L3 Lead Examiner Report 1806

BTEC

June 2018

Level 3 National in Applied Science Unit 5: Principles and Applications of Science II (31627H)

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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.

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Unit 5: Principles and Applications of Science II

Grade	Unclassified	Level 3			
		N	P	M	D
Boundary Mark	0	14	28	51	74

Introduction to the Overall Performance of the Unit

Biology

Many learners were well prepared for the examination and were able to read and understand the questions and select relevant and appropriate information to give their responses.

Some questions involving recall of learnt definitions or items of factual knowledge were not well answered.

Some of the questions involving application were better answered.

Some learners need more practice at interpreting graphs and with questions involving calculations.

Chemistry

Learners in this section of the paper generally did well where questions allowed for free response and the ability to express ideas (i.e. Q1(d), Q3(a) and Q5(c)). This reflects a welcome development from the first paper for this unit.

Using and applying information from questions met with a range of responses (ie Q1(b), Q1(c)(i) and Q5(c)). Stronger candidates often had a strategy or plan in place to deal with these types of question.

Equations and calculations, which are fundamental to the subject, proved to divide candidates sharply by ability (e.g. Q2(a) and Q5(b)(ii)), suggesting that further practice is required in these core skills.

Questions that proved to be the most challenging for this cohort of learners were those that required specific recall (e.g. Q1(a) – bond angle, Q1(c)(iii) – bonds in C=C). This was often compounded further when an explanation or description was also required (i.e. Q2(b), Q3(b) and Q5(a)). This suggests that closer focus upon revision of key facts is needed.

Physics

Learners appeared better prepared for the examination in this series. Learners found many of the Physics items less of a challenge compared to the 1801 series. It was pleasing to see that some definitions were able to be recalled and that

calculations were more accessible. There were some ideas and definitions that were confused such as the definition of thermal equilibrium and thermal capacity, and the idea of what a ductile material is. Those with good mathematical skills were able to access many of the marks associated with the calculations, those with weaker skills found great difficulty with the calculations, particularly with rearranging equations and dealing with the conversion of units. Centres should ensure that learners have the practice required to enable them to use simple algebra, rearrange equations, use powers of ten and know the meanings of prefixes such as kilo and mega. The specification requirements mean that learners have to use very big and very small numbers in this paper and on this occasion the calculations related to very large numbers, where standard form is the only way that they can be sensibly represented. Centres should devote time in preparation of learners by giving them practice in standard form as being the best way to handle very large numbers, in many cases the calculation was dimensionally correct, and the powers of ten were ignored by the learner.

Splitting the paper has enabled learners to access the whole paper. There was much less evidence to suggest that learners did not have time to complete the paper in the allotted time. Answers appeared more complete, and it was pleasing to see that there were fewer gaps in answers, learners attempted most questions in the examination.

Some key words and concepts were not understood by a significant number attempting the questions. In some cases, learners did not read the questions carefully, and provided general answers that did not fit the question that was set, for example Q5b asked about ductility, but many learners answered in terms of malleability. Centres should be aware that diagrams can help to explain answers and that questions set in this paper can be helped by a diagram, learners need to be made aware of this.

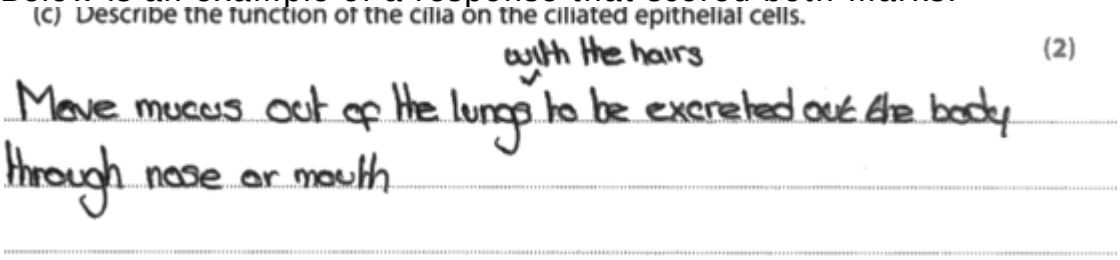
Individual Questions – Biology

Question 1a
The majority of learners correctly identified the cellular structures that transport mucin through goblet cells as vesicles. Incorrect responses included mitochondria or ribosomes.

Question 1b
This question asked learners to name the process by which mucin leave the goblet cells. Very few gave the correct response, which is exocytosis. Common responses included diffusion and active transport and sometimes endocytosis.

Question 1c
Many learners correctly stated that cilia move mucus but were rather vague about where the mucus was being moved to. Good responses said that the mucus was moved out of the airways. Learners also referred to cilia removing pathogens or dust that was trapped by the mucus. Incorrect responses included references to cilia trapping pathogens or confused cilia with microvilli and talked of them increasing the surface area of the cell for transport across the cell surface membrane.

Below is an example of a response that scored both marks.


(c) Describe the function of the cilia on the ciliated epithelial cells.

with the hairs ✓ (2)

Move mucus out of the lungs to be excreted out the body through nose or mouth

Question 1d
This question was not well answered and most candidates did not access the marks. Many appeared to misread the question and described features of the cell surface membrane, such as hydrophobic tails and hydrophilic heads. Some learners correctly referred to the phospholipid bilayer with proteins. They could refer to any sort of appropriate protein, such as channels or carriers, enzymes or antigens.

The example below scored both marks.

(d) The fluid mosaic model describes the structure of cell surface membranes.

State **two** features of the **fluid mosaic model**.

(2)

~~phosphob~~ it has a phospholipid bilayer

it has patches of protein to allow molecules to pass through.

Question 1e

Learners showed very little knowledge about the role of cholesterol in cell membranes. Many appeared to have not read the question carefully and described the part played by cholesterol in forming athermatous plaques in artery walls.

Below is an example of a response that gained both marks

(e) State **two** roles of cholesterol in cell surface membranes.

(2)

1 To give flexibility to the membranes.

2 To give stability.

Question 2a

The majority of learners knew that soda lime is to remove carbon dioxide but fewer went on to say why the carbon dioxide has to be removed, for example because it is toxic or it could cause the breathing rate to change or prevent the spirometer being used to measure oxygen consumption. Some learners thought that it changed carbon dioxide to oxygen.
The example below scored both marks.

(a) Explain why soda lime is used in the spirometer.

(2)

Soda lime is used to ~~a~~ absorb carbon dioxide as it is ~~poisonous~~ toxic when breathed back in.

Question 2b (i)

Most learners correctly indentified A as representing the vital capacity on the spirometer trace, indicating that they understand what is represented on a spirometer trace.

Question 2b (ii)

Most learners used the equation and counted the breaths per minute from the graph. Fewer correctly calculated the tidal volume, with a significant amount being a factor of 10 out, leading to power of ten error in their answer.

The response below gains both marks

The respiratory minute ventilation rate (RMV) is the volume of air passing into and out of the lungs in one minute.

(ii) Calculate, using the information in Figure 3, the RMV for the student during the **first** minute.

Use the equation: RMV = tidal volume x breaths per minute

Show your working.

(2)

RMV = 0.5 × 12

RMV = 6

RMV = ... 6 ..... L minute^{-1}

Question 2c

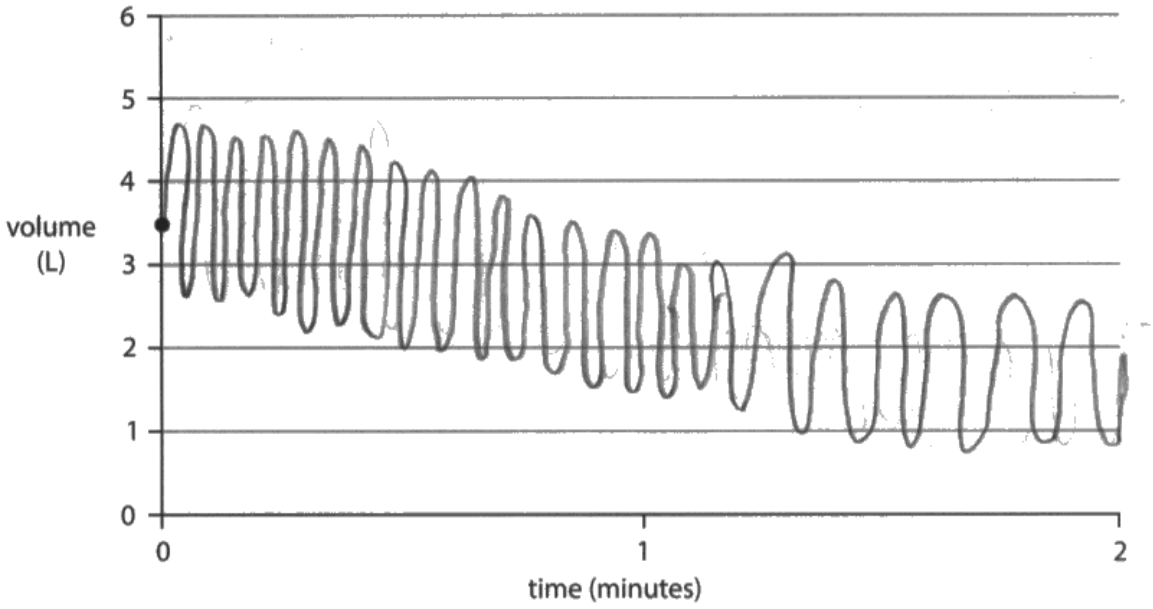
Many learners drew a trace showing either more breaths per minute or an increased tidal volume. Some learners drew a trace showing both but very fewer also showed that the trace sloped downwards left to right as oxygen consumption increased.

The response below gains all three marks

(c) The student then cycled on an exercise bike for two minutes whilst still connected to the spirometer.

Sketch on Figure 4, the spirometer trace for this student as they cycled. Start your trace from the ● on the y axis.

(3)



Question 3 a (i)

Many learners knew the meaning of myogenic but incorrect responses included reference to myogenic being a pacemaker or being concerned with the structure of the heart.

Each of the two examples below gained both marks

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

(2)

when the heart has it's own electrical impulses and generates and relaxes them by itself.n ~~ca~~ can

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

(2)

Starts ~~co-ordinating~~ contraction and relaxation without being stimulated by the nervous system

Question 3 a (ii)

The function of the coronary artery was not well known or understood. Many learners confused it with the aorta or with the pulmonary artery. Some, who did know it, lost one of the marks by failing to refer to the

heart muscle/tissue. Vague references to the heart did not gain a mark as that could refer to the atria or ventricles.
The response shown below gains both marks.

(ii) Describe the function of the coronary artery.

(2)

The coronary artery surrounds the heart and supplies the heart muscle with oxygenated blood to keep the heart alive.

Question 3b

Many learners did not read the question carefully and instead of addressing the issue of how a blocked coronary artery can lead to a heart attack they described how the plaque and clot/thrombus if formed. Many just missed a mark by referring to the heart rather than heart muscle or tissue. Few made the link between lack of oxygen (or glucose/lipid) and cells not being able to respire and produce ATP needed for the heart muscle to contract, therefore not beating. A significant percentage of learners thought that the heart worked harder and beat faster during or after a heart attack. However there were some very good responses.
The response below gains 3 marks as it refers to a region of the heart and then talks about the cells, so gains mp1. It gains mp 4 for saying heart cells die and mp 5 for the reference to the heart not being able to contract.

Explain how a blocked coronary artery may lead to a heart attack.

(4)

A blocked coronary artery stops blood flow to a region of the heart. Without oxygen, glucose and other nutrients, the cells where blood flow does not reach start to die out. The affected region over time becomes unable to perform its task (contraction) leading to a heart attack.

This response below also gains 3 marks for indicating that the heart cells do not receive oxygen and cannot respire and die. Had the learner said that the heart stopped contracting or beating or pumping, instead making the vague reference to it not working, they would have gained 4 marks.

If a coronary artery is blocked by something e.g a fatty deposit, it prevents the blood from flowing through efficiently. Blood carries oxygen which are needed for respiring cells. The Arteries carry this oxygenated blood to the respiring cells. If the cells do not receive enough oxygen they will not respire and eventually die out. If cells die out then tissues will and eventually the whole organ (heart) will stop working. This will cause a heart attack

Question 3 c (i)
Many learners correctly identified the P wave as the point on an electrocardiogram trace where the atria contract.

Question 3 c (ii)
This multiple choice question required more interpretation of the unfamiliar graph and more able learners deduced that when the ventricular volume was decreasing was when the ventricle was contracting (ventricular systole) and so correctly identified X as representing the period of the cardiac cycle when the ventricle was in systole.

Question 3 c (iii)
Learners were given the formula for calculating cardiac output and had to substitute the values for stroke volume and heart rate. Stroke volume could be deduced from figure 6b as it is the volume of blood leaving the ventricle in one beat/contraction, and is therefore 70 ml. Most learners correctly deduced this although a significant few read it as 50 ml or subtracted 50 ml form 70 ml, incorrectly calculating the stroke volume as 20ml. Learners were told that the duration of one heartbeat was 0.8 seconds so they had to divide 60 seconds (one minute) by 0.8 to calculate the heart rate, which was therefore 75 beats per minute. By multiplying 70 x 75 this gave them the correct stroke volume of 5250 ml. The most common errors made were when learners multiplied 60 seconds by 0.8 second, giving a heart rate of 48 beats per minute. By substituting that into the equation this calculated a stroke volume of 3360 ml. If one heart beat last less than one second, learners should have appreciated that there would be more than 60 beats per minute.
The example below gained all three marks

(iii) The duration of a heartbeat in Figure 6b is 0.8 seconds.

Calculate, using information from Figure 6b, the cardiac output for this heart.

Cardiac output = stroke volume (ml) X heart rate (beats per minute)

Show your working. Stroke vol

0.70 Litres × 75 = 5250 (3)

60 ÷ 0.8 = 75 70 × 75 = 5250 5250

cardiac output = 5250 ml minute $^{-1}$

The example below gained 2 marks as the stroke volume was correct and the wrongly calculated heart rate had been substituted into the equation and the two values correctly multiplied together.

(iii) The duration of a heartbeat in Figure 6b is 0.8 seconds.

Calculate, using information from Figure 6b, the cardiac output for this heart.

Cardiac output = stroke volume (ml) X heart rate (beats per minute)

Show your working. 0.8 × 60 = 48 (3)

CO = 70 × 48 = 3360

cardiac output = 3360 ml minute $^{-1}$

The following example gained one mark for correctly identifying the stroke volume but there was no error carried forward mark for multiplying this by the time of one heart beat.

(iii) The duration of a heartbeat in Figure 6b is 0.8 seconds.

Calculate, using information from Figure 6b, the cardiac output for this heart.

Cardiac output = stroke volume (ml) X heart rate (beats per minute)

Show your working. (3)

Cardiac output = 70 × 0.8

= 56

cardiac output = 56 ml minute $^{-1}$

Question 4a

Many learners correctly identified C as the loop of Henle and D as the distal convoluted tubule/DCT. Of those that did not identify the structures correctly, common errors were to identify D as the proximal convoluted tubule, indicating that those learners had not fully scrutinised the diagram and the information given in the table; and to confuse the loop of Henle and the DCT. A hew learners seemed to not know anything about the structure of a nephron and chose structures such as renal vein or renal artery for structures C and D.

The response below gained both marks

A Glomerulus
B Proximal convoluted tubule (PCT)
C descending tubule in loop of Henle
D DCT Distention
E Collecting duct

Question 4b

Few learners cored well on this question. Many had not read the question carefully and wrote about events leading to the production of aldosterone. Occasionally at the end of their account they included some relevant information that showed how aldosterone leads to an increase in blood pressure.

The response below is such as example. The first four lines are not incorrect but are not needed. However the learner then task of sodium ions and water being reabsorbed (2 marks) and this leads to an increase in blood volume – gaining a third mark.

Describe how aldosterone increases blood pressure.

(3)

When the blood pressure decreases there's an increase in renin. This goes to angiotenisnogen. There's an increase in angiotensin 1 an 2. Adrenal cortex. Then there is an increase in aldosterone. The Na^+ and H_2O in kidneys get reabsorbed. Then k^+ and H^+ secretes. The blood volume increases which then increases the blood pressure.

Question 4c

Many learners gave responses that included relevant information about the benefits and limitations of kidney transplantation to treat renal failure. Good responses gave several benefits and limitations of kidney transplantation, indicating a comprehensive knowledge of the topic. Their lines of reasoning were coherent and logical and easy to follow and indicated good understanding of the underpinning science.

The response below was placed at the top of band 3 and gained full marks

4c 6 marks

Advantages:

• One of the main advantages of kidney transplantation is that the patient does not require the use of a dialysis machine. This gives the patient more freedom (and is more effective) in the sense that they do

not need to book many appointments at the hospital to use the dialysis machine. It is also cost and time effective which is a huge benefit especially in institutions such as the NHS which are financially burdened and staff can use the time saved to treat other patients. Another advantage is that a real kidney is more effective at filtering the blood than a dialysis machine because, a real kidney adjusts the amount of water reabsorbed according to the body's requirements (eg more or less ADH is produced by neurosecretory cells in accordance with the amount of water in the blood detected by the osmoreceptors in the hypothalamus). Therefore, a kidney is more attuned to the body than a dialysis machine is.

Disadvantages - One of the main disadvantages of treating kidney failure with a kidney transplant is that the patient must take immunosuppressants so that the immune system does not attack the kidney (due to thinking it is a foreign object) which would lead to the body rejecting the kidney. Taking immunosuppressants drugs compromises the immune system of the patient, so they are more at risk of developing other infections as their immune system can not defend the patient. Another disadvantage of kidney transplantation is that it can negatively affect the donor (a living) as they are losing one kidney themselves. Furthermore, it is difficult to ascertain whether the new kidney being transplanted does not has damaged nephrons itself (albeit less than 50%.) and if the transplanted kidney does have damaged nephrons, it could also fail in the

long-term, ~~which~~ which would put the patient at risk. Another disadvantage is that finding a ~~match~~ kidney donor match is very difficult and the surgery required to transplant the kidney in ~~to~~ can be both expensive and complicated, which could again lead to complications that would negatively affect the patient. However, despite these disadvantages, I would argue that kidney transplantation is the best option for treating kidney failure as ~~it~~ in the long-term it is the most effective in terms of the function, most cost effective and time effective and gives the patient the most freedom.

(Total for Question 4 = 11 marks)

The response below was placed at the top of band 2 with 4 marks. The learner has given developed points for some advantages and disadvantages , showing good knowledge. The response is a little repetitive in parts, which somewhat adversely affects the structure of the response.

(c) Kidney failure occurs when 50% or more of the nephrons are damaged. Patients with kidney failure may be treated with kidney transplantation.

Discuss the advantages and disadvantages of treating kidney failure with kidney transplantation.

(6)

There are many advantages and disadvantages of having a kidney transplantation and people may have different views and preferences.

~~One~~ First of all one advantage of having a kidney transplant is that it means yours that isn't working will be taking out and a ~~brea~~ new one put in that is ~~gene~~ from another person, this means you don't have to worry about you having to get better

by taking medication.

one disadvantage of this is that it doesn't always work, the body doesn't always accept it, it may sometimes reject it but it just depends on how the body decides to work. This then means that you will have to keep having transplants until you find the right one that your body will accept. this option isn't always necessary and reliable for people that may have certain conditions

furthermore, another advantage is that you don't have to keep going to the hospital every week/month for check ups like you would if you had kidney dialysis.

The main disadvantage of kidney transplantation is there are a high demand for kidneys ~~because there~~, this then causes a problem as you can be on a waiting list for months and months until you are able to find a kidney that is right for you, this is due to many people aren't on the doner list so it means that there people ~~dying~~.

losing their ~~life~~ lives due to them having kidney failure and not able to have surgery to help them or they may have to have kidney dialysis which may not be the best option for them.

Depending on your age and ~~what~~ how active you are and if you have any medical conditions then it depends on what you and the doctor/nurse/specialist believe that is best for you, depending on recovery time, if there is any kidney available which you would need.

(Total for Question 4 = 11 marks)

The response below was placed at the top of band 1 with 2 marks. The response showed adequate knowledge and briefly outlined one advantage and two disadvantages of using kidney transplantation to treat renal failure.

(c) Kidney failure occurs when 50% or more of the nephrons are damaged. Patients with kidney failure may be treated with kidney transplantation.

Discuss the advantages and disadvantages of treating kidney failure with kidney transplantation.

(6)

One advantage of treating kidney failure with kidney transplantation is that it is the easiest way of treating it as the new kidney will not have damaged nephrons.

One disadvantage of kidney transplantation to treat kidney damage is that the kidney may become damaged during the transplantation process. This means that the kidney may no longer work to its best function.

Another disadvantage is that it is a dangerous complicated operation which could have a number of side effects occuring from it.

Most learners seemed to manage their time well and had enough time to tackle the last question.

Individual Questions – Chemistry

Question 1

This question relates to content from A2: Structures, reactions and properties of commercially important organic compounds. There is a particular focus on naming, electrophilic addition reactions, and bond lengths, strengths and angles in alkanes and alkenes.

Question 1 (a)

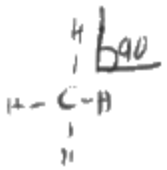
The correct bond angle of 109.5º for methane was not known by the majority of learners and then generally only by the strongest of candidates. There was a tendency for weaker candidates to select 90.0º which would suggest that they may have based their answer on a 2D representation of methane rather than a 3D representation.

It is recommended that learners are given opportunity to make 3D models of alkanes (and other hydrocarbons) as part of their chemistry studies for Units 1 and 5.

(a) Methane has the formula CH_4.

Which is the correct bond angle in methane?

- ☑ **A** 90.0°
- ☒ **B** 104.5°
- ☒ **C** 107.0°
- ☒ **D** 109.5°



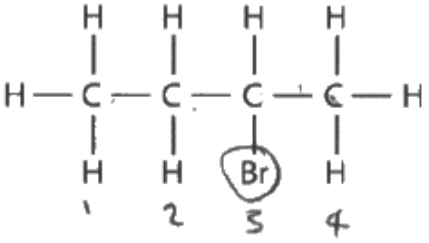
In this response, the learner has clearly drawn a 2D representation of methane and worked out 90º as the answer. (0 marks awarded)

Question 1 (b)

The correct answer of 2-bromobutane was the most common choice for the majority of candidates, revealing that naming and numbering conventions for organic molecules are generally well known. 3-bromobutane tended to be the common incorrect response. Again, some candidates would seem to have based their answer on what they have "seen" rather than applying naming rules. Learners should not be

deterred by reference to IUPAC as the focus is “name” and should always be encouraged to apply what they know. In spite of this being a multiple choice question, learners should also feel enabled to work out their answers where this is an option.

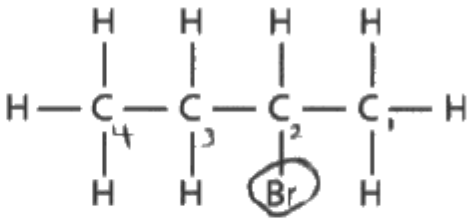
(b) Identify the IUPAC name for the compound in the diagram.



meth
eth
prop
but
pent
hex

- ☒ **A** 2-bromobutane
- ☒ **B** 3-bromobutane
- ☒ **C** ~~2-bromopentane~~
- ☒ **D** ~~3-bromopentane~~

In this response, the learner has worked out the chain name by recalling a list of stems on the right hand side. However, an attempt to number the carbon atoms on the structure is incorrect. (0 marks awarded)

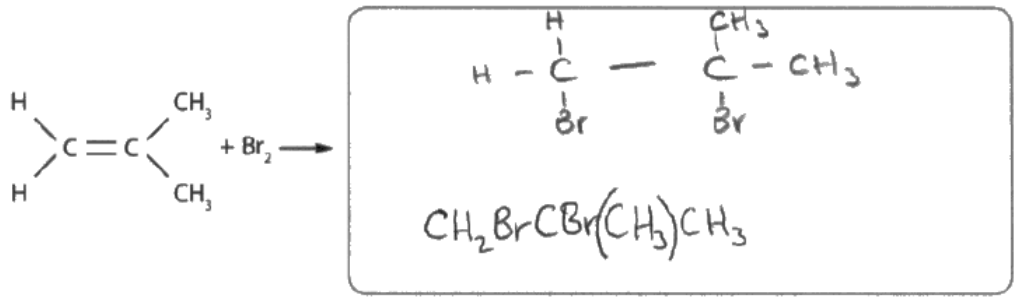


- ☒ **A** 2-bromobutane
- ☒ **B** 3-bromobutane
- ☒ **C** 2–bromopentane
- ☒ **D** 3-bromopentane

In this response, the learner has correctly recalled and applied IUPAC numbering conventions to work out the bromine atom position. (1 mark awarded)

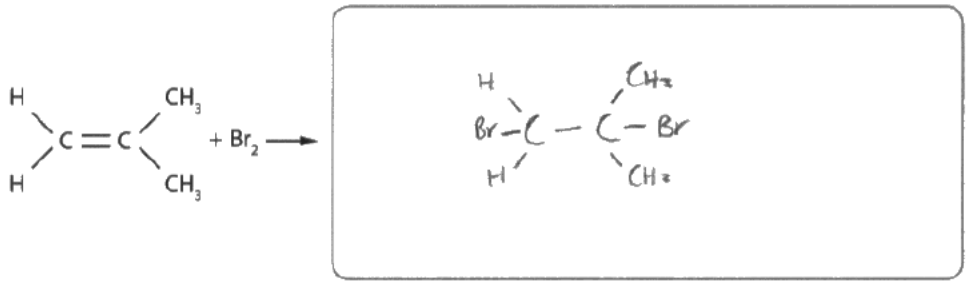
Question 1 (c)(i)

There were a number of accurate responses to this question but these tended to be from the best candidates. Correct responses often showed a combination of fully displayed and shortened structures, all of which were acceptable within this question. Orientation of bonds was also quite varied but again made no difference to the score, and learners should be encouraged to present answers in ways that they are comfortable with.



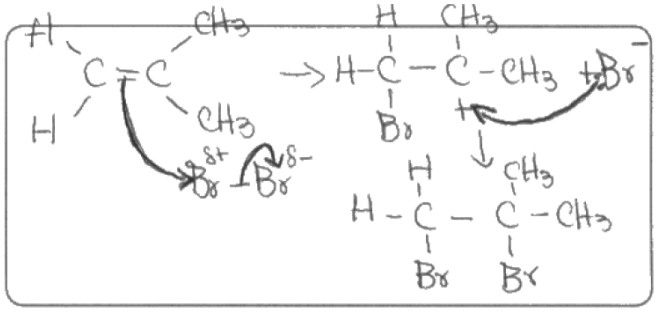
The response shows a combination of displayed and shortened structural features – either approach is acceptable. (2 marks awarded)

The best responses tended to show some strategy in place by the learner to work out the answer, such as carefully copying the original molecular structure and then modifying it appropriately:



(2 marks awarded)

A mechanism was occasionally seen which normally ensured the correct outcome. However, this was not a requirement of the question and learners should consider whether the investment of time in this way warrants the marks available.

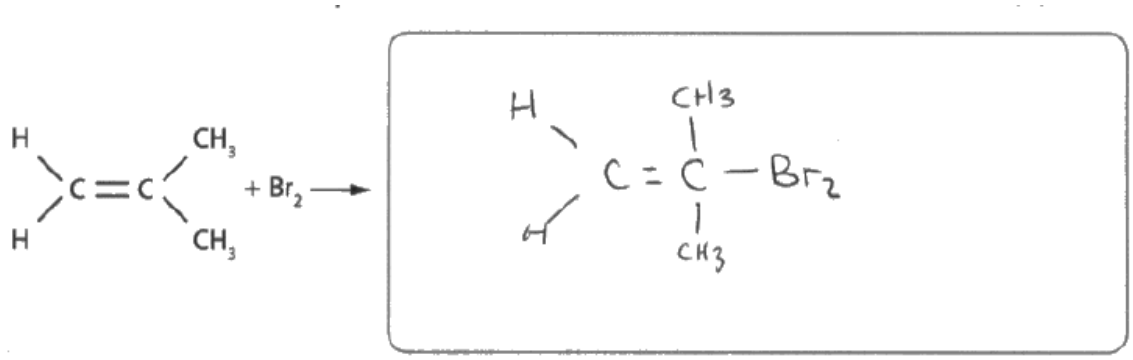


(2 marks awarded)

The majority of candidates, however, were unable to correctly deduce and draw the product from the addition of methylpropene and bromine.

Incorrect answers were very varied but included:

- redrawing the carbon chain as straight rather than branched
- showing carbon atoms with 3 or 5 bonds
- keeping the double bond intact
- placing bromine atoms on positions 2 and 3
- placing Br_2 as a complete molecule somewhere on the structure



(0 marks awarded)

It was rare to see responses that could be credited with 1 mark only, but when this was observed it was generally for those that placed Br atoms on carbons 1 and 2 but had drawn the rest of the molecule incorrectly.

Question 1 (c)(ii)

Some learners were able to classify or partly classify the reaction in 1(c)(i) as electrophilic addition (or use of one of the words) in order to score one or both marks. There tended to be a correlation with successful responses in part (i).

The majority of learners were not able to recall the reaction type, however. Incorrect responses tended to draw from different types of reaction referred to within the unit content: combustion, displacement, electrolysis, neutralisation, halogenation, exothermic or endothermic. A significant clue for learners that such answers would not be correct or adequate was given by the allocation of 2 marks for this question.

Organic chemical reactions are generally challenging for many learners so it is advisable to prepare them carefully to look for indications of particular reactions (eg alkenes / double bonds will tend to addition, whilst single bonds / alkanes will tend to substitution) and to practice writing them with care.

Question 1 (c)(iii)

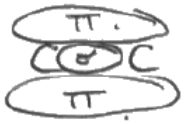
Each option was selected by at least one learner, but in general learners selected an option which had sigma and pi bonds. However, although the correct option C was a popular choice, it was not always chosen by the best candidates.

Option D was a very frequently selected option. It is likely that learners had not recognised the fact that the pi bond is represented as two lobes in diagrams rather than existing as two discrete bonds.

(iii) Which row in Table 1 shows the correct number of σ (sigma) and π (pi) bonds in the C=C bond?

	σ (sigma)	π (pi)
A	2	0
B	0	2
C	1	1
D	1	2

Table 1



☒ A

☒ B

☒ C

☒ D

(0 marks awarded)

The presentation of these options as information within a table meant that, like Q1(a)(ii), learners had to perform some analysis in addition to simple recall.

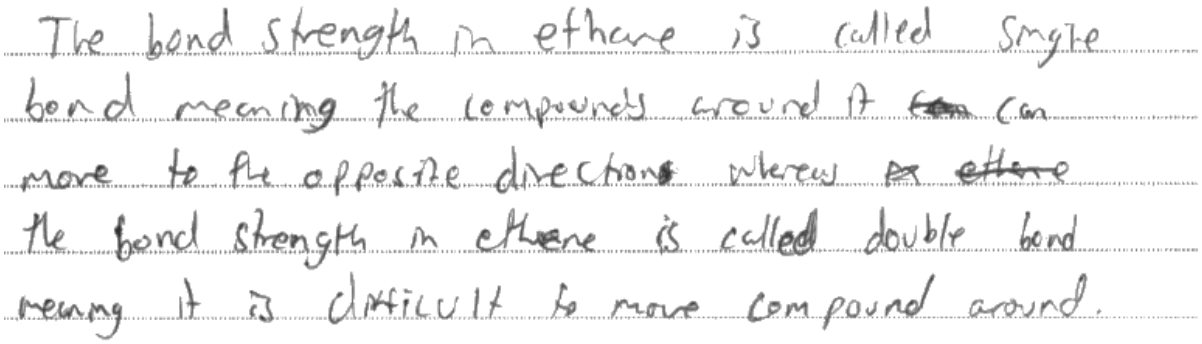
Question 1 (d)

This question was well attempted by the majority of learners, scoring at least 1 mark but most frequently 2 out of a possible 3.

It is pleasing to see candidate performance improving on this style of "explain" question where a comparison between an alkane and an alkene is required (see Examiner's Report January 2018 Q7(d)(iv)).

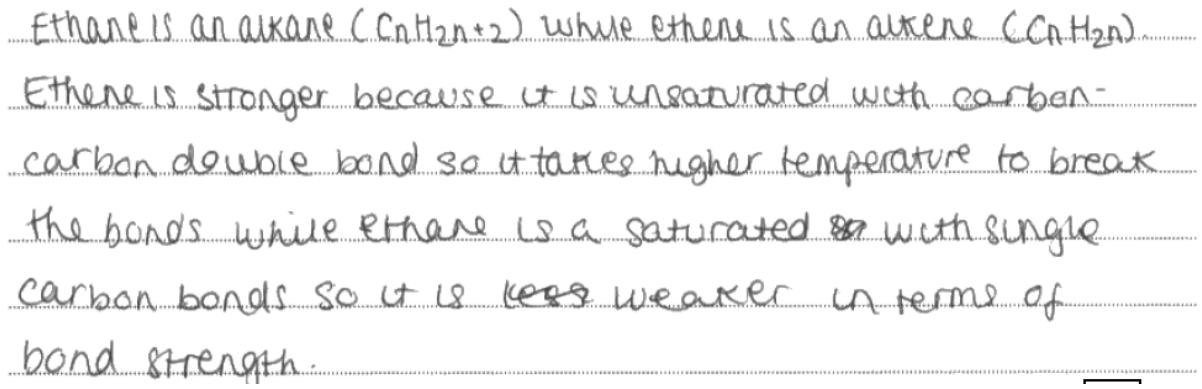
Specifically, learners should attempt to take an approach that clearly identifies the answer (1 mark), then explains (1 mark) and expands (1 mark) upon their point.

Weaker learners were usually able to identify a relevant difference between ethane and ethene carbon bonds, either that ethane's bond was weaker or that it was only a single bond (or the reverse arguments for ethene) for 1 mark.



This response identifies single and double bonds for ethane and ethene respectively, but does not clearly comment upon the strength and confuses the direction of the question by referring to molecular motion. (1 mark awarded)

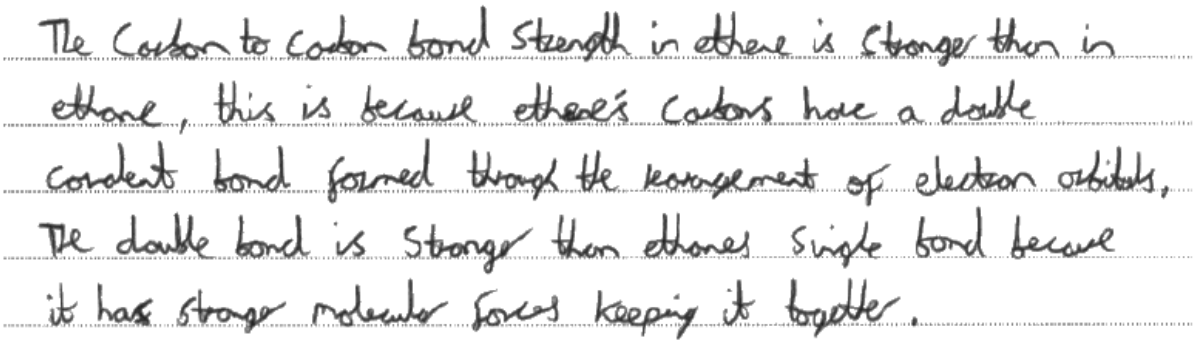
However, most learners were generally able to go further and explain that single bonds were weaker or longer and required less energy to break (or a reverse argument regarding double bonds). Answers that discussed the number of electrons shared between the carbon atoms and the strength of attraction between the two nuclei showed a more detailed understanding but this was seen only occasionally from the very best candidates.



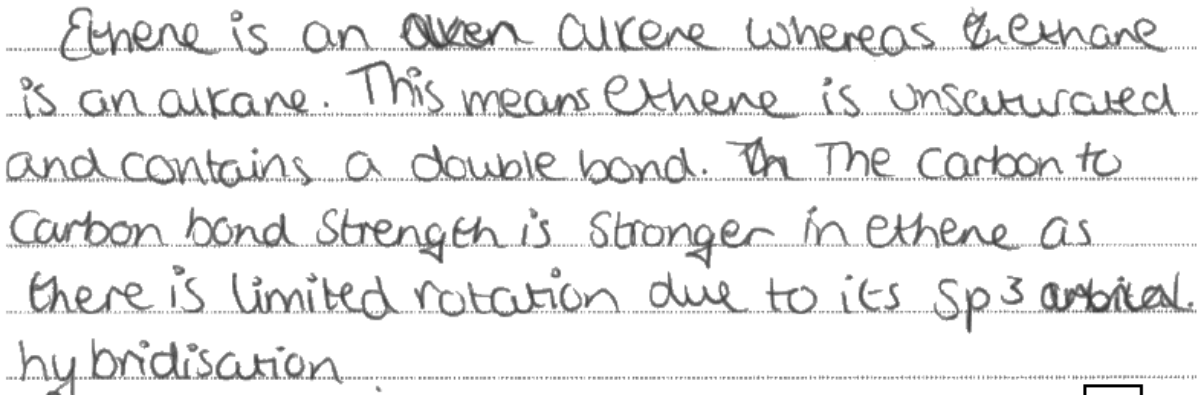
This response builds upon the identification of relative bond strength by explaining ethene has a double bond and that more energy ("temperature") is required to break a double bond. This is complimented by an explanation for ethane's bond strength. (3 marks awarded)

Generally, where learners did not manage to get beyond 2 marks, this was due to confused thinking where discussion of reactivity, intermolecular forces, bond rotation or sigma and pi bonds were introduced. Whilst it is encouraging to see learners practicing past paper

questions, caution must be exercised to ensure that answers are tailored accurately for the requirements of the question.



This response begins well but confuses bond strength with intermolecular forces in the last sentence rather than expand the answer by discussing energy requirements. (2 marks awarded)



This response also begins well but confuses bond strength with restricted bond rotation and hybridisation. (2 marks awarded)

Responses that attracted no marks often contained incorrect statements such as “ethane has a double bond” or “ethane has a stronger bond”. A small minority of learners must take more steps to ensure that spelling of ethane and ethene (or alkane and alkene) are made entirely unambiguous to examiners or they run the risk of losing marks.

Question 2

This question relates to content from A1: Relating properties to uses and production of substances. The question focuses specifically upon the electrolysis of brine, its products and the function of the membrane cell.

Question 2 (a)

This question was usually attempted but rarely had credit worthy responses and were provided only by the strongest candidates.

$2Cl^- \longrightarrow Cl_2 + 2e$ *(2 marks awarded)*

$2Cl^- - 2e^- \rightarrow Cl_2$ *(2 marks awarded)*

Whilst the majority of learners did appreciate that the equation involved chlorine and transfer of electrons, key problems encountered were writing the correct formulae and placing electrons on the correct side of the equation.

$2Cl^- + 2e^- \rightarrow Cl_2$

In this response, the chloride ion and chlorine molecule formulae are correct and in the right places but the learner has added electrons to the left hand side of the equation. (1 mark awarded)

$2Cl^- - 4e^- \rightarrow Cl_2$

In this response, the formulae are correct and in the right places but the learner has given too many electrons. (1 mark awarded)

$2Cl^+ + 2e^- \rightarrow Cl_2$

In this response, the electrons are on the wrong side and the chloride ion formula is incorrect. (0 marks awarded)

$Cl_2 + 2e^{*-} \rightarrow 2Cl^-$

In this response, the equation is the wrong way around. (0 marks awarded)

Question 2 (b)

Although learners could have provided several points regarding the function of the membrane in the electrolysis cell, it was rare to see responses that could be credited with more than 1 mark. Some learners misunderstood the question and provided detailed answers about the process of electrolysis rather than the function of the membrane.

The function of the electrolysis membrane is to [redacted] break down sodium chloride and water into ions, therefore completely seperating these producing Na^+ ions at cathode, and hydrogen gas produced out of membrane. At anode, OH^- ions are produced as a result of breakdown of water, and chlorine gas is produced out of the membrane. Electrolysis is the extraction of elements using electricity, and anode with a cathode to ensure ions are attracted to the opposite charge (Na^+ ion to a negative cathode).

This response describes electrolysis rather than the function of the membrane.
(0 marks awarded)

Other responses provided vague points about keeping various substances separate. Credit was awarded if learners could correctly specify a pair of substances that were formed that should be kept separate and why.

the membrane cell is used in electrolysis of brine as NaCl solution enters one side and Sodium hydroxide (& NaOH) leaves the other. It sp separates the chlorine from the Sodium which then reacts with water as chlorine can't get through the membrane like others can. chlorine is negative so is attracted to the anode that is not on the other side of the membrane.

This response focuses inaccurately upon keeping sodium and chlorine separate.
(0 marks awarded)

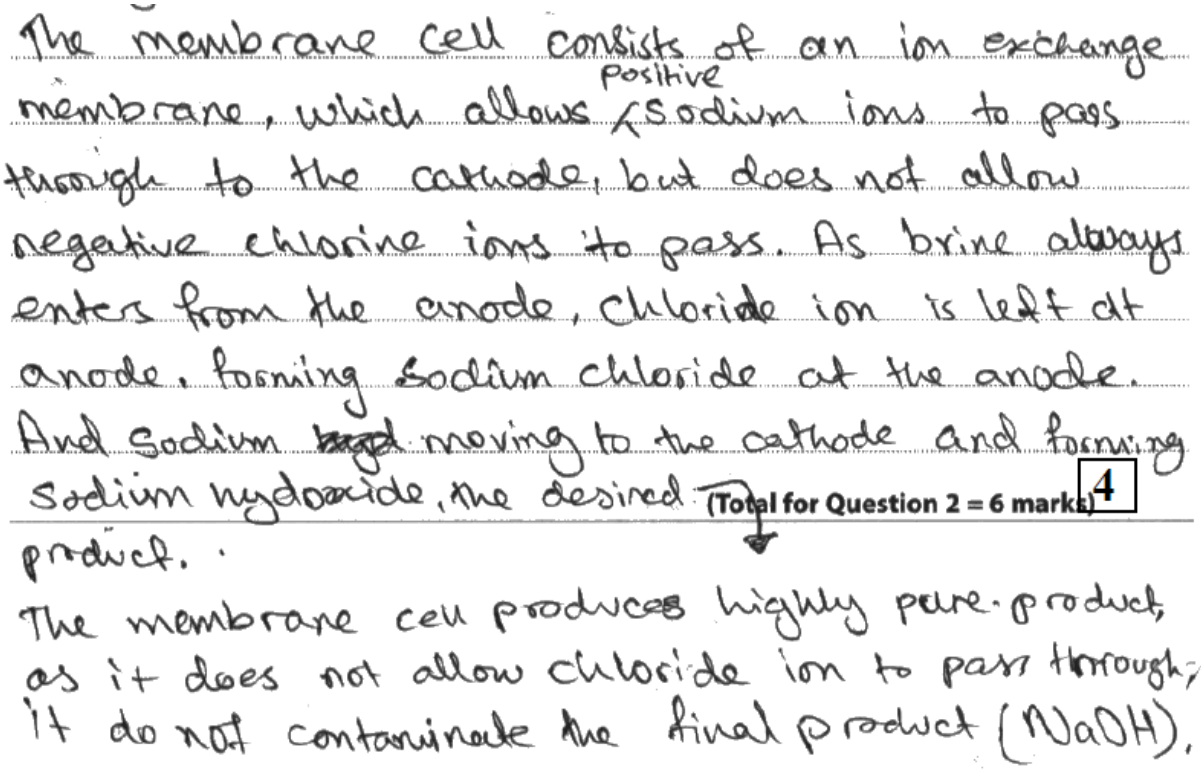
The membrane is slightly ~~for~~ porous allowing the sodium solution to pass through but prevents chlorine from ~~to~~ leaving and ~~the~~ to stops hydrogen from ~~to go~~ going back. This keeps the chlorine in ~~the~~ the chamber with the anode and the hydrogen in the chamber with the ~~the~~ cathode.

This response correctly indicates that the membrane keeps chlorine and hydrogen separate. If the response had gone on to explain that hydrogen and chlorine would react, a further mark could be credited. (1 mark awarded)

Better responses tended to focus upon a more detailed understanding of how the membrane functions and what the consequence of this is.

membrane cell is made out of polymer, it only allows positive ions through and negative ions are ~~to be~~ excreted, Therefore sodium ions can travel through and chloride ions are pushed out. This helps to separate sodium hydroxide from sodium chloride solution.

This response identifies that the membrane allows positive ions to pass through but not negative ions. Further marks would be gained if the consequences of this selectivity had been explored. (2 marks awarded)



This response again identifies that the membrane is selective but it is specific about which positive and negative ions. It explains that chloride ions would otherwise contaminate the product, and that high purity sodium hydroxide is formed. (4 marks awarded)

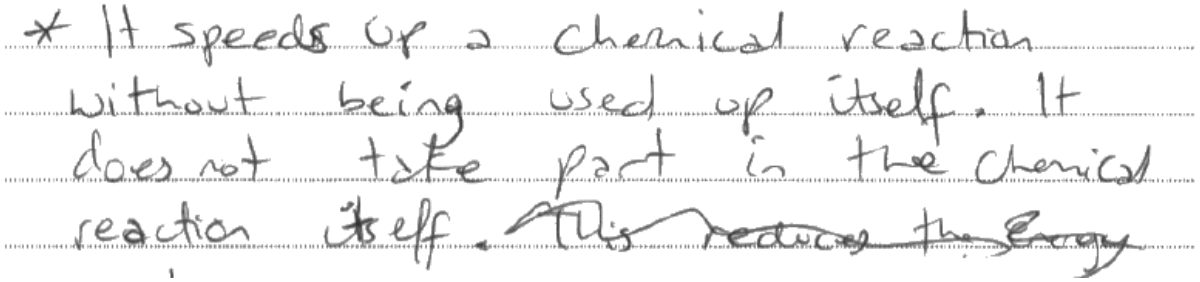
Unfortunately, many learners were hindered by poor expression and terminology: terms such as “ions”, “molecules”, “chlorine” and “sodium” were often used indiscriminately; ions, gases and solutions were often used interchangeably; and vague references “to stop substances mixing / reacting”.

Question 3

This question relates to content from A1: Relating properties to uses and production of substances. The question focuses specifically upon the use and function of transition metals and their complexes as catalysts.

Question 3 (a)

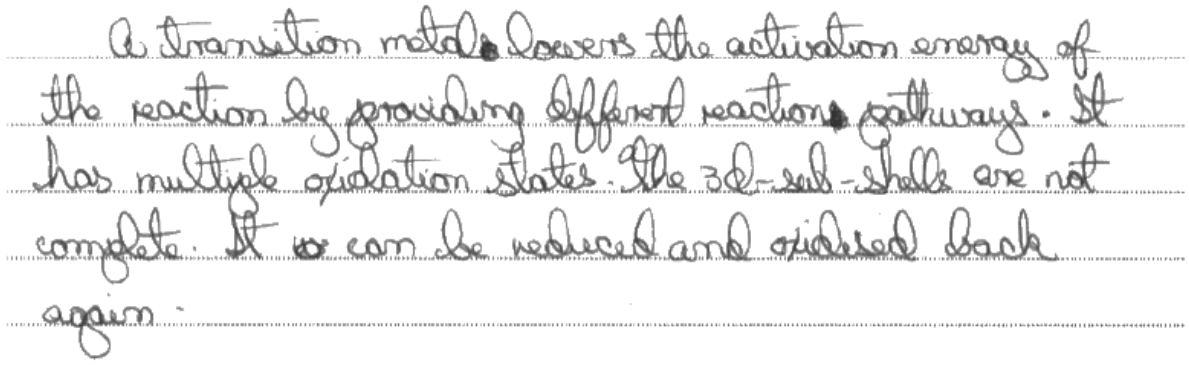
Responses to this question generally received credit. However, this often was for one relevant comment about how a transition metal acted as a catalyst and consequently many scores were just 1 mark.



This response identifies that a transition metal catalyst speeds up a reaction, but the other points do not explain or expand upon how this is achieved.

(1 mark awarded)

As noted for Q1(d), learners should plan and structure their answer as an identification, explanation and expansion in order to secure the full 3 marks.



This response offers two lines of reasoning: an explanation involving change in activation energy and a second involving change in oxidation state. This is sufficient to gain full marks but a better and more efficient answer would have been to identify the function of a catalyst followed it up with an explanation of two linked points.

(3 marks awarded)

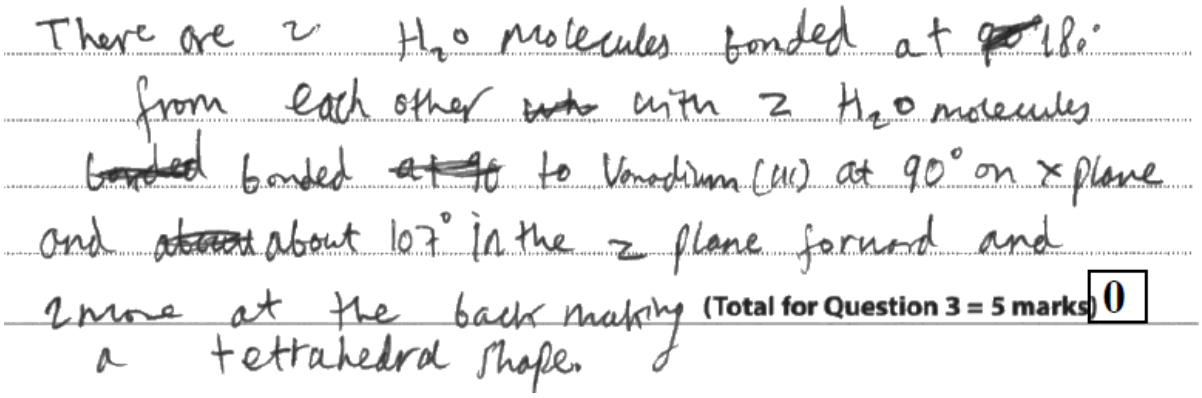
Again, it is clear that learners are practicing past paper questions, but consequently, many responses did contain characteristics of transition

metals such as colour and complex ion formation, which were not relevant to this question.

Question 3 (b)

This question was poorly answered in general.

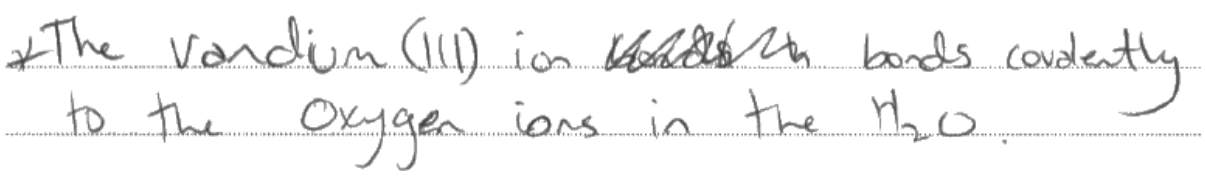
Many responses relied heavily upon what learners could observe within the diagram, but the answer required an underlying description of the bonding within the complex ion. Consequently, weaker answers focused upon the shape of the complex ion, the bond angle or the wedge style bonds shown in the picture.



The response does not focus upon the nature of the bonding and instead attempts to describe the diagram and the bond angles involved.

(0 marks awarded)

Responses that did focus on the nature of the bonding were often very varied. Ionic bonding, hydrogen bonding, and dipole-dipole interactions all regularly appeared. Reference to “covalent bonding” was often to general to score and referred back to sigma and pi bonding. Generally, learners that specified a type of bonding tended to confine their answer, missing the question’s prompt to “describe” as opposed to “state”.



The response names “covalent” bonding and makes reference to ions, but does not attempt to describe the bonding. (0 marks awarded)

Vanadium (III) as a transition metal in solution it forms complex ion, which is when transition metal are bonded to one or more ligands by dative covalent bond, in this case with the water molecule.

The response correctly identifies "dative covalent bonding" and can be credited with one mark. However, there is insufficient detail in the description about the nature of the bonding to credit a further mark. (1 mark awarded)

The water molecules donate pair of electrons to the central vanadium ion to form dative covalent bond. ligands are surrounded by the central ions.

In this response dative covalent bonding is referenced but is also described. A good answer will identify that the water molecule / oxygen atom has a lone pair of electrons, and that these are donated to the vanadium ion to form the bond.
(2 marks awarded)

Question 4

This question relates to content from A2: Structures, reactions and properties of commercially important organic compounds. There is a particular focus on the general formula of alkanes, cracking of hydrocarbons and the commercial importance of this process.

Question 4 (a)

The general formula of the alkane family was known by about half of the candidates, which were typically the best candidates.

C_nH_{2n+2}

(1 mark awarded)

Common errors tended to be mistakes in the formula but the formulae of specific molecules were often seen.

C_nH_{n+2} C_nH_{2n}

In these responses, the learner has made errors in formula for the H atom.
(0 marks awarded)

$C_n + H_{2n} + 2$

In this response, the learner has included + in front of H. In addition, more care needs to be taken over subscripts in the formula. (0 marks awarded)

C_1H_4

In this response, the learner has given a molecular formula rather than a general formula. (0 marks awarded)

Question 4 (b)

This question produced a variety of responses from learners. Generally, if learners did know the formula of ethene they were then able to work out the formula of the other compound as CH_4.

$C_3H_8 \longrightarrow C_2H_4 + CH_4$
Propane $\longrightarrow$ Ethene + Methane

(2 marks awarded)

A number of answers involved water, presumably because the next question referred to steam.

$2C_3H_8 \rightarrow 3C_2H_4 + 2H_2O$

In this response, although the chemical equation is incorrect, the learner has provided the correct formula of ethene as a product. (1 mark awarded)

Many answers revealed that learners did not understand that the cracking of propane meant to break the molecule into smaller formulae and also did not know the molecular formula of simple hydrocarbons.

Question 4 (c)

This question was generally well answered, with the majority of learners achieving at least 1 mark. Most answers tended to identify benefits as either producing more product in a shorter period of time, a lower temperature / amount of energy would be required, or that the catalyst could be reused. There were also a large number of responses that knew the process in more depth, identifying that a larger proportion of alkanes or aromatic hydrocarbons could also be produced.

Catalysts are reusable and so will require less energy. Catalysts can be used if the product of a higher yield needed is an alkane.

In this response, the learner indicates several benefits (ie that catalysts can be reused, less energy required and higher yield of alkanes).

(2 mark awarded)

Where responses tended not to score marks, it was because of vague and unqualified statements such as “less expensive”, “not used up” or that it was “better for the environment”. Occasionally, some learners would describe the process of catalytic cracking rather than provide two benefits.

Question 5

This question relates to content from A3: Energy changes in industry. There is a particular focus on the Kelvin scale of temperature, standard enthalpy change of combustion, calculation of enthalpy changes from supplied data and explaining reaction profile diagrams, although many other areas of the unit content are referenced within the question as well.

Question 5 (a)

The best candidates were able to recall a definition for the standard enthalpy change of combustion, with some responses providing very good detail.

Standard enthalpy change of combustion is 1 mole of a substance completely burned in oxygen under the standard condition (controlled temperature & pressure)

In this response, the learner has correctly specified that it is 1 mole that is being burnt and that this is completely in oxygen, and is awarded both marks. The response also correctly includes reference to standard conditions.

(2 marks awarded)

However, the definition (or even a description) was not well known generally. A small proportion of learners tended to omit key detail eg “1 mole”, “completely” or “oxygen”, which prevented full marks from being achieved.

The (heat) energy change of 1 mol of a substance when it is burned with oxygen under [redacted] standard pressure and conditions.

In this response, the learner has omitted “completely” so cannot be awarded 2 marks. An alternative would have been to have written “excess” oxygen.

(1 mark awarded)

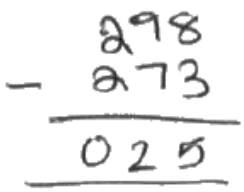
The change in enthalpy when the reactants are combusted (burnt) in Oxygen, ~~us~~ under stand -ard conditions, 298 k and [redacted] and 1 atm.

In this response, the learner has omitted "completely" but also reference to "1 mole" of the substance being burnt, so is does not specific enough to achieve any marks. *(0 marks awarded)*

More basic errors were often observed with weaker candidates, such as describing: energy or temperature change; change of physical state; oxidation or reaction with oxygen; or giving a definition of the standard enthalpy change of formation.

Question 5 (b)(i)

This question was answered correctly by about half of the candidates. Many candidates showed their working out of the conversion of 298 from the Kelvin scale into the Celsius scale, which was encouraging to observe.



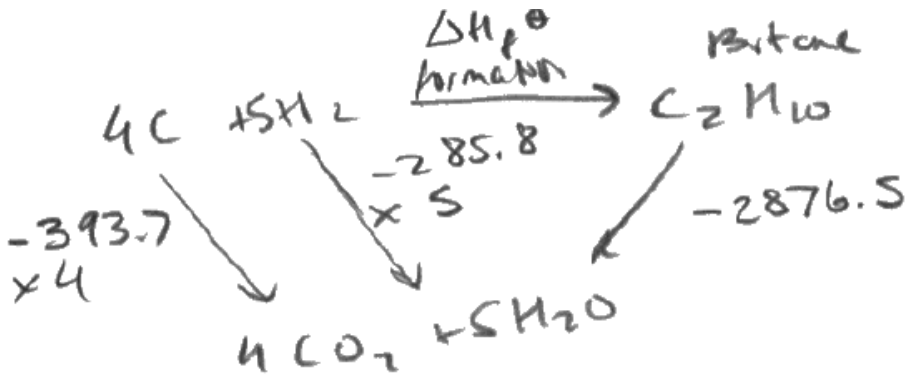
25 °C

(1 mark awarded)

Most incorrect answers tended to be in the range of 20 – 30 ^{o}C, indicating that learners knew to subtract a value from 298K. This also revealed a shaky recall of absolute zero as being -273 ^{o}C (or -273.15K) which needed to be used.

Question 5 (b)(ii)

This question was a challenging, multi-step calculation. However, the majority of learners managed to score at least 1 mark, with the best candidates tending to score between 3 to 5 marks.



$-393.7 \times 4 = -1574.8$

$-285.8 \times 5 = -1429$

$-1574.8 + -1429 + 2876.5 = -127.3$

In this response, the learner has used the energy cycle to correctly calculate the answer. *(5 marks awarded)*

$\Delta H^{\ominus}f = \left(\Delta H^{\ominus}c(C \times 4) + \Delta H^{\ominus}c(H_2 \times 5)\right) - \Delta H^{\ominus}c(C_4H_{10})$

$\Delta H^{\ominus}f = \left((-393.7 \times 4) + (-285.8 \times 5)\right) - -2876.5$

$\Delta H^{\ominus}f = (-1574.8 + -1429) - -2876.5$

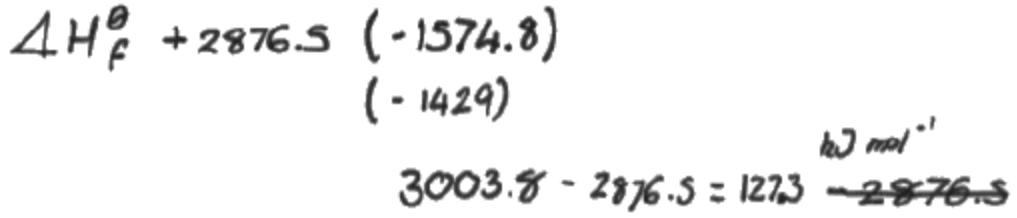
$\Delta H^{\ominus}f = -3003.8 - -2876.5$

$\Delta H^{\ominus}f = -127.3$

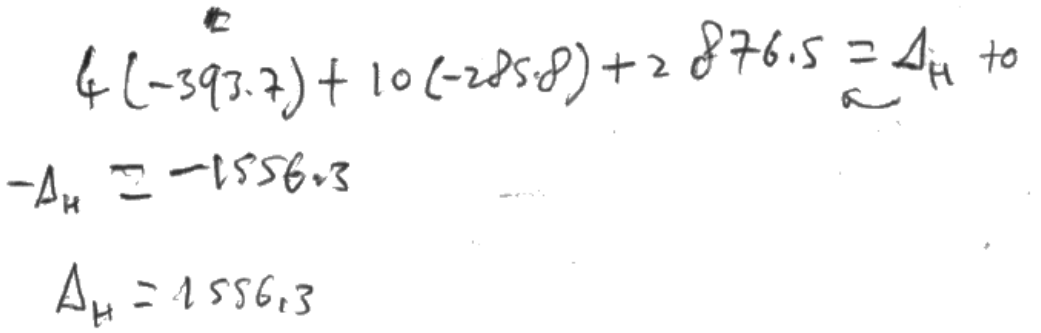
In this response, the learner has used an alternative method of working to correctly calculate the answer, which is permitted. *(5 marks awarded)*

Generally, where learners achieved 3 or 4 marks, very simple mistakes

had been made. These tended to be: not correctly finding the difference between the enthalpy of combustion of the reactants and product; incorrect multiplication of either enthalpy of combustion of carbon or hydrogen; or incorrect processing at some stage which prevented arriving at the correct answer.



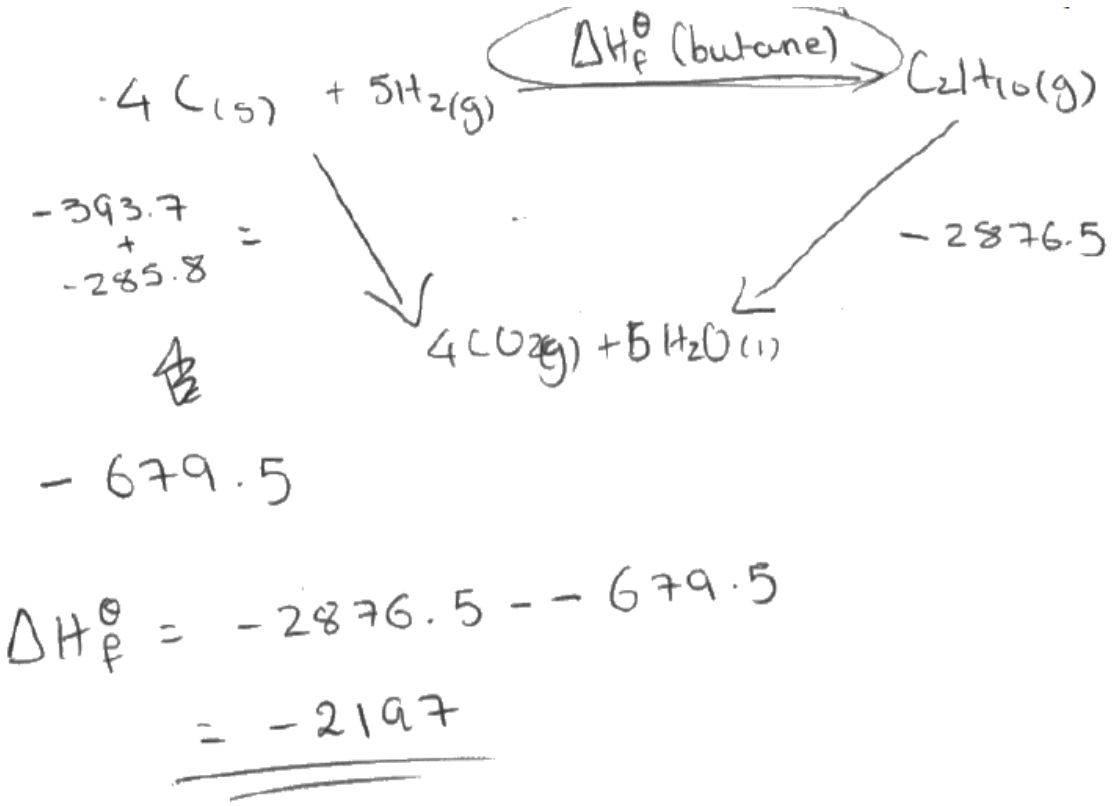
In this response, the learner has changed signs during their working and has arrived at +127.3. *(4 marks awarded)*



In this response, the learner generally shows good working but has made two errors so the overall score is 3 marks. Firstly, they have mistakenly multiplied the enthalpy of combustion of hydrogen by 10 rather than 5. Secondly, they have changed the sign of their answer. Although the working shows values being added, the learner has actually reversed the sign of the enthalpy of combustion of butane.

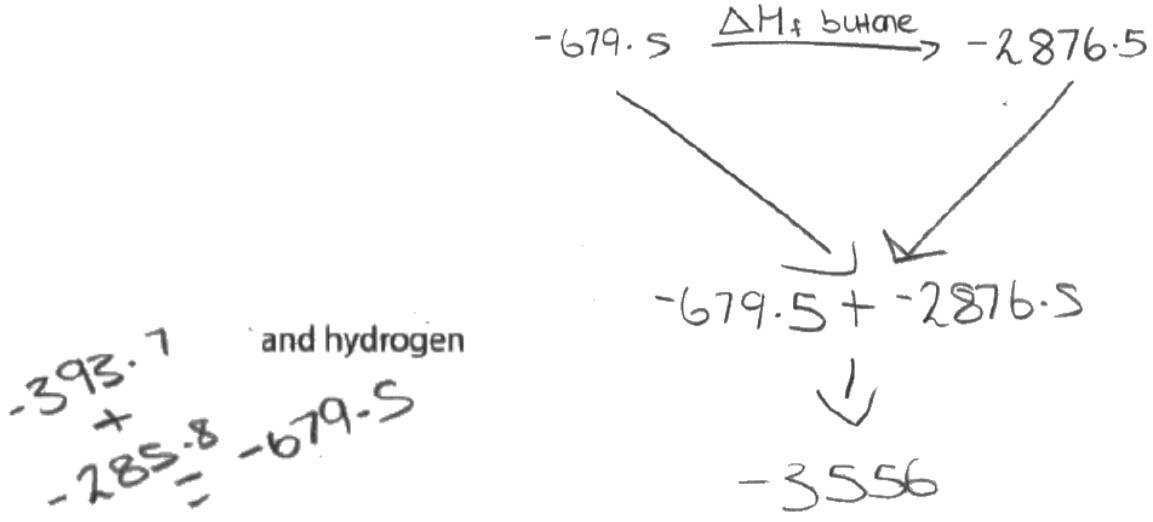
(3 marks awarded)

Responses scoring 2 or 1 mark tended to have a greater combination of flaws or were only partially completed. The multiplication factor for the combustion of carbon and / or hydrogen tended to be wrong, and the difference between this and the combustion of butane tended to be incorrectly set out, often with all of the values being added together. Processing to arrive at the answer could also be incorrect at some point in the working.



In this response, the learner has not multiplied the enthalpy of combustions of carbon or hydrogen, but has summated the two which would score 1 mark. A further mark has been awarded as there is an attempt to determine the difference, although this is actually enthalpy of products – enthalpy of reactants and the evaluation mark can, therefore, not be awarded.

(2 marks awarded)



This response again shows summation of the enthalpy of combustions of carbon and hydrogen on the left. However, this is then summated to the enthalpy of combustion of butane. The response can only score the summation mark of the reactant values. *(1 mark awarded)*

Learners that attempted this question but did not achieve any marks at all

tended to:

- use another operation (such as division)
- involved relative atomic mass in some way
- tried to determine the enthalpy change using mass x specific heat capacity x temperature change.

A number of learners did not attempt the question at all, which indicated unfamiliarity with this type of energy change calculation, and centres are advised to provide learners with examples of the use of energy cycles and other methods in order to determine enthalpy changes that cannot be determined directly.

(Please see Additional Sample Assessment Material for Unit 5 at https://qualifications.pearson.com/en/qualifications/btec-nationals/applied-science-2016.coursematerials.html#filterQuery=category:Pearson-UK:Category%2FSpecification-and-sample-assessments)

Question 5 (c)

The extended response question offered opportunity for learners to demonstrate their understanding of enthalpy change in relation to interpretation of two reaction profile diagrams. The majority of learners were able to provide credit worthy answers but it still proved challenging for a small number of learners and top scores were very rare.

Key issues found with responses that achieved no or few marks were:

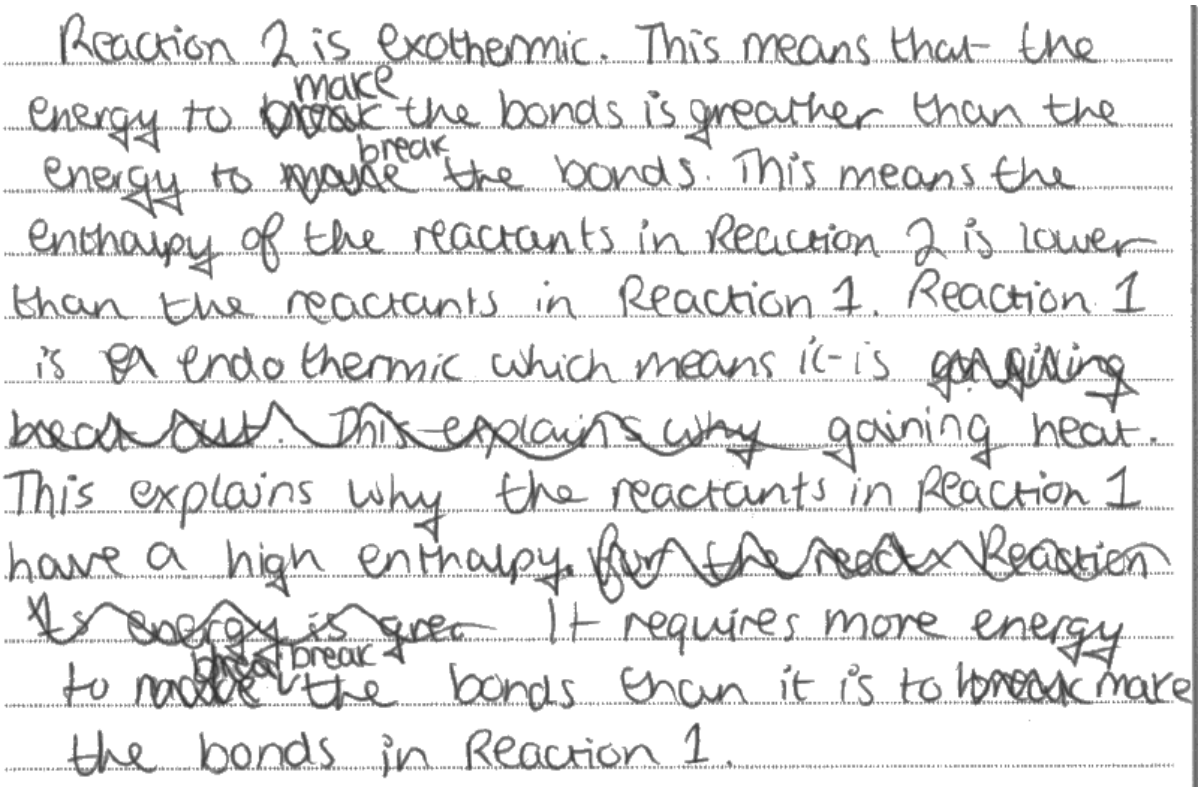
- no reference to energy or enthalpy but reference to “amount” or “yield” of products and reactants
- confusion between “exothermic” and “endothermic” in relation to the graphs but also what they actually meant
- description and comparison of the shape of the graphs without explaining what this showed

Level 1 responses tended to provide statements about the graph (eg graph 1 shows an exothermic reaction, graph 2 shows an endothermic reaction) or described what could be seen (eg energy level of the reactants is higher than the products in graph 1). A small number of learners just wrote about enthalpy changes without reference to the graphs. At the top of this level, typical responses were brief without expansion or linking of ideas, or did not show much coherence about exothermic and endothermic energy changes. More often than not, learners would achieve 1 mark at this level as better learners were able to examine the graph and link ideas, placing them at a higher level.

Level 2 responses built upon basic points by providing further detail and explanation of the differences. At this level, learners were able to identify each type of enthalpy change involved, and were able to qualify this by giving evidence from the graphs (ie the relative difference in enthalpy levels). Additionally, some further relevant knowledge was demonstrated such as whether the enthalpy change would be positive or negative, or the direction of energy transfer between the system and the surroundings, and would clearly distinguish this from Level 1. Many learners were, therefore, able to achieve 4 rather than 3 marks.

Whilst the logic and knowledge that was demonstrated in responses was generally clear, the “hump” of the graphs and reference to activation energy was absent, which held learners back from a comprehensive interpretation for Level 3. Relatively few responses were seen at this level, but were characterised by good understanding of activation energy and its impact upon each reaction (eg contribution to the overall enthalpy change, effect on rate). Few learners attempted to discuss overall enthalpy change in terms of relative amount of energy input and output which would have demonstrated comprehensive analysis and reasoning.

Level 1 (1 mark)



In this response, the learner has incorrectly assigned the type of enthalpy change for the two graphs. There is no strong attempt to identify features of the graphs to support the interpretation, mainly a weak comparison of the two graphs. However, the learner does demonstrate some knowledge of the terms exothermic and endothermic, and so can be awarded 1 mark.

(1 mark awarded)

Level 1 (2 marks)

In Reaction ~~2~~ 1 the reaction was exothermic. This is because there is more reactants and less products formed. Therefore, more heat may be given out so exothermic. Reaction 2 ~~2~~ is endothermic. This is because more products are formed compared to reactants. This reaction may have been a formation reaction as more product is formed.

In this example, the learner has correctly assigned the type of enthalpy change for the two graphs and an explanation provided. Although the explanation does show some structure and coherence, the learner has not actually referred to energy or enthalpy level, instead indicating whether more products or reactants have been formed which undermines the discussion. The learner does demonstrate some knowledge of the terms exothermic, in terms of heat given out so can be awarded 2 marks.

(2 marks awarded)

Level 2 (3 marks)

Reaction 1 Shows the enthalpy profile for a exothermic reaction. This often has a negative enthalpy change, this is because during exothermic reactions, bonds are being made which therefore releases heat to the Surroundings.

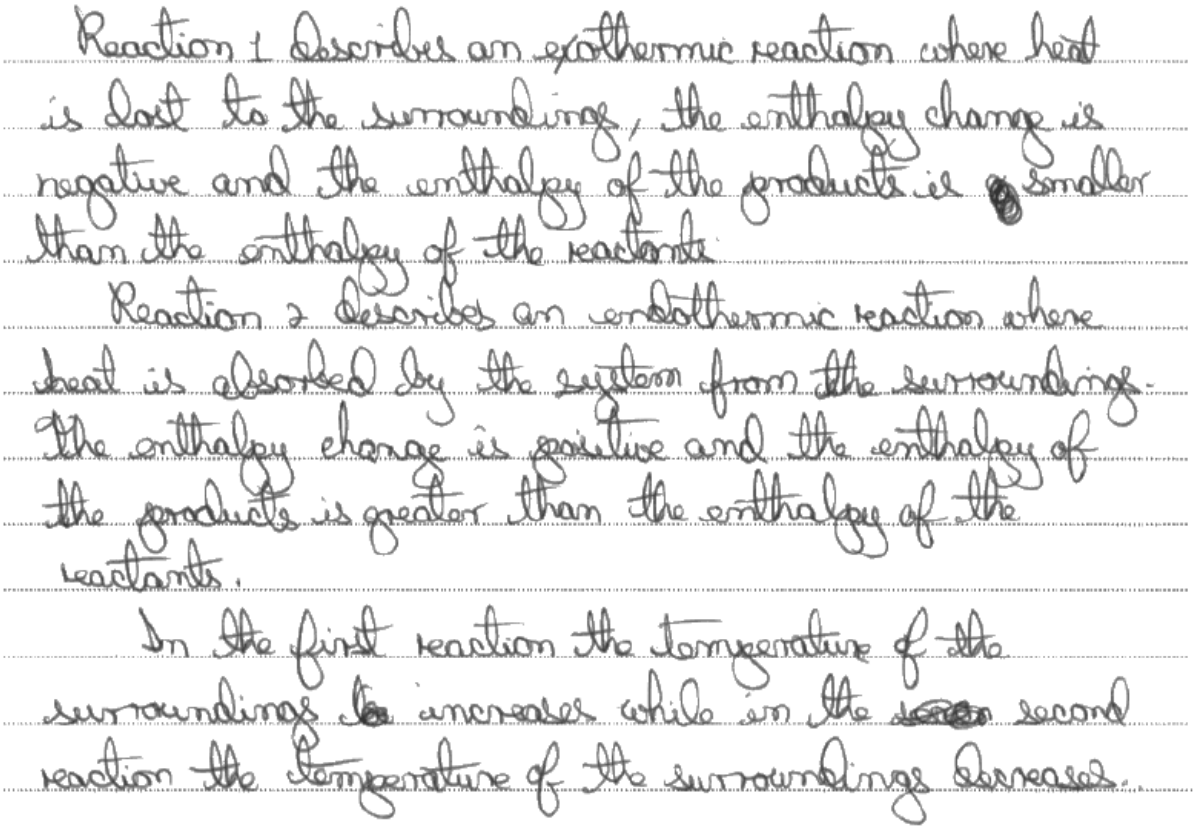
On the otherhand reaction 2 shows the enthalpy profile of an endothermic reaction. This always gives a positive enthalpy change. This is because bonds are broken during an endothermic reaction which takes in heat from the Surroundings in order to break the bonds.

Reaction 1 Shows that the enthalpy decreases compared to reaction 2 where it increases instead.

In this response, the type of enthalpy change has again been correctly identified. Relevant information and definitions have been provided and the response is factually correct and coherent. However, the graphs have not been used in order to support the deductions, which limits the extent of the learner's interpretation and use of relevant evidence at this level.

(3 marks awarded)

Level 2 (4 marks)


Reaction 1 describes an exothermic reaction where heat is lost to the surroundings, the enthalpy change is negative and the enthalpy of the products is smaller than the enthalpy of the reactants

Reaction 2 describes an endothermic reaction where heat is absorbed by the system from the surroundings. The enthalpy change is positive and the enthalpy of the products is greater than the enthalpy of the reactants.

In the first reaction the temperature of the surroundings increases while in the second reaction the temperature of the surroundings decreases.

In this example, the type of enthalpy change for each reaction profile has been correctly identified. Although each identification is initially supported by a description of the enthalpy change and its meaning, the learner also identifies how this is shown in the graph. This places the response at the top of Level 2 and 4 marks can be awarded.

(4 marks awarded)

Level 3 (5 marks)

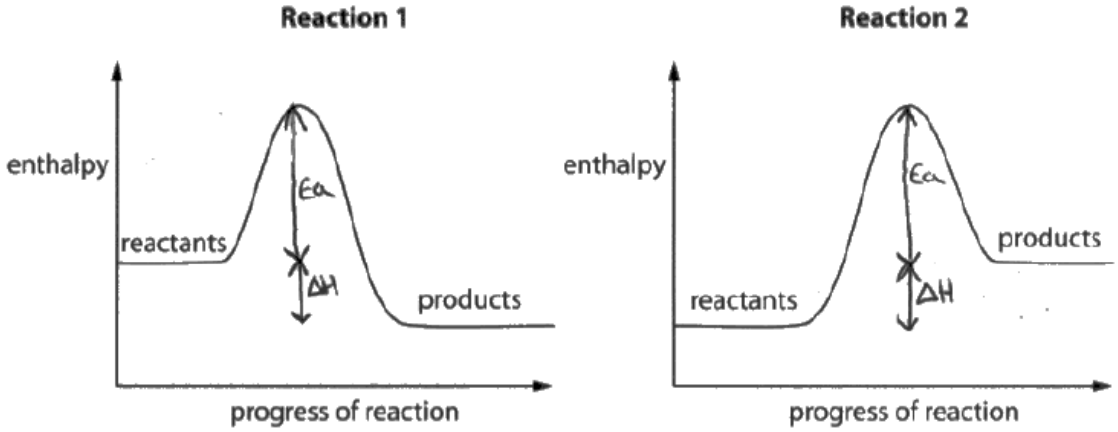


Figure 4

Explain the differences between Reaction 1 and 2, using the enthalpy profiles.

(6) 5 Q05c

Reaction 1 shows an exothermic reaction. This is because the reactants starts with more energy than the products meaning they have lost enthalpy. Reaction 2 shows an endothermic reaction where the products have more enthalpy than the reactants. This shows that the products had gained energy. Both reaction 1 and 2 have a high activation energy and a lower enthalpy change. Reaction 1 would have increased in temperature of the surroundings whereas reaction 2 would have decreased the temperature of the surroundings. In reaction 1 it would have shown a change between

chemical energy into heat to the surroundings. whereas in reaction 2 it would have shown the opposite where heat is converted ~~into~~ from the surroundings into chemical energy.

In this example, the learner has labelled the graphs – whilst this does not constitute an explanation, it has assisted them in ordering their thoughts and structuring their response. As in other examples, a correct identification has been made with a logical justification and extensive knowledge of the effects. Additionally, there has been an attempt to interpret the rise / "hump" in both graphs with reference to activation energy. However, the statement is not entirely clear or accurate, therefore not comprehensive enough for the top of this level. 5 marks can be awarded.

(5 marks awarded)

Level 3 (6 marks)

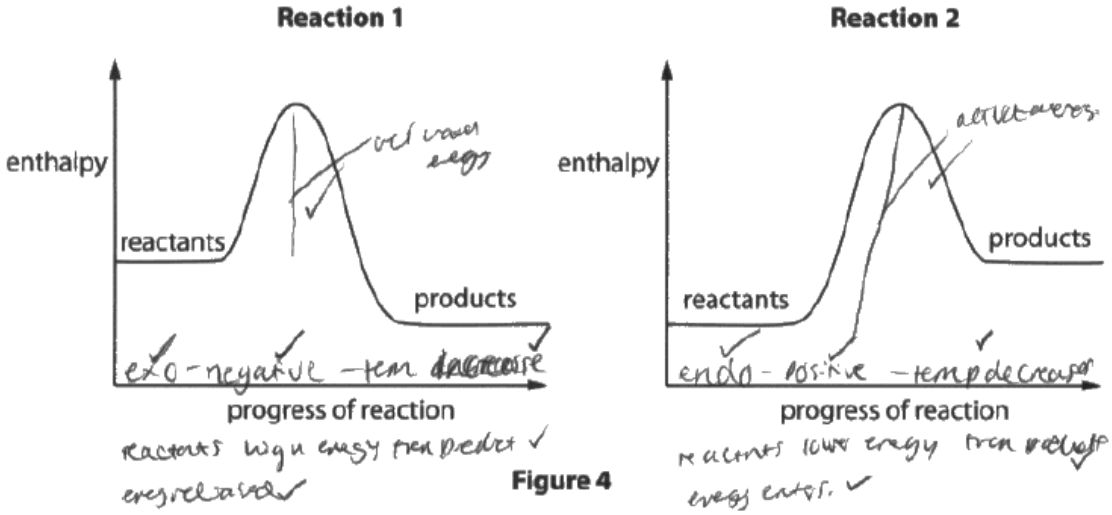


Figure 4

Explain the differences between Reaction 1 and 2, using the enthalpy profiles.

Reaction 1 is an exothermic reaction whereas reaction 2 is an endothermic reaction. Because reaction 1 is exothermic, the reactants have a more energy than the products do but because reaction 2 is endothermic, the products have more energy than the reactans. This is because the exothermic reaction (reaction 1) gives off and releases energy whereas the endothermic reaction (reaction 2) takes energy in. The endothermic reaction (reaction 2) is a positive reaction where the energy increases whereas the exothermic reaction (reaction 1) is a negative reaction as the energy decreases. The endothermic reaction (reaction 2) has more activation energy than the exothermic (reaction 1) because it requires more energy to start an endothermic reaction because there is an energy increase. The themperature of the endothermic reaction decreases but the temperature of the exothermic reaction increases.

In common with the previous example, the learner has annotated the graphs as a starting point and given a correct identification, justification and knowledge of the effects of energy transfer, showing a clear and logical structure. Furthermore, the learner has shown understanding of activation energy and identified the difference between the two reactions from the graphs. The interpretation and evaluation is therefore comprehensive, with strong lines of argument and application of evidence, placing this response at the top of Level 3.

(6 marks awarded)

Individual Questions – Physics

Q1ai and ii the first two items on the paper were multiple choice questions. These tested the idea of work done and the unit for pressure. Learners found Q1ai more difficult than expected. Under 40% gaining the mark for answer B. The following question gave a greater number of correct answers, however just under half of the cohort knew the correct unit which was answer D.

Q1b, was better answered, with over 75% of the cohort giving the correct conversion from kW to W.

Give the power output of the drill in watts.

This answer shows the working, however the number 400 alone was sufficient to score the mark. Where learners did not score the mark, the most common mistake was to give 40 or 4 as the answer.

Q2a was a question that asked about the relationship between pressure and velocity in a pipe in a qualitative way and targeted as a merit item. Learners were expected to deal with several ideas at once in answering this multiple choice question. Less than 20% of the cohort were able to give the correct answer B. The most common incorrect answer was D, which was the reverse of the correct answer. Centres should note that this relationship will be dealt with qualitatively as the use of a formula is not required for this specification statement.

Q2bi and 2bii were a pair of questions that asked learners to consider the relationship between the viscosity of an oil and its temperature. Learners were given some guidance in the question as to what the oil was supposed to do. The questions then asked for the effects of low and high temperatures on the oil.

Just under 45% of learners were able to score one mark for Q2bi, mainly for stating that the oil was thicker, or would not move through the engine easily, few learners, just over 10%, were able to explain the effect on the engine in terms of the oil lacking the ability to reach all parts of the engine quickly.

The response here, gained two marks for stating that the oil would be thick and so would not reach all engine parts.

(i) Explain the effects of **low** temperature on how well the oil acts as a lubricant.

(2)

On the low temperature, the oil will be more viscous which means it will be thick and it will be hard for it to move or reach all the moving parts. It will not act good as lubricant.

A more typical response gaining one mark is given here, for stating that the oil would not flow as quickly.

(2)

the oil will become more viscous meaning it won't flow as quickly, limiting its ~~lubricant~~ effect as a lubricant

A frequent error for learners was to write that as the temperature increased, the oil became more viscous or that high viscosity gave faster flow rates for the oil. There was some confusion in the relationship between the viscosity of the oil and the effect of temperature.

For **Q2bii**, the answer being looked for was that the oil became too thin to function as a lubricant as it would be too thin to coat the engine parts properly, therefore lead to greater friction and engine wear. Just over 40% of the cohort gained at least one mark for this question. Very few learners, less than 4%, were able to give full marks.

The answer below gained two marks, for the idea that the oil became runnier at high temperatures, but then went on to give the last marking point. The idea of it mot sticking to the engine, is conveyed in the last part of the answer, this was deemed to be sufficient to give the second mark.

(2)

High temperature causes the lubricant to become more runny (liquid like) making it easier to spread on all the parts of the engine, ~~it will also~~

However, high temperatures on the lubricant would make it more prone to coming off of the engine.

(Total for Question 2 = 5 marks)

This response is typical of answers that scored no marks. The learner has not given any

further information than what was in the stem of the question. They have then gone on to suggest incorrectly that a low viscosity would prevent the oil flowing.

High temperatures of oil will mean that it loses viscousity and will not allow all oil to move throughout the engines therefore making it less lubricant.

It was evident in both these questions that many learners were not clear of the meaning of the term 'viscous' and the effect temperature has on viscosity.

Q3ai and aii asked learners to undertake two calculations, the first was a 'show that'. In such questions, the learner is given the answer, and then they are expected to show by calculation that the answer obtained is close to that given. The answer is expected to at least one significant figure more than the value given in the question. The second calculation used the value from the first answer to find another value.

Just under 90% of the cohort were able to score at least one mark in Q3ai. Nearly 54% of the cohort were able to score full marks for this question.

This answer scored full marks, the answer was to more significant figures and in addition full working is shown. It should be noted that learners are reminded that working should be shown just above the answer space, there remains a small group of learners that do not do this

Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

Show your working.

$\Delta T = 80°C$ (3)

$497000\,J \div 80°C = 6212.5 \div 4200 = 1.48$

mass of water = 1.48 kg

"Show that' questions can be done in reverse, this makes them rather different from a standard calculation. The mark scheme therefore gave an alternative way to score marks. The example below is an example.

In this case the learner has started with the value 1.5kg and substituted it into the equation to determine the number of joules required, which is as given on the answer line. This was awarded two marks, as this method requires no rearrangement of the

formula.

Show your working.

$\Delta T = 80°C$

$m = 1.5kg$

$C = 4,200 Jkg^{-1}°C^{-1}$

$Q = 1.5 \times 4,200 \times 80 = 504,000$ (3)

mass of water = 504,000 kg

As in a 'show that' calculation the answer is given, quoting the answer does not score any marks, learners need to correctly give the answer evaluated as in the first example. This example scores one mark for giving the temperature difference. If that had not been shown, this answer would have scored no marks, as the learner has attempted a calculation and then put the answer equal to 1.5 on the answer line and there are no correct steps.

Show your working.

$m = \frac{Q}{C \Delta T}$

100°C
- 20°C
80°C

(3)

$m = 4200$ $Q = 80 \times 1.5 \times 4q7000$

$Q = 80 \times 1.5 \times 4200$

mass of water = 1.5 kg

For **Q3aii** just over 67% of the cohort gained at least one mark, most learners who scored marks on this question scored both marks. A typical response, that shows very clearly how a well set out answer should look like is given here, this scored both marks.

Show your working.

$Q = \Delta mL$

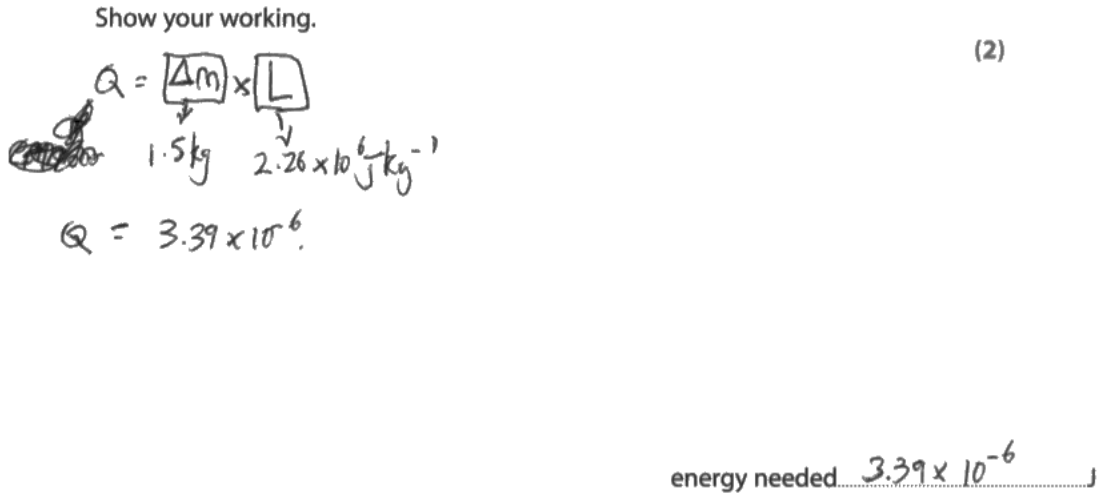
$Q = 1.5 \times (2.26 \times 10^6)$

$Q = 3390000 = 3.39 \times 10^6$ (2)

energy needed 3.39×10^6 J

Over half the cohort were able to give the fully correct answer for two marks.

This answer scored one mark, the calculation is fully correct, however the incorrect use of standard form lost a mark. Where learners did not score full marks, the wrong standard form, or the wrong number of zeros was the reason. Learners should spend some time checking their calculations to prevent this type of error.

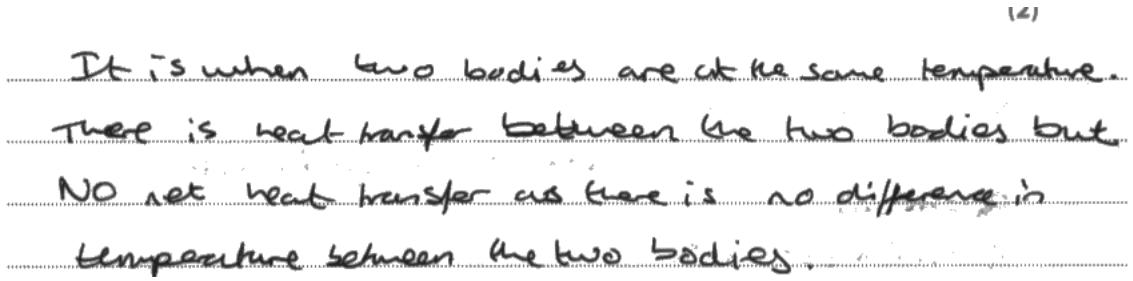


Some learners attempted to use the equation for 3ai to answer this part of the question, this was the most common reason for no marks to be scored here.

The final section of Q3 asked learners about two definitions of ideas in the specification. Both of these were not well answered. The ideas of thermal equilibrium and heat capacity appear to not be well understood by many learners.

Q3bi asked for a description of thermal equilibrium. Nearly 80% of learners were unable to score a mark for this. A tiny number scored full marks. Learners were expected to consider that there was a flow of energy in and out and that there was no net transfer, so describing a dynamic system. Many learners wrote about a flow of temperature, or that the temperature balanced which did not score marks.

A two mark response is shown here. The learner does mention temperature but does convey the idea of heat transfer and that there is no net transfer.



This learner has considered temperature alone so does not score any marks.

Describe what is meant by the term **thermal equilibrium**.

(2)

Thermal equilibrium is when two body are at the same temperature. Temperature balance.

Q3bii gave more marks. Nearly 50% of the cohort scored at least one mark, however it was a very few that scored full marks, less than 3%. Learners were able to state that thermal capacity was linked to the amount of energy, but then not go onto link it to temperature rise. Many learners therefore missed the second mark. Thermal capacity is a standard definition that links energy required to raising the temperature of a material. This response scored both marks.

Describe what is meant by the term **thermal capacity**.

(2)

Thermal capacity is the amount of energy needed to raise the temperature of a system by one degree.

The learner links energy required to a rise in temperature. 'one degree' was sufficient for the idea of temperature. A specific value of temperature was not required, the mark scheme wanted the link to temperature.

This kind of answer was quite rare, most that scored a mark considered the energy required, but not the temperature.

Many learners considered the term literally in the way that water would fill a tank for example, so they wrote about it being 'the maximum amount of heat that a body could take '. This is a typical answer that scored no marks.

Describe what is meant by the term **thermal capacity**.

(2)

The maximum temperature a material can reach.

Q4ai and ii were introductions to a question about the behaviour of gases and energy transfers. The definition of the conservation of energy, was the best known definition on the paper. Just under half the cohort could recall it. Some learners took the words literally and considered energy conservation in relation to saving energy and being environmentally friendly.

This example scored no marks

4 (a) (i) State the law of conservation of energy.

(1)

The conservation of energy is when energy is used up in an efficient way) and not wasted so it is conserved

Q4aii, was correctly answered by over 75% of the cohort, where answers were incorrect learners thought that the W in the equation meant watts in most cases.

Q4bi was one of the most challenging questions on the paper, it was mainly targeted at merit and distinction learners. The question asked learners to explain why the temperature of the air in a car tyre pump increased when the pump was used. Learners were expected to link the compression of the air to a decrease in volume or an increase in pressure of the air and then link the work done in compressing or increasing the pressure of the air on the air to an increase in the kinetic energy of the air molecules. To score full marks there had to be a clear link between the work cone on the air and an increase in kinetic energy. Many learners did not do this. In many cases learners wrote that because the pressure increased that the air molecules were pushed together, so collided more and that this increased the temperature. There was little or no realisation that there needed to be an energy input in some form to increase the kinetic energy, in this case provided by the work done on the air by compressing it.

This response scored all four marks. The learner states that the air pressure increases and on the sixth line indicates that the air is compressed and that is then linked to work being done on the air that results in an increase in kinetic energy of the air molecules. Such answers were rarely seen as the link between work done and increased kinetic energy was not made very often.

The temperature of the air in the barrel increases as the pressure of the air increases. This is because work is being done on the air and its is now being forced to move. As there The temperature increases due to the amount of kinetic energy ~~increasing~~ but of the molecules increasing. As work is being done on the air in when it is being compressed So it is forced to have energy is being transferred from potential energy to ~~kinetic energy~~ from the pump being pumped to the Kinetic energy of the air molecules

In many cases one or two marks were scored for answers that identified that the air was

compressed, and this resulted in an increase in the air pressure, or a reduction in the volume of air. Just over 50% of the learners in the cohort gained one mark or more. The number gaining more than two marks was less than 3%.

This answer scored the two hardest marks.

Explain why the temperature of the air in the barrel increases.

(4)

work is being done to the air inside the barrel as it is forced into the tyre. This causes the particles to gain more kinetic energy. colliding into each and ~~th~~ frequently transfering that energy.

Had the learner made a comment on the gas being compressed or there being in increase in pressure further marks could have been scored. Learners should be aware that the mark allocation gives an idea as to how many points should be made.

This answer also scored two marks, the learner making the points that the air is compressed, and the pressure increases. The learner then jumps to the temperature increasing without identifying where the energy required for this comes from. Many learners did this.

When pressure increases, temperature also increases. The air is being compressed and pressure and temperature increases as a result. Work is being done on the foot pump and the energy is converted into heat energy when atoms are compressed the pressure increases.

Many learners scored no marks for this question, mainly for considering the pump rather than the air or for identifying friction as being the reason the air heats up, despite being told in the question that friction is negligible.

Q4bii was a calculation that tested the use of an equation from the specification relating to the kinetic theory of gases. Over 80% of learners gained at least one mark, with over 30% scoring full marks.

This response scored full marks, with the calculation being set out and a good example of rounding at the end of the calculation.

$pV = nRT$

$n = \frac{pV}{RT} = \frac{(2.5 \times 10^5 \times 3.8 \times 10^{-4})}{(1.38 \times 10^{-23} \times 303)} = 2.271966327 \times 10^{22}$

$= 2.3 \times 10^{22}$

number of molecules = 2.3×10^{22}

Some learners rounded intermediate values, which then led to incorrect answers, the example below shows this. The example gained two marks.

Show your working.

(3)

$PV = NkT$

↑

No. of Particles

$\frac{PV}{kT}$

$2.5 \times 10^5 \times 3.8 \times 10^{-4} = 95$

$1.38 \times 10^{-23} \times 303 = 4.18 \times 10^{-21}$.

$\frac{95}{4.2 \times 10^{-21}} = 2.23 \times 10^{22}$

number of molecules = 2.23×10^{22}

The learner has correctly rearranged and substituted into the equation but has then rounded 4.18 to 4.2 before evaluating the answer. Learners should not round values at intermediate steps in their answers. Learners should use their calculated values and round in the final evaluation.

Many learners found the calculation difficult and, in their attempts, either substituted incorrectly, or were let down by their algebra and rearranged incorrectly. If learners did not score any marks but did quote the formula to be used a compensatory mark was

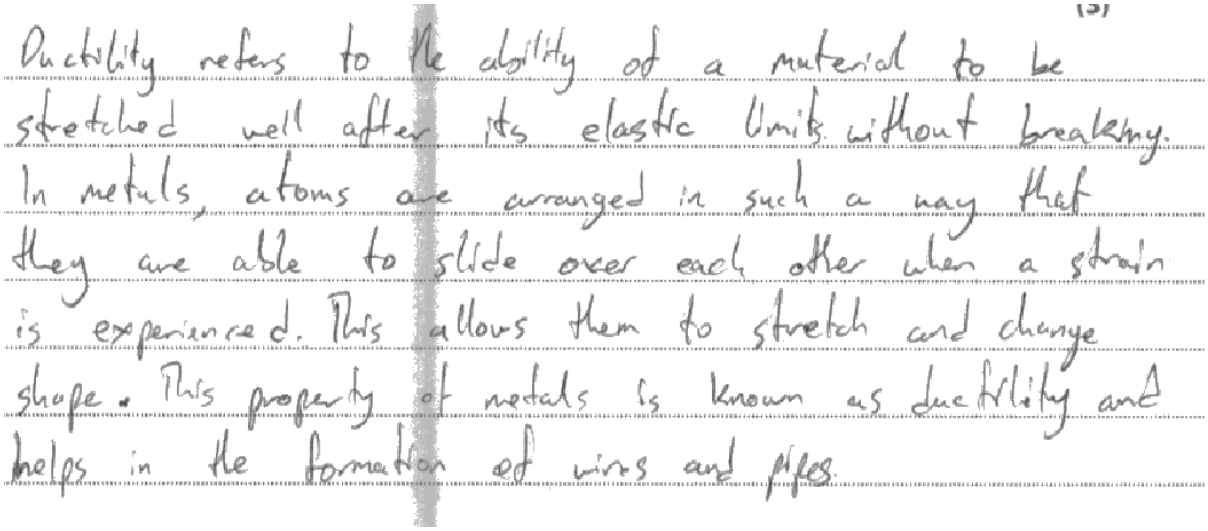
scored. This was the predominant reason many learners scored one mark.

The final question on the paper, Q5, was about materials and their properties.

Q5ai was a multiple choice question that scored very well, over 96% of learners gained the mark for answer C.

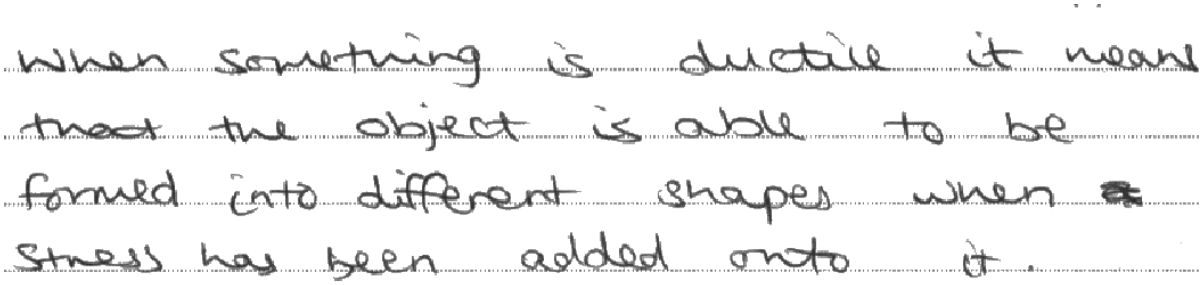
Q5b was much more poorly answered. The question asked learners to explain the term ductile. Over 60% of learners did not score a mark on this two mark item. The main reason was that learners explained the term malleable rather than ductile.

Full mark answers were rarely seen. The example below scored all the marks. The learner states that a ductile material can be stretched without breaking and that this allows it to be drawn into a wire, and finally gives an atomic explanation.


Ductility refers to the ability of a material to be stretched well after its elastic limit without breaking. In metals, atoms are arranged in such a way that they are able to slide over each other when a strain is experienced. This allows them to stretch and change shape. This property of metals is known as ductility and helps in the formation of wires and pipes.

Some learners stated that the wire could be pulled or drawn into wires, but then went no further.

Many learners gave answers such as the one below. These were about malleability rather than ductility.


when something is ductile it means that the object is able to be formed into different shapes when a stress has been added onto it.

Q5ci was the final calculation on the paper, this was a four mark question that required

learners to use a given equation and substitute, rearrange, convert and then evaluate a final answer. Many learners were able to substitute and rearrange to find a value but could not correctly convert to get the final answer. Nearly 30% of the cohort gained two or more marks for this calculation that was targeted at merit and distinction learners. A considerable number were able to gain one mark for identifying that the extension was 0.4cm. This was a compensatory mark given if no other mark was scored.

This is an example of a typical four mark answer. The learner sets out the calculation and converts before evaluating.

Show your working.

(4)

$W = \frac{1}{2} F x$

$F = \frac{W}{\frac{1}{2} x}$

$= \frac{100}{0.5 \times 0.4 \times 10^{-2}}$

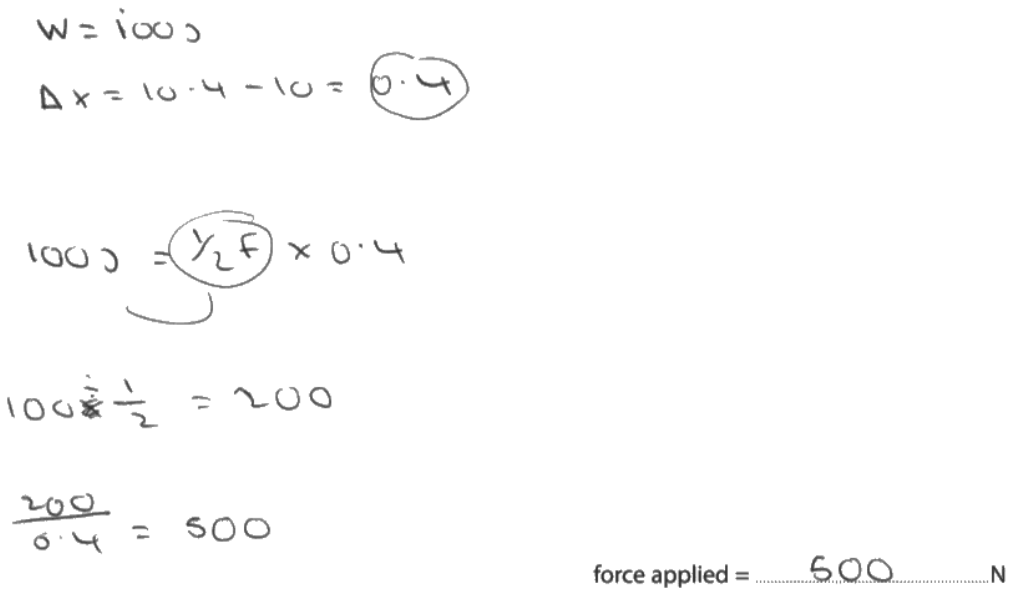
$= 50000$

force applied = 50000 N

Many learners either did not convert 0.4cm to 0.004m or did this incorrectly, the typical answer of 500N was obtained by learners that did not convert the cm tom, they gained 3 marks as all other steps were carried out correctly. The example below shows this.

Show your working.

(4)



Learners should be aware that most of the equations used in this part of the qualification operate with the appropriate SI unit. So for calculations involving length the values should be converted to metres from whatever values they are given in, similarly, vales of mass in grammes should be converted to kilogrammes.

Where learners gained zero marks, it was usually for using 10.4 directly so losing the substitution mark and the following marks.

Q5cii was the final question on the paper and was the six mark levelled question. It asked learners to consider a stress strain graph and to explain two regions of the graph identified in the question. In order to score full marks, learners had to consider both parts fully including an atomic explanation of why the steel behaved in the way the graph showed. Many learners simply described the shape of the graph, and this did not score any marks. Nearly 50% of learners were able to gain two marks for identifying key features from the graph and over 15% were able to score four marks for a fuller explanation of the features. Very few learners were able to fully explain the graph using an atomic model and sio there were few learners gaining six marks.

This response gained level 3 six marks. The learner explains features from two parts of the graph and then uses an atomic model to explain them. They have used ideas drawn from the indicative content.

(6)

From O to A, the stress applied to the steel bolt increases directly proportionally to the strain, obeying Young's Modulus $E = \frac{\text{Stress}}{\text{Strain}}$. ~~A is known as the~~ From O to A, that section of the graph shows the plastic deformation, where molecules ~~are~~ move further apart however, can still go back to their original position as long as they don't go beyond the yield point (B). A is known as the elastic limit, beyond it, the material becomes yielded and plastic deformation starts to occur, this happens between point B and C. Throught that section the materials layers of molecules slide over each other and cannot go back to their original form, meaning that steel will be permanantly deformed. At point C finally, the limit of plastic deformation is reached and the material breaks.

This response gained a level 2 4 marks. The response is very good, however without an atomic model being explained the mark was limited to a maximum of 4 marks, as a complete explanation woyld require this to be present.

Area O to A obeys Hook's Law because it is directly proportional to stress and strain / force and extention and ~~ge~~ goes through ~~the~~ the orgion.
This is the area of the graph where the steel bolt had not reached it's elastic limit / yelid strengh.
At area B to C the graph ^is no longer a straight line and does not increases this shows that it no longer obeys Hook's Law.
Futhermore, at point B to C ~~it~~ the graph also shows that the bolt is starting to become brittle as the excess stress is causing ~~roe~~ cracks to appear, until at point C the material has snapped due to the cracks increasing.

Futhermore the graph shows that the length of the steel bolt will slightly increase due to the stress test and force being ~~pe~~ applied/excess pressure.

The response below gained a level 1 2 marks for making some basic points, but these are not explained.

Between O to A the stress is increasing as well as the strain.
Then between B to C, B decreases slightly and then gradually increases again
Stress is the amount of force put onto an object
Strain is how the force affects the object such as fatigue.
So, between O and A force is being applied gradually to see how much force the steel bolt can handle.
Then at B it dips on the stress a bit which is when the steel bolt reaches its yield just before fatigue or creep.
Then the graph increases gradually to C but not in a straight line, this could show that the bolt has change shape through fatigue making it weaker and not being able to bear so much force which is why at C start to decrease at the end of the graph because it is going towards failure which is when the metal substance in this case the steel bolt snaps and is broken due to the increased force on it.

The learner devotes a good deal of the answer to describing the shape of the graph. Two aspects are credit worthy, the comment on yield point and breaking point. Without these this learner would have not scored marks.

This question was about explaining the behaviour of the steel, this required comments

and justifications. Many learners that did score on this question could have done better if they had justified the comments made.

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