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OCR
Oxford Cambridge and RSA

GCSE (9-1)

Examiners' report

GATEWAY SCIENCE COMBINED SCIENCE A

J250

For first teaching in 2016

J250/09 Summer 2023 series

Version 1

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Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Paper 9 series overview

Candidates generally performed well on this paper, demonstrating a wide variety of skills. While there were some misconceptions evident in the responses given, there were many areas where candidates have been more successful than in previous series.

Candidates performed well with the Level of Response question on electrolysis. Calculations were generally well performed with significant figures and decimal places expressed well. Candidates could correctly draw the shape of an exothermic reaction profile.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• demonstrated a knowledge of isotopes and how the number of protons determines the type of atom • calculated Rf values effectively • described how the structure of allotropes of carbon related to their properties • described and explained how to carry out electrolysis to extract copper from copper sulfate • described trends in a graph and related this to changes in the concentration of hydrogen ions • used a graph of concentration against pH to determine the mass of an acid present in a sample of a given volume • calculated energy transferred when bonds are broken and made to determine the total energy change and hence described the reaction as endothermic or exothermic • carefully drew a suitable reaction profile with correctly placed arrows and labels.	• were less successful at drawing the electron arrangement in ions • found it difficult to explain how the structure and bonding of an ionic compound related to its melting point • were less successful at identifying the stationary and mobile phase in thin layer chromatography • mixed up ideas about types of bonding and intermolecular forces when describing the similarities and differences in the properties of allotropes of carbon • struggled to draw a working diagram for carrying out electrolysis in the laboratory in their centre • were less successful at expressing ideas of working scientifically when explaining that pH would be better measured using a pH meter rather than universal indicator paper • found it difficult to calculate the total energy change for a reaction • struggled to accurately draw arrows on a reaction profile to describe the total energy change and the activation energy.

Section A overview

The multiple choice questions were generally well answered with Questions 5, 6, 9 and 10 being the most challenging for candidates.

Question 1

1 Which substance is described as **pure** by a scientist?

A A solution of sodium chloride

B An alloy

C Dilute sulfuric acid

D Distilled water

Your answer ☐ **[1]**

The majority of responses to this question were correct. The most common incorrect response was B, showing a lack of understanding of an alloy.

Question 2

2 A metal oxide has the formula $\mathbf{X}_2O$, where **X** is a Group 1 metal.

The relative formula mass of the metal oxide is 94.2.

Relative atomic mass (A_r): O = 16.0

What is the name of **X**?

A Lithium

B Potassium

C Rubidium

D Sodium

Your answer ☐ **[1]**

This required a calculation from the data and an understanding of chemical formula. It was pleasing to see that most responses were correct here.

Question 3

3 Which gas bleaches damp litmus paper?

A Carbon dioxide

B Chlorine

C Hydrogen

D Oxygen

Your answer ☐ **[1]**

Most candidates were given the mark for identifying the gas test described was to test for chlorine.

Question 4

4 Copper carbonate reacts with dilute hydrochloric acid to form copper chloride, water and a gas.

What is the formula of the gas?

A C

B CO

C CO_2

D CO_3

Your answer ☐ **[1]**

Most responses successfully identified the formula of carbon dioxide.

Question 5

5 Which row lists the material that has the weakest **intermolecular** forces?

Material	Structure	Melting point (°C)
A	giant covalent	1713
B	ionic compound	801
C	metal	98
D	polymer	105

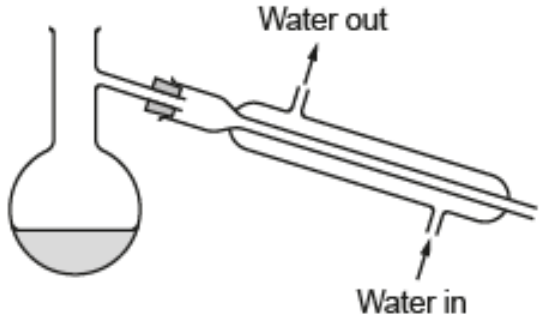
Your answer ☐ **[1]**

Candidates understood that weak intermolecular forces lead to lower melting points, however there was a lack of understanding that metals do not exhibit this type of force. This gave a common incorrect response of C rather than the correct response of D.

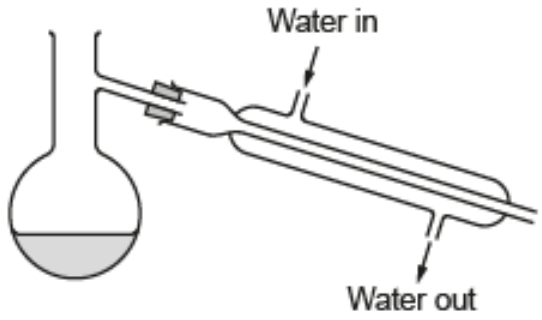
Question 6

6 Which diagram shows the correct equipment diagram for simple distillation?

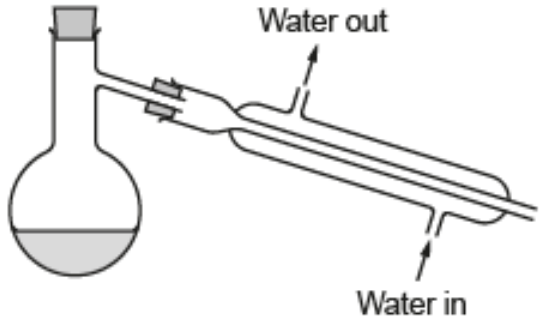
A



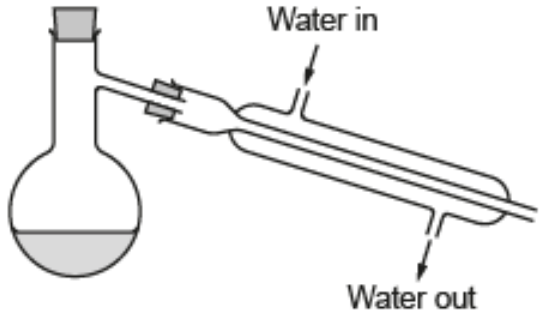
B



C



D

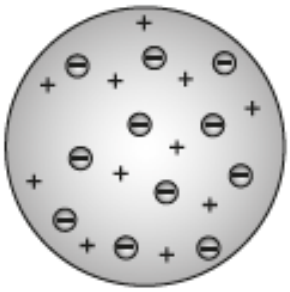


Your answer ☐ **[1]**

Candidates could identify the need for a bung in the top of the round bottom flask. The majority of candidates demonstrated a misconception of the direction of water flow within the condenser. An incorrect response of D was seen, rather than the correct response of C, with water going in at the bottom and out of the top of the condenser.

Question 7

7 Which scientist developed this model of the atom?



A Bohr

B Dalton

C Rutherford

D Thomson

Your answer ☐ **[1]**

The majority of responses identified the scientist responsible for this model.

Question 8

8 Lead, Pb, and dilute nitric acid, HNO_3 react.

$$Pb + xHNO_3 \rightarrow Pb(NO_3)_2 + yNO_2 + zH_2O$$

Which row correctly balances the equation?

	x	y	z
A	2	4	2
B	4	2	4
C	4	2	2
D	4	4	2

Your answer ☐ **[1]**

Most responses successfully balanced the equation and gave the correct response of C.

Question 9

9 This is the symbol for helium.

2
He
4.0

What is the mass of one atom of helium?

The Avogadro constant = 6.02×10^{23}

A 3.32×10^{-24} g

B 6.64×10^{-24} g

C 1.51×10^{23} g

D 3.01×10^{23} g

Your answer ☐ **[1]**

This question required a calculation. Only a small number of responses successfully calculated the mass of one atom using the information given.

Question 10

10 The diagram shows the particle model for the condensation of a gas into a liquid.

Which is a limitation of the particle model?

A It does not show the arrangement of the particles.

B It does not show the movement of the particles.

C It does not take account of the energy of the particles.

D It does not take account of the forces between particles.

Your answer ☐ **[1]**

Responses to this question gave both B and C as incorrect responses. The specification clearly states that the particle model is limited as it does not take into consideration the forces between particles.

Section B overview

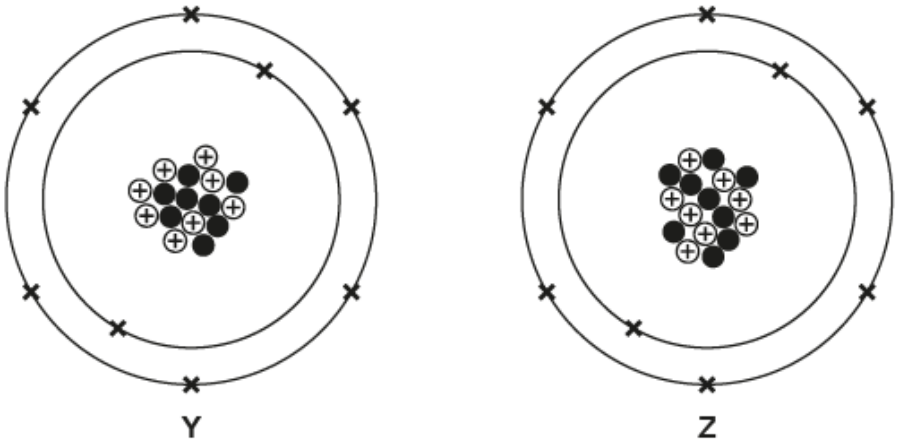
Candidates used the spaces given to them wisely and offered responses to almost all questions. Accuracy of diagrams is perhaps the key area for improvement moving forward to future series.

Question 11 (a)

11 Atoms of the same element can have different structures.

Fig. 11.1 shows the structure of two different atoms, **Y** and **Z**, of the same element.

Fig. 11.1



(a) What name is given to different atoms of the same element such as **Y** and **Z**?

..... **[1]**

Most responses identified these elements as isotopes.

Question 11 (b)

(b) Write the number of protons, neutrons and electrons in an atom of **Z**.

Number of protons = ...

Number of neutrons = ...

Number of electrons = ... **[2]**

Candidates could interpret the diagrams effectively to give the correct number of protons, neutrons and electrons.

Question 11 (c)

(c) Write the **mass number** of an atom of **Z**.

Mass number of an atom of **Z** = ... **[1]**

Most responses added together the number of protons and neutrons to give the correct mass number.

Question 11 (d)

(d) Write the name of the element that contains atoms of **Y** and **Z**.

Use the Periodic Table.

..... **[1]**

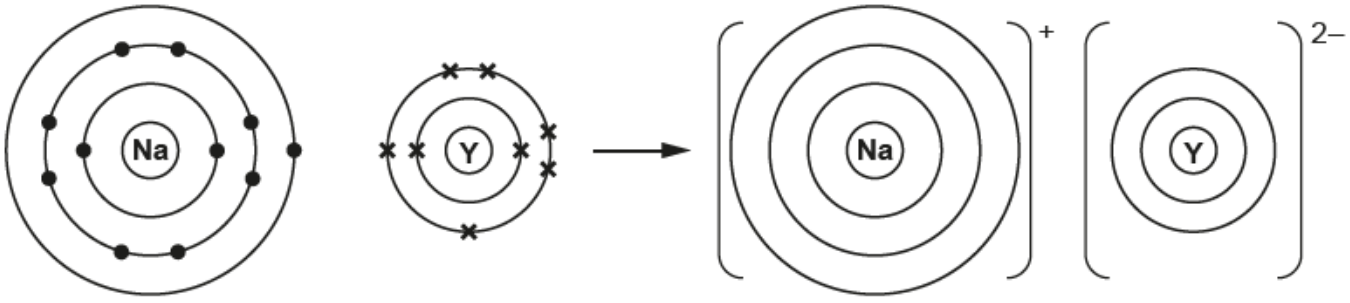
Most responses identified the element as oxygen, however the small number of candidates that did not gain credit for the correct number of protons, were given credit for identifying the element from their correct number of protons.

Question 11 (e) (i)

(e) Atoms of sodium react with atoms of **Y** to form an ionic compound.

Fig. 11.2 shows the ions formed when an atom of sodium reacts with an atom of **Y**.

Fig. 11.2



(i) Complete **Fig. 11.2** to show the arrangement of electrons in the ions. **[2]**

A number of candidates missed this question. Perhaps those candidates that did not read through the whole stem of the question, but instead skipped to the command words meant this question had a higher omission rate than expected. Not having eight electrons in the outer shell was the biggest misconception of the electronic configuration of an ion.

Question 11 (e) (ii)

(ii) What is the formula of the ionic compound formed when atoms of sodium react with atoms of **Y**?

Tick (✓) **one** box.

NaY_2 ☐

Na_2Y ☐

Na_2Y_2 ☐

[1]

Most responses identified the formula of the compound as the middle box.

Question 11 (e) (iii)

(iii) Why does sodium react with **Y** and **Z** in a similar way?

Tick (✓) **one** box.

Atoms of **Y** and **Z** have the same number of electrons. ☐

Atoms of **Y** and **Z** have the same number of neutrons. ☐

Atoms of **Y** and **Z** have the same number of protons. ☐

[1]

Most responses identified the number of electrons as the essential factor involved in a reaction.

Question 11 (e) (iv)

(iv) The ionic compound formed in **Fig. 11.2** has a high melting point.

Explain why. Use ideas about structure and bonding.

.....

.....

.....

.....

.....

..... **[3]**

They key areas for discussion in this question are the strength and type of the bonds and forces. The expectation was that candidates could link the electrostatic forces for attraction between positive and negative ions, to the amount of energy needed to overcome these forces. The majority of candidates could link the strength of the forces to the amount of energy needed to overcome them.

Exemplar 1

Because ionic ~~bonding~~ lattice consists of strong electrostatic forces of attraction between the oppositely charged ions and they consist of a metal and a non-metal. Due to the electrostatic forces of attraction being strong, a high amount of energy is required to break the bonds which is why the ionic compound has a high melting point. **[3]**

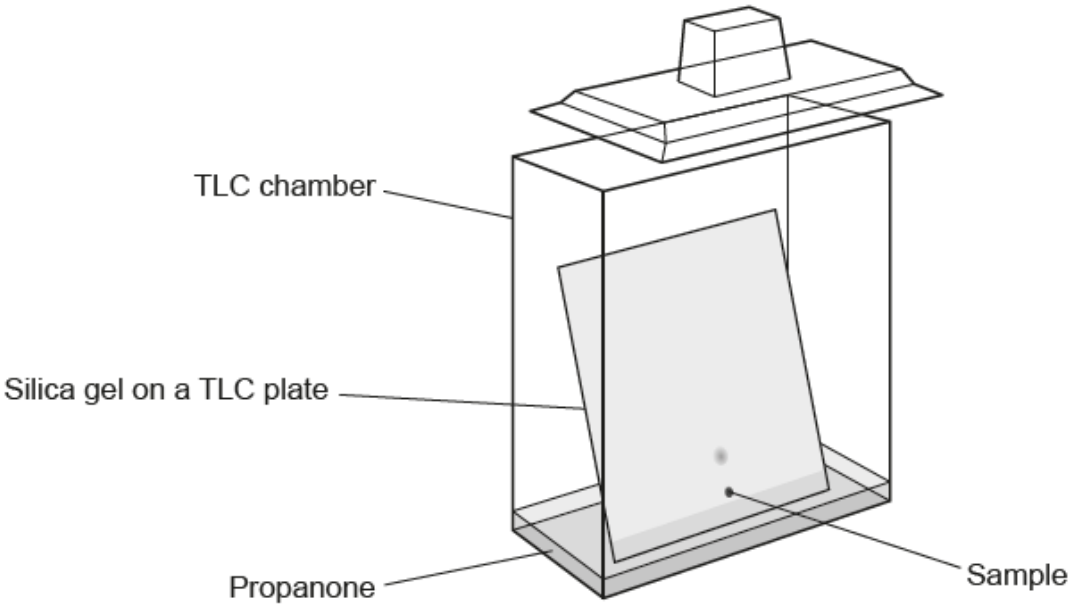
This response was given 3 marks and shows a clear understanding of the electrostatic forces of attraction between oppositely charged ions and the amount of energy needed to overcome these forces.

Question 12 (a)

12 Thin layer chromatography (TLC) is used to analyse and identify unknown samples.

Fig. 12.1 shows the apparatus used for thin layer chromatography.

Fig. 12.1



(a) Identify the stationary phase and mobile phase shown in **Fig. 12.1**.

Stationary phase .....

Mobile phase .....

[2]

Candidates found it easier to identify the mobile phase as the propanone (solvent). When trying to describe the stationary phase, a number of candidates gave the response of the 'sample'. This showed a lack of understanding that the sample is the substance that will be separated by moving up the stationary phase as the mobile phase progresses.

Question 12 (b)

(b) What determines how far the sample travels up the TLC plate?

Tick (✓) **one** box.

The amount of sample used. ☐

The size of the TLC chamber. ☐

The type of solvent used. ☐

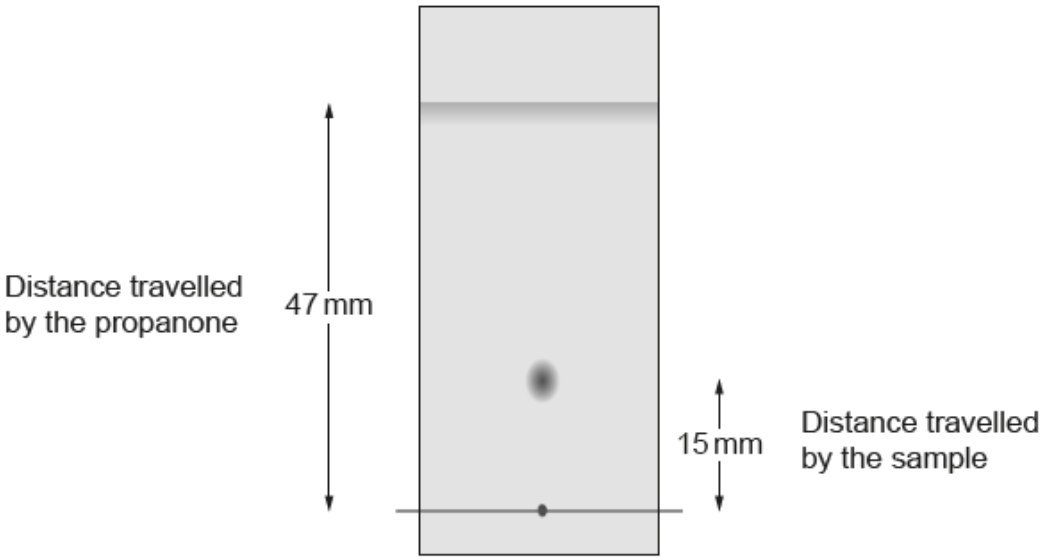
[1]

Most candidates could identify the type of solvent as the determining factor for how far the sample travels.

Question 12 (c) (i)

(c) **Fig. 12.2** shows the final TLC plate for a sample.

Fig. 12.2



(i) Calculate the R_f value for the sample.

Give your answer to **2** decimal places.

R_f value for sample = ... **[3]**

The vast majority of responses successfully calculated the Rf value from the data given. Where the candidates had not calculated the value correctly, they could at least give their value to two decimal places.

Question 12 (c) (ii)

(ii) The table shows the R_f values for four different substances.

Substance	R_f value
A	0.23
B	0.57
C	0.30
D	0.18

Use your answer to **(i)** to identify which substance, **A**, **B**, **C** or **D**, is the sample.

Tick (✓) **one** box.

The sample is substance **A** ☐ **B** ☐ **C** ☐ **D** ☐

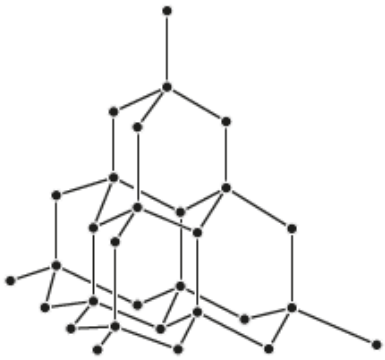
[1]

Most responses identified the substance as C.

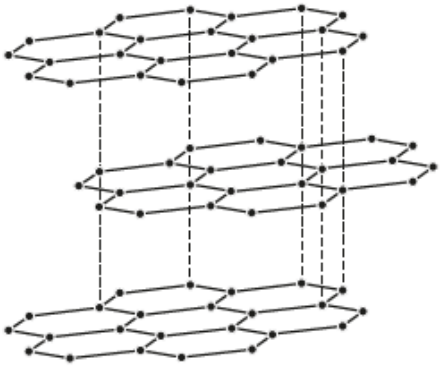
Question 13 (a)

13 Diamond and graphite are different forms of the same element.

The diagrams show the structures of diamond and graphite.



Diamond



Graphite

(a) Describe and explain **one** property of graphite that is **different** from diamond.

Property .....

Explanation .....

.....

.....

..... **[3]**

There were several ways in which marks were given for this question. The responses that were given the most marks discussed the ability of graphite to conduct electricity. Identifying this property allowed candidates to discuss delocalised electrons that are free to move. Candidates seemed well prepared to give these responses. Where candidates discussed layers of graphite, they struggled to link this to the property of softness of the graphite structure.

Question 13 (b)

(b) Describe and explain **one** property that is **similar** for both diamond and graphite.

Property .....

Explanation .....

.....

.....

..... **[3]**

Candidates identified the property of high melting point being common to both allotropes. They also discussed the large amount of energy needed to break these bonds. The more difficult concepts seemed to be that these are both giant covalent structures.

Question 13 (c)

(c) A student thinks that the models used to represent diamond and graphite have limitations.

Give **one** reason why they are **correct**.

.....

..... **[1]**

Candidates gave a variety of responses but were often not clear on their descriptions. Few candidates gave a clear limitation of the models. Perhaps centres could advise candidates to redirect their attention to the stem of the question and the diagrams available that might have helped them organise their ideas more carefully.

Question 14*

14* Copper sulfate solution, $CuSO_4$, contains copper ions, Cu^{2+}, and sulfate ions, SO_4^{2-}.

A student extracts copper from copper sulfate solution using electrolysis.

They use the following equipment:

- a power pack
- a small glass beaker
- crocodile clips
- carbon electrodes
- wires.

Describe and explain how the student extracts copper from the copper sulfate solution using the equipment provided.

Include a labelled diagram of how the equipment is used.

.....

.....

.....

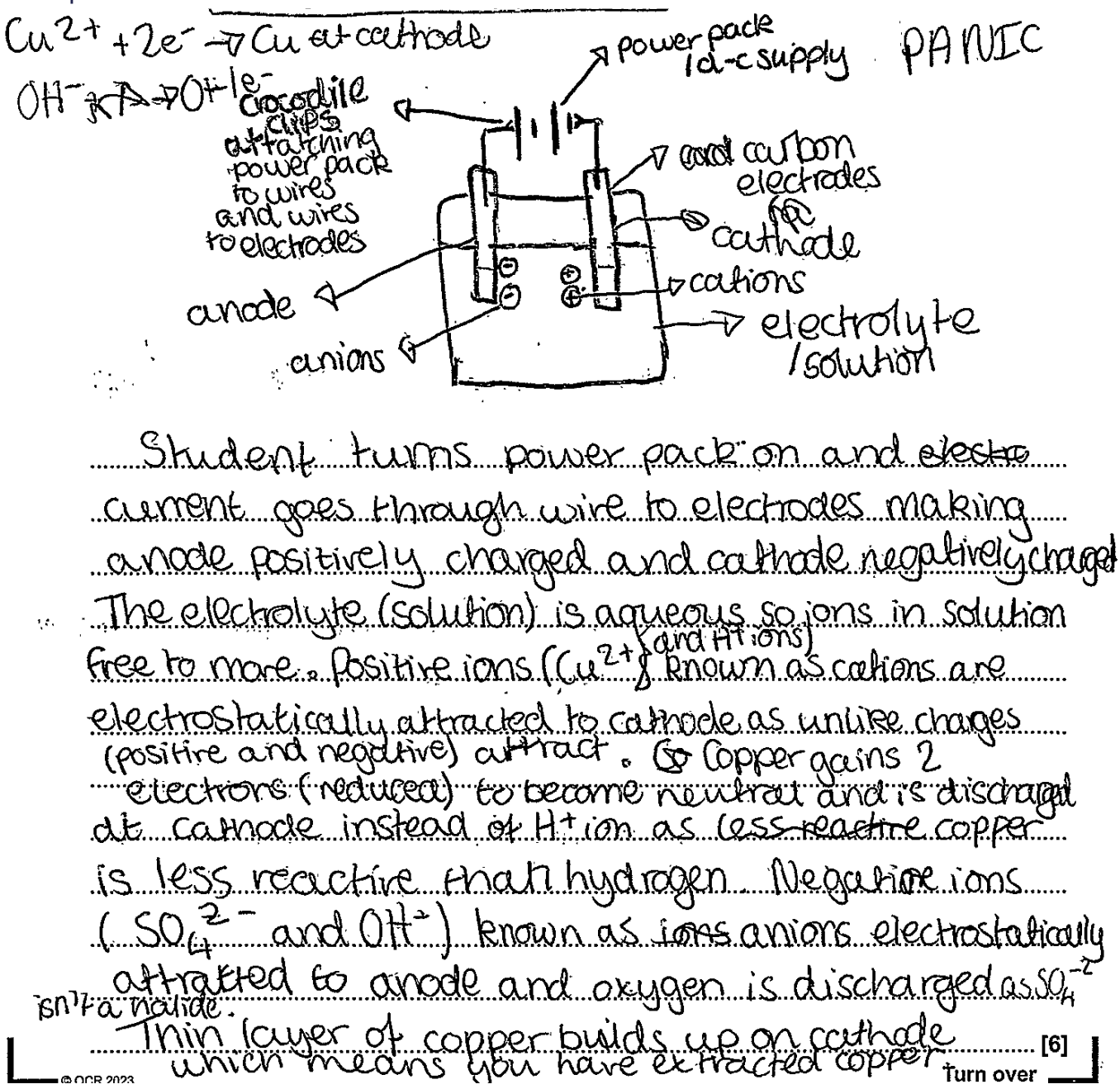
.....

.....

..... **[6]**

Almost all candidates followed the guidance in the stem of the question and attempted to draw a diagram. Some diagrams had electrodes above the copper sulfate solution, so this wouldn't work. Some diagrams had the anode and cathode connected incorrectly to the terminals of the power pack, e.g. the positive terminal connected to the cathode rather than anode. These circuits would not work. The majority of responses were given Level 2 or Level 3 marks after giving clear descriptions of the process in terms of the movement of ions to the correct electrodes. The candidates that gained Level 3 also explained the process of reduction in terms of a gain of electrons at the cathode where copper atoms could be collected. It was pleasing to see half equations correctly written to describe the reduction.

Exemplar 2



Student turns power pack on and electric current goes through wire to electrodes making anode positively charged and cathode negatively charged. The electrolyte (solution) is aqueous so ions in solution free to move. Positive ions (Cu^{2+} and H^+ ions) known as cations are electrostatically attracted to cathode as unlike charges (positive and negative) attract. Copper gains 2 electrons (reduced) to become neutral and is discharged at cathode instead of H^+ ion as less reactive copper is less reactive than hydrogen. Negative ions (SO_4^{2-} and OH^-) known as ~~ions~~ anions electrostatically attracted to anode and oxygen is discharged as SO_4^{-2} ~~isn't a halide~~. Thin layer of copper builds up on cathode which means you have extracted copper [6]

 Turn over

This 6 mark response includes a clear diagram of the equipment set up to carry out the process of electrolysis of copper sulfate. The description and explanation are clear and follow a logical order. This exemplar also gives an explanation of reduction at the cathode. It goes on to suggest an explanation of oxidation at the anode, which was not essential to reach Level 3.

Question 15 (a)

15 (a) Describe the difference between a strong acid and a weak acid.

.....

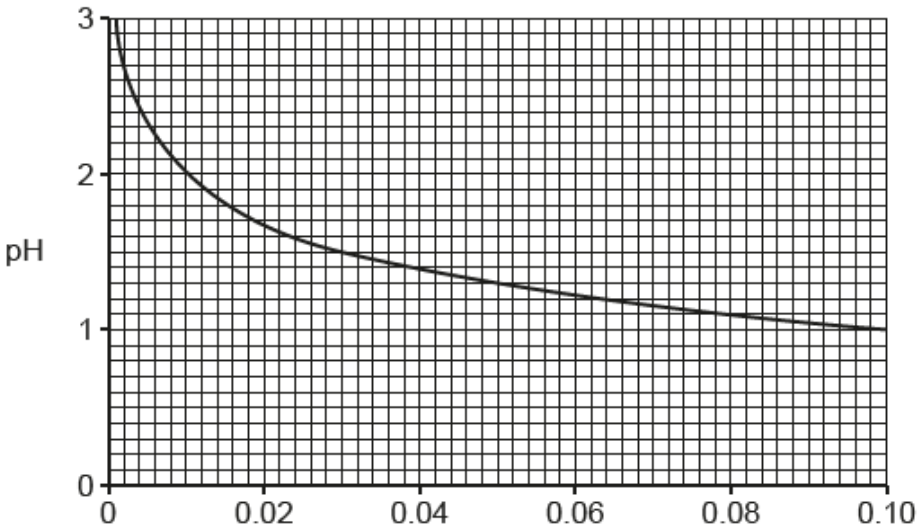
..... **[1]**

Responses found it a challenge to describe the difference between strong and weak acids. The words 'dissociate' and 'ionised' were rarely seen.

Question 15 (b) (i)

(b) Hydrochloric acid, $HCl(aq)$, is an example of a strong acid.

The graph shows the pH of a dilute hydrochloric acid solution at different concentrations.



(i) Write the formula of the ion that gives the dilute hydrochloric acid solution the pH shown on the graph.

..... **[1]**

A small number of responses identified H+ ions as the ion responsible for pH.

Question 15 (b) (ii)

(ii) The pH of the dilute hydrochloric acid solution can be measured using either universal indicator or a pH meter.

Explain which method would be better to use for measuring the pH shown on the graph.

.....

.....

.....

..... **[2]**

Most responses gained credit for the idea that a pH meter was more accurate than the universal indicator paper but few could articulate their ideas clearly about the judgement needed with universal indicator.

Question 15 (c)

(c) Describe how the pH changes with the concentration of dilute hydrochloric acid solution on the graph.

.....

.....

.....

.....

[2]

A significant number of responses were given 1 mark for describing how the concentration changes with pH. Those responses that gained both marks used the shape of the graph to add detail to their response.

Misconception

Concentration and strength of acids are often confused. Candidates need to describe the strength of an acid as the amount of dissociation that takes place, and therefore more dissociation leads to more free hydrogen ions, which decreases the pH. Concentration simply relates to the amount of a substance present, without the extent of the dissociation being considered.

Question 15 (d)

(d) As the concentration of the dilute hydrochloric acid solution increases by a factor of ten, the pH of the solution decreases by one.

Use data from the graph to show that this statement is **true**.

.....

.....

.....

..... **[2]**

The expectation in this question was that candidates would use the data from the graph to prove the statement correct. This required two sets of data points to be compared. Many candidates couldn't accurately read the data. At pH 3, zero was often misquoted rather than the correct value of 0.001 to allow a direct comparison.

Question 15 (e)

(e) Calculate the mass of hydrochloric acid, HCl, in $100\,cm^3$ of solution that gives a pH 1.5.

Use data from the graph.

Give your answer to **2** significant figures.

Relative molecular mass (M_r): $HCl = 36.5$

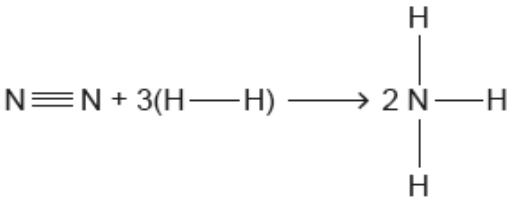
Mass of hydrochloric acid in $100\,cm^3$ = ... g **[4]**

Very few responses correctly processed the calculation to give a response to two significant figures. The most common errors were in the conversion of pH 1.5 to a concentration of 0.03 moles per decimetre cubed from the graph. If this conversion took place then candidates could multiply by 36.5. The missing step was then dividing by 10 to find the mass in 100 cubic centimetres.

For those candidates that did complete the calculation, it was pleasing to see the steps laid out clearly.

Question 16 (a) (i)

16 The reaction between nitrogen, N_2, and hydrogen, H_2, to form ammonia, NH_3, is an exothermic reaction which is shown in this equation.



The table shows some bond energies.

Bond	Bond energy (kJ/mol)
N≡N	945
H–H	435
N–H	390

(a) (i) Calculate the total energy transferred to break all the bonds in the reactants.

Energy transferred to break all the bonds = ... kJ/mol **[1]**

Most candidates correctly calculated the total energy transferred when bonds are broken.

Question 16 (a) (ii)

(ii) Calculate the total energy transferred when all the bonds in the products are made.

Energy transferred when all the bonds are made = ... kJ/mol **[1]**

Fewer responses correctly calculated the total energy transferred when bonds form compared to bonds broken.

Question 16 (a) (iii)

(iii) Use your answers to parts **(i)** and **(ii)** to calculate the energy change for the reaction.

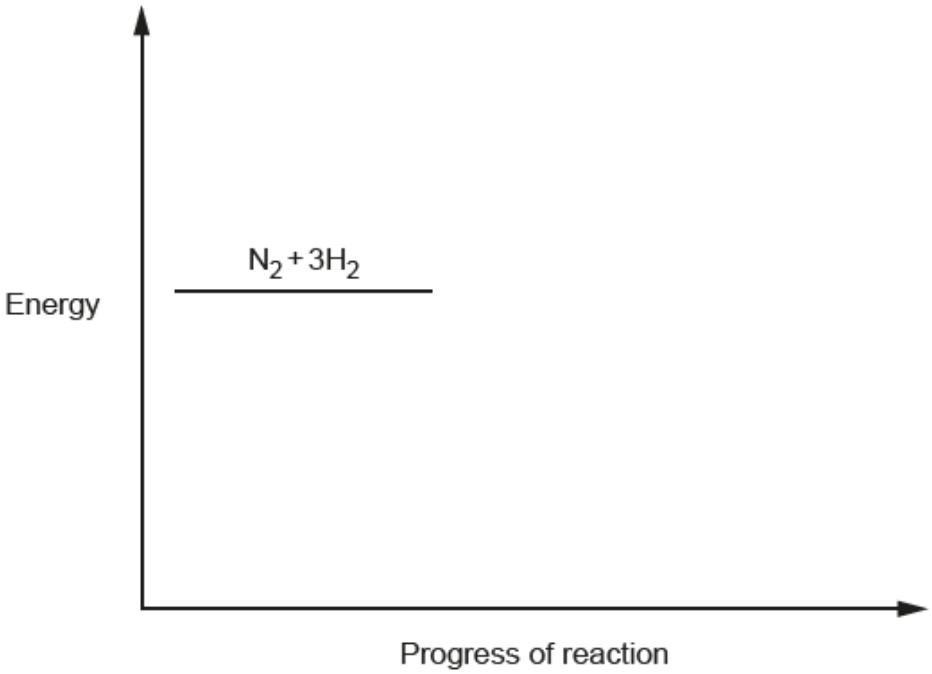
Energy change = ... kJ/mol **[1]**

For those responses that correctly calculated the energy transfers in Question 16(a)(i) and Question 16(a)(ii), the overall energy change was a straight forward subtraction. Misconceptions were in the form of subtracting the wrong way around.

Question 16 (b)

(b) Complete the reaction profile for the exothermic reaction of nitrogen, N_2, and hydrogen, H_2, to form ammonia, NH_3.

Label the energy change in the reaction and the activation energy.



[3]

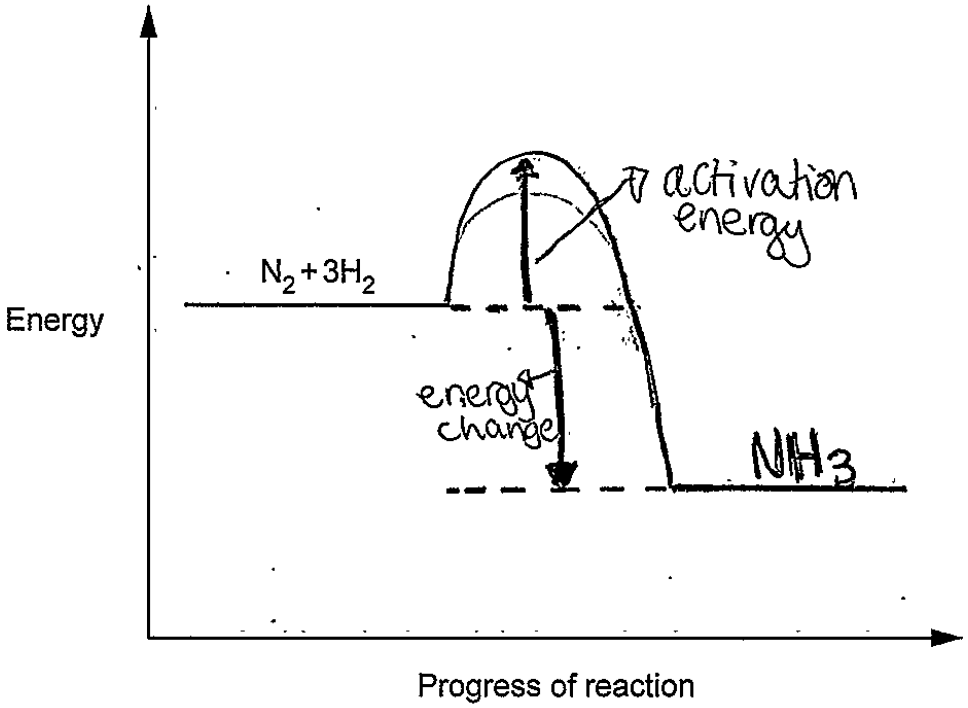
Most candidates were given marks for drawing the correct shape for the reaction profile and labelling the product line. However there were few responses that correctly drew the arrows to represent the activation energy and the total energy released. Double headed arrows were commonly drawn rather than the single arrows

Exemplar 3

19 heat exits reaction and temp of surroundings increase

(b) Complete the reaction profile for the exothermic reaction of nitrogen, N_2, and hydrogen, H_2, to form ammonia, NH_3.

Label the energy change in the reaction and the activation energy.



[3]

This 3 mark response shows how the arrows for activation energy and energy released should be correctly drawn.

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