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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 2019 series

Version 1

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. 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 can be downloaded from OCR.

Paper 9 series overview

The paper appeared to have suitable timing and all questions were accessible as there were very few questions that were not attempted.

Diagrams seemed to cause the most problems to candidates. Centres should perhaps focus on the recall of energy level diagrams for exothermic and endothermic reactions, as well as ionic, covalent and metallic bonding.

Calculations were well attempted, but centres should focus on the understanding of significant figures when expressing a final answer.

Section A overview

Multiple choice questions were positively approached and well answered. Candidates deduced answers and working was often shown with the correct answer selected.

Question 1

1 Which statement best describes an atom?

A The nucleus is small compared to the atom and contains little of the atom's mass.

B The nucleus is large compared to the atom and contains little of the atom's mass.

C The nucleus is small compared to the atom and contains most of the atom's mass.

D The nucleus is large compared to the atom and contains most of the atom's mass.

Your answer ☐ **[1]**

Most candidates could identify the nucleus is small in comparison to the atom and contains most of the mass. Incorrect responses usually gave letter D, suggesting candidates did not understand the size of the nucleus in comparison to the rest of the atom.

Question 2

2 Metals can have atoms of other elements mixed with them to change their properties.

What is the name for the type of substance formed?

A Alloy

B Compound

C Solution

D Suspension

Your answer ☐ **[1]**

Where an incorrect response was given, candidates tended to confuse Alloys and Compounds.

Question 3

3 How are atoms arranged in the modern Periodic Table?

A In order of atomic number

B In order of relative atomic mass

C In order of the number of neutrons

D In order of reactivity

Your answer ☐ **[1]**

Candidates were confused between the atomic number and relative atomic mass. This shows a misconception that needs to be addressed in centres. It should be made clear to candidates that the development of the periodic table moved from arranging the atoms in order of relative atomic mass to that of the increasing atomic number. Several seem stuck with the ideas that was discarded.

Question 4

4 Which separation technique in the laboratory requires a condenser?

A Chromatography

B Crystallisation

C Filtration

D Distillation

Your answer ☐ **[1]**

Candidates were very good at identifying distillation as the separation technique that requires a condenser.

Question 5

5 The following table contains information about protons, neutrons and electrons.

Particle	Relative mass	Relative charge
Proton	1	+1
Neutron	1	–1
Electron	0.0005	–1

One piece of information in the table is **incorrect**.

Which correction needs to be made?

A Electron charge should be 0.

B Electron mass should be 1.

C Neutron charge should be 0.

D Proton charge should be 0.

Your answer ☐ **[1]**

Almost all candidates could identify the error in the table as the neutron and that it should have a charge of zero.

Question 6

6 The particle model does not take into account certain information about the particles.

Which of the following **does** the particle model take into account?

A The size of the particles.

B The space between the particles.

C The number of particles.

D The force of attraction between the particles.

Your answer ☐ **[1]**

This question gave a wide variety of responses. Only higher ability candidates were able to identify the number of particles as being correctly represented in the particle model.

Question 7

7 Magnesium ions react with chloride ions to form magnesium chloride.

What is the correct ionic equation for this reaction?

A $Mg^{+} + Cl^{-} \longrightarrow MgCl$

B $Mg^{2+} + Cl^{2-} \longrightarrow MgCl$

C $Mg^{2+} + 2Cl^{-} \longrightarrow MgCl_2$

D $Mg^{2+} + Cl^{-} \longrightarrow Mg_2Cl$

Your answer ☐ **[1]**

Most candidates could identify the correct charge on the magnesium ions, as response A was the least favoured response. Response D was the most common incorrect response, showing a lack of understanding of the construction of a formula.

Question 8

8 The table shows bond energies.

Bond	Bond energy (kJ/mol)
H–H	436
Cl–Cl	243
H–Cl	432

Hydrogen reacts with chlorine to form hydrogen chloride.

$H–H + Cl–Cl \longrightarrow 2\ H–Cl$

What is the energy change, in kJ/mol?

A –247

B –185

C +185

D +247

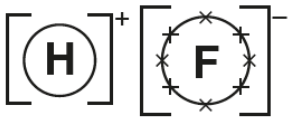
Your answer ☐ **[1]**

This was generally well answered, but where the candidates selected an incorrect response, it was usually due to choosing the incorrect sign and so 'C' was the most popular incorrect response given. Some candidates gave very clear working out in the space at the side of the question but chose the wrong sign for their numerical value.

Question 9

9 Which diagram correctly shows the bonding in a molecule of hydrogen fluoride?

A



B

C

D

Your answer ☐ **[1]**

A significant number of candidates could correctly identify the dot and cross diagram of hydrogen fluoride.

Question 10

10 What is the mass of 2 moles of calcium hydroxide?

A 148.2 g

B 164.1 g

C 220.1 g

D 328.2 g

Your answer ☐ **[1]**

Calculations seemed to pose more of a problem to some candidates as a range of choices of the statements offered were selected. The majority of the issues tended to come from candidates not being able to recall the formula for calcium hydroxide.

Section B overview

Candidates answered the questions well on the whole. Diagrams show areas for improvement, but the general shape of endothermic energy level diagrams has improved. Metallic bonding diagrams need improvement specifically in their labelling. Calculations were well expressed and showed clear processing for many candidates.

Question 11 (a)

11 A student investigates three reactions.

She wants to find out if the reactions are exothermic or endothermic.

Look at her results.

Reaction	Start temperature (°C)	Final temperature (°C)
X	21	25
Y	20	18
Z	22	24

(a) Which reaction, **X**, **Y** or **Z**, is **endothermic**? .....

Explain your answer.

.....

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

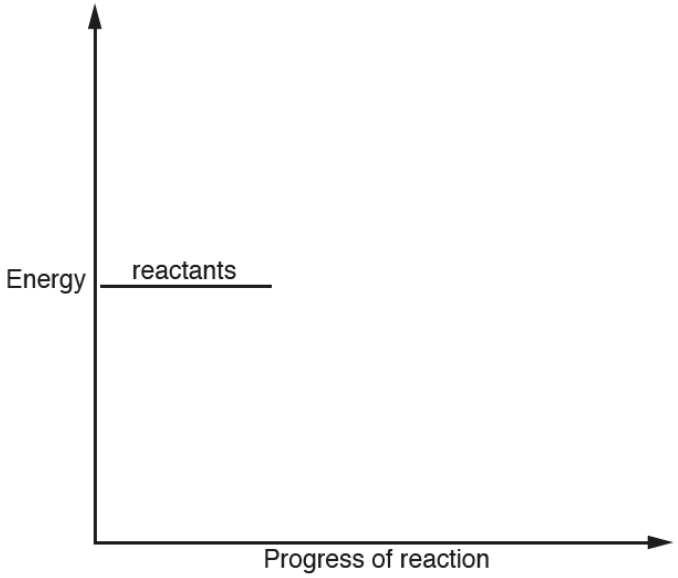
A significant number of candidates were credited with 2 marks on this question. Common misconceptions were shown when the candidate could identify reaction Y as the endothermic reaction. They sometimes said that energy was added to the system but then felt that this was linked to a rise rather than a fall in the temperature of the substance.

?	**Misconception**	Candidate confuse endothermic and exothermic reactions. Some candidates think that a rise in temperature not a fall in temperature show a transfer of energy to the system.

Question 11 (b)

(b) Draw a labelled reaction profile for an **endothermic** reaction.

Use the following labels on your reaction profile:
- products
- energy change
- activation energy.

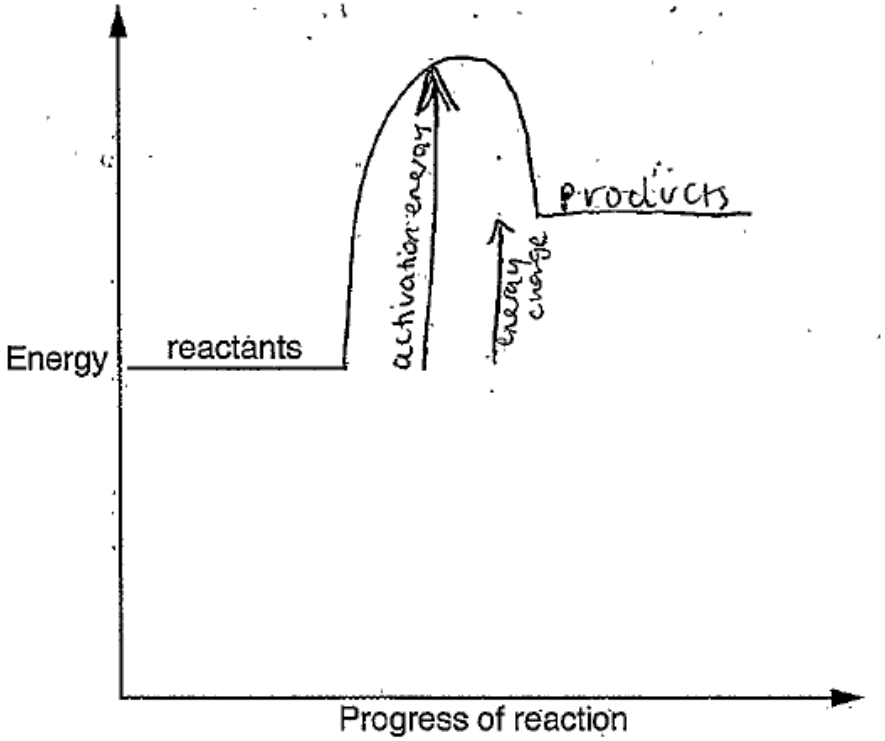


[4]

It was encouraging to see that the general shape of the graph (to include the activation energy) and the position of the products line was generally well answered. The biggest issue with candidate responses was the use of double headed arrows to show the activation energy and the energy change. It was made clear in the report from June 2018 that there was an expectation of single headed arrows when drawing such diagrams.

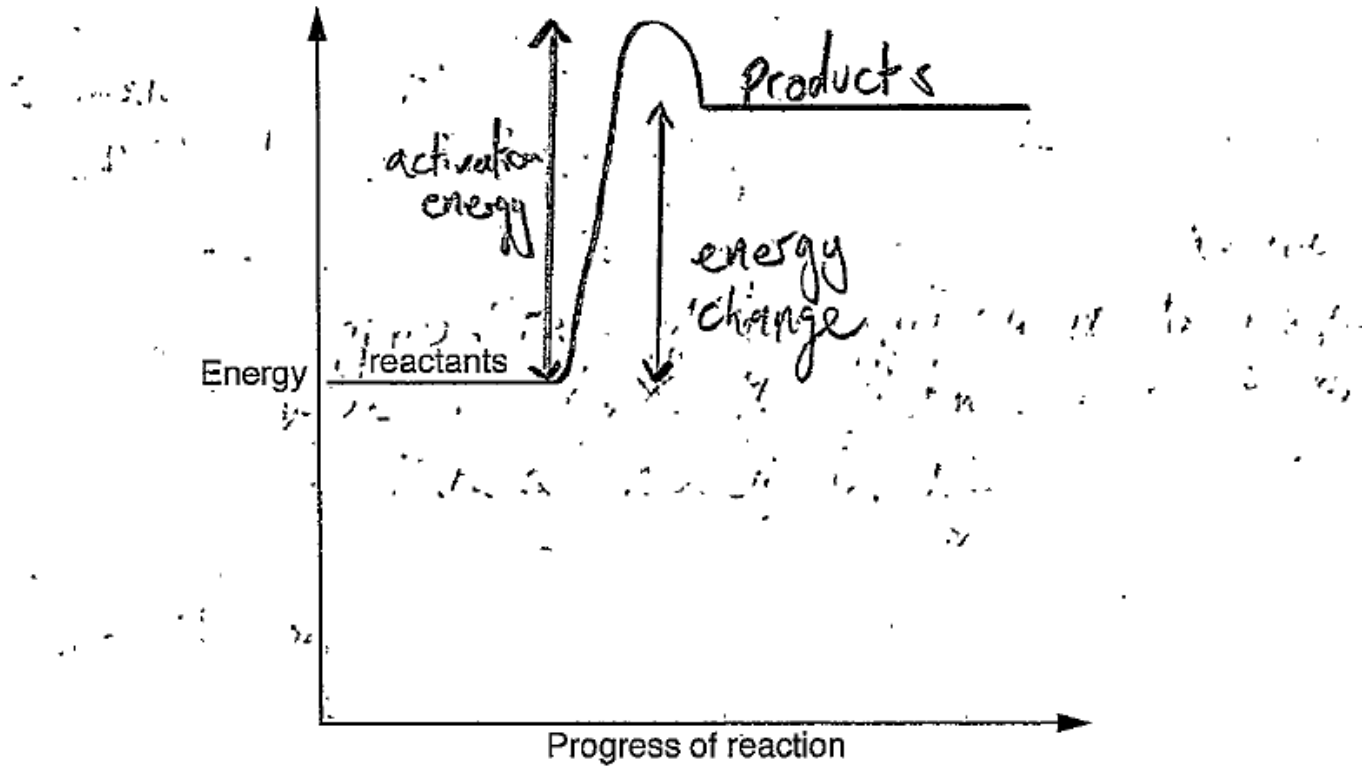
	AfL	Candidates must use single headed arrows on energy level diagrams to show whether there has been an increase or decrease of energy in the system during the reaction.

Exemplar 1



This is an example from a high ability student that has correctly drawn the position of the products, the curved line from the reactants tot the products and also the single headed arrows pointing upwards showing the activation energy and the energy change. All 4 marks are given here.

Exemplar 2



This exemplar shows the common misconception of arrows being double headed. This response scores 2 marks.

Question 11 (c)

(c) Another student repeats the same reactions.

The student does the experiment in a polystyrene cup instead of a beaker.

Explain why using a polystyrene cup is an improvement to the method.

.....

.....

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

Most candidates could identify polystyrene as an insulator but could not go on to gain full credit as they did not recognise that the insulator would give more accurate results than the original beaker. Some candidates misused keywords such as 'precise' and 'reliable'.

Question 11 (d) (i)

(d) The reaction between iron oxide and aluminium is very exothermic.

Look at the equation for the reaction.

$Fe_2O_3(s) + 2Al(s) \rightarrow Al_2O_3(s) + 2Fe(l)$

(i) During this reaction the aluminium is **oxidised**.

Explain what is meant by the term oxidised.

.....

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

Only a few lower ability candidates could not explain that oxidation is the loss of electrons or the gaining of oxygen during the reaction.

Question 11 (d) (ii)

(ii) Pure iron metal is produced in the reaction.

Draw a diagram to show the bonding in a metal.

Label your diagram clearly.

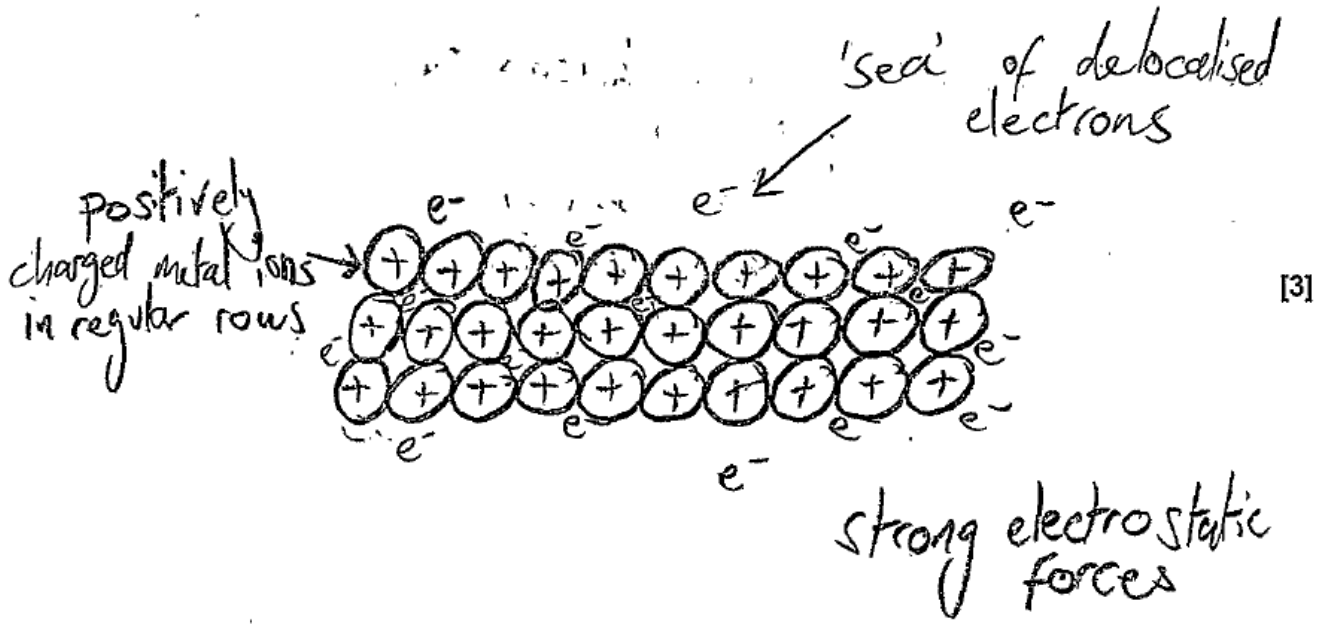
[3]

All but the higher ability students struggled to demonstrate a clear understanding of the structure of a metal and how the bonding takes place.

The responses tended to be very polarised between those candidates that recognised the diagram they had to draw to meet the requirements of the question and those candidates that had no experience of the diagrams and so were unable to attempt a sensible response. Centres should encourage candidates to practice drawing metallic bonding as well as dot and cross diagrams.

?	**Misconception**	Misconceptions included the drawing of a variety of covalent and ionic bonding dot and cross diagrams and the labelling of 'protons' rather than positive metal ions.

Exemplar 3



[3]

This exemplar shows the expected diagram and is given 3 marks.

Question 12

12* A student carries out an experiment using paper chromatography to distinguish between three substances.

Here is his method.

1. Draw a pen line half way up the paper.
2. Put a large spot of the substance to be tested onto the line.
3. Stand the paper in the solvent. The solvent should be at the same level as the spot.
4. Leave the beaker uncovered.
5. Remove the paper from the beaker before the solvent reaches the top.

He calculates the R_f value for each substance.

Look at his results.

Substance	Distance moved by solvent (mm)	Distance moved by spot (mm)	R_f value
X	95	78	1.22
Y	95	65	1.46
Z	95	51	1.86

His teacher noticed some mistakes with his method **and** his R_f values.

Describe and explain the **mistakes** the student has made and suggest corrections.

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

There were three major errors to identify, the baseline being drawn in pen rather than pencil, the baseline being placed below the solvent line, allowing the spots to dissolve in the solvent and finally the Rf value being incorrectly calculated due to the numbers in the equation being transposed. A significant number of candidates could identify some or all of these are areas for improvement for the experiment. Minor errors such as the lack of a lid, or the timing on the removal of the paper from the solvent and the size of the spots placed on the baseline were also identified. The minor errors were more frequently discussed by lower ability candidates. Higher ability candidates could differentiate the importance of the major and minor errors.

Question 13 (a) (i)

13 Aluminium, phosphorus and magnesium are all in Period 3 of the Periodic Table.

(a) Aluminium has an atomic number of 13 and mass number of 27.

(i) Describe the **nucleus** of an aluminium atom in terms of sub-atomic particles.

.....

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

Misconceptions surrounding the number of protons and neutrons were evident in this question. A number of candidates also included electrons as particles that were present in the nucleus, which negated the mark. Those candidates that made it clear they understood electrons were not in the nucleus were still credited for correct science.

Question 13 (a) (ii)

(ii) What is the overall charge on the nucleus of an atom of aluminium?

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

Where the overall charge was quoted numerically, the value was often incorrect. The number 3 was the most common incorrect response. This was understandable as this is the charge on the aluminium ion, but that was not the question asked.

Question 13 (a) (iii)

(iii) Which sub-atomic particles surround the nucleus?

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

The majority of candidates could identify the electron as the particle that surrounds the nucleus.

Question 13 (b)

(b) Phosphorus has a higher atomic number and a higher mass number than aluminium.

A student says that phosphorus must be an isotope of aluminium because it has a different number of neutrons.

Is the student correct?

Tick (✓) one box.

Yes ☐

No ☐

Explain your answer.

.....

.....

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

Candidates struggled to express their ideas clearly in this question. Atoms of the same element with a different number of neutrons are isotopes. Aluminium and phosphorous are not the same element so cannot be isotopes. The key ideas of the same number of protons or the same element was often not correctly recalled.

Question 13 (c) (i)

(c) Phosphorus can react with oxygen to form oxides. One oxide of phosphorus is called phosphorus pentoxide.

Phosphorus pentoxide has the molecular formula P_4O_{10}.

(i) What is the **empirical formula** of phosphorus pentoxide?

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

The empirical formula is often misunderstood. A variety of responses were seen here, including simply repeating the molecular formula.

Question 13 (c) (ii)

(ii) Aluminium oxide and phosphorus pentoxide have different types of bonding.

The boiling point of aluminium oxide is 2977 °C.

The boiling point of phosphorus pentoxide is 360 °C.

What conclusion can you make about the **type of bonding** in each oxide?

Explain your answers.

.....

.....

.....

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

Some candidates could correctly link the type of bonding to the boiling point. Credit was given for those candidates that could identify the type of bonding in each of the substances without boiling point links.

Question 13 (d) (i)

(d) The student is given a sample of the metal magnesium and a solution of an unknown nitrate of metal **M**, $\mathbf{M}NO_3(aq)$.

The student does an experiment to identify metal **M**.

The student weighs the magnesium. Then the student adds the magnesium to the solution of the metal nitrate.

A displacement reaction takes place forming metal **M**:

$$Mg(s) + 2\mathbf{M}NO_3(aq) \rightarrow 2\mathbf{M}(s) + Mg(NO_3)_2(aq)$$

The student separates the metal **M** and then weighs metal **M**.

Look at the student's results:
Mass of magnesium = 0.729 g
Mass of metal **M** = 6.476 g

(i) Calculate the moles of magnesium used in the experiment.

Moles of magnesium = ... **[1]**

The majority of candidates could not calculate the moles of magnesium accurately. Common errors included using molecular mass, M_r and dividing it by mass.

Question 13 (d) (ii)

(ii) Calculate the relative atomic mass of metal **M**.

Give your answer to **3** significant figures.

Relative atomic mass of metal **M** = ... **[3]**

There were only a small number of candidates that could correctly calculate the relative atomic mass of metal M. Of the steps in the calculation, many candidates omitted to multiply their value from Q13di by two to make sure the correct number of moles. Once the final value has been calculated, it was necessary to round the value to three significant figures. Credit was given for the process of correctly rounding the candidates value.

Exemplar 4

$$\frac{6.476}{(0.03 \times 2)} = 107.93$$

Relative atomic mass of metal **M** = 108 **[3]**

This exemplar shows the expected steps of the calculation. This was given 3 marks.

Exemplar 5

(ii) Calculate the relative atomic mass of metal **M**.

Give your answer to **3** significant figures.

$\text{moles} = \frac{\text{mass}}{Ar}$ $0.03 = \frac{6.476}{Ar}$ $Ar = \frac{6.476}{0.03}$

$Ar = 215.8666$

216

Relative atomic mass of metal **M** = 216 **[3]**

This candidate did not multiply the number of moles of magnesium by 2 before dividing so the value of 216 was given as a final response rather than 108. This was given 2 of the 3 marks.

Question 13 (d) (iii)

(iii) Use your answer from **(d)(ii)** and the Periodic Table to identify the metal **M**.

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

The responses were varied here due to the variety of responses in Question 13dii. The element named had to be a metal to gain credit.

Question 14 (a) (i)

14 Brine is the name given to the solution formed when sodium chloride, NaCl, dissolves in water.

(a) During the electrolysis of sodium chloride solution, two ions are attracted to the **negative** electrode (cathode).

(i) Identify the **two** ions attracted to the negative electrode (cathode).

1 .....

2 .....

[2]

Chlorine and oxygen were elements that were common misconceptions. The majority of candidates could identify one of the two ions attracted to the negative electrode.

Question 14 (a) (ii)

(ii) State and explain which product is formed at the negative electrode (cathode).

.....

.....

.....

.....

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

Only higher ability candidates could identify the product formed at the negative electrode. Fewer still could give an explanation involving the reactivity of the element formed. Sodium hydroxide was a common misconception here.

Question 14 (b)

(b) Electrolysis can also be carried out on molten ionic compounds such as magnesium oxide, MgO.

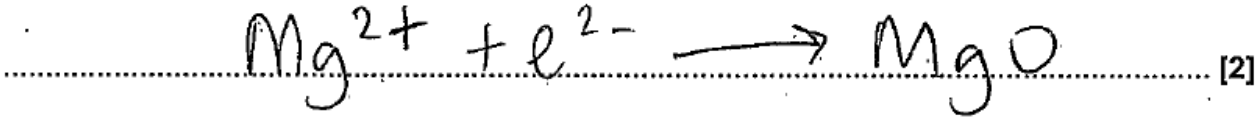
During the electrolysis of molten magnesium oxide, magnesium ions, Mg^{2+}, are **reduced** at the cathode.

Write a **balanced half equation** for this reaction.

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

There were many misconceptions here. For example, electrons were quoted with a charge of minus two or no charge, magnesium ions were placed on the wrong side of the equation and with an incorrect charge.

Exemplar 6



[2]

?	**Misconception**	This exemplar shows the common misconception of the minus two charge on an electron rather than having 2 electrons with a minus 1 charge.

Question 15 (a)

15 (a) Carbon is an element which can form a very wide range of compounds.

This is partly due to the number of bonds that a carbon atom can form.

State the **type** and **maximum number of bonds** that a carbon atom forms.

Type of bonds .....

Maximum number of bonds ..... **[2]**

Many candidates could identify the type of bonding present in carbon-based compounds correctly as covalent, but fewer could relate this to the correct number of bonds a carbon atom can form.

Question 15 (b) (i)

(b) Hex-1-ene is a carbon-based compound with the formula C_6H_{12}.

20.0 g of hex-1-ene is burned in oxygen. Carbon dioxide and water are made. Look at the equation for this reaction.

$C_6H_{12} + 9O_2 \rightarrow 6CO_2 + 6H_2O$

(i) Calculate the number of molecules in 20.0 g of hex-1-ene.

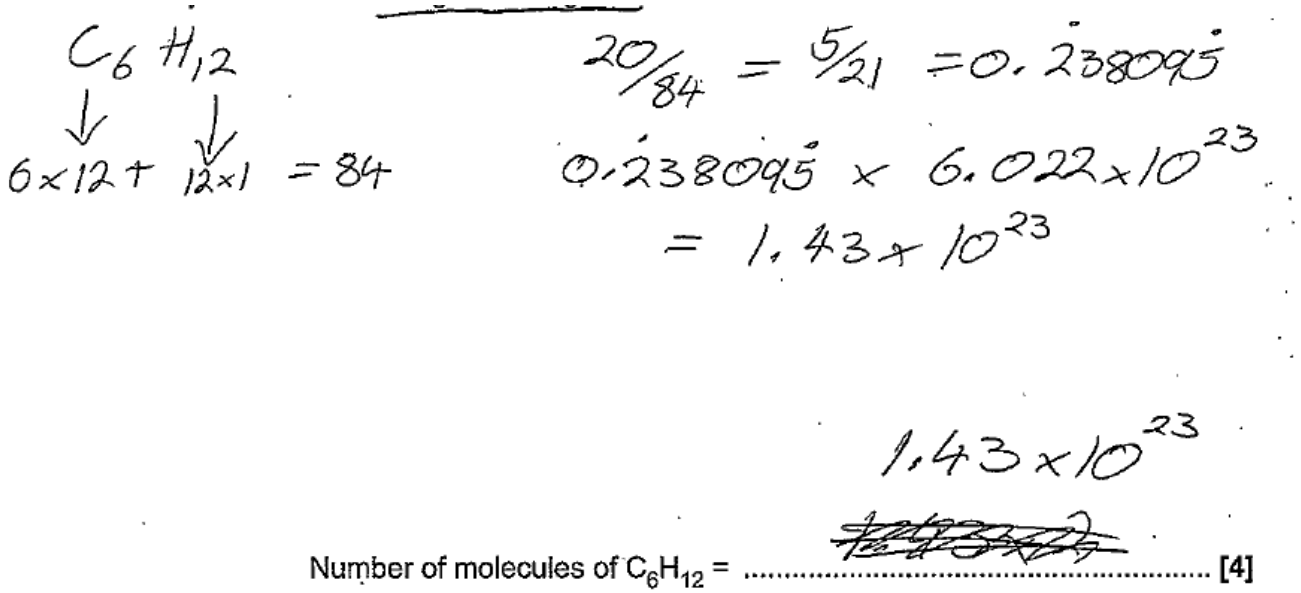
Avogadro's constant = $6.02 \times 10^{23}\,mol^{-1}$

Give your answer to **3** significant figures.

Number of molecules of C_6H_{12} = ... **[4]**

The calculation of atomic weight of Hex-1-ene was the section of the calculation where candidates gained the most credit. Fewer candidates could correctly calculate the number of moles of Hex-1-ene. The most common misconception here was the numbers being placed in the wrong place in the calculation. Even fewer candidates could then multiply by Avogadro's Constant to give the number of molecules. Standard form could only be handled correctly by the higher ability candidates. A significant number of candidates gained in mark by the conversion of a calculated value to three significant figures.

Exemplar 7



This exemplar shows the expected steps of the calculation and was given 4 marks as it has the final answer to the correct number of significant figures.

Exemplar 8

Mr Of Hex-1-ene

6 Carbon - 6 × 12
= 72

12 Hydrogen - 12 × 1
= 12

72 + 12 = 84

Moles = Mass / Mr or Ar

Moles = 20 / 84
= 0.23809
= 0.238

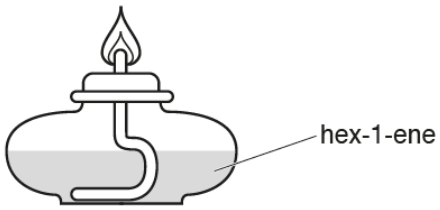
Number of molecules of C_6H_{12} = ~~0.28~~ 0.238 [4]

This exemplar shows all but the step where there should be a multiplication of Avogadro's Constant. This was given 3 marks for just one error in missing a stage of the calculation.

Question 15 (b) (ii)

(ii) Hex-1-ene was burned using a spirit burner in the laboratory.

The diagram shows the spirit burner.



Burning 20.0 g of hex-1-ene should produce 62.9 g of carbon dioxide.

The actual mass of carbon dioxide produced in the reaction was 48.4 g.

What conclusion can be made about the **mass of oxygen** available for combustion?

.....

.....

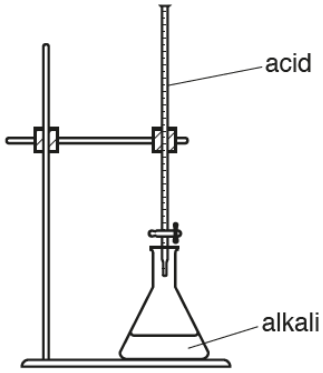
..... [1]

A large number of candidates discussed the amount of oxygen present and tried to calculate its numerical value rather than simply stating that the mass of oxygen would be less or limited.

Question 16 (a)

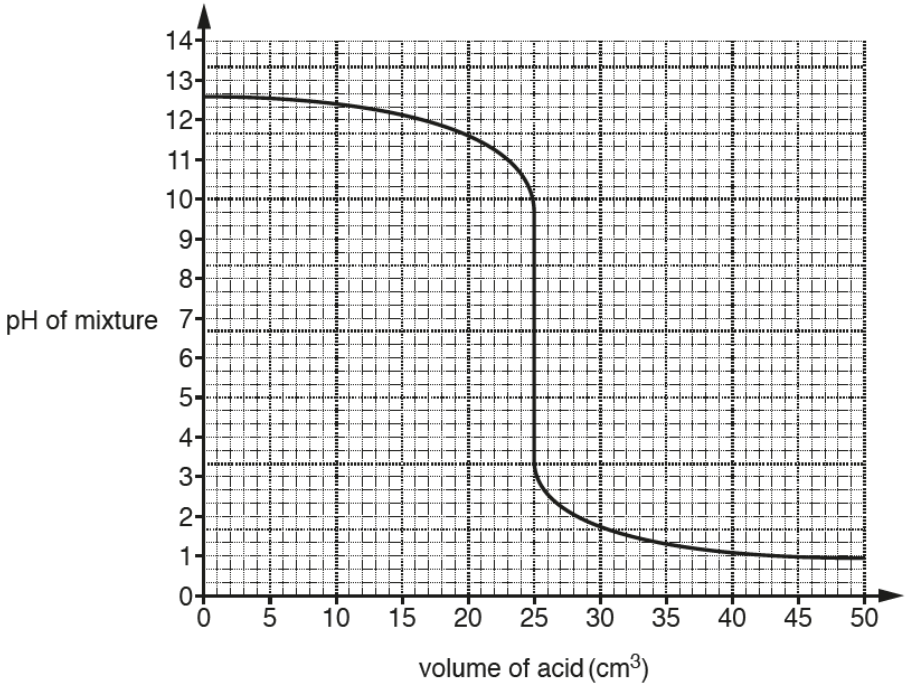
16 A student adds sulfuric acid to a solution of the alkali sodium hydroxide. A neutralisation reaction takes place.

This is the apparatus she uses.



The student measures how the pH of the solution changes as the acid is added.

Look at the graph of her results.



(a) What **volume of acid** is needed to neutralise the alkali?

Volume of acid = ... cm^3 **[1]**

Lower and higher ability candidates gained credit for reading the graph correctly.

Question 16 (b)

(b) The mixture becomes less alkaline as the acid is added.

Describe how the **pH of the mixture** changes as the acid is added.

.....

.....

.....

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

Lower ability candidates could identify the basic trend in the change of pH shown in the graph, but only higher ability candidates could explain the changing shape of the graph and relate this to the progress of the reaction.

Question 16 (c)

(c) Explain why the mixture becomes **less alkaline** as the acid is added.

Use ideas about hydrogen ions and pH in your answer.

.....

.....

.....

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

The change in pH was mentioned by several candidates but fewer could explain that it was the increase in hydrogen ions responsible for that change.

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