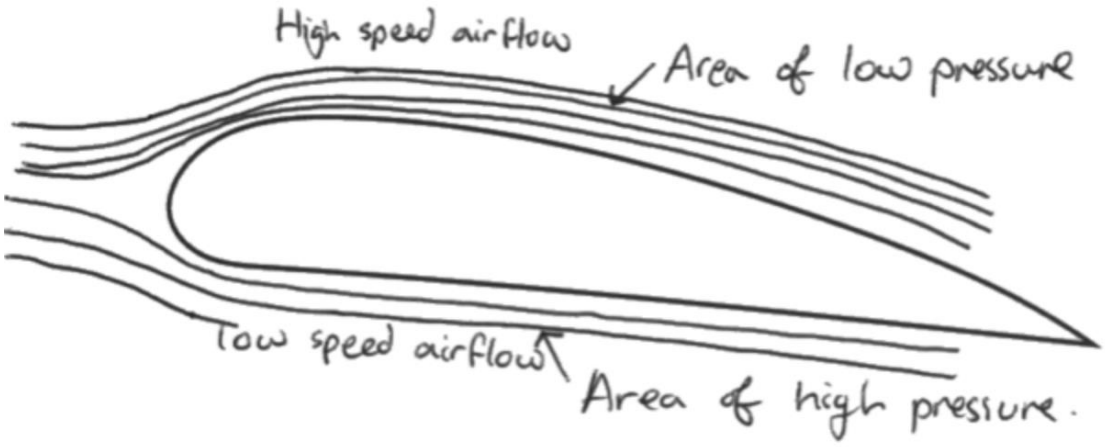


Figure 3

A pressure difference causes the upward force on the aeroplane wing.

Explain why there is a pressure difference.

You may annotate Figure 3 to support your answer.

(4)

An airplane wing is designed so that above the wing an area of low pressure is created. as the upper part of the wing is curved the air is forced to flow faster over the upper wing. The bottom part of the wing isnt curved this means air isn't forced to more faster so more air molecules are in contact with the wing as they arnt moving as fast therefore producing an area of high pressure under the wing generating lift.

(Total for Question 2 = 8 marks)

The learner has labelled the diagram, and this alone is worth three marks for marking points 1, 3 and 4 from the mark scheme. The learner's written answer also states these points, and also states that the wing is curved, which is the second marking point on the mark scheme. Answers such as this were not often

seen. Many learners drew lines with arrows on the diagram, but without labels or annotation they could not gain credit.

Q3 was based on the Kinetic Theory and the behaviour of gases and liquids.

Question 3ai

This was answered correctly by many learners. The correct answer was A, some learners thought that C was correct. It is evident that ideas from the kinetic theory is recalled more readily by learners than in previous series.

Question 3aii

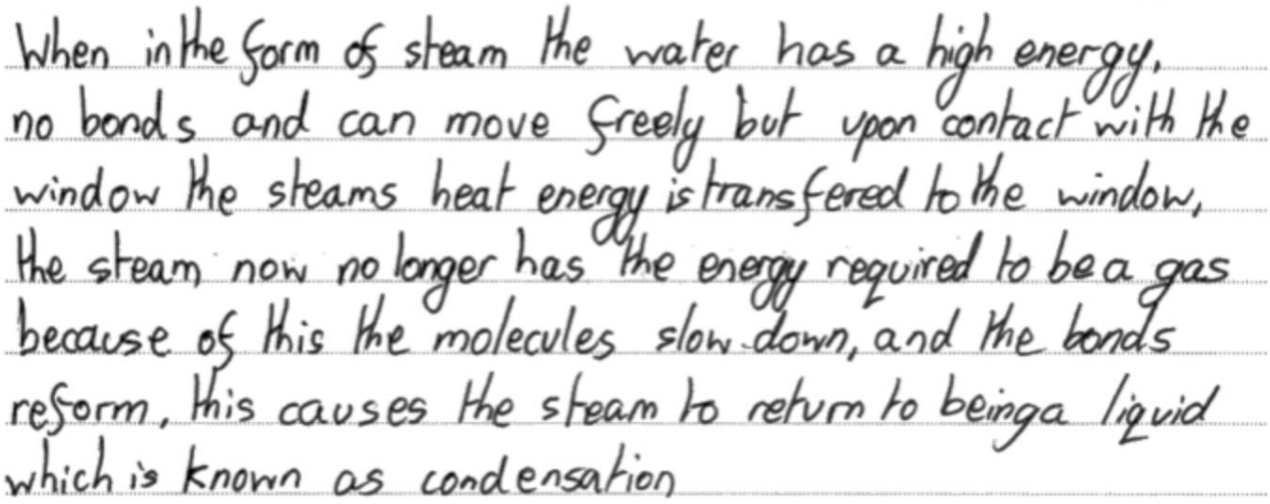
Asked learners to calculate the work done by a system. Many learners were able to substitute and evaluate the answer for this calculation.

Question 3b

Was a multiple choice question designed to test a more challenging idea. The question was targeted at merit level learners. Most learners did not score this mark, with many giving B rather than A as the answer. Learners find the idea of internal energy a challenging concept in terms of describing a gas.

Question 3c

Required learners to describe the process of condensation. This was designed to be a challenging question, and it turned out to be so. In order to fully answer the question, learners needed to give a logically ordered response that dealt with the behaviour of the molecules before, during and after contact with the window. Answers should have related to the energy and movement of the molecules. Some learners did not write about molecules, so did not answer the question, others did not give a logical sequence. It would greatly help learners prior to answering a question such as this, if they paused and planned out what they were going to write. In a number of cases learners put on paper all that they knew about kinetic theory in a random way, and in the process did not answer the question. A good four mark response is given here.


When in the form of steam the water has a high energy, no bonds and can move freely but upon contact with the window the steams heat energy is transfered to the window, the steam now no longer has the energy required to be a gas because of this the molecules slow down, and the bonds reform, this causes the steam to return to being a liquid which is known as condensation

The learner has given marking point 1 in the first two lines, the second marking point in the fifth line together with marking point 3. The sixth line gives marking point 4. This answer could be more logical, in sequence but this was very rarely seen. Very few learners were able to give a response as detailed as this. Many learners that did score a mark on this question, did so for giving the final marking point on the mark scheme.

Q4 was based on materials and their properties.

Question 4a

Learners have found in previous series recalling definitions challenging. This question was designed to give an easy start to the whole question by asking learners to complete a sentence with a key word, relating to strength of materials. The acceptable answers were wide ranging; however, most learners found this question difficult and did not score the mark. The answer to this question required the idea of a force being resisted.

Question 4b

Many learners found this item challenging. Many considered the behaviour as elastic rather than plastic. Learners were required to indicate that any change in the structure was permanent at the yield point.

Question 4ci

This four mark calculation required a conversion, substitution, rearrangement and evaluation. The question asked learners to show that the area of cross

section of a steel bar was approximately 0.007m^2. An answer to a greater number of decimal places was required to gain the marks, in this case 0.0069 m^2. Answers of 0.007 m^2 were not acceptable. In order to answer this question correctly, a learner should do the calculation and then show that the calculated value approximates to the value given in the stem of the question. Centres should make learners aware that this is the expected style of answer. There was a compensatory mark for recalling the correct formula which was scored by many learners that could not proceed with the calculation. The conversion from kN to N was challenging to many learners. The lack of converting the value of the force to newtons resulted in answers with a power of ten error, which were awarded three marks if the rest of the calculation was correct. Some learners calculated the stress that a bar of 0.007m^{2}would give, which is the reverse of the calculation expected. This scored partial marks as the question did not ask for this calculation. Centres should make clear to learners that full marks can only be gained by answering the question correctly.

It should be noted that in many cases a 'show that' type calculation has a follow on calculation that uses the answer from the 'show that' question. If a learner cannot do the 'show that' question the approximate value given in the stem of the question will score full marks if used correctly in the follow on question.

Question 4cii

Many learners were able to score marks on this question with a significant number able to score full marks; however, the majority of learners were unable to use correct algebraic manipulation to rearrange the given formula. The use of standard form also gave learners difficulties.

Q5 was based on the refrigerator as an example of a type of heat pump.

Question 5a

Was designed to be a straightforward introduction, testing a specific specification point on converting Celsius to Kelvin. This was found to be more challenging than expected. Many learners subtracted 6 from 273 to give 267. Other learners missed the point of the Kelvin scale by writing the correct value as a negative. Approximately half of learners scored the mark.

Question 5b

Was a challenging calculation. The mathematics required to subtract 1 from a fraction proved difficult for many learners. Many learners could substitute into

the given equation and then find the difference between 1 and 0.35 but could then not rearrange and evaluate the answer. Approximately 10% evaluated the correct value for the input energy. Common errors included forgetting to subtract the 1 from the fraction and rearranging the equation incorrectly.

Question 5c

This was the final levels based question on the paper. This 6 mark item was very poorly answered. Learners were required to look at the four parts of the refrigeration system identified and comment on the efficiency of each in terms of what that part did. So for example, the compressor, compresses the gas and turns it into a liquid, in the process the motor gets hot and so energy is lost to the surroundings so making the device less efficient. It is also the case that some parts are more efficient than others, for example the expansion device is more efficient than the compressor. Learners struggled with misconceptions, with many suggesting that the cold air inside the refrigerator was circulated through the pipes. Many had the right idea but considered that a liquid circulated around the pipes and that there was no phase change in any part of the system. A few learners implied that heat was drawn into the system rather than being removed. Learners were expected to make a correct comment on different parts of the refrigerator to gain marks in the higher bands.

Summary

Organs and Systems (Biology)

Based on their performance on this paper, learners should:

- Always read the question carefully and understand which command word is being used and tailor their response accordingly.
- Read the information/scenario given in the stem of the question as it will help and guide you towards the appropriate response
- Do not repeat the question as part of your response
- Use appropriate technical terminology throughout your responses. For example when talking about energy for activity, refer to ATP for muscle contraction
- Tailor your response based on the command word in the question; state does not require any expansion of a point but explain will require a reason for how or why something happens
- Use the number of marks gained and the space available as a guide to the depth of response required. If the command word is 'idemtify' or 'name' then usually only a word is needed. Do not waste time writing more; that time can be better used when answering the longer questions.
- Be clear about terminology used in the specification as these words will be repeated in the exam paper, e.g. endocytosis and exocytosis.
- Use the question scenario to demonstrate your ability to apply your knowledge to a new situation
- Try to spell words correctly. We usually accept phonetic spellings but sometimes a mis-spelt word becomes another word and then it cannot be accepted, for example septum and sepsis; urine and urea.
- Make sure you understand how to calculate percentage changes
- Make sure you understand how to calculate surface area: volume ratios

Properties and Uses of Substances (Chemistry)

Candidates should:

- Learn the details for the extraction and purification of metals and other substances referred to in the specification (eg titanium, aluminium oxide)
- Understand the chemistry behind the processes (eg the reason for the use of substances, such as argon and sodium hydroxide)
- Examine diagrams carefully to identify relevant points (ie bond angles, bond lengths)
- Re-read questions for relevant information, particularly if a question is part of a bigger question eg Q1(b)(iii)
- Practice on explanation style questions beginning from a statement and then expanding upon this to meet the allocated marks shown
- Practice equation writing techniques and drawing of mechanisms
- Interpret given equations so that reactions are fully understood (eg reversible, states of matter, number of moles)

Thermal Physics, Materials and Fluids (Physics)

- Learners need to be given practice in rearranging equations, so that they can develop the skills needed to answer the calculations in this paper.
- Learners should have the opportunity to practice answers to questions with a variety of command words. They should also have the opportunity to learn the meanings of command words.
- Learners need to learn the basic definitions of words such as ‘strength’, or the difference between plastic and elastic deformation so that they can recall their meanings.
- Learners should be given opportunities to practice answers where an annotation to diagrams is made, so that they are fully labelled correctly.
- When answering an explain type question, learners need to make sure that they give a justification to a statement made. In many cases marks were lost in these questions as there was no justification.
- When describing a sequence of events in a process, learners should make sure that this is in a logical order.

Centers should be aware that additional guidance on the content that is tested is to be found for this unit on the BTEC L3 Applied Science website via this link.https://qualifications.pearson.com/en/qualifications/btec-nationals/applied-science-2016.coursematerials.html#filterQuery=Pearson-UK:Category%2FExternal-assessment