Example Candidate Responses

Cambridge O Level

Chemistry

5070

For examination from 2015

Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge O Level Chemistry (5070), and to show how different levels of candidates' performance relate to the subject's curriculum and assessment objectives.

In this booklet a range of candidate responses to questions in Paper 2 Theory, Paper 3 Practical and Paper 4 Alternative to Practical have been chosen as far as possible to exemplify high, middle and low marks. Each response is accompanied by a brief commentary explaining the strengths and weaknesses of the answers.

This booklet does not cover Paper 1 as it contains multiple-choice questions where the mark scheme provides sufficient detail sand the candidate answers do not require examiner commentary to expand on how the marks were gained.

For ease of reference the following format for each component has been adopted:

Mark scheme

Example candidate response
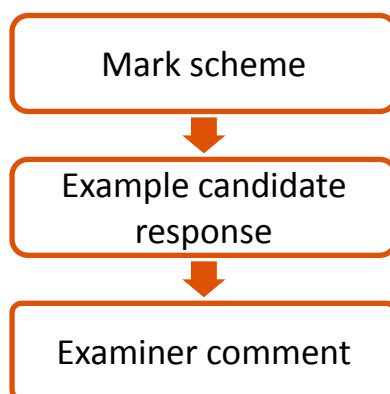
Examiner comment

The mark scheme, as used by examiners, is followed by examples of marked candidate responses, each with an examiner comment on performance. Comments are given to indicate where and why marks were awarded, and how additional marks could have been obtained. In this way, it is possible to understand what candidates have done to gain their marks and what they still have to do to improve their grades.

This document illustrates the standard of candidate work for those parts of the assessment which help teachers assess what is required to achieve high, mid and low grades beyond what should be clear from the mark scheme.

Past papers, Examiner Reports and other teacher support materials are available on Teacher Support at **https://teachers.cie.org.uk**

Assessment at a glance

For the Cambridge O Level in chemistry, candidates take **three** components: Paper 1 **and** Paper 2 and either Paper 3 **or** Paper 4.

Paper 1: Multiple Choice	1 hour
40 compulsory multiple-choice questions. A copy of the Periodic Table is provided as part of this paper. 40 marks	

Paper 2: Theory	1 hour 30 minutes
This paper has two sections. Section A has a small number of compulsory, structured questions of variable mark value. 45 marks in total are available for this section. Section B has four questions to choose from and candidates must answer **three**. Each question is worth 10 marks. A copy of the Periodic Table is provided as part of this paper. 75 marks	

Paper 3: Practical Test	1 hour 30 minutes	Paper 4: Alternative to Practical	1 hour
Details of the syllabus and requirements for this paper are given in section 5. Candidates may **not** refer to notebooks, textbooks or any other information during the practical examination. Qualitative Analysis Notes are provided. 40 marks scaled to a mark out of 30		A written paper of compulsory short-answer and structured questions designed to test familiarity with laboratory practical procedures. Further details are given in section 5. Qualitative Analysis Notes are **not** provided. 60 marks scaled to a mark out of 30	

Teachers are reminded that the full syllabus is available at **www.cie.org.uk**

Paper 2 Theory

Section A
Question A1
Mark scheme

A1 **(a)** **(i)** C (1) [1]

      (ii) A (1) [1]

      (iii) F (1) [1]

      (iv) G (1) [1]

    (b) A **AND** B / A **AND** G (1) [1]

[Total: 5]

Example candidate response – high

A1 Choose from the following compounds to answer the questions opposite.
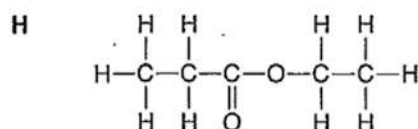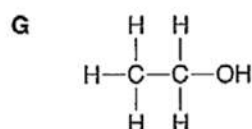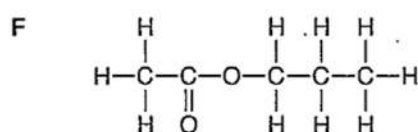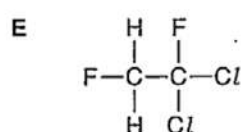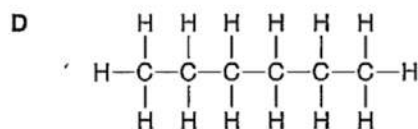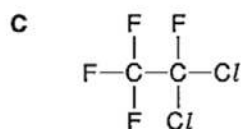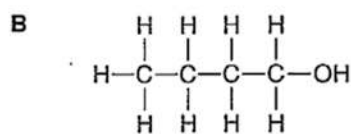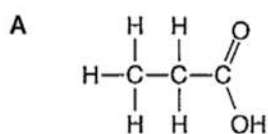
Each compound can be used once, more than once or not at all.

(a) Give the letter of the compound which

    (i) is a CFC,

       ......C..........................   [1]

    (ii) is propanoic acid,

       ......A..........................   [1]

    (iii) is propyl ethanoate,

       ......H..........................   [1]

    (iv) can be oxidised to ethanoic acid.

       ......G..........................   [1]

(b) Give the letters of **two** compounds that react together to make an ester.

                        ......A............ and ......B..................... [1]

                                          [Total: 5]

Examiner comment – high
A1(a)

This candidate was able to select the CFC structure in **(i)**. Most high grade candidates were able to select the CFC structure.

The candidate was able to select the structure of propanoic acid in **(ii)**. Most high grade candidates were able to select the structure of propanoic acid.

Although many high grade candidates could identify the structure of propyl ethanoate in **(iii)** this candidate identified another ester, ethyl propanoate, instead and so was not awarded a mark.

This candidate was able to select a compound that could be oxidised to ethanoic acid in **(iv)**. Most high grade candidates were able to select a compound that could be oxidised to ethanoic acid from the list of structures provided.

Mark awarded = 3 out of 4

A1(b)

Most high grade candidates selected an alcohol and a carboxylic acid from the structures provided. This candidate chose propanoic acid and butanol although there was another alcohol that could have been chosen.

Mark awarded = 1 out of 1

Total mark awarded = 4 out of 5

Example candidate response – middle

A1 Choose from the following compounds to answer the questions opposite.
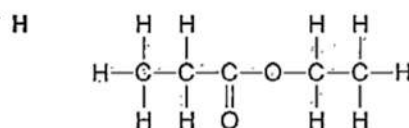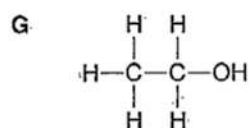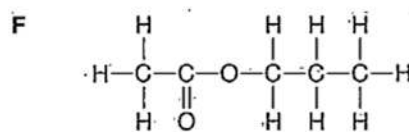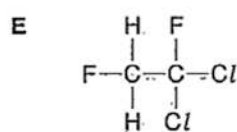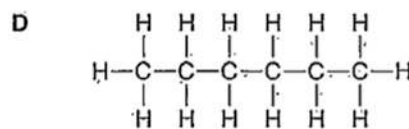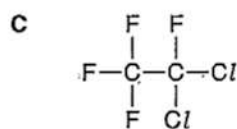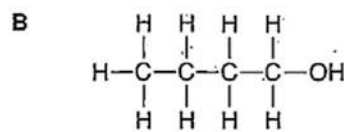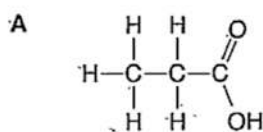
Each compound can be used once, more than once or not at all.

(a) Give the letter of the compound which

(i) is a CFC,

.............C............. [1]

(ii) is propanoic acid,

.............~~B A~~ e............. [1]

(iii) is propyl ethanoate,

.............F............. [1]

(iv) can be oxidised to ethanoic acid.

.............~~B~~ H............. [1]

(b) Give the letters of **two** compounds that react together to make an ester.

.............G............. and ......~~A~~ e A...... [1]

[Total: 5]

Examiner comment – middle
A1(a)

This candidate was able to select the CFC structure in **(i)**. Many mid-grade candidates were able to select the CFC structure.

This candidate selected the CFC rather than propanoic acid in **(ii)**.

This candidate was able to identify the correct ester in **(iii)**. Some mid-grade candidates could identify the structure of propyl ethanoate; other candidates chose the other ester shown in the structures.

This candidate was not able to identify ethanol in **(iv)** and instead chose an ester. Many mid-grade candidates were able to select ethanol.

Mark awarded = 2 out of 4

A1(b)

Many mid-grade candidates selected an alcohol and a carboxylic acid from the structures provided. This candidate chose propanoic acid and ethanol although there was another alcohol that could have been chosen.

Mark awarded = 1 out of 1

Total mark awarded = 3 out of 5

Example candidate response – low

A1 Choose from the following compounds to answer the questions opposite.
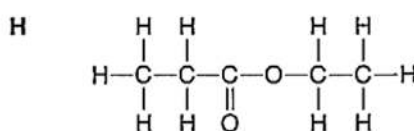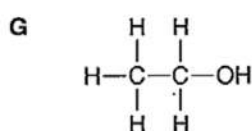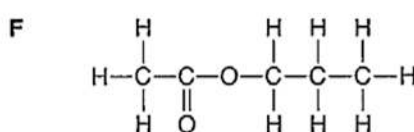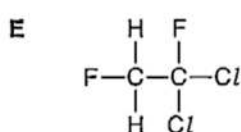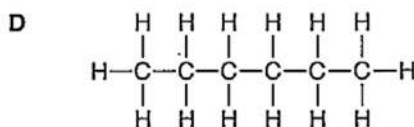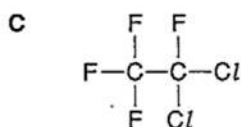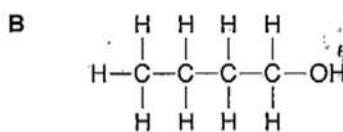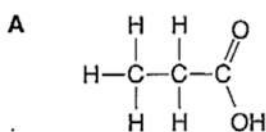
Each compound can be used once, more than once or not at all.

(a) Give the letter of the compound which

   (i) is a CFC,

   ....C.............   [1]

   (ii) is propanoic acid,

   ....A.............   [1]

   (iii) is propyl ethanoate,

   ....H.............   [1]

   (iv) can be oxidised to ethanoic acid.

   ....F.............   [1]

(b) Give the letters of **two** compounds that react together to make an ester.

                                      ....B............. and ....H............. [1]

                                                         [Total: 5]

Examiner comment – low

A1(a)

This candidate was able to select the CFC structure in **(i)**. Some low-grade candidates were able to select the CFC structure.

This candidate selected the structure of propanoic acid in **(ii)**.

This candidate identified another ester, ethyl propanoate, instead and so was not awarded a mark in **(iii)**.

This candidate did not chose ethanol in **(iv)** but chose the halogenated ethane.

Mark awarded = 2 out of 4

A1(b)

This candidate chose one of the alcohols but did not choose the carboxylic acid structure.

Mark awarded = 0 out of 1

Total mark awarded = 2 out of 5

Question A2
Mark scheme

A2 **(a)** Fluorine (1)   [1]

(b) **(i)** Bond breaking absorbs energy **AND** bond making releases energy / bond breaking is endothermic **AND** bond making is exothermic (1)

Less energy absorbed than released / more energy released than absorbed / endothermic energy change is less than exothermic energy change / exothermic energy change is more than endothermic energy change (1)   [2]

(ii) Moles of chlorine = 1.5 (1)

Energy released = 277.5 (kJ) (1)   [2]

(c) **(i)** Unchanged / does not move (1)

Same number of moles (of gas) on both sides / equal volumes (of gases) on both sides / equal number of molecules on both sides (of the equation) (1)   [2]

(ii) Moves to the left / backward reaction favoured / moves to reactants / moves to H_2 or I_2 (1)

(Forward) reaction is endothermic / reverse reaction is exothermic (1)   [2]
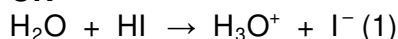
(d) **(i)** $HI \rightarrow H^+ + I^-$ (1)
OR
$H_2O + HI \rightarrow H_3O^+ + I^-$ (1)   [1]

(ii) $Ca + 2HI \rightarrow CaI_2 + H_2$ [1]

(iii) $CO_3^{2-} + 2H^+ \rightarrow H_2O + CO_2$ (1)
OR
$CO_3^{2-} + 2H^+ \rightarrow H_2CO_3$ (1)
OR
$CO_3^{2-} + H^+ \rightarrow HCO_3^-$ (1)   [1]

[Total: 12]

Paper 2 Theory
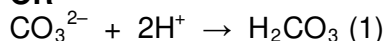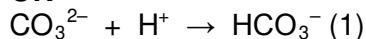
Example candidate response – high

A2 Hydrogen reacts with halogens to form hydrogen halides.

(a) Predict which halogen reacts most violently with hydrogen.

Chlorine (Cl) .....[1]

(b) The reaction between hydrogen and chlorine is exothermic.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g) \qquad \Delta H = -185\,kJ/mol$$
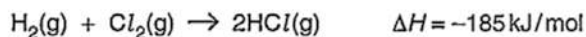
(i) Explain, in terms of bond breaking and bond forming, why this reaction is exothermic.

The activation energy required to break the bonds of Hydrogen and chlorine is less than energy produced by making of HCl bond. Enthalpy change is negative. [2]

(ii) When one mole of chlorine molecules reacts, 185 kJ of energy is released.

Calculate the amount of energy released when 106.5 g of chlorine reacts.

$n = \dfrac{106.5}{71}$

$= 1.5$

$1 \longrightarrow 185$

$1.5 \longrightarrow 185 \times 1.5$

energy released = _277.5_ kJ [2]

(c) Hydrogen reacts with iodine in a reversible reaction.

This reaction reaches an equilibrium if carried out in a closed system.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +53\,kJ/mol$$
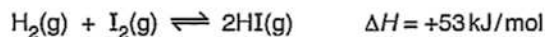
(i) The reaction is studied at a temperature of 400 °C.

Describe and explain what happens to the position of equilibrium if the pressure is increased.

The particles will come closer and will collide more frequently. Higher frequency of successful collisions will increase rate of reaction. [2]

Example candidate response – high, continued

(ii) The reaction is studied at 25 atmospheres pressure.

Describe and explain what happens to the position of equilibrium if the temperature is decreased.

The forward reaction is endothermic, so reduction of temperature will shift equilibrium to the backward (leftward). Because backward reaction is not endothermic. [2]

(d) Hydrogen iodide dissolves in water to form hydroiodic acid, HI(aq).

Hydroiodic acid is a strong acid.

(i) Write an equation to show the dissociation of hydroiodic acid.

$$H_2(g) + I_2(g) \rightarrow 2HI(aq)$$ [1]

(ii) Hydroiodic acid reacts with calcium.

Write the equation for this reaction.

$$Ca(s) + 2HI(aq) \rightarrow CaI_2(aq) + H_2(g)$$ [1]

(iii) Hydroiodic acid reacts with sodium carbonate.

Write the ionic equation for this reaction.

$$NaCO_3 \ Na^+(s) + 2H^+(aq) \rightarrow Na^{2+}(aq) + H_2(aq)$$ [1]

[Total: 12]

$$2HI + NaCO_3 \rightarrow NaI_2 + H_2O + CO_2$$

$$2HI + Ca \rightarrow CaI_2 + H_2$$
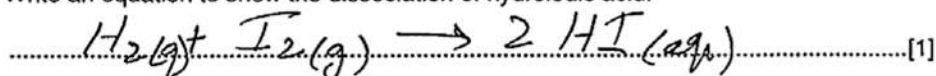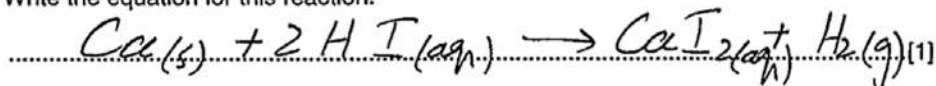
Examiner comment – high
A2(a)

This candidate did not refer to fluorine and so was not awarded a mark. The candidate also gave an incorrect formula which should have been Cl_2 instead of Cl. If candidates uses a formula then it must be totally correct.

Mark awarded = 0 out of 1

A2(b)

This answer on **(b)(i)** appreciates that energy is required to break bonds and that more energy is released during bond formation. Other high grade candidates gave clear answers involving bond breaking absorbing energy and bond forming releasing energy and then made a comparison between the size of the energy changes as a second sentence.

The candidates gave a correct answer to **(b)(ii)** which included the working out.

Mark awarded = 4 out of 4

A2(c)

In the answer to **(i)** this candidate makes a common misconception and confused rate of reaction with position of equilibrium. The best answers here stated what happens to the position of equilibrium and then explained the answer in terms number of moles of gas on each side of the equation.

In **(ii)** the candidate explained what happened to the position of equilibrium and related this to the endothermic nature of the forward reaction.

Mark awarded =2 out of 4

A2(d)

The candidate did not show dissociation of hydriodic acid and so is not given a mark in **(d)(i)**.

In **(d)(ii)** the equation is correct. The candidate does not need to include the state symbols to be awarded full marks. When state symbols are needed it is indicated in the question.

All high grade candidates found **(iii)** very demanding and as in this candidate's answer many included ions that do not react rather than focussing on the carbonate and the hydrogen ion.

Mark awarded = 1 out of 3

Total mark awarded = 7 out of 12

Example candidate response – middle

A2 Hydrogen reacts with halogens to form hydrogen halides.

(a) Predict which halogen reacts most violently with hydrogen.

................................Floorine...[1]

(b) The reaction between hydrogen and chlorine is exothermic.

Bond breaking is greater than bond making

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g) \qquad \Delta H = -185\,kJ/mol$$

(i) Explain, in terms of bond breaking and bond forming, why this reaction is exothermic.

...........This reaction is exothermic becaus
.......bond bonds in react products are
.......greater than the bonds in reactants.
The energy required for bond making [2]
is less than the energy required for bond breaking.

(ii) When one mole of chlorine molecules reacts, 185 kJ of energy is released.

Calculate the amount of energy released when 106.5 g of chlorine reacts.

Mr of Cl = 35.5

$$Moles = \frac{Mass}{Mr}$$

$$35.5 = \frac{Mass}{355}$$... (crossed out)

$$7 = \frac{Mass}{355}$$

$$35.5 = Mass$$

35.5 g → 185 kJ energy
106.5 → ?
35.5 : 185 → 555 kJ
106.5 : u

energy released = ...555.......... kJ [2]

(c) Hydrogen reacts with iodine in a reversible reaction.

This reaction reaches an equilibrium if carried out in a closed system.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +53\,kJ/mol$$
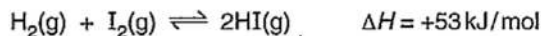
(i) The reaction is studied at a temperature of 400 °C.

Describe and explain what happens to the position of equilibrium if the pressure is increased.

.....If the pressure is increased a
.....change will accur in the position
.....of equilibrium. The rate of
.....forward reaction will be [2]
greater than the rate of backward
reaction. Thus, changing the position
of equilibrium.

Example candidate response – middle, continued

(ii) The reaction is studied at 25 atmospheres pressure.

Describe and explain what happens to the position of equilibrium if the temperature is decreased.

.....IF the temperature is dicreased the rate of backward reaction will be greater than the rate of forward reaction. Thus, bringing about [2] a change in equilibrium.

(d) Hydrogen iodide dissolves in water to form hydroiodic acid, HI(aq).

Hydroiodic acid is a strong acid.

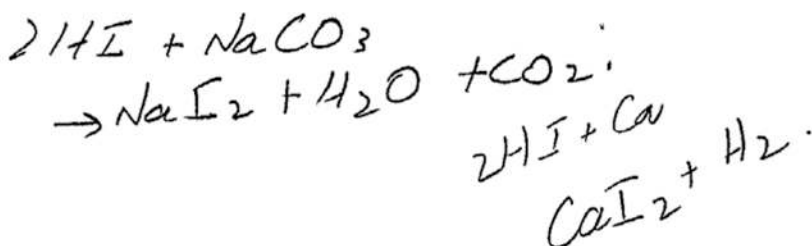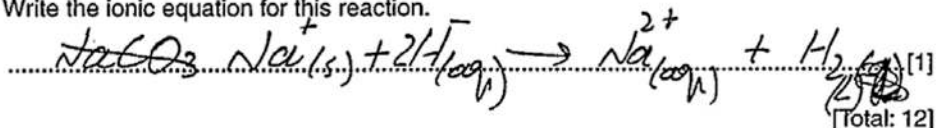(i) Write an equation to show the dissociation of hydroiodic acid.

$$HI \longrightarrow H^+ + I^-$$ .....[1]

(ii) Hydroiodic acid reacts with calcium.

Write the equation for this reaction.

$$HI_{(aq)} + Ca^+_{(aq)} \longrightarrow CaI_{(aq)} + H_{2(g)}$$ .....[1]

(iii) Hydroiodic acid reacts with sodium carbonate.

Write the ionic equation for this reaction.

$$H^+ + CO_3^- \longrightarrow CO_2^- + OH^-$$ .....[1]

[Total: 12]

$$HI + NaCO_3 \longrightarrow NaI + CO_2 + OH$$

$$H^+ \ I^- + Na^+ \ CO_3^- \longrightarrow Na^+ \ I^- + CO_2 + OH$$
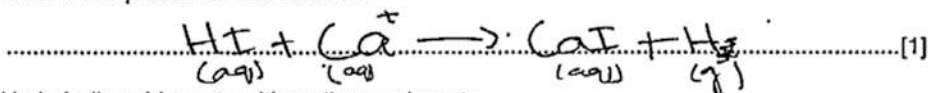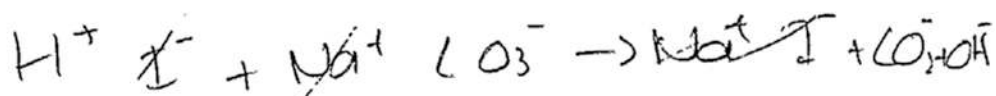
Examiner comment – middle
A2(a)

The candidate correctly recognised that fluorine was the most reactive halogen. The incorrect spelling was ignored.

Mark awarded = 1 out of 1

A2(b)

In **(i)** this candidate did not appreciate that bond making releases energy and referred to the energy required in bond making. There is a reference to bond breaking being larger than bond making which is incorrect, and also does not specifically refer to the energy change. Many mid-grade candidates found this a challenging question and would be advised to answer this question in terms of three bullet points.
- bond breaking absorbs energy
- bond making releases energy
- more energy released than absorbed

In **(ii)** the candidate did not use the correct value for the relative molecular mass of chlorine and as a result obtained double the correct answer. This answer was worth one mark since the rest of the calculation was correct. The working out shown by this candidate made it very easy to award the error-carried-forward mark.

Mark awarded = 1 out of 4

A2(c)

This candidate only referred to the position of equilibrium changing in **(i)** and attempted to explain the answer in terms of rate of reaction. The candidate did not appreciate that the number of moles of gas on both sides of the equation were equal.

This candidate only referred to the position of equilibrium changing in **(ii)** and attempted to explain the answer in terms of rate of reaction. The candidate did not appreciate the importance of the exothermic nature of the reaction.

Mark awarded = 0 out of 4

A2(d)

This candidate wrote the correct equation for the dissociation of hydriodic acid in **(i)**.

The equation in **(ii)** did not include the correct formulae and so could not be balanced correctly.

All candidates found **(iii)** very demanding. This candidate did not know the formula of the carbonate ion which made balancing the equation impossible.

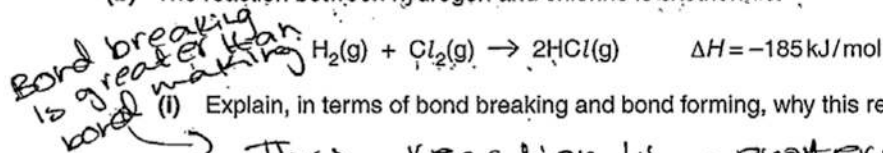**Mark awarded = 1 out of 3**

Total mark awarded = 3 out of 12

Example candidate response – low

A2 Hydrogen reacts with halogens to form hydrogen halides.

(a) Predict which halogen reacts most violently with hydrogen.

.... Krypton ....[1]

(b) The reaction between hydrogen and chlorine is exothermic.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g) \qquad \Delta H = -185\,kJ/mol$$
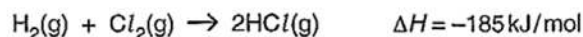
(i) Explain, in terms of bond breaking and bond forming, why this reaction is exothermic.

.... The reaction is exothermic ....

.... because it gives out heat. ....

....

....[2]

(ii) When one mole of chlorine molecules reacts, 185 kJ of energy is released.

Calculate the amount of energy released when 106.5 g of chlorine reacts.

energy released = ... 12702.5 .... kJ [2]

(c) Hydrogen reacts with iodine in a reversible reaction.

This reaction reaches an equilibrium if carried out in a closed system.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +53\,kJ/mol$$
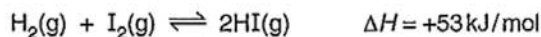
(i) The reaction is studied at a temperature of 400 °C.

Describe and explain what happens to the position of equilibrium if the pressure is increased.

.... As the pressure increases the

.... position of the equilibrium ~~shifts~~

.... ~~to the right~~. stays same

....[2]

Example candidate response – low, continued

(ii) The reaction is studied at 25 atmospheres pressure.
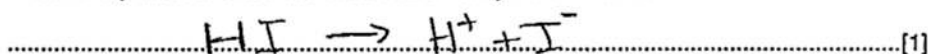
Describe and explain what happens to the position of equilibrium if the temperature is decreased.

when the temperature decreases the position of the equilibrium will shidt to the left.

....[2]

(d) Hydrogen iodide dissolves in water to form hydroiodic acid, HI(aq).

Hydroiodic acid is a strong acid.

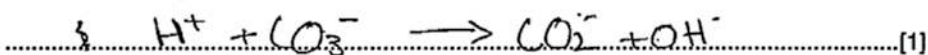**(i)** Write an equation to show the dissociation of hydroiodic acid.

Hcl ⇌ "— Hcl + H₂O ....[1]

HI + H₂O → HI₂ + H

(ii) Hydroiodic acid reacts with calcium.

Write the equation for this reaction.

Ca + HCl → CaCl + H₂ ....[1]

(iii) Hydroiodic acid reacts with sodium carbonate.

Write the ionic equation for this reaction.

2Hcl + NaCO₂ → NaCl + CO₂ + H₂ ....[1]

[Total: 12]

Examiner comment – low

A2(a)

This candidate gave the name of a noble gas rather than a halogen.

Mark awarded = 0 out of 1

A2(b)

In **(i)** this candidate just defined the meaning of the term exothermic and made no reference to bond making and bond forming.

The candidate gave an answer which was the product of the enthalpy change and the mass of chlorine used on **(ii)** rather than calculate the moles of chlorine used.

Most of the low grade candidates found this question extremely challenging.

Mark awarded = 0 out of 4

A2(c)

This candidate was able to describe what happens to the position of equilibrium in both **(i)** and **(ii)** but did not attempt to make an explanation in either question.

Mark awarded = 2 out of 4

A2(d)

In **(i)** the candidate did wrote an equation involving HI and H_2O but it did not show a dissociation. Most candidates found this a very challenging question.

The candidate used hydrochloric acid rather than hydriodic acid in the equation in **(ii)** and also wrote the wrong formulae for the products.

The candidate did not write an ionic equation in **(iii)** and used HCl rather than HI again.

Mark awarded = 0 out of 3

Total mark awarded = 2 out of 12

Question A3
Mark scheme

A3 (a) (Different) number of neutrons / (different) mass number / (different) nucleon number / phosphorus 32 has one extra neutron / atomic mass / mass (1)

(Same) number of protons / (same) atomic number / both have 15 protons (1) [2]

(b) P_4 (1) [1]

(c) (i) Weak intermolecular forces / weak attraction between molecules (1) [1]

(ii) No free electrons / no delocalised electrons / all electrons used in bonding / no mobile electrons(1) [1]

(d)

number of neutrons	**16** (1)
number of protons	**15** (1)
electronic configuration	**2,8,8** (1)

[3]

(e) All three shared pairs between H and P (1)

Rest of structure correct (1) [2]

(f) $2PH_3 + 4O_2 \rightarrow P_2O_5 + 3H_2O$
Correct formulae (1)
Balancing – dependent on correct formulae (1) [2]

[Total: 12]

Example candidate response – high

A3 Two isotopes of phosphorus are $^{31}_{15}P$ and $^{32}_{15}P$.

(a) State one difference and one similarity between these two isotopes.

- difference

The two isotopes have the same number of protons

similarity

The two isotopes have different nucleon number and so will have different number of neutrons

[2]

(b) Phosphorus forms simple molecules which have a relative molecular mass of 124.

Suggest the formula of a phosphorus molecule.

P_4 ....[1]

(c) Phosphorus has a low melting point and does not conduct electricity.

(i) Explain why phosphorus has a low melting point.

Phosphorus is in group 5 of the periodic table. It is a non-metal and so does not have strong forces of attraction. [1]

(ii) Explain why phosphorus does not conduct electricity.

Phosphorus does not conduct electricity because it has no free moving electrons [1]

(d) Complete the table for $^{31}_{15}P^{3-}$.

number of neutrons	16
number of protons	15
electronic configuration	2, 8, 8

[3]

Example candidate response – high, continued

(e) Phosphorus forms a compound called phosphine, PH_3.

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of phosphine.

Only draw the outer shell electrons.

[2]

(f) Phosphine ignites in air to make water and phosphorus(V) oxide.

Construct the equation for this reaction.

$$2PH_3 + 4O_2 \longrightarrow P_2O_5 + 3H_2O_{(l)}$$ [2]
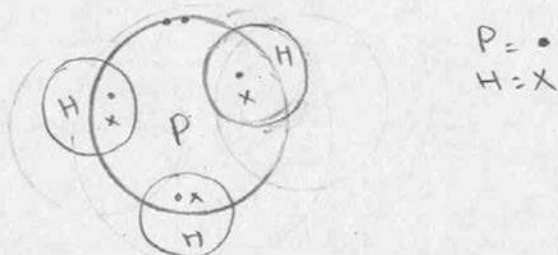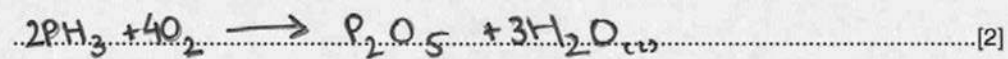
[Total: 12]

Examiner comment – high
A**3(a)**

Most high grade candidates scored maximum marks for this question. This candidate gave answers that referred to the same number of protons but different number of neutrons. Other candidates went further and gave the actual numbers of protons and neutrons within their answers.

Mark awarded = 2 out of 2

A3(b)

The correct formula for a phosphorus molecule, P_4, was given.

Mark awarded = 1 out of 1

A3(c)

In **(c)(i)** this candidate did not specify the presence of weak intermolecular forces that are easily broken. The candidate's statement of 'not having strong forces of attraction' does not imply the presence of weak intermolecular forces, the comment is also incorrect since the covalent bonds within the phosphorus molecules are strong.

As with many other high grade candidates this candidate was able to give a clear explanation in **(c)(ii)** as to why phosphorus does not conduct electricity.

Mark awarded = 1 out of 2

A3(d)

This candidate was able to complete the table and appreciated that the ion contains 18 electrons rather than 15 electrons.

Mark awarded = 3 out of 3

A3(e)

This candidate drew a correct 'dot-and-cross' diagram for phosphine. The candidate used dots and crosses but full marks would have been given even if all the electrons were drawn as either dots or crosses.

Mark awarded = 2 out of 2

A3(f)

This candidate gave a correct balanced equation.

Mark awarded = 2 out of 2

Total mark awarded = 9 out of 12

Example candidate response – middle

A3 Two isotopes of phosphorus are $^{31}_{15}P$ and $^{32}_{15}P$.

(a) State one difference and one similarity between these two isotopes.

difference

They have different nucleon number.
(and atomic mass.)

similarity

They have same number of protons
(atomic number).

[2]

(b) Phosphorus forms simple molecules which have a relative molecular mass of 124.

Suggest the formula of a phosphorus molecule.

P_3

[1]

(c) Phosphorus has a low melting point and does not conduct electricity.

(i) Explain why phosphorus has a low melting point.

Because the bonding between its atoms
is low covalent bonding with triple bond.

[1]

(ii) Explain why phosphorus does not conduct electricity.

Because there are no free ions in
Phosphorus.

[1]

(d) Complete the table for $^{31}_{15}P^{3-}$.

number of neutrons	16
number of protons	15
electronic configuration	2, 8, 5

[3]

Example candidate response – middle, continued

(e) Phosphorus forms a compound called phosphine, PH_3.

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of phosphine.

Only draw the outer shell electrons.

[2]

(f) Phosphine ignites in air to make water and phosphorus(V) oxide.

Construct the equation for this reaction.

$$4PH_3 + 13O_2 \longrightarrow 4PO_5 + 6H_2O$$

[2]

[Total: 12]

Cambridge O Level Chemistry 5070
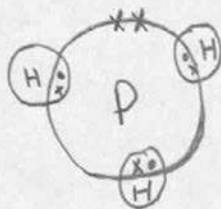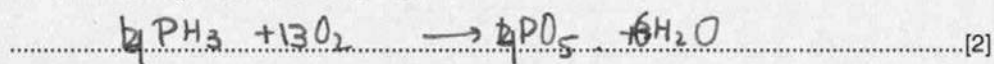
Examiner comment – middle

A3(a)

This candidate gave answers that referred to the same number of protons but different nucleon number. Other candidates went further and gave the actual numbers of protons and neutrons within their answers.

Mark awarded = 2 out of 2

A3(b)

This candidate gave an answer of P_3 and provided no justification for this answer.

Mark awarded = 0 out of 1

A3(c)

In **(i)** this candidate made no reference to weak intermolecular forces being broken and only referred to the bonding between atoms rather than between molecules. Most mid-grade candidates found this question very challenging.

This candidate referred to the presence of free ions rather than free electrons in **(ii)**.

Mark awarded = 0 out of 2

A3(d)

This candidate was able to complete the table but did not appreciate that the ion contains 18 electrons rather than 15 electrons.

Mark awarded = 2 out of 3

A3(e)

This candidate drew a correct 'dot-and-cross' diagram for phosphine. The candidate used dots and crosses but full marks would have been given even if all the electrons were drawn as either dots or crosses.

Mark awarded = 2 out of 2

A3(f)

This candidate could not write the formula for phosphorus(V) oxide and so was not able to write the balanced equation.

Mark awarded = 0 out of 2

Total mark awarded = 6 out of 12

Example candidate response – low

A3 Two isotopes of phosphorus are $^{31}_{15}P$ and $^{32}_{15}P$.

(a) State one difference and one similarity between these two isotopes.

difference

...They have different number of Neutrons...

similarity

...They have same number of protons and electrons...

[2]

(b) Phosphorus forms simple molecules which have a relative molecular mass of 124.

Suggest the formula of a phosphorus molecule.

$P\ ^{124}_{15}$

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

(c) Phosphorus has a low melting point and does not conduct electricity.

(i) Explain why phosphorus has a low melting point.

..Phosphorus is non-metal. it has weak electrostatic Forces between them. ...[1]

(ii) Explain why phosphorus does not conduct electricity.

..Phosphorus does not have Free moving $\bar{e}$ to carry out electricity. ...[1]

(d) Complete the table for $^{31}_{15}P^{3-}$.

number of neutrons	13
number of protons	18
electronic configuration	2, 8, 8, 18, 3

[3]

Example candidate response – low, continued

(e) Phosphorus forms a compound called phosphine, PH_3.

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of phosphine.

Only draw the outer shell electrons.

[2]

(f) Phosphine ignites in air to make water and phosphorus(V) oxide.

Construct the equation for this reaction.

$$PH_{3 (s)} + O_{2 (g)} \xrightarrow{air} PO + H_2O$$ [2]
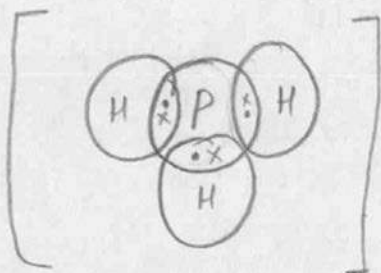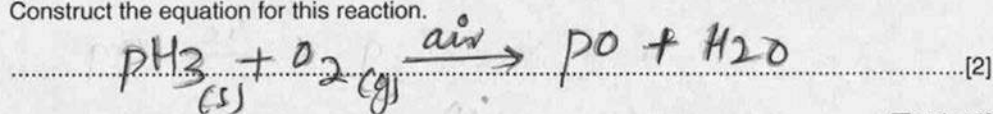
[Total: 12]

Examiner comment – low

A3(a)

The candidate gave two correct answers involving the numbers of neutrons, protons and electrons.

If the candidate had referred to the different relative atomic mass this would have been incorrect, however if it had been the different atomic mass then this would have been awarded mark.

Mark awarded = 2 out of 2

A3(b)

The formula for the molecule should have been P_4.

Mark awarded = 0 out of 1

A3(c)

In **(i)** this candidate refers to weak electrostatic forces between them but does not define what them refers to. If molecules had been referred to this would have been worth a mark.

The lack of free moving electrons in **(ii)** was a good answer.

Mark awarded = 1 out of 2

A3(d)

All three entries into the table were incorrect. This candidate used the mass number to determine how many electrons in the phosphide ion rather than the atomic number and the charge on the ion.

Mark awarded = 0 out of 3

A3(e)

This candidate scored the first mark for showing the pairs of electrons shared between hydrogen and phosphorus. However, the diagram did not show any lone pairs of electrons.

Mark awarded = 1 out of 2

A3(f)

This candidate was not able to deduce the formula of phosphorus(V) oxide and as a result could not construct a balanced equation. Most low grade candidates were unable to deduce the formula for phosphorus(V) oxide.

Mark awarded = 0 out of 2

Total mark awarded = 4 out of 12

Question A4
Mark scheme
A4 (a) (i) B is SO_2 (1) [1]

(ii)

	S	O
Mole ratio	$\dfrac{40}{32}$ **OR** 1.25	$\dfrac{60}{16}$ **OR** 3.75
Simplified ratio	1	3

Mole ratio line (1)
Empirical formula SO_3 (1)
Sulfur trioxide / sulfur(VI) oxide (1) [3]

(iii) Fe_2O_3 (1) [1]

(b) $Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$
Equation (1)
State symbols – dependent on correct formulae (1) [2]

(c) Any soluble barium compound e.g. barium nitrate / barium chloride (1)

$BaSO_4$ (1) [2]

[Total: 9]

Example candidate response – high

A4 The flow chart shows some reactions of iron(II) sulfate, $FeSO_4$.
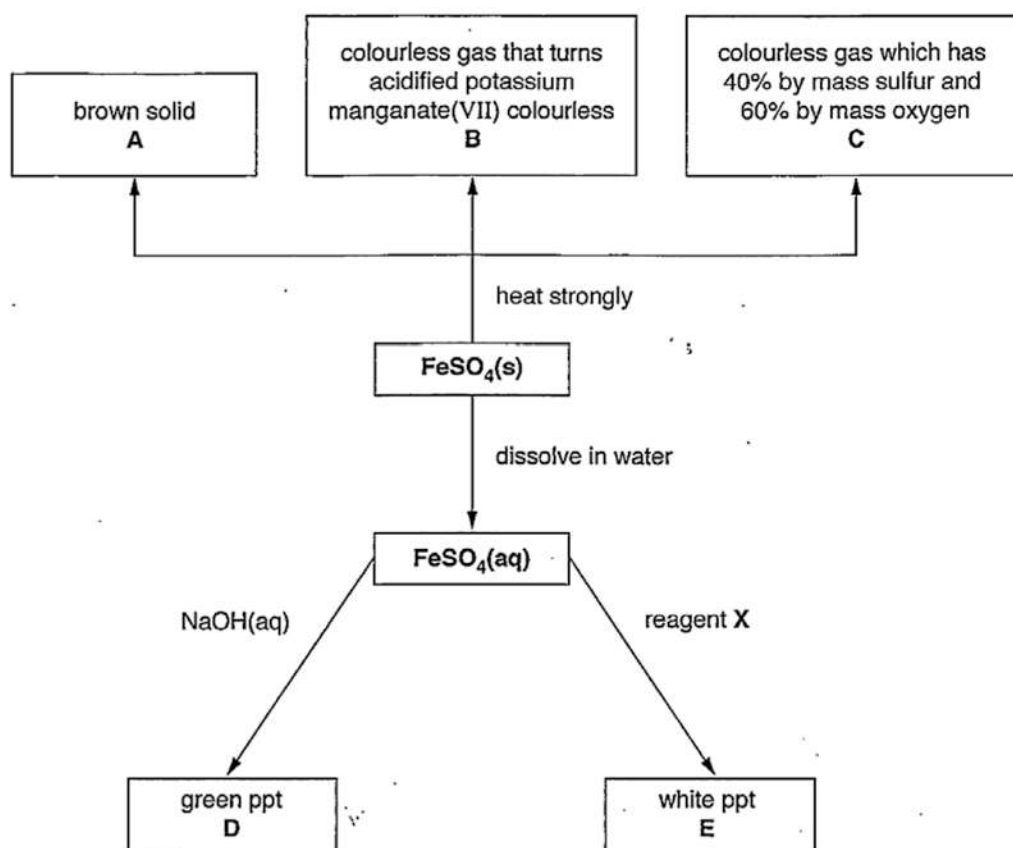
(a) Iron(II) sulfate is heated strongly.

(i) Write the formula of gas **B**.

..........O_2..[1]

(ii) Calculate the empirical formula of gas **C**.

Name gas **C**.

$S = \dfrac{40}{32}$ $O = \dfrac{60}{16}$

$= \dfrac{1.25}{1.25}$ $\dfrac{3.75}{1.25}$ SO_3

1   3

empirical formula is ....SO_3..

name ....Sulphur trioxide..[3]

Example candidate response – high, continued

(iii) Two moles of iron(II) sulfate decompose to form one mole of solid **A**, one mole of gas **B** and one mole of gas **C**.

Deduce the formula of solid **A**.

formula of **A** .... Fe^{3+} ....[1]

(b) Write an ionic equation, including state symbols, for the formation of the green precipitate **D**.

~~Fe^{2+}~~ .... $H^+ \quad +OH^- \rightarrow H_2O$ ....[2]
$(l) \qquad (aq) \qquad\qquad (l)$

(c) Suggest the name of reagent **X** and give the formula for the white precipitate **E**.

name of reagent **X** .... Barium nitrate ....

formula of precipitate **E** .... $Ba\,SO_4$ ....[2]

[Total: 9]

Examiner comment – high
A4(a)

In **(a)(i)** the candidate gave the answer of O_2 rather than SO_2. Since the question asked for the formula of the gas then any answers that gave only the correct name would also not have been awarded a mark.

In **(ii)** the candidate gave a very clear answer with the complete working out and the answer and so was awarded full marks.

The candidate did not show any working out in **(iii)** and gave the incorrect answer of Fe^{3+}. The best answers from high grade candidates used their answers from **(i)** and **(ii)** to deduce the correct formula of Fe_2O_3.

Mark awarded = 3 out of 5

A4(b)

Many high grade candidates found this a difficult question and gave a variety of ionic equations which often did not relate to the reaction in the question. This candidate gave an ionic equation with state symbols but it related to neutralisation rather than precipitation so was not awarded any marks.

Mark awarded = 0 out of 2

A4(c)

Many high grade candidates found this difficult but this candidate gave two correct answers. It is important that the instructions in the question are followed in terms of the name (of the reagent) and then the formula (of the precipitate).

Mark awarded = 2 out of 2

Total mark awarded = 5 out of 9

Example candidate response – middle

A4 The flow chart shows some reactions of iron(II) sulfate, $FeSO_4$.
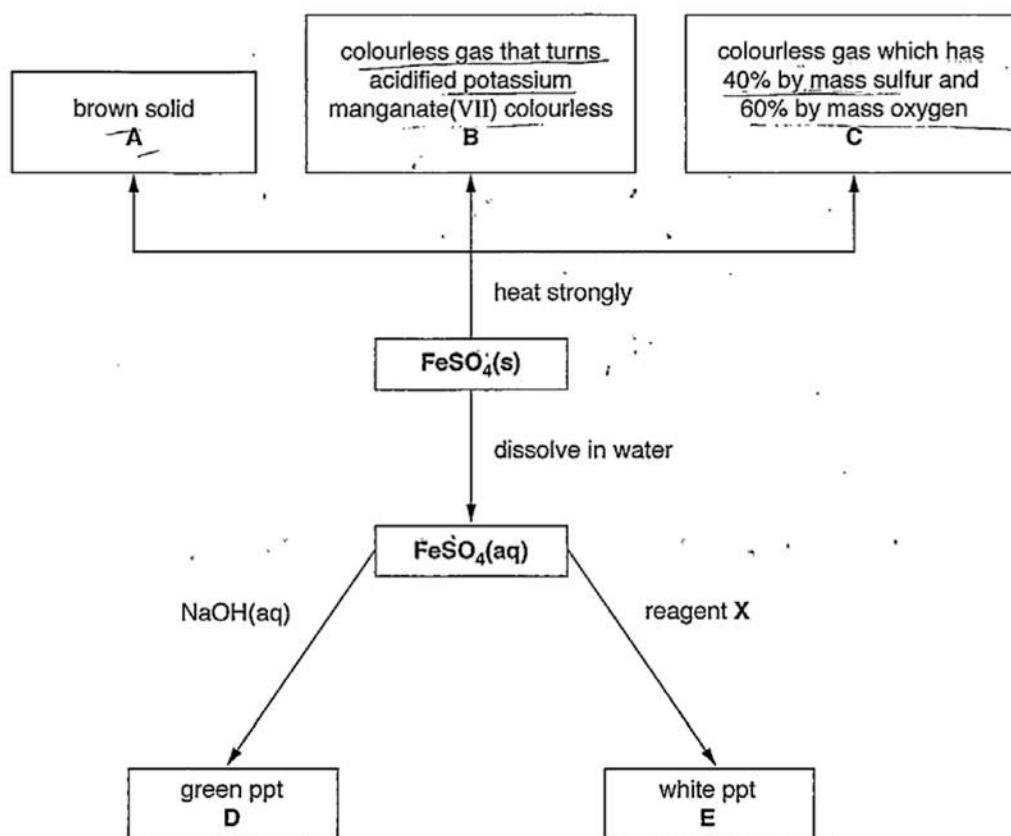
(a) Iron(II) sulfate is heated strongly.

(i) Write the formula of gas **B**.

.... $KMcl$ ....[1]

(ii) Calculate the empirical formula of gas **C**.

Name gas **C**.

$$Sulfur \quad : \quad oxygen$$

$$\frac{40}{32} \quad : \quad \frac{60}{16}$$

$$\frac{1.25}{1.25} \quad : \quad \frac{3.75}{1.25}$$

$$1 \quad : \quad 3$$

empirical formula is .... SO_3 ....

name .... Sulfurdioxide ....[3]

Example candidate response – middle, continued

(iii) Two moles of iron(II) sulfate decompose to form one mole of solid **A**, one mole of gas **B** and one mole of gas **C**.

Deduce the formula of solid **A**.

formula of **A** ....Sulfate.................................[1]

(b) Write an ionic equation, including state symbols, for the formation of the green precipitate **D**.

.....Added.............iron (II)..[2]

(c) Suggest the name of reagent **X** and give the formula for the white precipitate **E**.

name of reagent **X** ....Zn..

formula of precipitate **E** ....$Zn + SO_4 \rightarrow ZnSO_4$..................[2]

[Total: 9]

Examiner comment – middle
A4(a)

In **(i)** this candidate could not write the formula of a gas.

This candidate could calculate the empirical formula for the gas in **(ii)** and showed the working out very clearly. However this candidate thought that SO_3 was sulfur dioxide rather than sulfur trioxide.

This candidate did not write a formula for the solid but gave it the name of 'sulphate'. When a question asks for a formula then there will be no marks for a correct name.

Mark awarded = 2 out of 5

A4(b)

This candidate did not attempt to write an ionic equation. This question was very challenging to mid-grade candidates.

Mark awarded =0 out of 2

A4(c)

This candidate could not name the reagent or give the formula of the precipitate.

If the correct formula rather than the name of the reagent was given, a mark was awarded, but with the precipitate it had to be the correct formula.

Mark awarded = 0 out of 2

Total mark awarded = 2 out of 9

Example candidate response – low

A4 The flow chart shows some reactions of iron(II) sulfate, $FeSO_4$.
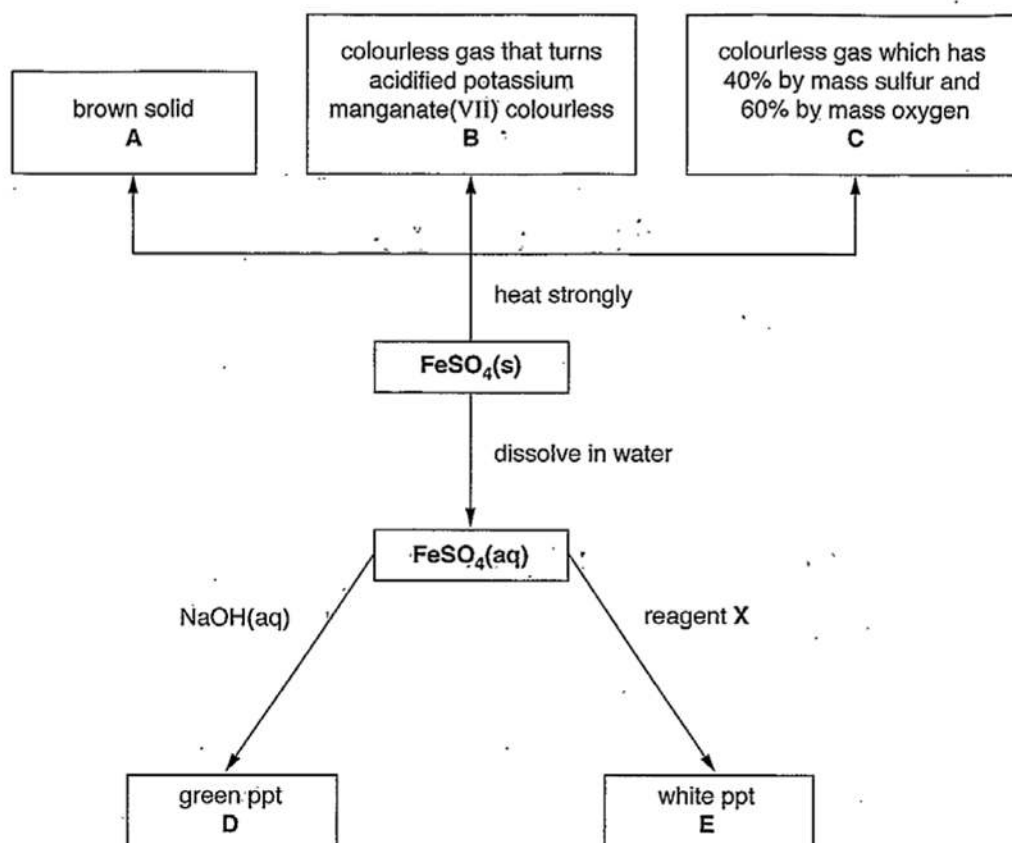
(a) Iron(II) sulfate is heated strongly.

(i) Write the formula of gas **B**.

.... Hydrogen gas ....[1]

(ii) Calculate the empirical formula of gas **C**.

Name gas **C**.

$$S \quad\quad O_2$$
$$40/100 \quad\quad 60/100$$
$$0.4 \quad\quad 1.6$$
$$SO_2$$

empirical formula is .... SO_2 ....

name ...... Salphur dioxide ....[3]

Example candidate response – low, continued

(iii) Two moles of iron(II) sulfate decompose to form one mole of solid **A**, one mole of gas **B** and one mole of gas **C**.

Deduce the formula of solid **A**.

$$2 FeSO_4 \rightarrow H_2 + SO_2 + FeSO_2$$
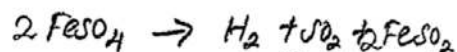
formula of **A** ....$FeSO_2$...[1]

(b) Write an ionic equation, including state symbols, for the formation of the green precipitate **D**.

..........$FeSO_4 (aq) + NaOH_{(aq)} \rightarrow FeOH_{2(aq)} + NaSO_{2(s)(aa)} + O_{2(aq)}$..........[2]
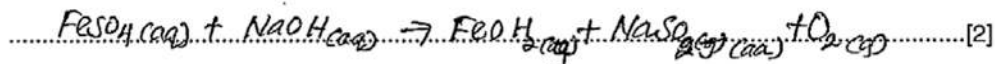
(c) Suggest the name of reagent **X** and give the formula for the white precipitate **E**.

name of reagent **X** ....NH_4SO_4..

formula of precipitate **E** ....$Fe_2 NH_4 + l$...[2]

[Total: 9]

Examiner comment – low
A4(a)

In **(i)** this candidate stated that the gas was hydrogen rather than the gas sulfur dioxide.

This candidate did not use the data to calculate the empirical formula in **(ii)** and instead used the simplest ratio of the percentage by mass data. The candidate was able to obtain an error carried forward mark by naming sulfur dioxide from their answer of SO_2.

This candidate made an attempt in **(iii)** to use their answers to deduce a formula for the solid **A** but with the answer of hydrogen from **(i)** this was not possible.

Mark awarded = 1 out of 3

A4(b)

This candidate attempted to write an equation for the reaction but did not get the formulae correct for the products. The question needed an ionic equation and this candidate did not include any ions in their equation.

Mark awarded = 0 out of 2

A4(c)

Both formulae given by this candidate were incorrect. The reagent should have been a name although if a correct formula had been given it would have been awarded a mark.

Mark awarded = 0 out of 2

Total mark awarded = 1 out of 9

Question A5
Mark scheme

A5 (a) (i) $Mg^{2+} + 2e^- \rightarrow Mg$ (1)

$2Cl^- \rightarrow Cl_2 + 2e^-$ (1)   [2]
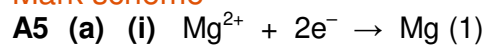
(b) (i) Impure copper (1)   [1]

(ii) Pure copper (1)   [1]

(c) Moles of $NaCl = 55 \times 3.5$ **OR** 192.5 (1)

Moles of $Cl_2 = 96.25/96.3/$ idea of dividing moles by 2 (1)

Volume = 2310 (dm^3) (1)   [3]

[Total: 7]

Example candidate response – high

A5 Electrolysis is often used in the extraction and purification of elements.

(a) Magnesium is manufactured by the electrolysis of molten magnesium chloride.

Write equations for the two electrode reactions that occur during this electrolysis.

$Mg^{2+} + 2e^- \rightarrow Mg$ Cathode $= Mg^{2+} + 2e^- \rightarrow Mg$

Anode $= Cl_2 \rightarrow Cl^{2-} + 2e^-$ ....[2]

(b) Copper can be purified using the electrolysis of aqueous copper(II) sulfate.

(i) What is used as the anode (positive electrode)?

Copper Impure Copper ....[1]

(ii) What is used as the cathode (negative electrode)?

Copper ....[1]

(c) Chlorine can be made by the electrolysis of concentrated aqueous sodium chloride.

The overall process can be represented by the following equation.

$$2NaCl(aq) + 2H_2O(l) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$
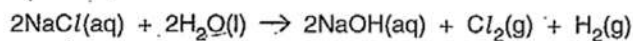
$55\,dm^3$ of $3.5\,mol/dm^3$ aqueous sodium chloride is electrolysed.

What is the maximum volume of chlorine that can be formed, measured at room temperature and pressure?

Moles of NaCl $= \dfrac{55\,dm^3 \times 3.5\,mol/dm^3}{1000}$

$= 0.1925$ moles.

$\therefore$ Moles of chlorine $= \dfrac{0.1925}{2}$

$= 0.09625$ mole.

$\therefore$ Volume of chlorine $= 0.09650\ 0.09625 \times 24\,dm^3$
formed.
$= 2.31\,dm^3$

volume of chlorine = ...2.31.......... dm^3 [3]

[Total: 7]

Examiner comment – high

A5(a)

High grade candidates found this question challenging and rarely got both of the equations correct. This candidate got the cathode equation correct but failed to get the anode reaction correct. The candidate did not start with chloride ions, instead they used chlorine molecules, although the electrons were on the correct side of the equation.

Mark awarded = 1 out of 2

A5(b)

The purification of copper was known by most candidates. In **(i)** this candidate gave impure copper and in **(ii)** just copper. There was no need to state in **(ii)** that it was pure copper.

Mark awarded = 2 out of 2

A5(c)

This candidate gave an extremely clear answer with all the relevant steps in the calculation shown. The candidate mistakenly divided by 1000 in the first step and so lost the first mark but gained the two subsequent marks.

Mark awarded = 2 out of 3

Total mark awarded = 5 out of 7

Example candidate response – middle
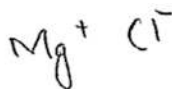
Mg^+ Cl^-

A5 Electrolysis is often used in the extraction and purification of elements.

(a) Magnesium is manufactured by the electrolysis of molten magnesium chloride.

Write equations for the two electrode reactions that occur during this electrolysis.

At Cathode:— $^{-ve}$ $^{+ve}$ $Mg^{8+} \longrightarrow Mg^{2+} + 2e^-$

At Anode:— $^{+ve}$ $^{-ve}$ $Cl^- + 2e^- \rightarrow Cl$ ....[2]

(b) Copper can be purified using the electrolysis of aqueous copper(II) sulfate. Cu^+

(i) What is used as the anode (positive electrode)?

Impure Copper plate ....[1]

(ii) What is used as the cathode (negative electrode)?
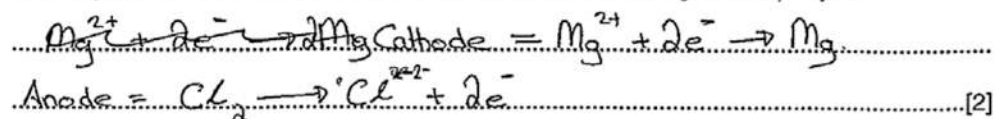
Pure Copper plate ....[1]

(c) Chlorine can be made by the electrolysis of concentrated aqueous sodium chloride.

The overall process can be represented by the following equation.

$$2NaCl(aq) + 2H_2O(l) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$
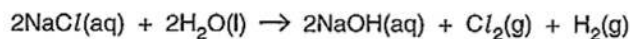
$55\,dm^3$ of $3.5\,mol/dm^3$ aqueous sodium chloride is electrolysed.

What is the maximum volume of chlorine that can be formed, measured at room temperature and pressure?

Volume = ?

$\Rightarrow$ Mr of Cl_2 = 35.5 × 2 = 71

$\Rightarrow$ Mr of of NaCl = 23 + 35.5 = 58.5

$\Rightarrow$ $= \dfrac{55 \times 3.5}{1000} = 0.1925$

2NaCl Cl_2 31.42
55          $\dfrac{55 \times 2}{3.5}$ volume of chlorine = ... dm^3 [3]

[Total: 7]

Cambridge O Level Chemistry 5070

https://xtremepape.rs/

Examiner comment – middle

A5(a)

This candidate wrote two equations but they did not represent the discharge of ions. This was because at the cathode magnesium atoms were shown to be losing electrons and at the anode chloride ions were gaining electrons rather than losing electrons. This type of error was typical of a mid-grade candidate.

Mark awarded = 0 out of 2

A5(b)

The purification of copper was known by most candidates. In **(i)** this candidate gave impure copper and in **(ii)** pure copper. There was no need to state in **(ii)** that it was pure copper since copper on its own was sufficient.

Mark awarded = 2 out of 2

A5(c)

This candidate showed the working out which demonstrated that they had used the wrong approach to the question. The candidate did not work out the number of moles of sodium chloride from the concentration and volume. They did not use the mole ratio to calculate the moles of chlorine produced, and finally they did not use the molar volume of gases.

Mark awarded = 0 out of 3

Total mark awarded = 2 out of 7

Example candidate response – low

A5 Electrolysis is often used in the extraction and purification of elements.

(a) Magnesium is manufactured by the electrolysis of molten magnesium chloride.

Write equations for the two electrode reactions that occur during this electrolysis.

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

$$Mg^- + e^- \rightarrow Mg$$

....[2]
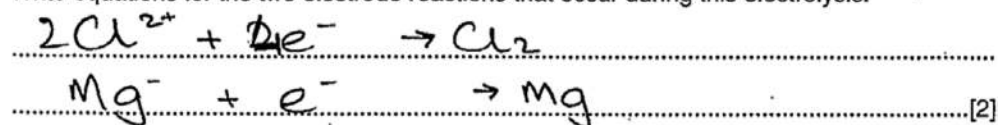
(b) Copper can be purified using the electrolysis of aqueous copper(II) sulfate.

(i) What is used as the anode (positive electrode)?

Sulphur

....[1]

(ii) What is used as the cathode (negative electrode)?

Copper.

....[1]
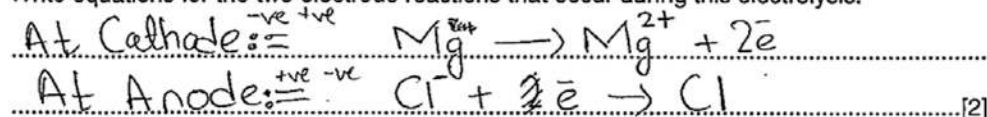
(c) Chlorine can be made by the electrolysis of concentrated aqueous sodium chloride.

The overall process can be represented by the following equation.

$$2NaCl(aq) + 2H_2O(l) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$
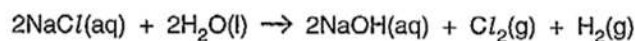
$55\,dm^3$ of $3.5\,mol/dm^3$ aqueous sodium chloride is electrolysed.

What is the maximum volume of chlorine that can be formed, measured at room temperature and pressure?

$$55 \div 24 \text{ mol/dm}^3$$

volume of chlorine = ...2 . 29........... dm^3 [3]

[Total: 7]

Examiner comment – low
A5(a)

This candidate wrote two electrode equations that were incorrect. The formula for the ions were incorrect and had the wrong charges, in addition both equations showed the gain of electrons.

Mark awarded = 0 out of 2

A5(b)

In **(i)** the wrong name of the electrode was stated and it should have been impure copper however in **(ii)** copper was correct. There was no need to put pure copper in **(ii)** to be awarded the mark.

Mark awarded = 1 out of 2

A5(c)

This candidate attempted the question but used the wrong approach to the calculation. The candidate should have calculated the moles of sodium chloride, then the moles of chlorine and finally used the molar gas volume to calculate the volume of chlorine.

Mark awarded = 0 out of 3

Total mark awarded = 1 out of 7

Section B
Question B6
Mark scheme

B6 **(a)** white solid disappears / pungent smell / condensation / colourless droplets (1)   [1]

    (b) For ammonia:
Test with (moist red) litmus (1)
turns blue (1)
OR
Test (with stopper / glass rod from) (concentrated) HCl (1)
white smoke / white fumes(1)

For carbon dioxide:
Test with limewater (1)
Goes milky / cloudy / white precipitate / goes white (1)   [4]

    (c) Add soluble zinc compound / zinc chloride / zinc sulfate / zinc nitrate / other named soluble zinc compound (1)

Filter (1)
NOTE: This mark can only be scored for filtration directly after mixing the reagents and implying that it is the solid that is on the filter paper

Wash and (air) dry residue (1)
NOTE: This mark cannot be scored if there is no filtering.   [3]

    (d) $3(NH_4)_2CO_3 + 2H_3PO_4 \rightarrow 2(NH_4)_3PO_4 + 3CO_2 + 3H_2O$
Correct formulae (1)
Balancing – dependent on correct formulae (1)   [2]

[Total: 10]

Example candidate response – high

B6 Ammonium carbonate, $(NH_4)_2CO_3$, is a white solid that is a component of 'smelling salts'.

It decomposes when it is heated.

$$(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + H_2O(g) + CO_2(g)$$
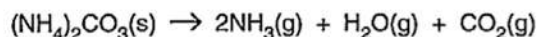
(a) A sample of ammonium carbonate is heated strongly until it all decomposes.

Suggest what you would observe during the experiment.

Pungent smell of ammonia is released.

....[1]

(b) Describe how you would show that both ammonia and carbon dioxide are formed in this decomposition.

Bring a ~damp~ litmus paper ~close in~ in contact with ammonia gas, If the colour changes from red to blue, which marks the presence of ammonia gas. ~Collect~ ~Pass~ the carbondioxide in a gas syringe and pass it through limewater. limewater turns milky wich mean carbondioxide gas is present.

....[4]

(c) Ammonium carbonate is soluble in water but zinc carbonate is insoluble in water.

Describe how you would prepare a sample of pure, dry zinc carbonate using a solution of ammonium carbonate.

Two soluble compounds are taken, i.e. Ammonium carbonate and zinc nitrate and are mixed. Reaction takes place, producing crystals of zinc carbonate. ~tdarb~ Leave the ~product~ ~crystals~ in the sunlight to dry. Wash it with distilled water and dry.

....

....

....[3]

(d) Excess ammonium carbonate reacts with phosphoric acid, H_3PO_4.

Construct an equation for this reaction.

$$3(NH_4)_2CO_3 + 2H_3PO_4 \rightarrow CO_2 + H_2O + 2(NH_4)_3PO_4$$ ....[2]
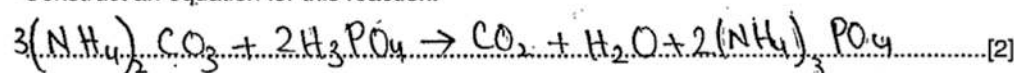
[Total: 10]

Examiner comment – high

B6(a)

This candidate identified the formation of ammonia from the equation and correctly recognised that it has a pungent smell. Other candidates appreciated that the white solid would disappear or that the mass of the solid would decrease.

Mark awarded = 1 out of 1

B6(b)

Most high grade candidates found this question about the tests for carbon dioxide and ammonia very straight forward. This candidate clearly describes the effect of ammonia on damp red litmus and of carbon dioxide on limewater. The extra information about collecting the gas in a syringe was ignored since it was not necessary.

Mark awarded = 4 out of 4

B6(c)

Most high grade candidates found this question about the preparation of zinc carbonate very demanding and only a small proportion of candidates appreciated that the method of choice was precipitation.

This candidate was able to identify the use of the correct reagents but did not describe a filtration stage followed by drying the residue. For mark 3 it must be clear that it is the residue on the filter paper that is being washed and dried. The candidate referred to crystallisation rather than precipitation in their answer.

Mark awarded = 1 out of 3

B6(d)

The candidate was able to deduce the correct formulae for the reactants and products for one mark but did not correctly balance the equation.

Mark awarded = 1 out of 2

Total mark awarded = 7 out of 10

Example candidate response – middle

B6 Ammonium carbonate, $(NH_4)_2CO_3$, is a white solid that is a component of 'smelling salts'.

It decomposes when it is heated.

$$(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + H_2O(g) + CO_2(g)$$
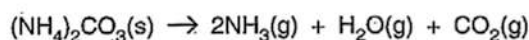
(a) A sample of ammonium carbonate is heated strongly until it all decomposes.

Suggest what you would observe during the experiment.

....During experiment, it is observed that Ammonia, hydrogen
and Carbondioxide is given off..[1]

(b) Describe how you would show that both ammonia and carbon dioxide are formed in this decomposition.

For ammonia, dip the litmus paper if ammonia is present
it will turn the moist red litmus paper into blue. Secondly,
for checking for CO₂, the solution should pass through the
lime water. If lime water turns milky than it means CO₂ is
also present in the decomposition. By this way we can
know that ammonia and carbondioxide is present or not.
....[4]

(c) Ammonium carbonate is soluble in water but zinc carbonate is insoluble in water.

Describe how you would prepare a sample of pure, dry zinc carbonate using a solution of ammonium carbonate.

The Zinc carbonate is insoluble in the water. So, for
this first take the zinc carbonate is conical flask and add
few drops of ammonium carbonate until the reaction of
the gas which is produced during the reaction is constant.
Then, remove the extra or excess ammonium carbonate
by using filteration. By this way same of pure dry zinc
carbonate can be achieve. And they then dry the solution until
the first crystal has appeared of zinc d carbonate which is...[3]
                                                                    pure crystaline

(d) Excess ammonium carbonate reacts with phosphoric acid, H_3PO_4.

Construct an equation for this reaction.

....$(NH_3)(CO_3 + H_3PO_4 \rightarrow CO_2 + H_2O + (NH_3)PO_4$....[2]
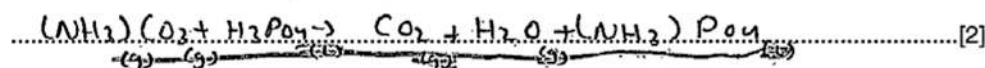
[Total: 10]

Examiner comment – middle

B6(a)

This candidate did not give an observation but just described in words the chemical equation. Good answers used the information in the equation such as the state symbols to deduce an observation such as 'the mass would decrease' or 'the solid would eventually disappear'.

Mark awarded = 0 out of 1

B6(b)

This candidate was able to describe the use of litmus to test for ammonia and of limewater to test for carbon dioxide. The candidate gave both the reagents and the expected result and so obtained full marks for this part question.

Mark awarded = 4 out of 4

B6(c)

Candidates at mid-grade found this question very demanding and often were not able to describe the correct method of purification. Some candidates used a base and acid method, others a titration method and a significant proportion of mid-grade candidates did not answer the question.

This candidate used the reagents of zinc carbonate and ammonium carbonate rather than a soluble zinc salt and ammonium carbonate. Although the answer included a filtration stage it refers to removing excess ammonium carbonate rather than collecting the product of zinc carbonate. Furthermore the answer also describes crystallising zinc carbonate which is incorrect.

Mark awarded = 0 out of 3

B6(d)

Although this candidate attempted to write an equation some of the formulae were incorrect which made balancing the equation impossible.

Mark awarded = 0 out of 2

Total mark awarded = 4 out of 10

Example candidate response – low

B6 Ammonium carbonate, $(NH_4)_2CO_3$, is a white solid that is a component of 'smelling salts'.

It decomposes when it is heated.

$$(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + H_2O(g) + CO_2(g)$$
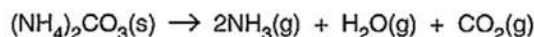
(a) A sample of ammonium carbonate is heated strongly until it all decomposes.

Suggest what you would observe during the experiment.

The limewater turns milky. ~~Pappes~~ ~~Scocce~~ ~~is~~ ~~produced.~~ Ammonia gas is released. .....[1]

(b) Describe how you would show that both ammonia and carbon dioxide are formed in this decomposition.

We will show that when ammonium carbonate is heated ammonia gas will be ~~pr~~ released and ammonium(NH4) becomes ammonia(NH3). And when ~~carbood cood~~ the lime water turns milky it means that ~~@~~carbondioxide is ~~produced~~ produced. .....[4]

(c) Ammonium carbonate is soluble in water but zinc carbonate is insoluble in water.

Describe how you would prepare a sample of pure, dry zinc carbonate using a solution of ammonium carbonate.

First we will put ~~some~~ a piece of zinc in a solution of ammonium carbonate. so as zinc is reactive then ammonium so it can displace ammonium and ~~mix~~ with carbonate to form zinc carbonate. .....[3]

(d) Excess ammonium carbonate reacts with phosphoric acid, H_3PO_4.

Construct an equation for this reaction.

$(NH_4)_2CO_3 + H_3PO_4 \rightarrow NH_3PO_4 + H_2O + CO_2$
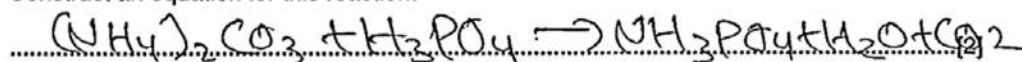
[Total: 10]

Examiner comment – low

B6(a)

This candidate did not quote observations and so was not awarded a mark. This candidate needed to state that a pungent gas was released rather than just ammonia was released to get a mark. The comment about the limewater was irrelevant in this question.

Mark awarded = 0 out of 1

B6(b)

This candidate gave the limewater test for carbon dioxide but did not give a test to identify ammonia. The most popular test for ammonia was that it turns moist red litmus blue.

Mark awarded = 2 out of 4

B6(c)

All candidates found this question very challenging and most low grade candidates did not score with this question.

This candidate did not give the correct reagents, giving ammonium carbonate and zinc rather than ammonium carbonate and a soluble zinc salt. This candidate did not describe the experimental details and so did not have access to the filtration and the wash and dry mark.

Mark awarded = 0 out of 3

B6(d)

This candidate did not write the correct formula for ammonium phosphate and so could not balance the equation. This was a very challenging question for low grade candidates.

Mark awarded = 0 out of 2

Total mark awarded = 2 out of 10

Question B7
Mark scheme

B7 (a) TiCl_4 + 2Mg $\rightarrow$ 2MgCl_2 + Ti (1)   [1]

(b) Reduction because Ti ions gain electrons / oxidation number of Ti decreases (1)

Oxidation since Mg loses electrons / oxidation number of Mg increases (1)   [2]

(c) M_r of TiCl_4 = 190 (1)

Moles of TiCl_4 is 0.658 / % of Ti = 25.3 (1)

Mass of Ti = 31.6 (g) (1)   [3]

(d) Titanium because magnesium can displace titanium (1)   [1]

(e) (Simple) molecular / reference to molecules (1)

Covalent (1)   [2]

(f) Electron(s) can move / has delocalised electron(s) (1)   [1]

[Total: 10]

Example candidate response – high

B7 Titanium can be manufactured by heating titanium(IV) chloride, $TiCl_4$, with magnesium.

(a) Construct the equation for this reaction.

$$TiCl_4 + 2Mg \rightarrow 2MgCl_2 + Ti$$ ....[1]
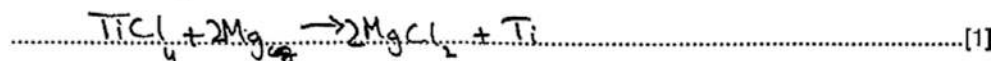
(b) Explain why this reaction involves both oxidation **and** reduction.

This reaction is a redox reaction because magnesium loses 2 of its electrons to chlorine and hence oxidation occurs. Whereas chlorine gains these 2 electrons and its oxidation state reduces so reduction occurs. ....[2]

(c) What mass of titanium can be made from 125 g of titanium(IV) chloride?

Moles of Titanium chloride = 0.657

Mass of Titanium = 0.657 × 48
                 = 31.57g

mass of titanium = ...31.5...... g [3]

(d) Which metal is the less reactive, magnesium or titanium?

Explain your answer.

Titanium is the less reactive metal since it gets replaced by Magnesium. ....[1]

(e) Titanium(IV) chloride is a liquid with a low boiling point of 126 °C.

Suggest the structure and bonding of titanium(IV) chloride.

The structure of titanium(IV) chloride could have an octagonal lattice structure in which is bonded ionically. ....[2]

(f) Explain how titanium metal conducts electricity.

Titanium metal has a sea of free electrons which allow electricity to conduct. ....[1]

[Total: 10]

Examiner comment – high

B7(a)

The candidate gave the correct balanced equation.

Mark awarded = 1 out of 1

B7(b)

The candidate appreciated that magnesium loses electrons and that this is oxidation which is one of the marking points. Although the candidate appreciates that reduction is the gain of electrons they stated that chlorine gains electrons which is incorrect so they did not get the second mark for this question.

Some high grade candidates were not sufficiently precise with their answers and gave answers that did not identify the correct chemical species being oxidised or reduced. Other high grade candidates gave answers that referred to specific oxidation states such as magnesium is oxidised since its oxidation state increases from 0 to +2. The calculation of actual oxidation states is not a requirement of the syllabus though correct statements were credited.

Mark awarded = 1 out of 2

B7(c)

This candidate gave the correct answer and so was awarded all three marks however they did not show all the working out. In this question the incorrect use of decimal places and significant figures were ignored so the incorrect rounding to 31.5 was not penalised.

Mark awarded = 3 out of 3

B7(d)

The candidate appreciated that titanium was less reactive than magnesium and referred to magnesium replacing titanium. This idea was sufficient to award a mark although better answers referred to magnesium displacing titanium.

Mark awarded = 1 out of 1

B7(e)

This question was found to be very challenging even by high grade candidates. This candidate only refers to ionic bonding which is incorrect so the answer was given no marks. The best answers referred to simple molecules with covalent bonding. These answers used the properties of the compound to deduce the structure and bonding.

Mark awarded = 0 out of 2

B7(f)

This candidate referred to the presence of a sea of free electrons which was sufficient for the award of a mark. Most high grade candidates were able to score a mark for this question.

Mark awarded = 1 out of 1

Total mark awarded = 7 out of 10

B7 Titanium can be manufactured by heating titanium(IV) chloride, TiCl_4, with magnesium.

(a) Construct the equation for this reaction.

$$TiCl_4 + Mg \rightarrow MgCl_2 + TiCl_2 \quad \text{[1]}$$
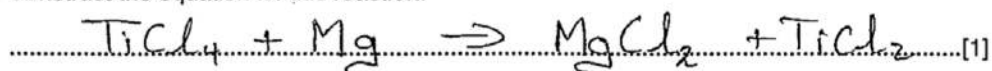
(b) Explain why this reaction involves both oxidation **and** reduction.

Because this reaction is oxidise and reduce also. Cl oxidise this reaction and reduction is also take place in the reaction thats why this reaction is both. [2]

oxidise ~~oxidation~~ oxidation and reduce.

(c) What mass of titanium can be made from 125 g of titanium(IV) chloride?

$$= \frac{125}{190}$$

$$= 0.6578 \times 48$$

$$= 31.57 \text{ Ans}$$

mass of titanium = ...31.57....... g [3]

(d) Which metal is the less reactive, magnesium or titanium?

Explain your answer.

Titanium because it is lower in reactivite series. ......[1]

(e) Titanium(IV) chloride is a liquid with a low boiling point of 126 °C.

Suggest the structure and bonding of titanium(IV) chloride.

Titanium (IV) chloride have covalent bonding. ......[2]

(f) Explain how titanium metal conducts electricity.

Because it has free ions or electrons for conducting electricity. ......[1]

[Total: 10]

Examiner comment – middle

B7(a)

This equation quotes the wrong product in $TiCl_2$ when it should be titanium metal, Ti. Other candidates at this level often gave incorrect formulae and so could not balance the equation.

Mark awarded = 0 out of 1

B7(b)

This candidate does not give any explanation and only refers to one substance in the answer. To be able to be awarded a mark, the idea that reduction was gain of electrons and oxidation was loss of electrons had to be made. For a second mark the correct species gaining or losing electrons had to be identified.

Mark awarded = 0 out of 2

B7(c)

This candidate obtained the correct answer and showed sufficient working out to show that they had used a molar approach rather than one using percentage composition. In this question rounding-up errors were ignored.

Mark awarded =3 out of 3

B7(d)

The candidate correctly stated that titanium was less reactive but did not offer an explanation. The most common correct explanation at was that magnesium displaced the titanium.

Mark awarded = 0 out of 1

B7(e)

The candidate correctly identified the bonding as covalent but did not mention anything about the simple molecular structure. Many candidates at this level referred to ionic bonding and this resulted in no marks being awarded.

Mark awarded = 1 out of 2

B7(f)

This candidate identifies the presence of free electrons which is a marking point but also refers to the presence of free ions which is a contradictory statement.

Mark awarded = 0 out of 0

Total mark awarded = 4 out of 10

B7 Titanium can be manufactured by heating titanium(IV) chloride, $TiCl_4$, with magnesium.

(a) Construct the equation for this reaction.

.... $2TiCl_4 + Mg \rightarrow Ti_2Mg + Cl_2$ ....[1]
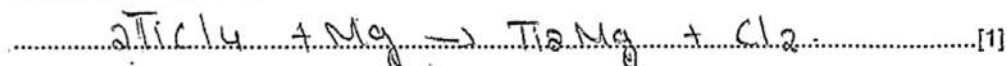
(b) Explain why this reaction involves both oxidation **and** reduction.

The reaction involves two oxidation & redution because it gain Electron and became oxidixe & then it loss electron & reduction occur. So lossing & gaining of Electron is oxidration and reduction [2]

(c) What mass of titanium can be made from 125 g of titanium(IV) chloride?

Mass of titanium : 48

48/1000 = 0·048

0·048 × 125
= 6

mass of titanium = ... 6 .... g [3]

(d) Which metal is the less reactive, magnesium or titanium?

Explain your answer.

The titrate is less reactive because it has the less mass the Magnesium and it lay below Magnesium in reactive series [1]

(e) Titanium(IV) chloride is a liquid with a low boiling point of 126 °C.

Suggest the structure and bonding of titanium(IV) chloride.

The titanium Chlorid is the weak Compoub. The bonding of titon titanium chloride is [2] Covalent bond. It has the Electron are not so closs to Euch other.

(f) Explain how titanium metal conducts electricity.

It conduct Electricity because titanium metal has one free mobile Electron. [1]

[Total: 10]

Examiner comment – low
A7(a)

This candidate was not able to construct the equation because they wrote the incorrect formulae for the products in the reaction.

Mark awarded = 0 out of 1

B7(b)

This candidate described oxidation as the gain of electrons and reduction as the loss of electrons and so was not awarded a mark. In addition the candidate did not identify the chemical species that were oxidised or reduced.

Mark awarded = 0 out of 2

B7(c)

This candidate attempted the calculation but did not use the correct approach to the question. The most popular approach was to calculate the moles of titanium chloride, deduce the moles of titanium and then calculate the mass of titanium made.

Mark awarded = 0 out of 3

B7(d)

This candidate did state that titanium was less reactive but they did not explain this deduction using information form the equation. The explanation needed to refer to magnesium being able to displace titanium from its compounds.

Mark awarded = 0 out of 1

B7(e)

This candidate did state that the compound had covalent bonding but did not mention anything about the structure of the compound. The comments about the electrons not being close to each other was irrelevant and was ignored.

Mark awarded = 1 out of 2

B7(f)

This candidate gave a good answer referring to the presence of free mobile electrons.

Mark awarded = 1 out of 1

Total mark awarded = 2 out of 10

Question B8
Mark scheme

B8 **(a)** Any correct equation e.g.

$C_{17}H_{36} \rightarrow C_3H_6 + C_{14}H_{30}$ (1)   [1]

(b) Reaction is faster because particles are moving faster / rate increases because particles have more energy (1)

More particles have energy above the activation energy / more effective collisions / more fruitful collisions / more energetic collisions / more (chance of) successful collisions (1)   [2]

(c) **(i)** Has carbon-carbon double bond / has C=C bond (1)   [1]

(ii) Add bromine (water) (1)

Goes from (orange / brown / red / red-brown) / to colourless / (bromine) is decolourised (1)   [2]
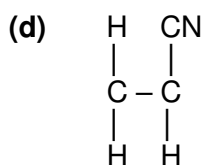
(d)
```
      H   CN
      |   |
      C – C
      |   |
      H   H
```
Correct repeat unit (1)

Free bonds at the end (1)   [2]

(e) Maximum / predicted mass = 1750 (tonnes)

OR

$1750 \times \dfrac{95}{100}$ (1)

Mass of product = 1662.5 (tonnes) (1)   [2]

[Total: 10]

Example candidate response – high

B8 The flow chart shows the steps involved in the manufacture of poly(propenenitrile).
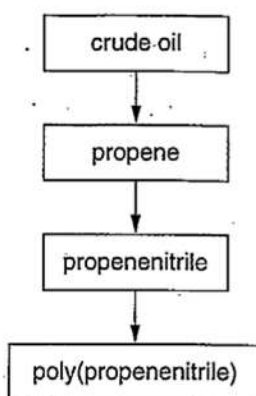
```
            ┌───────────────┐
            │   crude oil    │
            └───────────────┘
                    │
                    ▼
            ┌───────────────┐
            │    propene     │
            └───────────────┘
                    │
                    ▼
            ┌───────────────┐
            │ propenenitrile │
            └───────────────┘
                    │
                    ▼
        ┌───────────────────────┐
        │  poly(propenenitrile)  │
        └───────────────────────┘
```

(a) Long chain alkanes such as $C_{17}H_{36}$ can be cracked to form propene, C_3H_6.

Construct an equation to show the cracking of $C_{17}H_{36}$ to form propene.

$$C_{17}H_{36} \rightarrow C_{15}H_{30} + C_3H_6$$ ....[1]

(b) The equation shows the reaction to make propenenitrile.

$$2C_3H_6(g) + 2NH_3(g) + 3O_2(g) \rightarrow 2C_3H_3N(g) + 6H_2O(g)$$
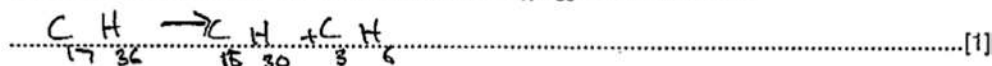
Describe and explain what happens to the rate of this reaction if the temperature is increased.

...If the temperature is increased, then the rate of this...
...reaction becomes faster. This is because the particles...
...collide with more energy...

....[2]

Example candidate response – high, continued

(c) The structure of propenenitrile is shown.

H   H
\\   /
C=C
/   \\
H   C≡N
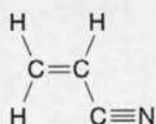
(i) Explain why propenenitrile is unsaturated.

It is unsaturated because it has a c=c double bond
....[1]

(ii) Describe a chemical test to show that propenenitrile is unsaturated.

We react it with aqueous bromine which is a reddish
brown liquid. If propenenitrile is unsaturated then the
solution will ~~become color~~ change its colour from
reddish brown to colourless ....[2]

(d) Draw part of the structure of poly(propenenitrile).
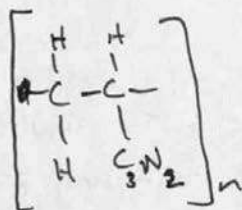
$$\left[\begin{array}{c} H\ \ \ H \\ \mid\ \ \ \ \mid \\ C - C - \\ \mid\ \ \ \ \mid \\ H\ \ \ C_3N_2 \end{array}\right]_n$$

                                                             [2]

(e) A factory uses 1750 tonnes of propenenitrile to produce poly(propenenitrile).

The percentage yield is 95%.

Calculate the mass of poly(propenenitrile) produced.

~~% yield = theoretic~~

$\dfrac{95}{100} = \dfrac{1750}{w}$

Mass of poly(propenenitrile) = 1750 × 95%
= 1662.5

$w = 1842.1$

mass of poly(propenenitrile) = ~~1842.1~~ 1662.5 tonnes [2]

[Total: 10]

Examiner comment – high

B8(a)

This candidate gave an equation with two alkenes, C_3H_6 and $C_{15}H_{30}$ which is incorrect. Many high grade candidates were able to construct correct equations.

Mark awarded = 0 out of 1

B8(b)

This candidate appreciated that the particles collide with more energy but did not include any comment about the particles moving faster or having more kinetic energy. Other candidates referred to more successful collisions instead of more energetic collisions and this was given credit.

Mark awarded = 1 out of 2

B8(c)

This candidate referred to the presence of the carbon-carbon double bond in **(i)** and so was awarded a mark. Candidates that did not mention that the double bond was between carbon atoms were not awarded a mark.

This candidate described using bromine to test for unsaturation and gave the correct observation and so was awarded two marks. Most high grade candidates were able to gain these two marks.

Mark awarded = 3 out of 3

B8(d)

This candidate could not draw the structure of the polymer because they used the wrong formula for the cyano group using C_3N_2 rather than CN. The candidate did however draw in a two carbon skeleton with free bonds at either end so was awarded this marking point. Many high grade candidates were able to get both marks for this question.

Mark awarded = 1 out of 2

B8(e)

The candidate clearly crossed out the incorrect answer and replaced it with the correct answer and working out to be awarded two marks. The incorrect answer was often given by candidates answering this question.

Mark awarded = 2 out of 2

Total mark awarded = 7 out of 10

Example candidate response – middle

B8 The flow chart shows the steps involved in the manufacture of poly(propenenitrile).
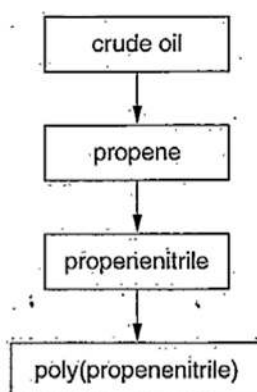
crude oil
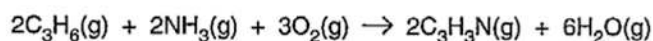
↓

propene

↓

propenenitrile

↓

poly(propenenitrile)

(a) Long chain alkanes such as $C_{17}H_{36}$ can be cracked to form propene, C_3H_6.

Construct an equation to show the cracking of $C_{17}H_{36}$ to form propene.

$C_{17}H_{36} \rightarrow C_3H_6 + C_{14}H_{30}$ ....[1]

(b) The equation shows the reaction to make propenenitrile.

$$2C_3H_6(g) + 2NH_3(g) + 3O_2(g) \rightarrow 2C_3H_3N(g) + 6H_2O(g)$$

Describe and explain what happens to the rate of this reaction if the temperature is increased.

If the temperature is increased the production of propenenitrile will decrease so it is exothermic reaction and favours low temperature for greater production. The reaction ~~Exothermic~~ would go from right to left from higher moles to lower moles. [2]

Example candidate response – middle, continued

(c) The structure of propenenitrile is shown.
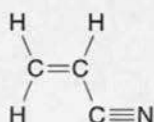
(i) Explain why propenenitrile is unsaturated.

The Pro.pene.nitrile is onsaturated as it cantains the boubled cavalent bond in ther the structure. [1]

(ii) Describe a chemical test to show that propenenitrile is unsaturated.

The test for unsaturated propenitrile is bromine test. The Unsaturated molecule will decolourised the water of bromine. This is the identities to indentify between unsaturated and saturated molecules. [2]

(d) Draw part of the structure of poly(propenenitrile).
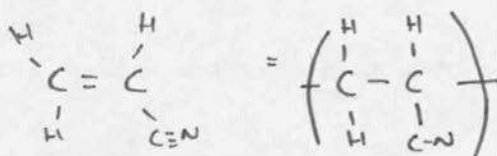
[2]

(e) A factory uses 1750 tonnes of propenenitrile to produce poly(propenenitrile).

The percentage yield is 95%.

Calculate the mass of poly(propenenitrile) produced.

$C_3H_3 = 53$

$Moles = \dfrac{Mass}{Mr}$

$Moles = \dfrac{1750}{95} \times 100 = 1842.1$

$1842.1 = \dfrac{mass}{53}$

$mass = 1842.1 \times 53 = 97631.6$

mass of poly(propenenitrile) = ...97631.6............ tonnes [2]

[Total: 10]

Examiner comment – middle
B8(a)

This candidate constructed a suitable equation for cracking. Although other equations were allowed in the mark scheme this was the most common equation given by mid-grade candidates.

Mark awarded = 1 out of 1

B8(b)

This candidate referred to the position of equilibrium rather than rate of reaction and so was not awarded any marks. The candidate assumed that the reaction was exothermic and states that the production of propenenitrile decreased rather than that the rate of reaction increases. The answer needed to refer to molecules moving faster and having more successful collisions.

Mark awarded = 0 out of 2

B8(c)

This candidate only referred to the presence of a double bond in **(i)** but this was not sufficient and had to be identified as a carbon-carbon double bond to be awarded a mark.

In **(ii)** this candidate gave a good answer referring to the use of bromine to test for unsaturated compounds. The reference to decolourised was sufficient to get the observation mark.

Mark awarded = 2 out of 2

B8(d)

This candidate could draw the structure of the polymer but did not show the triple bond between the carbon and the nitrogen atom and so only scored one mark. If the group was shown as CN rather than C—N then this would have been acceptable for the second mark.

Mark awarded = 1 out of 2

B8(e)

The candidate was not available to complete this calculation and used an approach using moles rather than using the connection between percentage yield, actual yield and predicted yield.
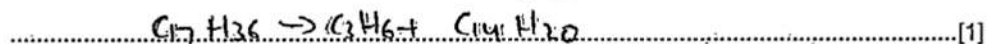
Mark awarded = 0 out of 2

Total mark awarded = 4 out of 10

Example candidate response – low

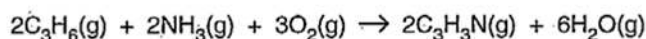**B8** The flow chart shows the steps involved in the manufacture of poly(propenenitrile).
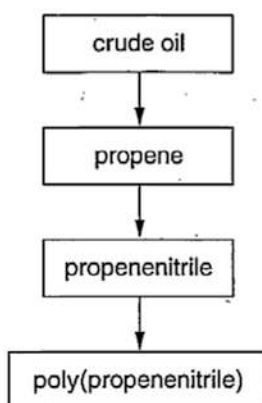
```
┌──────────────┐
│   crude oil  │
└──────────────┘
        │
        ▼
┌──────────────┐
│   propene    │
└──────────────┘
        │
        ▼
┌──────────────┐
│ propenenitrile │
└──────────────┘
        │
        ▼
┌──────────────────────┐
│ poly(propenenitrile) │
└──────────────────────┘
```

(a) Long chain alkanes such as $C_{17}H_{36}$ can be cracked to form propene, C_3H_6.

Construct an equation to show the cracking of $C_{17}H_{36}$ to form propene.

$C_{17}H_{36} + CO \longrightarrow C_{17}H_{36} \; C_3H_6$ .....[1]

(b) The equation shows the reaction to make propenenitrile.

$$2C_3H_6(g) + 2NH_3(g) + 3O_2(g) \rightarrow 2C_3H_3N(g) + 6H_2O(g)$$
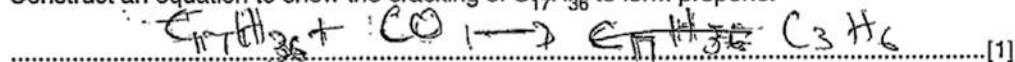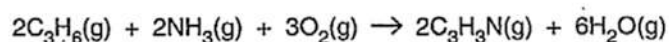
Describe and explain what happens to the rate of this reaction if the temperature is increased.

The rate of reaction increased so the breaking making of bonding could occur & they can be hydroxide. Speed the process of Hydroxide. .....[2]

Example candidate response – low, continued

(c) The structure of propenenitrile is shown.

$$
\begin{array}{c}
H \quad\quad H \\
\diagdown \quad\quad \diagup \\
C = C \\
\diagup \quad\quad \diagdown \\
H \quad\quad C \equiv N
\end{array}
$$
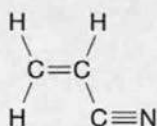
(i) Explain why propenenitrile is unsaturated.

They have triple bonds. They have a unsaturated monomdimers monomolimen is their is double bonding is not appropriate unstable. [1]

(ii) Describe a chemical test to show that propenenitrile is unsaturated.

Propeneitrile is unsaturate because when their have the bonding we could make the double bound but the one C is left & is not bond so we would make the triple bond of N. [2]

(d) Draw part of the structure of poly(propenenitrile).
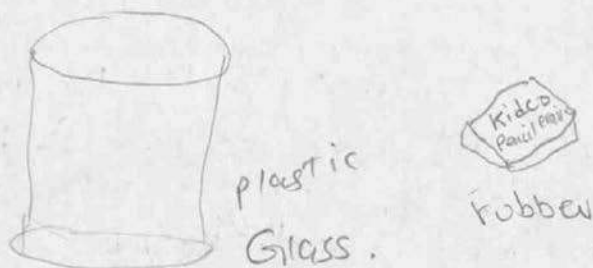
plastic
Glass.

rubber

[2]

(e) A factory uses 1750 tonnes of propenenitrile to produce poly(propenenitrile).

The percentage yield is 95%.

Calculate the mass of poly(propenenitrile) produced.

$$\frac{1750}{158} \times 95$$

mass of poly(propenenitrile) = ...1662.5........ tonnes [2]

[Total: 10]

Examiner comment – low
B8(a)

This candidate could not construct the balanced equation for the cracking of $C_{17}H_{36}$ since they included an extra reactant in the equation and only had C_3H_6 as the product.

Mark awarded = 0 out of 1

B8(b)

This candidate appreciated that the rate of reaction would increase but did not explain why in terms of particles moving faster and having more successful collisions.

Mark awarded = 0 out of 2

B8(c)

This candidate referred to the presence of the triple bond in **(i)** but in this structure it does not make the compound unsaturated since the triple bond is between carbon and nitrogen. The answer had to refer to the presence of a double bond between two carbon atoms.
In **(ii)** this candidate did not mention the use of bromine to test for unsaturation and so was awarded no marks.

Mark awarded = 0 out of 3

B8(d)

This candidate misunderstood the question and drew plastic items instead. The correct answer needed to be a structure of the polymer showing the bonds and atoms present.

Mark awarded = 0 out of 2

B8(e)

This candidate was able to use the information to calculate the mass of the polymer formed. This candidate showed working out that was clear to follow.

Mark awarded = 2 out of 2

Total mark awarded = 2 out of 10

Question B9
Mark scheme

B9 **(a)** Melting point below 25 °C (1)
Boiling point above 25 °C (1)   [2]

(b) Particles move faster / particles gain energy (1)

Particles spread out / move away from each other (1)   [2]

(c) Volume of gas increases (1)

Particles spread out (1)   [2]

(d) Ethene has a lower (relative) molecular mass / ethene has a lower formula
mass / or reverse argument (1)   [1]

(e) ANY TWO FROM

(1)   (1)

(1)   [2]

(f)
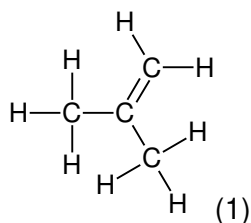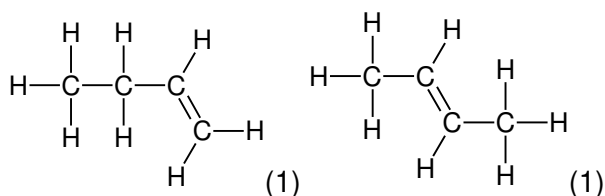
OR

(1)   [1]

[Total: 10]

Example candidate response – high

B9 Alkenes are a homologous series of unsaturated hydrocarbons.

The table shows information about some alkenes.

alkene	molecular formula	melting point /°C	boiling point /°C
ethene	C_2H_4	−169	−105
butene	C_4H_8	−185	−6
hexene	C_6H_{12}	−140	63
decene	$C_{10}H_{20}$	−66	171
dodecene	$C_{12}H_{24}$	−35	214

(a) Decene is a liquid at 25 °C.

How can you make this deduction from the data in the table?

The melting point of decene is lower than 25°C and the boiling point is higher than 25°C. So decene is liquid at 25°C. ....[2]

(b) Butene boils at −6 °C.

Use the kinetic particle theory to explain what happens when butene boils.

When Butene boils, the molecules gain heat energy and have increased kinetic energy and therefore have frequent collisions.

....[2]

(c) A sample of ethene gas in a gas syringe is heated from 20 °C to 100 °C.

The pressure remains constant.

Describe and explain, in terms of the kinetic particle theory, what happens to the volume of the gas.

As the temperature is in increased, the particles gain more heat energy, thereby having an increased kinetic energy. So the molecules gas expands thereby increasing the volume of gas. ....[2]

(d) At room temperature ethene diffuses faster than butene.

Explain why.

The molecular relative molecular mass of ethene is lower than butene, so ethene diffuses faster. ....[1]

Example candidate response – high, continued

(e) Draw the structure, showing all the atoms and all the bonds, for two isomers with the molecular formula C_4H_8.

H—C—C=C—C—H (with H atoms shown on each carbon)

H—C—C—C=C—H (with H atoms shown on each carbon)

[2]

(f) The structure of hexene is shown.

H—C—C—C—C—C=C—H (with H atoms shown on each carbon)

Draw the structure, showing all the atoms and all the bonds, for the product of the reaction of hexene with steam.

H—C—C—C—C—C—C—O—H (with H atoms shown on each carbon)

[1]
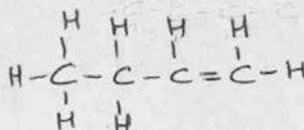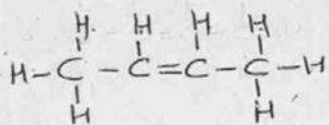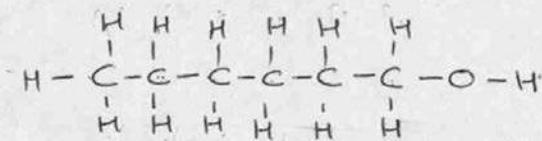
[Total: 10]

Examiner comment – high
B9(a)

This candidate gave an accurate answer referring to both the melting point being lower than $25^{\circ}C$ and the boiling point above $25^{\circ}C$. Other candidates referred to room temperature rather than $25^{\circ}C$ and this was accepted in the mark scheme. A common error was to refer only to the melting point or the boiling point.

Mark awarded = 2 out of 2

B9(b)

This candidate appreciated that the particles gained energy but did not mention any idea of the particles spreading out or that intermolecular forces were broken. Candidates that mentioned atoms or ions instead of particles or molecules were awarded no marks for the question.

Mark awarded = 1 out of 2

B9(c)

This candidate appreciated that the volume of the gas increases but was not able to give an adequate explanation and did not mention that the particles would move away from each other. The most common incorrect explanation referred to particles moving faster or having more collisions.

Mark awarded = 1 out of 2

B9(d)

This candidate appreciated that ethene has a lower molecular mass than butene and so would diffuse faster.

Mark awarded = 1 out of 1

B9(e)

This candidate drew both structures very clearly and was awarded both marks. Some high grade candidates drew cycloalkanes such as cyclobutane and these were accepted as correct.

Mark awarded = 2 out of 2

B9(f)

This candidate drew a clear structure of hexanol, and made certain that the hydroxyl group was drawn out fully and so was awarded a mark. Either hexan-1-ol or hexan-2-ol was accepted as correct.

Mark awarded = 1 out of 1

Total mark awarded = 8 out of 10

Example candidate response – middle

B9 Alkenes are a homologous series of unsaturated hydrocarbons.

The table shows information about some alkenes.

alkene	molecular formula	melting point /°C	boiling point /°C
ethene	C_2H_4	−169	−105
butene	C_4H_8	−185	−6
hexene	C_6H_{12}	−140	63
decene	$C_{10}H_{20}$	−66	171
dodecene	$C_{12}H_{24}$	−35	214

(a) Decene is a liquid at 25°C.

How can you make this deduction from the data in the table?

...... Because this value comes between its

..... melting point and boiling point.

....[2]

(b) Butene boils at −6°C.

Use the kinetic particle theory to explain what happens when butene boils.

... When it boils, it is particles collide with

... each other and will vibrate. Molec Particles with

... more kinetic energy will escape and turn

... into gas.

....[2]

(c) A sample of ethene gas in a gas syringe is heated from 20°C to 100°C.

The pressure remains constant.

Describe and explain, in terms of the kinetic particle theory, what happens to the volume of the gas.

... Because of heat, particles will gain more kinetic energy

and will collide fa at faster rate. Because of

collision,

this collides they will cover more area and/volume will [2]

increased

(d) At room temperature ethene diffuses faster than butene.

Explain why.

... ℓ Ethene is lighter than butene as it contains less

... Carbon bonds than Butene.

....[1]
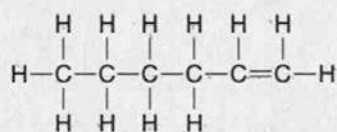
Example candidate response – middle, continued

(e) Draw the structure, showing all the atoms and all the bonds, for two isomers with the molecular formula C_4H_8.

(handwritten candidate structures)

[2]

(f) The structure of hexene is shown.

(structure of hexene drawn:)

H−C−C−C−C−C=C−H with H atoms shown on each carbon

Draw the structure, showing all the atoms and all the bonds, for the product of the reaction of hexene with steam.

$C_6H_{12} + H_2O$

(handwritten candidate structure)

H−C−C−C−C−C−C−O−H with H atoms shown on each carbon

[1]
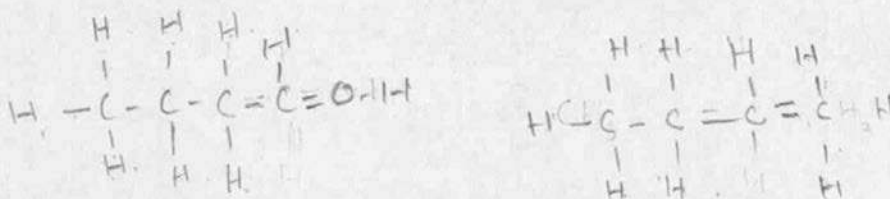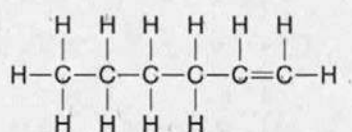
[Total: 10]

Examiner comment – middle
B9(a)

In this question the candidate needed to make a specific reference to 25°C (or room temperature) to be awarded a mark. It was not sufficient for this candidate to state that this value was between the melting point and the boiling point. The question uses many values so it is not clear what value is being referred to. The best answers stated that 25°C was above the melting point but below the boiling point.

Mark awarded = 0 out of 0

B9(b)

This candidate gave an imprecise answer and was only awarded one mark. There is no specific statement that the particles gain energy or move faster and so the first marking point in the mark scheme cannot be awarded. The idea that the particles escape the liquid is equivalent to the particles breaking free from the liquid so is awarded the second marking point in the mark scheme.

Mark awarded 1 out of 2

B9(c)

The candidate does state that the volume increases but although they appreciate that the particles have more energy they do not describe that the particles spread out from one another.

Mark awarded = 1 out of 2

B9(d)

The candidate only refers to ethene being lighter but to be awarded a mark must refer to the relative molecular mass of ethene being smaller than that of butane.

Mark awarded = 0 out of 1

B9(e)

The left hand side structure is incorrect with the inclusion of an oxygen atom. The second double bond in the right hand structure has been erased so that this structure is acceptable and this candidate is awarded one mark.

Mark awarded = 1 out of 2

B9(f)

This candidate has drawn a correct structure with the hydroxyl group shown in full. The structure of hexan-2-ol would also have been acceptable. The reference to C_6H_{12} and H_2O is considered as working out and was ignored.

Mark awarded = 1 out of 1

Total mark awarded = 4 out of 10

Example candidate response – low

B9 Alkenes are a homologous series of unsaturated hydrocarbons.

The table shows information about some alkenes.

alkene	molecular formula	melting point /°C	boiling point /°C
ethene	C_2H_4	−169	−105
butene	C_4H_8	−185	−6
hexene	C_6H_{12}	−140	63
decene	$C_{10}H_{20}$	−66	171
dodecene	$C_{12}H_{24}$	−35	214

(a) Decene is a liquid at 25 °C.

How can you make this deduction from the data in the table?

Since it boiling point is at 171°c and melting point is at −66°c we can see that the decene is in its liquit stage. [2]

(b) Butene boils at −6 °C.

Use the kinetic particle theory to explain what happens when butene boils.

when butene heats, the bonds between carbon and hydrogen break and spread moving in random directions. water vapor is also produced. [2]

(c) A sample of ethene gas in a gas syringe is heated from 20 °C to 100 °C.

The pressure remains constant.

Describe and explain, in terms of the kinetic particle theory, what happens to the volume of the gas.

The volume of the gas increases as the particles move at a faster speed in all directions spreeding around. [2]

(d) At room temperature ethene diffuses faster than butene.

Explain why.

Ethene was already a gas which was diffusing when butene had turned into a gas so naturally ethene diffused faster [1]

Example candidate response – low, continued

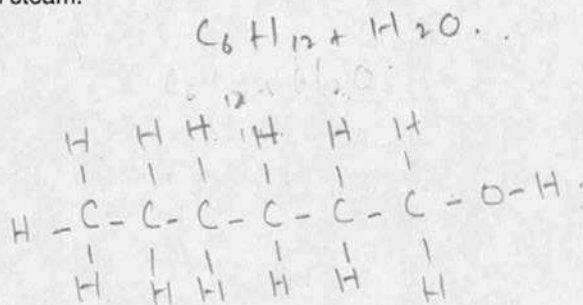(e) Draw the structure, showing all the atoms and all the bonds, for two isomers with the molecular formula C_4H_8.

H
|
H — C — C — H
| |
H H — C — H
|
H

[2]

(f) The structure of hexene is shown.

```
    H  H  H  H  H  H
    |  |  |  |  |  |
 H—C—C—C—C—C=C—H
    |  |  |  |
    H  H  H  H
```

Draw the structure, showing all the atoms and all the bonds, for the product of the reaction of hexene with steam.

H H H H H H
| | | | | |
H — C — C — C — C — C — C — OH
| | | | |
H H H H H

[1]
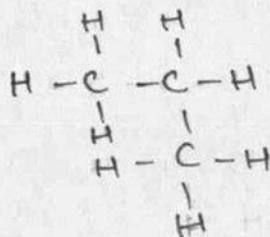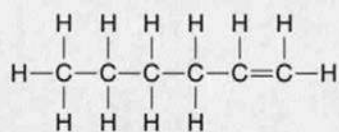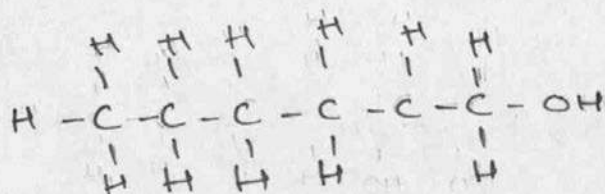
[Total: 10]

Examiner comment – low

B9(a)

This candidate only quoted the data given in the table and made no attempt to relate this to 25°C and the state of the alkene. The candidate needed to state clearly that the melting point is less than 25°C so it had melted and that 25°C is less than the boiling point so it had not yet boiled.

Mark awarded = 0 out of 2

B9(b)

This candidate had the misconception that covalent bonds between carbon atoms and hydrogen atoms are broken when a liquid boils. Candidates needed to clearly state that it was forces between molecules that were broken.

Mark awarded = 0 out of 2

B9(c)

This candidate clearly states that the volume increases, and then explains why in terms of particles spreading around.

Mark awarded 2 out of 2

B9(d)

This candidate did not appreciate that the rate of diffusion depends on the relative molecular mass of the compounds and instead related it to the state of the compound.

Mark awarded = 0 out of 1

B9(e)

This candidate only drew one structure and this structure was incorrect since it had only three carbon atoms and did not have a double bond.

Mark awarded = 0 out of 2

B9(f)

This candidate missed out one hydrogen atom in the structure and as a result did not get a mark. Although the candidate drew the hydroxyl group as –OH rather than –O—H bond this was not penalised in this question.

Mark awarded = 0 out of 1

Total mark awarded = 2 out of 10

Paper 3 Practical Test

Question 1
Mark scheme

1 **(a)** Temperature readings

F: full set of temperatures provided for columns D and E (1)
R: temperatures recorded to 0.5 °C (1)
S: temperature rises correctly calculated, 6 correct (1) OR all correct (2)
P: pattern of results:
    a general rise then fall (1)
    experiments 1–3 increasing temperature rise (1)
    experiments 4–7 decreasing temperature rise (1)

Accuracy:
For each of the experiments 1–7 give 1 mark for each temperature rise within 1.0 °C
of the supervisor's value (7)   **[14]**

(b) Graph

Correct plotting of all the points (1)
Two intersecting straight lines which fit the results as plotted (1)   **[2]**

(c) Volume of **P**

Correct recording of the volume from the graph at the point of intersection of the two
lines (1)   **[1]**

Mark parts **(d)** – **(f)** using the candidate's volume of **P**.

Assuming the volume of **P** is 23.0 cm^3:

(d) Number of moles of HCl in 23.0 cm^3 of **P**

$$= \frac{23.0 \times 1.50}{1000}$$

$$= 0.0345 \ (1)$$ **[1]**

(e) Number of moles of NaOH which react

$$= 0.0345 \ (1)$$ **[1]**

Mark scheme, continued

(f) Concentration in mol/dm^3 of **Q**

Volume of **Q**

$50.0 - 23.0 = 27.0$ (1)

Concentration of **Q**

$$= \frac{0.0345 \times 1000}{27.0}$$

$= 1.28$ (1)

<div align="right">[2]
[Total: 21]</div>

Example candidate response – high

1 Reactions between alkalis and acids are exothermic. The change in temperature when aqueous sodium hydroxide is added to dilute hydrochloric acid of known concentration can be used to determine the concentration of the alkali.

P is 1.50 mol/dm^3 hydrochloric acid.
Q is aqueous sodium hydroxide.

(a) **(i)** Put **P** into a burette and use it to measure 10 cm^3 of **P** into a plastic cup. Measure the temperature of **P** to the nearest 0.5 °C and record the value in column D of the table.

(ii) Using a measuring cylinder, measure 40 cm^3 of **Q** as accurately as possible. Pour this volume of **Q** into the plastic cup containing **P**. Stir, using the thermometer, and measure the highest temperature reached. Record the value in column E of the table.

(iii) Empty the plastic cup and rinse it with water.

(iv) Repeat the procedure described in **(i)** to **(iii)** but using the different volumes of **P** and **Q** given in columns B and C of the table for experiments 2 to 7.

(v) For each experiment, calculate the temperature rise and record the value in column F.

	A	B	C	D	E	F
	experiment number	volume of **P** /cm^3	volume of **Q** /cm^3	initial temperature of **P** /°C	highest temperature of mixture /°C	temperature rise /°C
Sup						
3·5	1	10	40	31 0	34 0	3.0 ✓
5·0	2	15	35	30.5	36.0	5. 5 ✓
7·0	3	20	30	31.0	37.0	6.0 ✓
6·5	4	25	25	31.0	37 5	6.5 ✓
5·0	5	30	20	31.0	36.5	5.5 ✓
3·0	6	35	15	31.5	35 0	3.5 ✓
2·5	7	40	10	32 0	34 0	2.0 ✓

F ✓ R ✓ S ✓✓ P ✓✓✓

[14] /4

(b) Plot a graph of temperature rise (column F) against volume of **P** (column B) on the grid opposite. Using these points, draw two intersecting straight lines. [2] 2

Example candidate response – high, continued
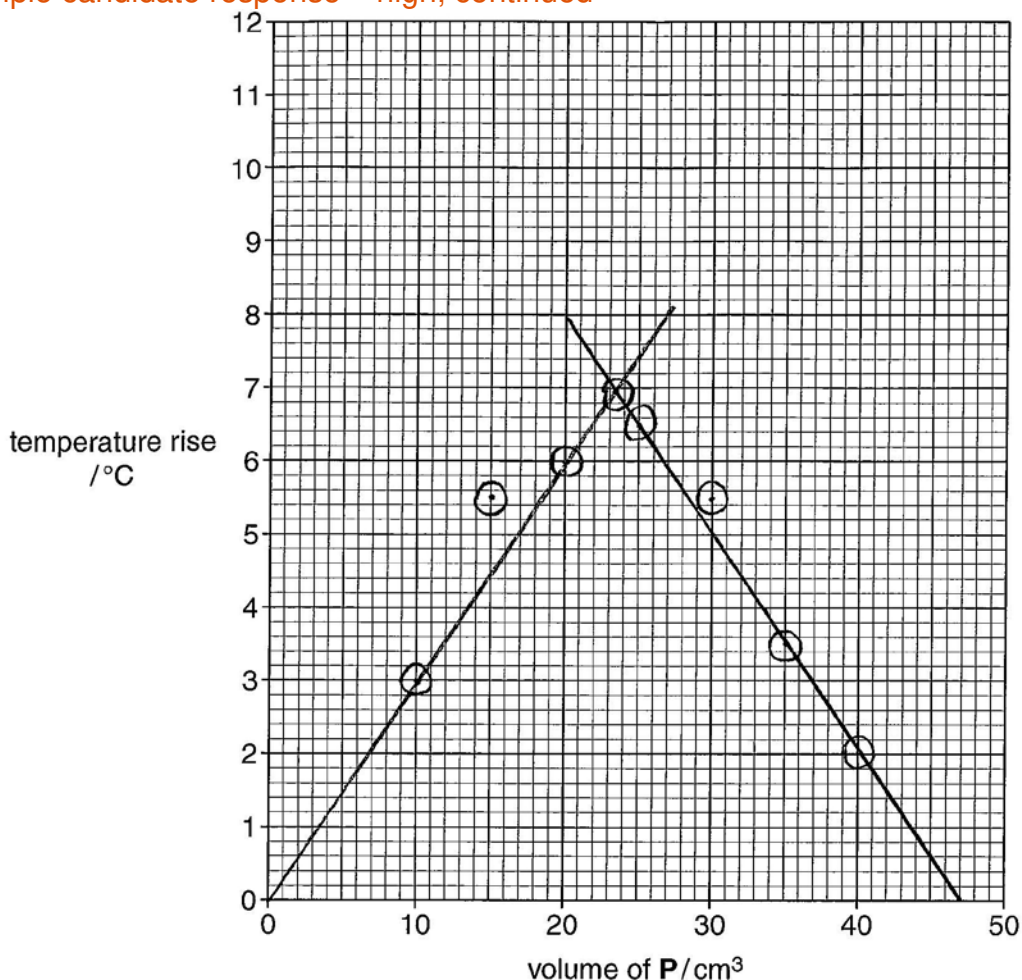
(c) From the graph, read the volume of **P** where the two lines cross.

volume of **P** .... 27.0 ...... X .... cm³ [1] O

(d) Calculate the number of moles of hydrochloric acid present in the volume of **P** you gave as an answer to **(c)**.

no. of moles of HCl = concentration of HCl (in mol/dm³) X volume of HCl (in dm³)

$$= 1.50 \times \frac{21.0}{1000}$$

= 0.0405 moles

moles of hydrochloric acid ..... 0.0405 moles .... [1] |

(e) Deduce the number of moles of sodium hydroxide which react with the number of moles of hydrochloric acid you gave as an answer to **(d)**.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

1 mole HCl reacts with 1 mole NaOH.

$\left(\frac{MV}{n}\right)_{NaOH} = \left(\frac{MV}{n}\right)_{HCl} \Rightarrow$ ∴ 0.0405 moles HCl react with 0.0405 moles NaOH. |
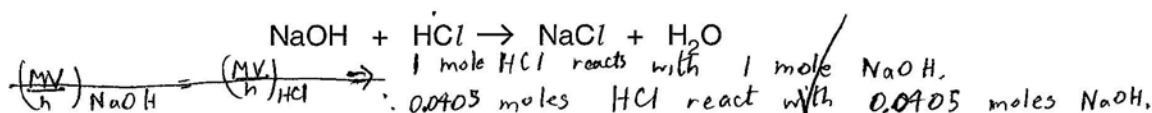
moles of sodium hydroxide .... 0.0405 moles .... [1]

Example candidate response – high, continued

(f) Calculate the concentration, in mol/dm³, of the aqueous sodium hydroxide, **Q**.

concentration of NaOH (in mol/dm³) = $\dfrac{\text{no. of moles of NaOH}}{\text{volume of NaOH used (in dm}^3)}$ ✓

$= \dfrac{0.0405}{\frac{23}{1000}}$

$= \dfrac{40.5}{23}$

$= \cancel{17.6} \; 1.76 \; mol/dm^3$ ✓

concentration of **Q** ......1.76........................ mol/dm³ [2] ✓

[Total: 21]

20 ✓

Examiner comment – high

(a) By completing the practical work described the candidate produces a full set of temperature measurements (columns D and E) which are recorded to the nearest 0.5 °C. The temperature rises (column F) are all correctly calculated and follow the expected pattern of rise and fall. The labelled row of ticks below the table shows the seven marks awarded.

Each experiment's temperature rise is within 1.0 °C of the supervisor's value provided on the left of the table and so another seven marks are obtained.

Mark awarded = 14 out of 14

(b) The required data is correctly plotted and used to draw two intersecting straight lines.

Mark awarded = 2 out of 2

(c) The candidate misreads from the graph the volume of **P** which should be 23.0 or 23.5 cm³.

Mark awarded = 0 out of 1

(d) The volume of P from (c) is clearly and correctly used to calculate the number of moles of acid.

Mark awarded = 1 out of 1

(e) The number of moles of alkali is the same as the number of moles of acid in **(d)**.

Mark awarded = 1 out of 1

(f) 23 cm³ is the volume of **Q** which reacts with 27 cm³ of **P** so the candidate scores the first mark and then a correct calculation follows to produce the concentration of the alkali for the second.

Mark awarded = 2 out of 2

Total mark awarded = 20 out of 21

Example candidate response – middle

1   Reactions between alkalis and acids are exothermic. The change in temperature when aqueous sodium hydroxide is added to dilute hydrochloric acid of known concentration can be used to determine the concentration of the alkali.

P is 1.50 mol/dm^3 hydrochloric acid.
Q is aqueous sodium hydroxide.

(a) (i)   Put P into a burette and use it to measure 10 cm^3 of P into a plastic cup. Measure the temperature of P to the nearest 0.5 °C and record the value in column D of the table.

(ii) Using a measuring cylinder, measure 40 cm^3 of Q as accurately as possible. Pour this volume of Q into the plastic cup containing P. Stir, using the thermometer, and measure the highest temperature reached. Record the value in column E of the table.

(iii) Empty the plastic cup and rinse it with water.

(iv) Repeat the procedure described in (i) to (iii) but using the different volumes of P and Q given in columns B and C of the table for experiments 2 to 7.

(v) For each experiment, calculate the temperature rise and record the value in column F.

A	B	C	D	E	F
experiment number	volume of P /cm^3	volume of Q /cm^3	initial temperature of P /°C	highest temperature of mixture /°C	temperature rise /°C
1	10	40	28 °C	32 °C	4 °C ✓
2	15	35	28 °C	34 °C	6 °C ✓
3	20	30	29 °C	36 °C	7 °C ✓
4	25	25	29 °C	37 °C	8 °C ✓
5	30	20	29 °C	35 °C	4 °C sub 6 °C ✓
6	35	15	29 °C	32 °C	3 °C ✓
7	40	10	29 °C	31 °C	2 °C ✓

Sup
4·0
5·5
7·5
7·0
5·5
4
2·5

✓ ✗ ✓ ✗ ✓✓✓   [14] 12

(b) Plot a graph of temperature rise (column F) against volume of P (column B) on the grid opposite. Using these points, draw two intersecting straight lines.   [2] 1

Example candidate response – middle, continued

(c) From the graph, read the volume of **P** where the two lines cross.

volume of **P** ....18.......... X .... cm^3 [1] O

(d) Calculate the number of moles of hydrochloric acid present in the volume of **P** you gave as an answer to **(c)**.

0.0015 x18   ecf

= 0.027

moles of hydrochloric acid ....0.027....✓.................. [1] |

(e) Deduce the number of moles of sodium hydroxide which react with the number of moles of hydrochloric acid you gave as an answer to **(d)**.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

1 : 1
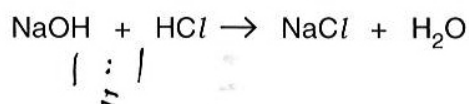
moles of sodium hydroxide ....0.027....✓.......... [1] |

Example candidate response – middle, continued

(f) Calculate the concentration, in mol/dm^3, of the aqueous sodium hydroxide, **Q**.

$\underline{\underline{0.027}}$ $\qquad$ $C = \dfrac{m}{V}$

$$\dfrac{0.027}{18} = 1.5 \times 10^{-03}$$

0.0015 $\quad$ ✗ $\qquad$ 0

concentration of **Q** .... mol/dm^3 [2]

[Total: 21]

(15) ✓

Examiner comment – middle

(a) While there is a full set of temperature measurements provided, there is no indication that the readings have been taken to the nearest 0.5 °C and the candidate makes a subtraction error in experiment 5. The pattern of temperature change is correct. Consequently, there are five ticks below the table.

All the temperature rises are within 1.0 °C of the supervisor's – the corrected value for experiment 5 is the one used to make comparison.

Mark awarded = 12 out of 14

(b) The required data is correctly plotted but two intersecting straight lines have not been drawn.

Mark awarded = 1 out of 1

(c) Without two straight lines the candidate does not have a point of intersection but the mark would have been awarded if 25 cm^3 had been given as the volume.

Mark awarded = 0 out of 1

(d) The volume of **P** from **(c)** is correctly used to calculate the number of moles of acid.

Mark awarded = 1 out of 1

(e) The number of moles of alkali is the same as the number of moles of acid in **(d)**.

Mark awarded = 1 out of 1

(f) The volume of **Q** is incorrect and so is the concentration calculation which follows.

Mark awarded = 0 out of 2

Total mark awarded = 15 out of 21

Example candidate response – low

1 Reactions between alkalis and acids are exothermic. The change in temperature when aqueous sodium hydroxide is added to dilute hydrochloric acid of known concentration can be used to determine the concentration of the alkali.

P is 1.50 mol/dm^3 hydrochloric acid.   *(handwritten: HCl)*

Q is aqueous sodium hydroxide.   *(handwritten: NaOH)*

(a) (i) Put P into a burette and use it to measure 10 cm^3 of P into a plastic cup. Measure the temperature of P to the nearest 0.5 °C and record the value in column D of the table.

(ii) Using a measuring cylinder, measure 40 cm^3 of Q as accurately as possible. Pour this volume of Q into the plastic cup containing P. Stir, using the thermometer, and measure the highest temperature reached. Record the value in column E of the table.

(iii) Empty the plastic cup and rinse it with water.

(iv) Repeat the procedure described in (i) to (iii) but using the different volumes of P and Q given in columns B and C of the table for experiments 2 to 7.

(v) For each experiment, calculate the temperature rise and record the value in column F.

(handwritten margin: S UP 4 6 8 8 7 5 3)

A	B	C	D	E	F	
experiment number	volume of P /cm^3	volume of Q /cm^3	initial temperature of P /°C	highest temperature of mixture /°C	temperature rise /°C	
1	10	40	25.5°C	31°C	5.5°c	✗
2	15	35	25.5°C	31°C	5.5°c	✓
3	20	30	25.5°c	31°c	5.5°c	✗
4	25	25	25.5°C	31°c	5.5°c	✗
5	30	20	25.5°c	31°c	5.5°c	✗
6	35	15	25.5°c	30°c	4.5°c	✓
7	40	10	25.5°c	29°c	3.5°c	✓

(handwritten below table: F✓ R✓ S✓✓ P✗ ✗ ✗)

[14]

(b) Plot a graph of temperature rise (column F) against volume of P (column B) on the grid opposite. Using these points, draw two intersecting straight lines.   [2]

Example candidate response – low, continued
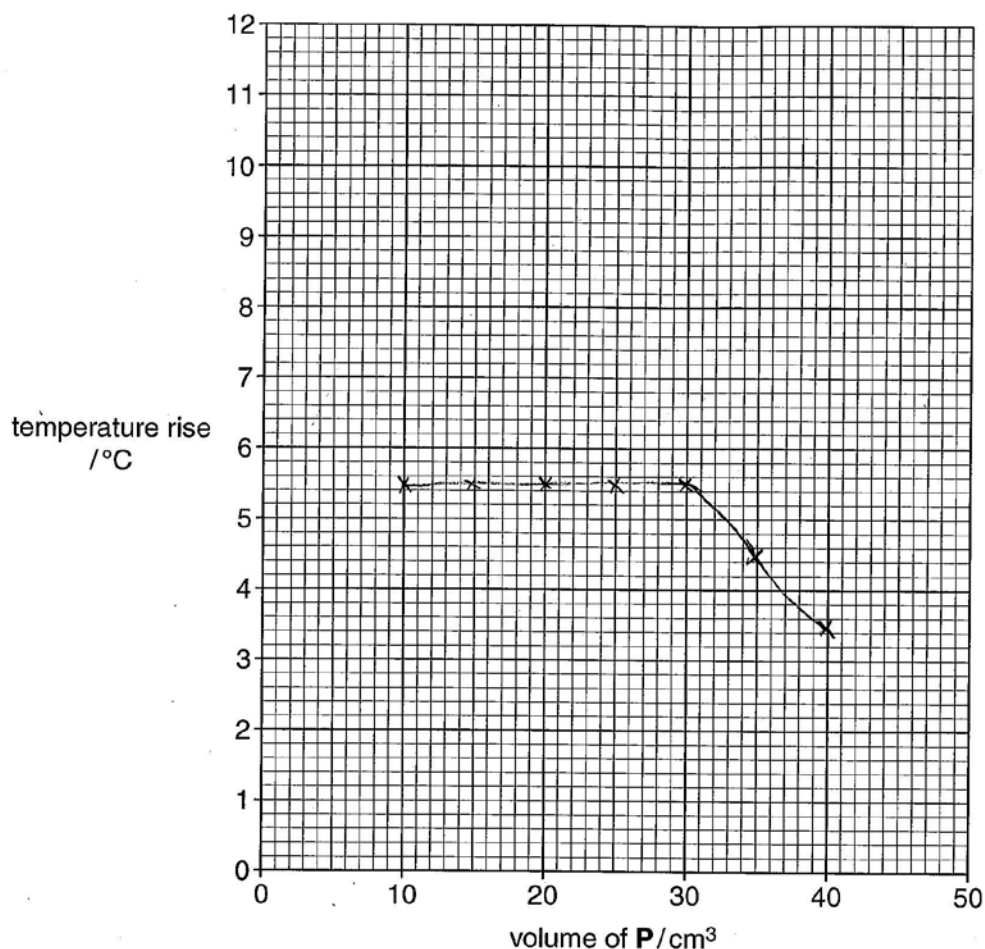
**(c)** From the graph, read the volume of **P** where the two lines cross.

volume of **P** ....30..................................../..... cm³ [1]

(d) Calculate the number of moles of hydrochloric acid present in the volume of **P** you gave as an answer to **(c)**.

$$m\,ol = \frac{volume}{24dm}$$

$$= \frac{0.03}{24}$$

$$= 1.25 \times 10^{-3}$$

moles of hydrochloric acid ....1.25×10^{-3}.... mol/dm³ .... [1]

(e) Deduce the number of moles of sodium hydroxide which react with the number of moles of hydrochloric acid you gave as an answer to **(d)**.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

1mol of HCl $\longrightarrow$ 1.25×10^{-3}

1mol of NaOH $\longrightarrow$ n

moles of sodium hydroxide ....1.25×10^{-3} mol/dm³.......... [1]

ecf
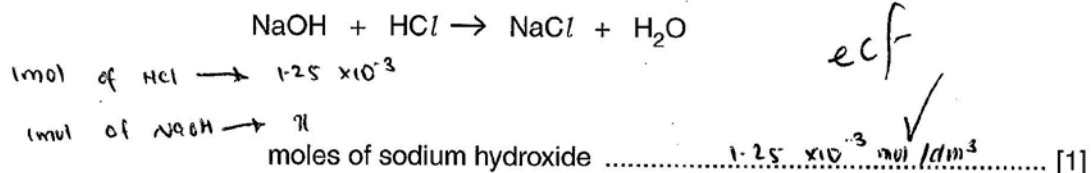
Example candidate response – low, continued

(f) Calculate the concentration, in mol/dm^3, of the aqueous sodium hydroxide, **Q**.

$$\frac{1.5 \times 10}{x \times 40} = \frac{1}{1}$$

$$40x = 15$$

$$x = \frac{15}{40}$$

$$= 0.375$$

concentration of **Q** ....0.375.............. mol/dm^3 [2]

[Total: 21]

Examiner comment – low

(a) While the candidate has provided a full set of temperatures in columns D and E, recorded to the nearest 0.5 °C and correctly calculated all the temperature rises, the pattern of results is not as expected. Nevertheless, three of the temperature rises are within 1.0 °C of the supervisor's values.

Mark awarded = 7 out of 14

(b) The required data is correctly plotted but two intersecting straight lines have not been drawn.

Mark awarded = 1 out of 2

(c) The volume given is that at the point where the two lines meet and as such was judged worthy of the mark.

Mark awarded = 1 out of 1

(d) The candidate is not secure in the use of concentration and instead calculates the number of moles in 30 cm^3 of gas. If extra data, such as molar volume of a gas or relative mass, is needed, it will be provided.

Mark awarded = 0 out of 1

(e) Despite the wrong answer for the number of moles of acid in **(d)**, the candidate correctly uses the relationship in the equation to deduce the number of moles of alkali.

Mark awarded = 1 out of 1

(f) While the formula written by the candidate can produce the right answer, the volumes used are not those for neutralisation.

Mark awarded = 0 out of 2

Total mark awarded = 10 out of 21

Question 2
Mark scheme

2   **R** is hydrochloric acid   **S** is sodium thiosulfate

Test	Notes
General points For ppt allow solid, suspension, powder For gases Name of gas requires test to be at least partially correct. Effervesces = Bubbles = gas vigorously evolved but not gas evolved	
Test 1 bubbles (1) gas pops with a lighted splint (1) hydrogen (1) metal disappears (1) [4]	to score hydrogen mark there must be some indication of a test e.g. 'popped with a splint', 'tested with a burning splint'
Test 2 **(a)** white ppt (1) **(b)** ppt remains (1) [2]	
Test 3 white or yellow ppt (1) manganate(VII) decolourised (1) pungent gas / sulfur dioxide (1) [3]	allow turns colourless / white / brown
Test 4 decolourised (1) [1]	allow turns colourless
Test 5 white / yellow / red / brown ppt (1) colour of ppt darkens (1) [2]	

Mark scheme, continued

Test	Notes
Test 6	
(a) solution turns purple/red/violet (1)	accept dark brown
solution finally colourless/pale yellow (1)	accept colour fades/becomes paler
(b) green (1)	accept black-green
ppt (1)	
insoluble in excess (1) [5]	

[maximum 16 marks from 17 scoring points]

Conclusions

Cation in **R** is H^+. (In Test 1 metal reacts.) (1)

Anion in **R** is Cl^-. (In Test 2 there must be a white ppt which remains in nitric acid.) (1)

If both ions in **R** are correct but inverted, allow one mark from the previous two.

S is a reducing agent. (Test 4 decolourised or green ppt in Test 6) (1)   [3]

[Total: 19]

Example candidate response – high

2   You are provided with solutions **R** and **S**.

Carry out the following tests and record your observations in the table. You should test and name any gas evolved.

test no.	test	observations	
1	To 2 cm depth of **R** in a test-tube, add a piece of magnesium.	Gas is evolved vigorously. Effervescence is seen. Solid magnessium dissolves and ~~th~~ a colourless solution is formed. The gas evolved is tested with a lighted splint, lighted splint extinguishes with a pop sound. Hydrogen is given off.	4
2	(a) To 1 cm depth of **R** in a test-tube, add a few drops of aqueous silver nitrate.	White precipitate is formed.	
	(b) To the mixture from (a), add dilute nitric acid.	White precipitate remains insoluble. White precipitate does not dissolve	2
3	To 2 cm depth of **R** in a boiling tube, add an equal volume of **S** and warm the mixture **gently**. Place over the mouth of the boiling tube, a piece of filter paper which has been soaked in acidified aqueous potassium manganate(VII).	A pale yellow solution is formed. The filter paper changes colour from purple to brown. ~~k~~ Acidified KMnO₄ is decolourised.	1
4	To 1 cm depth of aqueous iodine in a test-tube, add **S**.	Brown solution turns colourless. Aquaeous iodine is decolourised. A colourless solution is formed.	1
5	To 2 cm depth of aqueous silver nitrate in a test-tube, add a few drops of **S** and leave to stand until no further change is seen.	Initially yellow precipitate is formed. Then precipitate colour changes to orange and then it turns brown. Finally a black lump of solid remains	2

Example candidate response – high, continued

6	(a)	To 1 cm depth of aqueous iron(III) chloride in a test-tube, add an equal volume of **S** and mix well.	Initially a black colour solution is formed which disappears on mixing. The colour slowly fades on mixing. Finally an orange coloured solution remains
	(b)	To the mixture from **(a)**, add aqueous sodium hydroxide until no further change occurs.	Dirty green precipitate is formed with few drops of NaOH. Dirty green precipitate remains insoluble in excess. 4

[16]

Conclusions

Give the formula for a cation and the formula for an anion in **R**.

A cation in **R** is ……… H^+ ✓ …… and an anion in **R** is …… Cl^- ✓ ……   3

In Tests **4** and **6**, **S** is acting as …… Reducing …… agent ✓ ……

[3]

[Total: 19]

(17) ✓

Examiner comment – high

Test 1   The observations are clearly made and the gas is tested and so identified.

Test 2   Both scoring points are covered.

Test 3   While the candidate notes reaction taking place, the yellow is due to a precipitate (solid sulfur) and the decolourisation of the manganate(VII) by a pungent gas (sulfur dioxide).

Test 4   Any one of the three sentences is a correct description worth the mark available.

Test 5   The candidate's good description of the changes that occur when a few drops of **S** are added, reveal careful execution of the test and recording of observations.

Test 6   While the colours noted i.e. black and orange, are not correct, the candidate has observed the colour of the solution become dark and then lighten. A perfect description follows of what occurs on addition of aqueous alkali to the mixture from **(a)**.

Mark awarded = 14 out of 16

Conclusions The candidate makes all the correct conclusions and has the necessary supporting evidence.

Mark awarded = 3 out of 3

Total mark awarded = 17 out of 19

Example candidate response – middle

2   You are provided with solutions **R** and **S**.

Carry out the following tests and record your observations in the table. You should test and name any gas evolved.

test no.	test	observations	
1	To 2 cm depth of **R** in a test-tube, add a piece of magnesium.	Large amount of effervescence produced. The magnesium ribbon started to dissolve in R. The reaction is exothermic.	2
2	(a) To 1 cm depth of **R** in a test-tube, add a few drops of aqueous silver nitrate.	White precipitate forms.	2
	(b) To the mixture from (a), add dilute nitric acid.	The precipitate remains insoluble. No further reaction or change occurs.	
3	To 2 cm depth of **R** in a boiling tube, add an equal volume of **S** and warm the mixture **gently**. Place over the mouth of the boiling tube, a piece of filter paper which has been soaked in acidified aqueous potassium manganate(VII).	Pale yellow precipitate forms. Purple colour of acidified aqueous potassium manganate(VII) decolourised. ✓	2
4	To 1 cm depth of aqueous iodine in a test-tube, add **S**.	The brown colour of iodine solution becomes lighter than it decolourises. ✓	1
5	To 2 cm depth of aqueous silver nitrate in a test-tube, add a few drops of **S** and leave to stand until no further change is seen.	Black precipitate forms that deposits at the bottom of the test-tube. Pale brown solution formed above.	1

Example candidate response – middle, continued

6	(a)	To 1 cm depth of aqueous iron(III) chloride in a test-tube, add an equal volume of **S** and mix well.	~~Light~~ ~~yellow~~ Pale yellow/solution forms.	
	(b)	To the mixture from (a), add aqueous sodium hydroxide until no further change occurs.	Dark green precipitate forms and pale yellow solution. ~~the green p~~	3

[16]

Conclusions

Give the formula for a cation and the formula for an anion in **R**.

A cation in **R** is (H⁺) hydrogen ion and an anion in **R** is (Cl⁻) Chloride ion   2

In Tests **4** and **6**, **S** is acting as ..... ~~reducing~~ oxidising ..... agent. ✗   [3]

[Total: 19]

13

Examiner comment – middle

Test 1 The candidate records the reaction of the magnesium with the acid but does not follow up on the gas produced, despite the regular exam instruction immediately above 'You should test and name any gas evolved'.

Test 2 Both observations are clearly and accurately made.

Test 3 While the changes in the liquid and with the filter paper are well made, the mark associated with the gas produced, is missed.

Test 4 The loss of colour of the aqueous iodine is noted.

Test 5 The formation of a precipitate indicates the practical instructions were followed but the candidate has only recorded the last colour of the solid and not noted the darkening of the precipitate as the test-tube stands.

Test 6 In **(a)** the candidate correctly describes the final colour of the solution but makes no mention of the aqueous iron(III) chloride turning dark-violet initially. While the darkening of the colour may have been missed, it could be that the candidate is again only recording the final result as in

Test 5. The construction of the observation, resulting from the addition of excess alkali or ammonia to a solution, must always state what happens in excess – see Qualitative Analysis Notes on the question paper.

Mark awarded = 11 out of 16

Conclusions Having identified both the ions in **R**, the candidate chooses the wrong type of redox agent. The reduction of iron(III) to iron(II) in **Test 6** should have convinced but the use of iodine, as a test for reducing agents rather than iodide in testing for oxidising agents, may have caused the confusion.

Mark awarded = 2 out of 3

Total mark awarded = 13 out of 19

Example candidate response – low

2   You are provided with solutions **R** and **S**.

Carry out the following tests and record your observations in the table. You should test and name any gas evolved.

test no.	test	observations
1	To 2 cm depth of **R** in a test-tube, add a piece of magnesium.	Bubbles of Hydrogen gas are produced. The reaction is exothermic. 1
2	**(a)** To 1 cm depth of **R** in a test-tube, add a few drops of aqueous silver nitrate. **(b)** To the mixture from **(a)**, add dilute nitric acid.	Colour Change from colourless to white precipitate. No change is observed 2
3	To 2 cm depth of **R** in a boiling tube, add an equal volume of **S** and warm the mixture **gently**. Place over the mouth of the boiling tube, a piece of filter paper which has been soaked in acidified aqueous potassium manganate(VII).	The solution turns yellow from colourless when heated The paper turns colourless 1
4	To 1 cm depth of aqueous iodine in a test-tube, add **S**.	The solution turns from red to colourless 1
5	To 2 cm depth of aqueous silver nitrate in a test-tube, add a few drops of **S** and leave to stand until no further change is seen.	The colour change to dark yellow 0

Example candidate response – low, continued

6	(a)	To 1 cm depth of aqueous iron(III) chloride in a test-tube, add an equal volume of **S** and mix well.	Colour change from light red to black
	(b)	To the mixture from **(a)**, add aqueous sodium hydroxide until no further change occurs.	The colour change to black 0

[16]

Conclusions

Give the formula for a cation and the formula for an anion in **R**.

A cation in **R** is ....H⁺ (Hydrogen)..... and an anion in **R** is ...Cl⁻ (Chloride)..   3

In Tests **4** and **6**, **S** is acting as ....Reducing agent................ .

[3]

[Total: 19]

8

Examiner comment – low

Test 1 The candidate's 'bubbles' correctly shows that a gas is seen in the reaction of the acid with the metal but no evidence is provided that the gas is hydrogen. A test with its result must be given for hydrogen to score a mark. The metal's disappearance is also omitted.

Test 2 The observations cover both scoring points.

Test 3 The candidate records colour changes but there is a yellow precipitate formed in the solution and a pungent gas causes the paper to turn colourless. These details are missing.

Test 4 The recording of the colour change secures the mark here.

Test 5 Here, as in **Test 3**, the candidate focuses on the colour but does not record that it is the colour of a precipitate.

Test 6 The observations provided in **(a)** and **(b)** are not sufficient to score any marks.

In **(a)** it may be that the colour lightened after the solution turned black but there is no description provided. The statement in **(b)** perhaps suggests it was not black when the alkali was added because it becomes black again. The addition of alkali to excess ought to prompt the candidate to provide comment about precipitate as described in the Qualitative Analysis Notes.

Mark awarded = 5 out of 16

Conclusions After a disappointing score in the Tests, the candidate nevertheless makes the most of the evidence recorded and scores all three marks in this section.

Mark awarded = 3 out of 3

Total mark awarded = 8 out of 19

Paper 4 Alternative to Practical

Question 1
Mark scheme

1 **(a)** **(i)** (gas) syringe (1) [1]

(ii) 16 (1) cm^3 [1]

(b) **(i)** carbon dioxide / CO_2 (1)
limewater turns milky (1)
$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ (1) [3]

(ii) Hydrogen / H_2 (1) pops in a flame (1)
$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ (1) [3]

[Total: 8]

Example candidate response – high
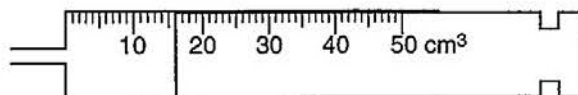
1

(a) (i) Name the apparatus shown above.

..........Gas.......Syringe.. [1]

(ii) What is the volume of gas in the apparatus?

...........................16.. cm^3 [1]

(b) Each of the following pairs of substances react together to produce a gas as one of the products.

In each case
* name the gas produced,
* describe a test for the gas,
* construct an equation for the reaction.

(i) calcium carbonate and dilute hydrochloric acid

gas ....Carbon....dioxide...

test ......bubble....gas..through......limewater..it..turns..milky

equation for the reaction ....$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$ [3]

(ii) zinc and dilute sulfuric acid

gas ....Hydrogen..

test ....Bring..it....close..to..a..lighted..splint...which.will..give..a..'pop'

equation for the reaction ....$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$......... [3]

[Total: 8]

Examiner comment – high

(a) (i)(ii) The candidate identified the gas syringe from the diagram and correctly recorded the volume of gas in the syringe.

Mark awarded = 2 out of 2

(b) (i) The candidate named the gas evolved as carbon dioxide and gave a correct test, bubbling the gas through limewater turning it milky, to confirm its presence.

(ii) The candidate named the gas as hydrogen and gave a correct test, a lighted splint producing a pop, to confirm its presence.

In both of the answers the candidate gave a perfect description of each test and a balanced equation.

Mark awarded = 6 out of 6

Total mark awarded = 8 out of 8
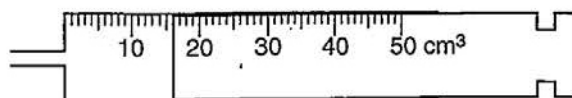
Example candidate response – middle

1

(a) (i) Name the apparatus shown above.

Gas Syringe [1]

(ii) What is the volume of gas in the apparatus?

16 cm³ [1]

(b) Each of the following pairs of substances react together to produce a gas as one of the products.

In each case
- name the gas produced,
- describe a test for the gas,
- construct an equation for the reaction.

(i) calcium carbonate and dilute hydrochloric acid

gas ~~Hydrogen~~ *Carbon dioxide*

test *~~"Pops" with a lighted splint~~. turns lime water milky.*

equation for the reaction $CaCO + HCl \rightarrow CaCl + COH$ [3]

(ii) zinc and dilute sulfuric acid

gas *Hydrogen*

test *"Pops" with a lighted splint.*

equation for the reaction $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ [3]

[Total: 8]

Examiner comment – middle

(a) (i)(ii) The candidate identified the gas syringe from the diagram and correctly recorded the volume of gas in the syringe.

Mark awarded = 2 out of 2

(b) (i) The candidate named the gas evolved as carbon dioxide and gave a correct test to confirm its presence. The formulae of calcium carbonate and calcium chloride in the equation were incorrect and the products did not include carbon dioxide.
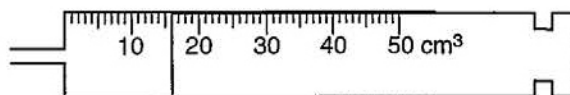
(ii) The candidate named the gas as hydrogen and gave a correct test, a lighted splint producing a pop, to confirm its presence. A correct equation was given.

Mark awarded = 5 out of 6

Total mark awarded = 7 out of 8

Example candidate response – low

1

(a) (i) Name the apparatus shown above.

.............Syringe............... [1]

(ii) What is the volume of gas in the apparatus?

................16................ cm³ [1]

(b) Each of the following pairs of substances react together to produce a gas as one of the products.

In each case
- name the gas produced,
- describe a test for the gas,
- construct an equation for the reaction.

(i) calcium carbonate and dilute hydrochloric acid

gas ....Carbondioxide   Hydrogen.............

test ......Turns lime water milky produces a pop sound......

equation for the reaction ......$CaCO_3 + HCl \rightarrow CaCl + H$........ [3]

(ii) zinc and dilute sulfuric acid

gas ....Hydrogen.............

test ......makes a pop sound when a glaring splint is placed......

equation for the reaction ......$Zn + H_2SO_4 \rightarrow ZnSO_4 + H$...... [3]

[Total: 8]

Examiner comment – low

(a) (i)(ii) The candidate identified the gas syringe and correctly recorded the volume of gas in the syringe.

Mark awarded = 2 out of 2

(b) (i) The candidate suggested that hydrogen was evolved. The test, which stated it produces a pop, was not sufficient to obtain a mark. The equation was not correct.

(ii) Although hydrogen had been suggested as a product in the previous part of the question it was acceptable in this part.

The test was incorrect as it involved a glowing splint, which is used in the test for oxygen, not a flame to produce a pop. Although the equation was correct in terms of the reactants and products the mark was lost for stating. H as a product rather than H_2.

Mark awarded = 1 out of 6

Total mark awarded = 3 out of 8

Question 2
Mark scheme

2 **(a)** **(i)** off white or cream or pale yellow (1)   [1]

        (ii) filtration / filter (1)   [1]

    (b) **(i)** 0.05 (1) moles   [1]

        (ii) 0.06 (1) moles   [1]

    (c) 0.05 (1) × 188 = 9.4 g (1)   [2]

    (d) 0.03 (1) × 188 = 5.64 g (1)   [2]

[Total: 8]

Example candidate response – high

2   A student adds 50.0 cm³ of 1.0 mol/dm³ aqueous silver nitrate to a beaker containing 40.0 cm³ of 1.5 mol/dm³ aqueous sodium bromide.

   (a) (i)   A precipitate of silver bromide is produced.

        Suggest the colour of the precipitate.

        Cream colour. .... [1]

       (ii) How is the precipitate separated from the reaction mixture?

        By filteration. .... [1]

   (b) (i)   Calculate the number of moles of silver nitrate in 50.0 cm³ of 1.0 mol/dm³ silver nitrate.

        no. of moles = concentration x volumes
                     = 1.0 mol/dm³ x 0.050 dm³ = 0.05 ✓   .... 0.05 ✓ .... moles [1]

       (ii) Calculate the number of moles of sodium bromide in 40.0 cm³ of 1.5 mol/dm³ sodium bromide.

        no. of moles = concentration x volume
                     = 1.5 mol/dm³ x 0.040 dm³   .... 0.06 ✓ .... moles [1]
                     = 0.06 mol ✓

   (c) The equation for the reaction is

        $$AgNO_3 + NaBr \rightarrow NaNO_3 + AgBr$$

        Using your answers to (b)(i), (b)(ii) and the equation, calculate the mass of silver bromide produced in the experiment.
        [A_r: Ag, 108; Br, 80]

        Molar ratio → $AgNO_3 : AgBr$ ⇒ moles = 0.05 mol ✓
                                1 : 1

        Molar mass = 108 + 80 = 188 g mol⁻¹.

        mass = molar mass x moles   .... 9.4 ✓ .... g [2]
             = 188 g mol⁻¹ x 0.05 mol = 9.4 ✓

   (d) The student repeats the experiment using 50.0 cm³ of 1.0 mol/dm³ silver nitrate with 60.0 cm³ of 0.5 mol/dm³ sodium bromide.

        Calculate the mass of silver bromide produced in this experiment.

        moles of $AgNO_3$ (silver nitrate) = volume x concentration
                                           = 0.050 dm³ x 1.0 mol/dm³
                                           = 0.05 mol ✓

        moles of $NaBr$ (sodium bromide) = volume x concentration
                                         = 0.060 dm³ x 0.5 mol/dm³ ⇒ 0.03 mol ✓

        molar ratio → $NaBr : AgBr$ ⇒ 0.03 moles ✓   .... 5.64 ✓ .... g [2]
                        1 : 1

        mass = molar mass x moles   [Total: 8]
             = 188 g mol⁻¹ x 0.03 mol ⇒ 5.64 ✓

Examiner comment – high

(a) (i) The candidate suggested correctly that the colour of silver bromide precipitate is cream.

    (ii) The statement that the precipitate may be separated by filtration was also correct.

Mark awarded = 2 out of 2

(b) (i)(ii) The question required the candidate to calculate the number of moles of silver nitrate in each of the two solutions. The candidate's answers of 0.05 moles and 0.06 moles were correct.

Mark awarded = 2 out of 2

(c) This question required the candidate to realise that the smaller number of moles was the limiting factor in calculating the mass of silver bromide produced. 0.05 moles was the smaller of the two and should be multiplied by the molar mass of silver bromide, 188. The candidate deduced this correctly and obtained the answer of 9.4 g.

(d) The candidate calculated that the number of moles in 60.0 cm^3 of 0.5 mol / dm^3 sodium bromide was 0.03 and, on multiplying by 188, obtained the correct answer of 5.64 g.

Mark awarded = 4 out of 4

Total mark awarded = 8 out of 8

Example candidate response – middle

2 A student adds 50.0 cm^3 of 1.0 mol/dm^3 aqueous silver nitrate to a beaker containing 40.0 cm^3 of 1.5 mol/dm^3 aqueous sodium bromide.

(a) (i) A precipitate of silver bromide is produced.

Suggest the colour of the precipitate.

............Wwhite.............................. [1]

(ii) How is the precipitate separated from the reaction mixture?

...........Fractional distillation [1]

(b) (i) Calculate the number of moles of silver nitrate in 50.0 cm^3 of 1.0 mol/dm^3 silver nitrate.

$c \cdot \frac{r}{v}$ $n = cxv$ ....0.05.............moles [1]

$= 0.05 \times 1.0 = 0.05$

(ii) Calculate the number of moles of sodium bromide in 40.0 cm^3 of 1.5 mol/dm^3 sodium bromide.   NaBr

$n = c \times V$
$= 1.5 \times 0.04$ ....0.06........................moles [1]
≈ 0.06 moles

(c) The equation for the reaction is

$$AgNO_3 + NaBr \rightarrow NaNO_3 + AgBr$$
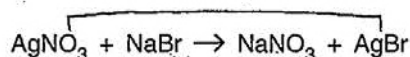
Using your answers to (b)(i), (b)(ii) and the equation, calculate the mass of silver bromide produced in the experiment.
[A_r: Ag, 108; Br, 80]

$AgBr = 188$ $= 0.05 \times 188 = 9.4$
                $= 0.06 \times 188 = 11.28$
                                    $\overline{20.68}$
Mass $= \frac{mole \times Mr}{Mr}$ ....20.68..........g [2]

(d) The student repeats the experiment using 50.0 cm^3 of 1.0 mol/dm^3 silver nitrate with 60.0 cm^3 of 0.5 mol/dm^3 sodium bromide.

Calculate the mass of silver bromide produced in this experiment.

$0.05 \times 18.8 = 9.4$

$c = \frac{n}{v}$

$n = 0.5 \times 0.06$

$n = 0.03$

$0.03 \times 188 = 5.64$

Mass of Silver Bromide $= 9.4 + 5.64 = 15.04$

..........15.04..........g [2]

[Total: 8]

Examiner comment – middle

(a) (i) White was suggested as the colour of silver bromide which is not correct.

(ii) The precipitate cannot be removed by fractional distillation.

Both marks were lost for part **(a)** of the question.

Mark awarded = 0 out of 2

(b) (i)(ii) The question required the candidate to calculate the number of moles of silver nitrate in each of the two solutions. The candidate's answers of 0.05 moles and 0.06 moles were correct.

Mark awarded = 2 out of 2

(c) Instead of multiplying 188 by the smaller number of moles, 0.05, the candidate added together both numbers of moles together to give 0.11 and multiplied this by 188.

One mark was awarded for the correct final calculation and use of 188.

(d) The candidate calculated that the number of moles in $60.0\,cm^3$ of 0.05 moles of sodium bromide was 0.03 but then multiplied 0.05 by 188, the higher of the two moles.

One mark was awarded for the calculation of 0.03 moles of silver bromide.

Mark awarded = 2 out of 4

Total mark awarded = 4 out of 8

Example candidate response – low

2 A student adds 50.0 cm³ of 1.0 mol/dm³ aqueous silver nitrate to a beaker containing 40.0 cm³ of 1.5 mol/dm³ aqueous sodium bromide.

    (a) (i) A precipitate of silver bromide is produced.

            Suggest the colour of the precipitate.

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

      (ii) How is the precipitate separated from the reaction mixture?

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

    (b) (i) Calculate the number of moles of silver nitrate in 50.0 cm³ of 1.0 mol/dm³ silver nitrate.

$$Moles = \frac{50.0}{1000} \times 1.0 = 0.05$$

            ....*0.05*................. moles [1]

      (ii) Calculate the number of moles of sodium bromide in 40.0 cm³ of 1.5 mol/dm³ sodium bromide.

$$Moles = \frac{40.0}{1000} \times 1.5 = 0.06$$

            ....*0.06*................. moles [1]

    (c) The equation for the reaction is

$$AgNO_3 + NaBr \rightarrow NaNO_3 + AgBr$$

Using your answers to (b)(i), (b)(ii) and the equation, calculate the mass of silver bromide produced in the experiment.
[A_r: Ag, 108; Br, 80]

$$Moles = \frac{Mass}{Mr.}$$

$$0.05 = \frac{Mass}{108} \quad 8.4 = Mass$$

$$\frac{0.06}{8} \qquad 0.06 \times 80 = Mass$$
$$4.8$$

            ....*10.2*........... g [2]

    (d) The student repeats the experiment using 50.0 cm³ of 1.0 mol/dm³ silver nitrate with 60.0 cm³ of 0.5 mol/dm³ sodium bromide.

Calculate the mass of silver bromide produced in this experiment.

$$10.2 \;-\; 50.0$$
$$x \;-\; 60.0$$

            ....~~10.2~~ *12.24*........... g [2]

                                            [Total: 8]

Examiner comment – low

(a) (i) Yellow was suggested as the colour of silver bromide which is not correct.

(ii) The precipitate can be removed by filtration.

Mark awarded = 1 out of 2

(b) (i)(ii) The question required the candidate to calculate the number of moles of silver nitrate in each of the two solutions. The candidate's answers of 0.05 moles and 0.06 moles were correct.

Mark awarded = 2 out of 2

(c) The candidate was confused as to how the molar mass should be involved in the calculation. 0.05 was multiplied by 108 and 0.06 was multiplied by 80. No marks were awarded.

(d) The candidate did not calculate the number of moles of silver bromide and was not awarded any marks for this part of the question.

Mark awarded = 0 out of 4

Total mark awarded = 3 out of 8

Question 3
Mark scheme

3 **(a)** C_6H_{14} **AND** C_7H_{16} (1)   [1]

   (b) reaction flask with some form of heat indicated (1)
           thermometer + cork / bung / closed (1)
           condenser with water circulating in the correct direction (1)
           receiver flask, not closed (1)   [4]

                                                                                                      [Total: 5]

Example candidate response – high

3 **(a)** Using the general formula for the homologous series of alkanes, suggest the formula for both hexane and heptane, the sixth and seventh members of the alkane series respectively.

hexane

C_6H_{14}

heptane

C_7H_{16}

[1]

(b) A mixture of hexane (b.p. 69 °C) and heptane (b.p. 89 °C) may be separated by fractional distillation.

The diagram below shows a fractionating column attached to a flask which contains a mixture of hexane and heptane.

Complete the diagram by adding further apparatus to enable each alkane to be collected.

[4]

[Total: 5]
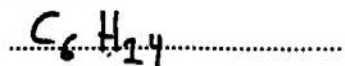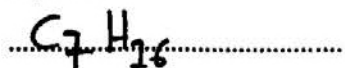
Examiner comment – high

(a) Both formulae were correct

Mark awarded = 1 out of 1

(b) The candidate completed the diagram using all the correct apparatus and labelled as appropriate.

A water bath was used and not a Bunsen as the reactants are both flammable. The thermometer was correctly positioned and inserted in a cork.

The drawing of the condenser was accurate and the flow of water was indicated. A receiver flask was added and left open.

Mark awarded = 4 out of 4

Total mark awarded = 5 out of 5

Example candidate response – middle

$C_n H_{2n+2}$

3 **(a)** Using the general formula for the homologous series of alkanes, suggest the formula for both hexane and heptane, the sixth and seventh members of the alkane series respectively.
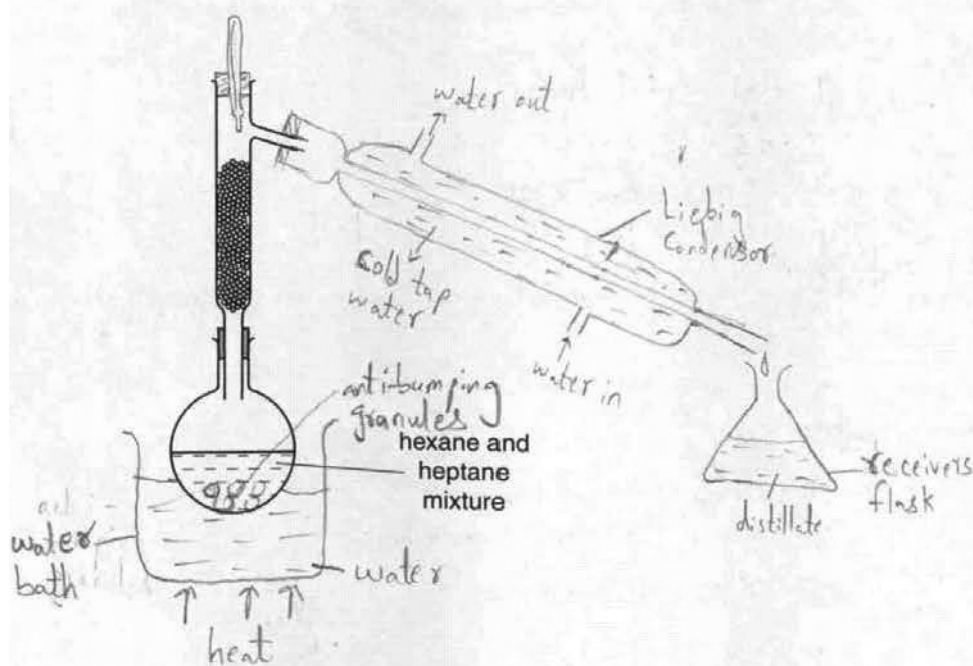
6
hexane $C_6 H_{12+2}$

.... $C_6 H_{14}$ ....

7
heptane $C_7 H_{14+2}$

.... $C_7 H_{16}$ ....

[1]

(b) A mixture of hexane (b.p. 69 °C) and heptane (b.p. 89 °C) may be separated by fractional distillation.

The diagram below shows a fractionating column attached to a flask which contains a mixture of hexane and heptane.

Complete the diagram by adding further apparatus to enable each alkane to be collected.

[4]

[Total: 5]

Examiner comment – middle

(a) Both formulae were correct.

Mark awarded = 1 out of 1

(b) The candidate did not suggest any method of heating.

The thermometer was correctly positioned and inserted in a cork.

Although the drawing of the condenser was acceptable, the flow of water was reversed and incorrect. A beaker to collect was added and left open.

Mark awarded = 2 out of 4

Total mark awarded = 3 out of 5

Example candidate response – low

3 (a) Using the general formula for the homologous series of alkanes, suggest the formula for both hexane and heptane, the sixth and seventh members of the alkane series respectively.

hexane

C_6H_{14}

heptane

C_7H_{16}

[1]

(b) A mixture of hexane (b.p. 69 °C) and heptane (b.p. 89 °C) may be separated by fractional distillation.

Alkanes

The diagram below shows a fractionating column attached to a flask which contains a mixture of hexane and heptane.

Complete the diagram by adding further apparatus to enable each alkane to be collected.

Air in

Air out

Stopper

beaker

hexane and heptane mixture

[4]

[Total: 5]
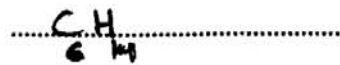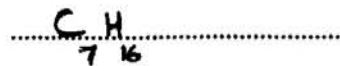
Examiner comment – low

(a) Both formulae were correct.

Mark awarded = 1 out of 1

(b) The candidate did not suggest any method of heating.

There was no thermometer in the top the column.

The condenser did not have an inner section and there was no indication of water flow. An open receiver beaker was added.

Mark awarded = 1 out of 4

Total mark awarded = 2 out of 5

Question 9
Mark scheme

9 **(a)** 3.85 g (1)   [1]

(b) $ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$ (1)   [1]

(c) red / pink to yellow (1)   [1]

(d)

25.2	31.1	48.3	(1)
0.0	6.8	23.8	(1)
25.2	24.3	24.5	(1)

Mean titre = 24.4 cm^3 (1)

1 mark for each correct row <u>or</u> column to the benefit of the candidate.   [4]

(e) 0.00244 (1) moles   [1]

(f) 0.00122 (1) moles   [1]

(g) 0.0122 (1) moles   [1]

(h) 0.05 (1) moles   [1]

(i) 0.0378 (1) moles   [1]

(j) 0.0378 (1) moles   [1]

(k) 3.06 g (1)   [1]

(l) 79.5% (1)   [1]

[Total: 15]

Example candidate response – high

9   A student determines the percentage of zinc oxide in mixture **C**, containing both copper and zinc oxide.

(a) A sample of **C** is added to a previously weighed beaker which is then reweighed.

mass of beaker + **C**   =   29.15 g
mass of beaker   =   25.30 g

Calculate the mass of **C** used in the experiment.

.....................................3.85.....................................g [1]

(b) 50.0 cm^3 of 1.00 mol/dm^3 sulfuric acid (an excess) is added to the beaker containing the sample of **C**. This mixture is warmed gently while being stirred and then left to stand for a few minutes.

Zinc oxide reacts with sulfuric acid but copper does not.

The unreacted copper settles at the bottom of the beaker and is removed by filtration.

Construct the equation for the reaction between zinc oxide and sulfuric acid.

.............$ZnO + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$.............[1]

(c) When the reaction has finished the mixture is transferred to a volumetric flask and made up to 250 cm^3 with distilled water. This is solution **D**.

Using a pipette, 25.0 cm^3 of **D** is transferred into a conical flask and a few drops of methyl orange indicator are added.

A burette is filled with 0.100 mol/dm^3 sodium hydroxide.

Aqueous sodium hydroxide is run into the conical flask containing **D** until the end-point is reached.

What is the colour change of the methyl orange during the reaction?

The colour changes from ....red....... to ....yellow   [1]

Example candidate response – high, continued

The student does three titrations. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.

1st titration   2nd titration   3rd titration

(d) Use the diagrams to complete the following results table.

titration number	1	2	3
final reading/cm^3	25.2	31.1	48.3
initial reading/cm^3	0	6.8	23.8
volume of 0.100 mol/dm^3 sodium hydroxide/cm^3	25.2	24.3	24.5
best titration results (✓)		✓	✓

Summary

Tick (✓) the best titration results.
Using these results, the average volume of 0.100 mol/dm^3 sodium hydroxide is

.................................24.4.................................cm^3. [4]

(e) Calculate the number of moles of sodium hydroxide in the average volume of 0.100 mol/dm^3 sodium hydroxide in (d).

$$Moles = \frac{24.4 \times 0.100}{1000}$$

= 0.00244 moles   ....0.00244............ moles [1]

(f) Sodium hydroxide reacts with sulfuric acid according to the following equation.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$
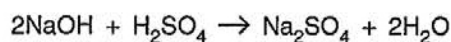
Calculate the number of moles of sulfuric acid which reacts with the sodium hydroxide in (e).

..........0.00122.................... moles [1]

(g) Using your answer in (f), calculate the number of moles of sulfuric acid in 250 cm^3 of D.

..........0.0122.................... moles [1]

Example candidate response – high, continued

(h) Calculate the number of moles of sulfuric acid in 50.0 cm³ of 1.00 mol/dm³ sulfuric acid.

$$\text{Moles} = \frac{50 \times 1}{1000}$$
$$= 0.05$$

.... 0.05 .... moles [1]

(i) Using your answers in **(g)** and **(h)**, calculate the number of moles of sulfuric acid which reacts with the zinc oxide in the sample of **C**.

$$\text{No. of moles} = 0.05 - 0.0122$$
$$= 0.0378$$

.... 0.0378 .... moles [1]

(j) Using your equation in **(b)** and your answer in **(i)**, deduce the number of moles of zinc oxide in the sample of **C**.

.... 0.0378 .... moles [1]

(k) Calculate the mass of zinc oxide in the sample of **C**.
[A_r: Zn, 65; O, 16]

$$\text{Mass} = 0.0378 \,(65 + 16)$$
$$= 0.0378 \times 81$$
$$= 3.0618$$

.... 3.0618 .... g [1]

(l) Using your answers in **(a)** and **(k)** calculate the percentage by mass of zinc oxide in the sample of **C**.

$$\% \text{ by mass} = \frac{3.0618}{3.85} \times 100$$

.... 79.53 .... % [1]

[Total: 15]

Examiner comment – high

(a) The candidate calculated the mass of **C** used in the experiment.

(b) All the formulae in the equation were correct and the equation was balanced.

(c) The colour change of the indicator, red to yellow, was correct.

Mark awarded = 3 out of 3

(d) All the burette diagrams were read accurately and the volumes were correctly inserted into the table.

The mean reading was taken using the appropriate two titres.

Mark awarded = 4 out of 4

(e)–(l) This question required the candidate to complete a series of calculations each one based on the previous answer. Candidates are expected to maintain accuracy at each stage, neither rounding down nor up an answer and maintaining a minimum of three significant figures throughout.

Using the mean titre the candidate completed all the calculations successfully.

All answers were given to a minimum of three significant figures and the final answer 79.53% was correct.

Mark awarded = 8 out of 8

Total mark awarded = 15 out of 15

Example candidate response – middle

9   A student determines the percentage of zinc oxide in mixture **C**, containing both copper and zinc oxide.

(a)   A sample of **C** is added to a previously weighed beaker which is then reweighed.

mass of beaker + **C**   =   29.15 g
mass of beaker   =   25.30 g

Calculate the mass of **C** used in the experiment.

Mass of c = 29.15 – 25.30

= 3.85 g   ....3.85..........g [1]

(b)   50.0 cm³ of 1.00 mol/dm³ sulfuric acid (an excess) is added to the beaker containing the sample of **C**. This mixture is warmed gently while being stirred and then left to stand for a few minutes.

Zinc oxide reacts with sulfuric acid but copper does not.

The unreacted copper settles at the bottom of the beaker and is removed by filtration.

Construct the equation for the reaction between zinc oxide and sulfuric acid.

$$\dots ZnO_{(s)} + H_2SO_{4(aq)} \longrightarrow ZnSO_4 + H_2O \dots [1]$$

(c)   When the reaction has finished the mixture is transferred to a volumetric flask and made up to 250 cm³ with distilled water. This is solution **D**.

Using a pipette, 25.0 cm³ of **D** is transferred into a conical flask and a few drops of methyl orange indicator are added.

A burette is filled with 0.100 mol/dm³ sodium hydroxide.

Aqueous sodium hydroxide is run into the conical flask containing **D** until the end-point is reached.

What is the colour change of the methyl orange during the reaction?

The colour changes from ....red............ to ...yellow.......   [1]

Example candidate response – middle, continued

The student does three titrations. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.

1st titration	2nd titration	3rd titration

(d) Use the diagrams to complete the following results table.

titration number	1	2	3
final reading/cm^3	25.2	31.1	48.3
initial reading/cm^3	0	6.8	23.8 ~~23.7~~
volume of 0.100 mol/dm^3 sodium hydroxide/cm^3	25.2	24.3	24.5
best titration results (✓)		✓	✓

Summary

Tick (✓) the best titration results.
Using these results, the average volume of 0.100 mol/dm^3 sodium hydroxide is

$$\frac{24.3 + 24.5}{2} = 24.4 \text{ cm}^3$$

..........24.4.........cm^3. [4]

(e) Calculate the number of moles of sodium hydroxide in the average volume of 0.100 mol/dm^3 sodium hydroxide in (d).

$n = V C$
$= 0.0244 \times 0.1$
$= 2.44 \times 10^{-3}$

..........2.44 × 10^{-3}.......... moles [1]

(f) Sodium hydroxide reacts with sulfuric acid according to the following equation.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$
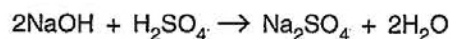
Calculate the number of moles of sulfuric acid which reacts with the sodium hydroxide in (e).

$$\frac{2.44 \times 10^{-3}}{2}$$

..........1.22 × 10^{-3}.......... moles [1]

(g) Using your answer in (f), calculate the number of moles of sulfuric acid in 250 cm^3 of D.

~~$n = VC$~~
~~$= 0.25 \times 1$~~
$n = VC$
$= 0.25 \times 0.1$
~~$= 0.025$~~ $= 2.5 \times 10^{-3}$

..........0.0125.......... moles [1]

Example candidate response – middle, continued

(h) Calculate the number of moles of sulfuric acid in $50.0\,cm^3$ of $1.00\,mol/dm^3$ sulfuric acid.

$$n = v\,c$$
$$= 0.05 \times 1$$
$$= 0.05\,moles$$

.................................0.05.................... moles [1]

(i) Using your answers in **(g)** and **(h)**, calculate the number of moles of sulfuric acid which reacts with the zinc oxide in the sample of **C**.

$$\frac{0.05}{0.0125} = 4\,moles$$

....4...... moles [1]

(j) Using your equation in **(b)** and your answer in **(i)**, deduce the number of moles of zinc oxide in the sample of **C**.

$$ZnO + H_2SO_4 \longrightarrow ZnSO_4 + H_2O$$
$$+ \ 0.0125$$

....0.05.... moles [1]

(k) Calculate the mass of zinc oxide in the sample of **C**.
$[A_r: Zn, 65; O, 16]$

$$n = \frac{Mass}{Mr} \qquad 0.05 = \frac{6}{81}$$

....4.....g [1]

(l) Using your answers in **(a)** and **(k)** calculate the percentage by mass of zinc oxide in the sample of **C**.

$$\frac{3.85}{4} \times 100\%.$$

................................96.25...............% [1]

[Total: 15]

Examiner comment – middle

(a) The candidate calculated the mass of **C** used in the experiment.

(b) All the formulae in the equation were correct and the equation was balanced.

(c) The colour change of the indicator, red to yellow, was correct.

Mark awarded = 3 out of 3

(d) All the burette diagrams were read accurately and the volumes were correctly inserted into the table.

The mean reading was taken using the appropriate two titres.

Mark awarded = 4 out of 4

(e)–(l) The candidate's answers to **(e)** and **(f)** were correct.

Answer **(g)** required the candidate to multiply answer **(f)**, 0.00122, by 10.

The answer of 0.0125 lost the mark but this answer may then be used in subsequent parts of the calculation.

Part **(h)** was correct.

Part **(i)** required subtracting answer **(g)** from answer **(h)** but the candidate divided **(h)** by **(g)** and then did not obtain any further marks in the question.

Mark awarded = 3 out of 8

Total mark awarded = 10 out of 15

Example candidate response – low

9 A student determines the percentage of zinc oxide in mixture **C**, containing both copper and zinc oxide.

(a) A sample of **C** is added to a previously weighed beaker which is then reweighed.

mass of beaker + **C** = 29.15 g
mass of beaker = 25.30 g

Calculate the mass of **C** used in the experiment.

.... 3·85 ....g [1]

(b) 50.0 cm^3 of 1.00 mol/dm^3 sulfuric acid (an excess) is added to the beaker containing the sample of **C**. This mixture is warmed gently while being stirred and then left to stand for a few minutes.

Zinc oxide reacts with sulfuric acid but copper does not.

The unreacted copper settles at the bottom of the beaker and is removed by filtration.

Construct the equation for the reaction between zinc oxide and sulfuric acid.

..$Zn(OH)_2$ + H_2SO_4 → $ZnSO_4$ + H_2O ....[1]

(c) When the reaction has finished the mixture is transferred to a volumetric flask and made up to 250 cm^3 with distilled water. This is solution **D**.

Using a pipette, 25.0 cm^3 of **D** is transferred into a conical flask and a few drops of methyl orange indicator are added.

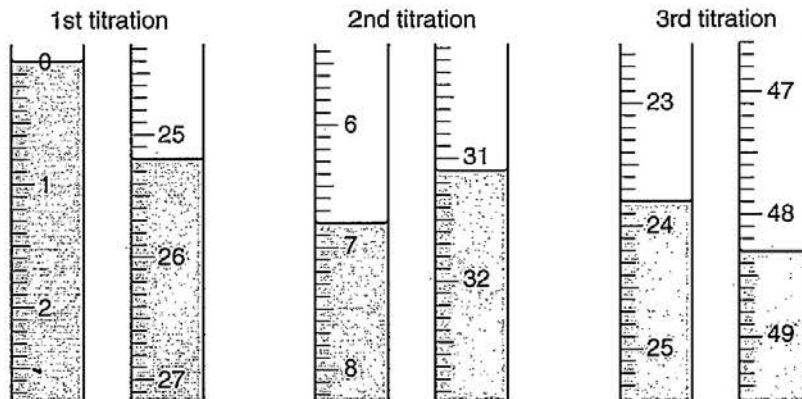A burette is filled with 0.100 mol/dm^3 sodium hydroxide.

Aqueous sodium hydroxide is run into the conical flask containing **D** until the end-point is reached.

What is the colour change of the methyl orange during the reaction?

The colour changes from ..red........... to ...yellow...... [1]

Example candidate response – low, continued

The student does three titrations. The diagrams below show parts of the burette with the liquid levels at the beginning and end of each titration.

1st titration	2nd titration	3rd titration

(d) Use the diagrams to complete the following results table.

titration number	1	2	3
final reading/cm³	25·2	31·1	48·3
initial reading/cm³	0	6·8	23·8
volume of 0.100 mol/dm³ sodium hydroxide/cm³	25·2	24·3	24·5
best titration results (✓)		✓	✓

Summary

Tick (✓) the best titration results.
Using these results, the average volume of 0.100 mol/dm³ sodium hydroxide is

$$\frac{24.3 + 24.5}{2}$$

............24.4............cm³. [4]

(e) Calculate the number of moles of sodium hydroxide in the average volume of 0.100 mol/dm³ sodium hydroxide in (d).

$$0.100 \times \frac{24.4}{1000}$$

......0.00244...... moles [1]

(f) Sodium hydroxide reacts with sulfuric acid according to the following equation.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$
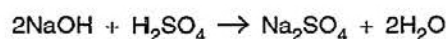
Calculate the number of moles of sulfuric acid which reacts with the sodium hydroxide in (e).

$$\frac{0.00244}{2}$$

......0.00122...... moles [1]

(g) Using your answer in (f), calculate the number of moles of sulfuric acid in 250 cm³ of D.

$$n = C \times V$$
$$= 0.00122 \times \frac{250}{1000}$$

......0.000305...... moles [1]

Example candidate response – low, continued

(h) Calculate the number of moles of sulfuric acid in 50.0 cm³ of 1.00 mol/dm³ sulfuric acid.

...0.00006 1............... moles [1]

(i) Using your answers in **(g)** and **(h)**, calculate the number of moles of sulfuric acid which reacts with the zinc oxide in the sample of **C**.

0.05
...~~0.0024~~........... moles [1]

(j) Using your equation in **(b)** and your answer in **(i)**, deduce the number of moles of zinc oxide in the sample of **C**.

.................1................. moles [1]

(k) Calculate the mass of zinc oxide in the sample of **C**.
[A_r: Zn, 65; O,16]

...........................g [1]

(l) Using your answers in **(a)** and **(k)** calculate the percentage by mass of zinc oxide in the sample of **C**.

...........................% [1]

[Total: 15]

Examiner comment – low

(a) The candidate correctly calculated the mass of **C** used in the experiment.

(b) The candidate lost the mark for the equation by entering the formula for zinc hydroxide rather than that of zinc oxide.

(c) The colour change of the indicator was correctly given as red to yellow.

Mark awarded = 2 out of 3

(d) All the burette diagrams were read accurately and the volumes were correctly inserted into the table.

The mean reading was taken using the appropriate two titres.

Mark awarded = 4 out of 4

(e)–(l) The candidate gave correct answers to **(e)** and **(f)**. To obtain the correct answer to **(g)** answer **(f)** should be multiplied by 10. The candidate however multiplied by 250/1000, then failed to give any further correct answers and lost all subsequent marks.

Mark awarded = 2 out of 8

Total mark awarded = 7 out of 15

Question 10
Mark scheme

10 **(a)** colourless (1) to brown / black (1)

(b) orange (1) to green (1)

(c) purple / pink (1) to colourless (1)

[Total: 6]

Cambridge O Level Chemistry 5070

Example candidate response – high

10 A student does some reactions using gas **X** and gas **Y**.

A colour change is seen in each case.

Complete the observations by stating the initial and final colours in each test.

test	observations	conclusions
(a) **X** is passed through aqueous potassium iodide.	Colour change from colourless to brown colour is observed.	**X** is an oxidising agent.
(b) **Y** is passed through acidified potassium dichromate(VI).	Colour change from orange to green colour is observed	**Y** is a reducing agent.
(c) **Y** is passed through acidified potassium manganate(VII).	Colour change from purple to colourless is observed.	**Y** is a reducing agent.

[Total: 6]

Examiner comment – high

(a) The candidate gave the correct colour change of colourless to brown and gained both marks.
In some cases candidates reversed the colours.
E.g. brown <u>from</u> colourless.
In such cases both marks can still be obtained.
An alternative answer such as 'the solution goes brown' gains the second mark only.

   Mark awarded = 2 out of 2

(b) The candidate gave the correct colour change of orange to green and gained both marks.

   Mark awarded = 2 out of 2

(c) The candidate gave the correct colour change of purple to colourless and gained both marks.

   Mark awarded = 2 out of 2

   Total mark awarded = 6 out of 6

Example candidate response – middle

10 A student does some reactions using gas **X** and gas **Y**.

A colour change is seen in each case.

Complete the observations by stating the initial and final colours in each test.

test	observations	conclusions
(a) **X** is passed through aqueous potassium iodide.	Color changes from colorless to brown	**X** is an oxidising agent.
(b) **Y** is passed through acidified potassium dichromate(VI).	Color changes from orange to green	**Y** is a reducing agent.
(c) **Y** is passed through acidified potassium manganate(VII).	Color changes from colorless to purple	**Y** is a reducing agent.

[Total: 6]

Examiner comment – middle

(a) The candidate gave the correct colour change of colourless to brown and gained both marks.

Mark awarded = 2 out of 2

(b) The candidate gave the correct colour change of orange to green and gained both marks.

Mark awarded = 2 out of 2

(c) The candidate suggested that the colour changes from colourless to purple, the reverse of the correct answer and lost both marks.

Mark awarded = 0 out of 2

Total mark awarded = 4 out of 6

Example candidate response – low

10 A student does some reactions using gas **X** and gas **Y**.

A colour change is seen in each case.

Complete the observations by stating the initial and final colours in each test.

	test	observations	conclusions
(a)	**X** is passed through aqueous potassium iodide.	Pink to colourless	**X** is an oxidising agent.
(b)	**Y** is passed through acidified potassium dichromate(VI).	Orange to green	**Y** is a reducing agent.
(c)	**Y** is passed through acidified potassium manganate(VII).	colourless to purple	**Y** is a reducing agent.

[Total: 6]

Examiner comment – low

(a) The candidate suggested that the colour changed from pink to colourless. This is incorrect and both marks were lost.

Mark awarded = 0 out of 2

(b) The candidate gave the correct colour change of orange to green and gained both marks.

Mark awarded = 2 out of 2

(c) The candidate suggested that the colour changes from colourless to purple, the reverse of the correct answer and lost both marks.

Mark awarded = 0 out of 2

Total mark awarded = 2 out of 6

Question 11
Mark scheme

11 **(a)** maximum temperature: 24.5, 29, 27, 23.5 (1)
temperature rise: 4.5, 9.0, 7.0, 3.5 (1)   [2]

(b) All four points plotted correctly (1)
Draw two straight lines only (1)
Line 1 must involve points 1 and 2
Line 2 must involve points 3 and 4
Lines intersect without use of a curve (1)   [3]

(c) **(i)** mixture 1: **H** = 74 cm^3 **AND J** = 26 cm^3 (1)
mixture 2: **H** = 34 cm^3 **AND J** = 66 cm^3 (1)   [2]

    (ii) 9.8 °C (1)   [1]

   (iii) **H** = 56 cm^3 **AND J** = 44 cm^3 (1) [1]

In questions **(c)** read candidate's graph to +/– half a small square.
In answers **(c)(i)** and **(iii)** totals must add up to 100 cm^3.

(d) No. of moles of **J** (1)
M = 44 × 1.00 / 56 × 2 = 0.393 (0.39) mol/dm^3 (1)   [2]

(e) **(i)** 4.9 °C (1)   [1]

    (ii) 56 cm^3 **H AND** 44 cm^3 **J** (1) [1]

[Total: 13]
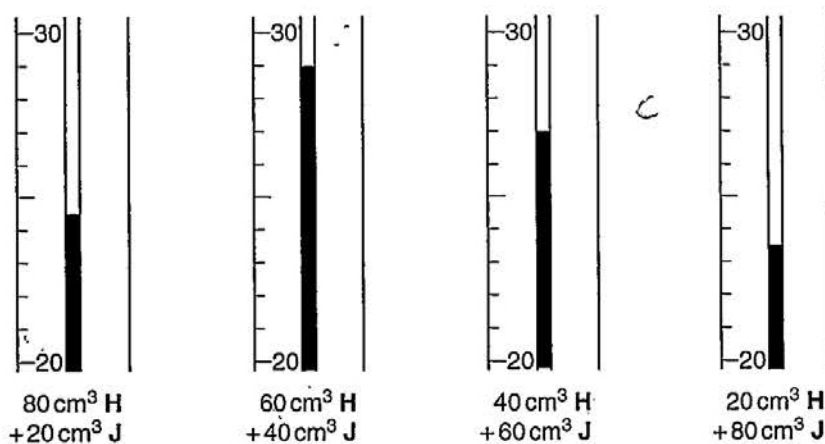
Example candidate response – high

11 The addition of an acid solution to aqueous sodium hydroxide produces a rise in temperature.

A student is provided with **H**, aqueous sulfuric acid, and **J**, $1.00\,mol/dm^3$ sodium hydroxide.

He investigates the changes in temperature produced on mixing together different volumes of **H** and **J** while, in each experiment, keeping the total volume of solution constant at $100\,cm^3$.

The initial temperature of both **H** and **J** is $20\,°C$.

The diagrams below show parts of the thermometer stems indicating the maximum temperature recorded in each experiment.

| $80\,cm^3$ **H**	$60\,cm^3$ **H**	$40\,cm^3$ **H**	$20\,cm^3$ **H**
$+20\,cm^3$ **J**	$+40\,cm^3$ **J**	$+60\,cm^3$ **J**	$+80\,cm^3$ **J**

(a) Record these temperatures in the table below and then calculate the rise in temperature in each case.

volume of H/cm³	volume of J/cm³	maximum temperature /°C	temperature rise/°C
80	20	24.5	4.5
60	40	29.0	9.0
40	60	27.0	7.0
20	80	23.5	3.5

[2]

Example candidate response – high, continued

(b) Plot these results on the grid below.
Using the points, draw two intersecting straight lines.

[3]
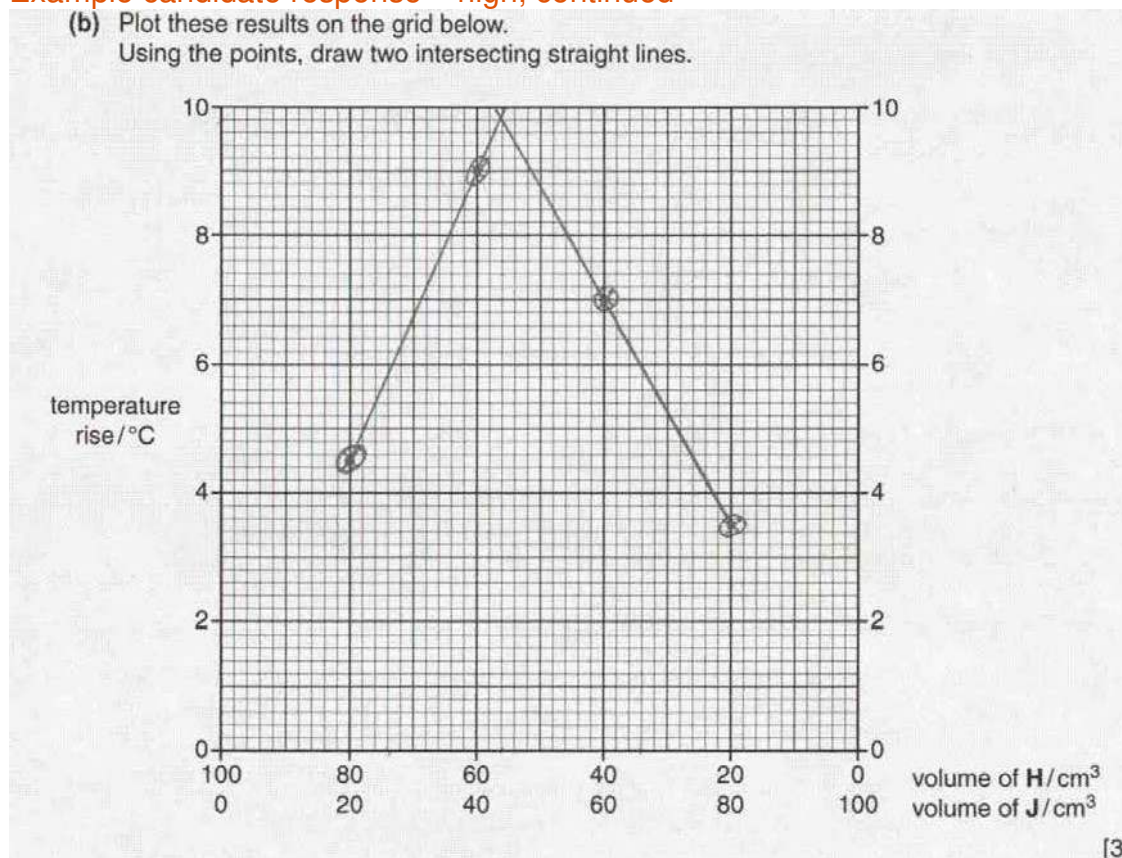
(c) Use your graph to deduce

(i) the volumes of **H** and **J** in two mixtures, each of which produces a final temperature of 26°C,

	volume of H/cm³	volume of J/cm³
mixture 1	74	26
mixture 2	34	66

[2]

(ii) the greatest temperature rise that can occur,

...............................9.8...............................°C [1]

(iii) the volumes of **H** and **J** which produce this temperature rise.

H ....56............................... cm³

J ....44............................... cm³

[1]

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Example candidate response – high, continued

(d) Solution **J** is 1.00 mol/dm³ sodium hydroxide.
H is aqueous sulfuric acid.

Sodium hydroxide reacts with sulfuric acid according to the following equation.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$
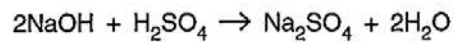
Using this equation and your answers to **(c)(iii)**, calculate the concentration of **H**.

$$Moles = \frac{44 \times 1}{1000}$$
$$= 0.044 \ moles$$
Moles of H_2SO_4 = 0.022 moles

Concentration = $\frac{0.022 \times 1000}{56}$
= 0.39 mol/dm³

..............0.39..............mol/dm³ [2]

(e) The student repeats the experiment having first diluted the concentrations of both **H** and **J** to half those used in the original experiment.

Suggest

(i) the greatest temperature rise that would occur,

..............4.9..............°C [1]

(ii) the volumes of both **H** and **J** that would produce this temperature rise.

H ....56.............. cm³

J ....44.............. cm³

[1]

[Total: 13]

Examiner comment – high

(a) The candidate read the thermometer readings, inserted them into the table and calculated each temperature rise.

(b) The candidate accurately plotted all the points on the grid and joined them up with two intersecting straight lines as instructed in the question.

Mark awarded = 5 out of 5

(c) (i) Candidates are asked to read, from their graphs, the volumes of **H** and **J** in two mixtures each of which produces a final temperature of 26 °C. Thus the candidate should read the volumes corresponding to a temperature rise of 6 °C. The candidate's answers were correct.

(ii) The intersection of the two straight lines represents the maximum temperature rise that can occur. The candidate's graph gave the correct rise of 9.8 °C.

(iii) This maximum temperature rise should occur at volumes of 56 cm^3 of **H** and 44 cm^3 of **J**.

The candidate's graph corresponded to these values.

The answers to parts **(i)** to **(iii)** showed the accuracy to which the candidate had completed the graph.

(d) The volumes of **H** and **J** given in **(c)(iii)** are used to calculate the concentration of **H**.

Candidates are given the equation for the reaction between sodium hydroxide and sulfuric acid, to assist them with the calculation.

The candidate calculated the concentration of **H** correctly, recording the answer to two significant figures as required.

Mark awarded = 6 out of 6

(e) (i)(ii) The final part of the question asks the candidate to consider the effect on the final temperature of diluting the concentrations of both **H** and **J** to half those used in the original experiment.

Candidates should realise that as there were half as many moles of **H** and **J** used, the rise in temperature would be half that originally determined. The candidate's suggestion, that the temperature rise is 4.9 °C but the volumes of **H** and **J** are unchanged, was correct.

Mark awarded = 2 out of 2

Total mark awarded = 13 out of 13
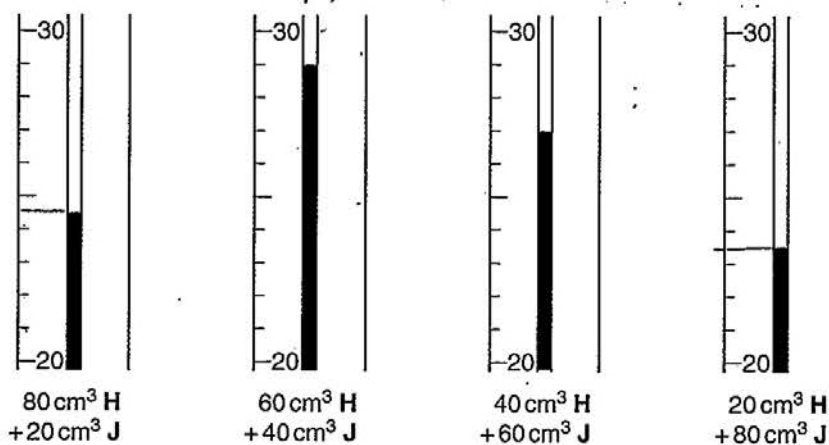
Example candidate response – middle

11 The addition of an acid solution to aqueous sodium hydroxide produces a rise in temperature.

A student is provided with **H**, aqueous sulfuric acid, and **J**, 1.00 mol/dm³ sodium hydroxide.

He investigates the changes in temperature produced on mixing together different volumes of **H** and **J** while, in each experiment, keeping the total volume of solution constant at 100 cm³.

The initial temperature of both **H** and **J** is 20 °C.

The diagrams below show parts of the thermometer stems indicating the maximum temperature recorded in each experiment.

| 80 cm³ **H** +20 cm³ **J**	60 cm³ **H** +40 cm³ **J**	40 cm³ **H** +60 cm³ **J**	20 cm³ **H** +80 cm³ **J**

(a) Record these temperatures in the table below and then calculate the rise in temperature in each case.

volume of **H**/cm³	volume of **J**/cm³	maximum temperature /°C	temperature rise/°C
80	20	24.5	4.5
60	40	29	9
40	60	27.	7
20	80	23.5	3.5

[2]

Example candidate response – middle, continued

(b) Plot these results on the grid below.
Using the points, draw two intersecting straight lines.

[3]
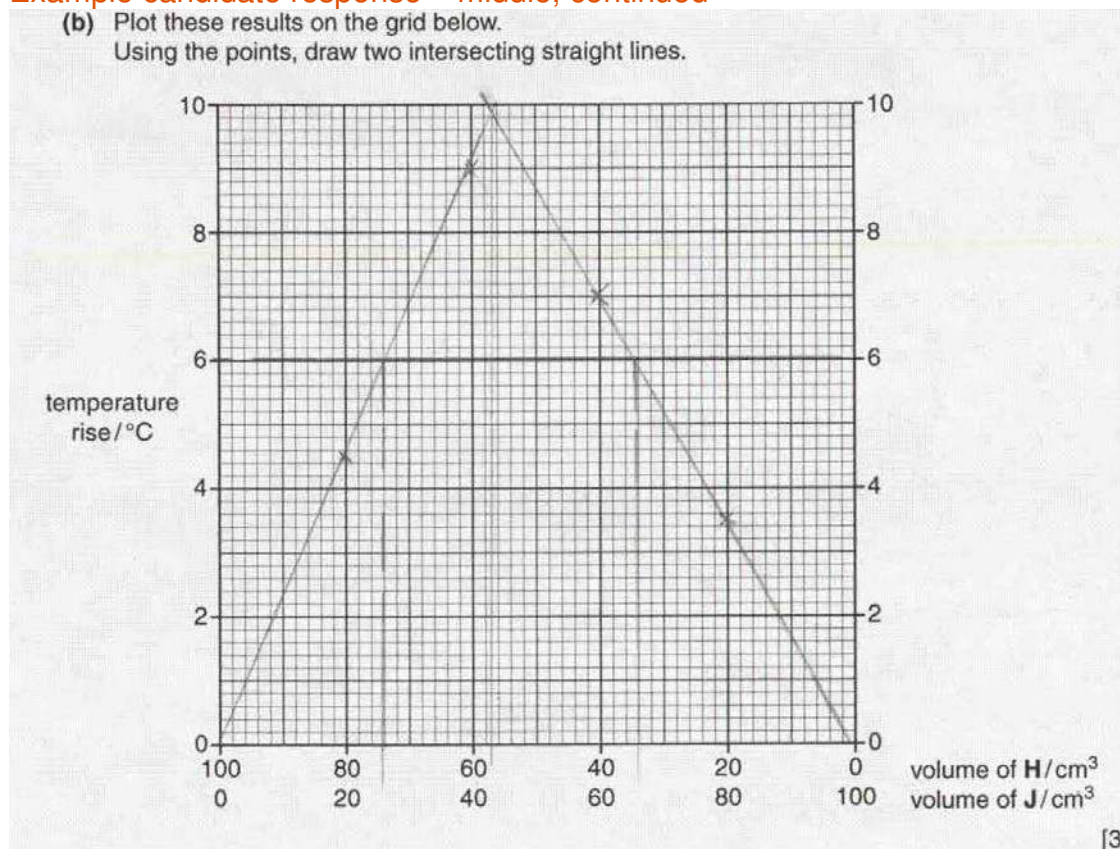
(c) Use your graph to deduce

(i) the volumes of **H** and **J** in two mixtures, each of which produces a final temperature of 26 °C,

	volume of **H**/cm^3	volume of **J**/cm^3
mixture 1	74	~~34~~ 26
mixture 2	34	66

[2]

(ii) the greatest temperature rise that can occur,

........................9.9........................°C [1]

(iii) the volumes of **H** and **J** which produce this temperature rise.

H ....57................. cm^3

J ....43................. cm^3

[1]

Example candidate response – middle, continued

(d) Solution **J** is 1.00 mol/dm³ sodium hydroxide.
   H is aqueous sulfuric acid.

   Sodium hydroxide reacts with sulfuric acid according to the following equation.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$
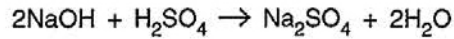
   Using this equation and your answers to **(c)(iii)**, calculate the concentration of **H**.

Moles = Volume × concentration : 1

1 = 57 × concentration? 57

$\frac{57}{1000}$ = 0·057

2 : 1
0·057 : 0·043

............0·057............mol/dm³ [2]

(e) The student repeats the experiment having first diluted the concentrations of both **H** and **J** to half those used in the original experiment.

   Suggest

   (i) the greatest temperature rise that would occur,

   ....4·95............°C [1]

   (ii) the volumes of both **H** and **J** that would produce this temperature rise.

   H ....28·5............ cm³

   J ....21·5............ cm³
   [1]

[Total: 13]

Examiner comment – middle

(a) The candidate read the thermometer readings, inserted them into the table and calculated each temperature rise.

(b) The candidate accurately plotted all the points on the grid and joined them up with two intersecting straight lines as instructed in the question.

Mark awarded = 5 out of 5

(c) (i) Candidates are asked to read, from their graphs, the volumes of **H** and **J** in two mixtures each of which produces a final temperature of 26 °C. Thus the candidate should read the volumes corresponding to a temperature rise of 6 °C. The candidate's answers were correct.

(ii) The intersection of the two straight lines represents the maximum temperature rise that can occur. The candidate's graph gave the correct rise from the graph of 9.9°.

(iii) This maximum temperature rise should occur at volumes of 56 cm^3 of **H** and 44 cm^3 of **J**.

The candidate's graph corresponded to these values.

The answers given by the candidate to parts **(ii)** and **(iii)**, showed the accuracy to which the candidate had completed the graph.

Mark awarded = 4 out of 4

(d) The candidate was not able to complete the calculation.

The equation was not used and only the volume of **H** was used.

(e) The candidate correctly suggested that the greatest temperature would be half the initial temperature, but also halved the volumes of **H** and **J**.

Mark awarded = 1 out of 4

Total mark awarded = 10 out of 13
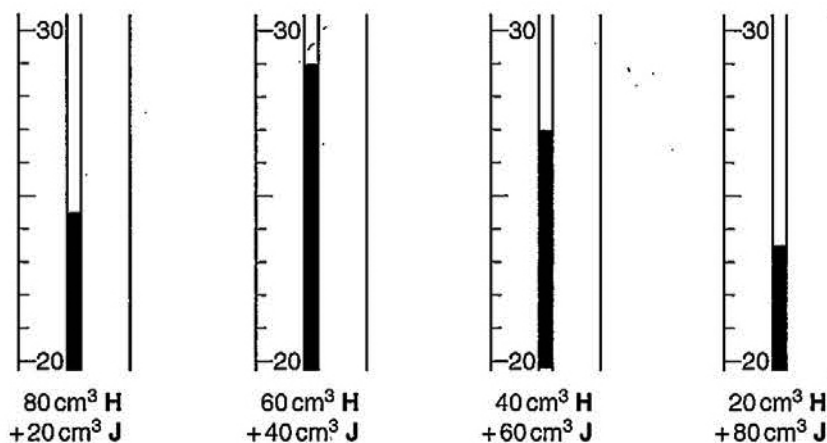
Example candidate response – low

11 The addition of an acid solution to aqueous sodium hydroxide produces a rise in temperature.

A student is provided with **H**, aqueous sulfuric acid, and **J**, $1.00\,mol/dm^3$ sodium hydroxide.

He investigates the changes in temperature produced on mixing together different volumes of **H** and **J** while, in each experiment, keeping the total volume of solution constant at $100\,cm^3$.

The initial temperature of both **H** and **J** is 20 °C.

The diagrams below show parts of the thermometer stems indicating the maximum temperature recorded in each experiment.

|			
80 cm³ **H** +20 cm³ **J**	60 cm³ **H** +40 cm³ **J**	40 cm³ **H** +60 cm³ **J**	20 cm³ **H** +80 cm³ **J**

(a) Record these temperatures in the table below and then calculate the rise in temperature in each case.

volume of H/cm³	volume of J/cm³	maximum temperature /°C	temperature rise/°C
80	20	24.5	4.5
60	40	29	9
40	60	27	7
20	80	24.5	4.5

[2]

Example candidate response – low, continued

(b) Plot these results on the grid below.
Using the points, draw two intersecting straight lines.

[3]
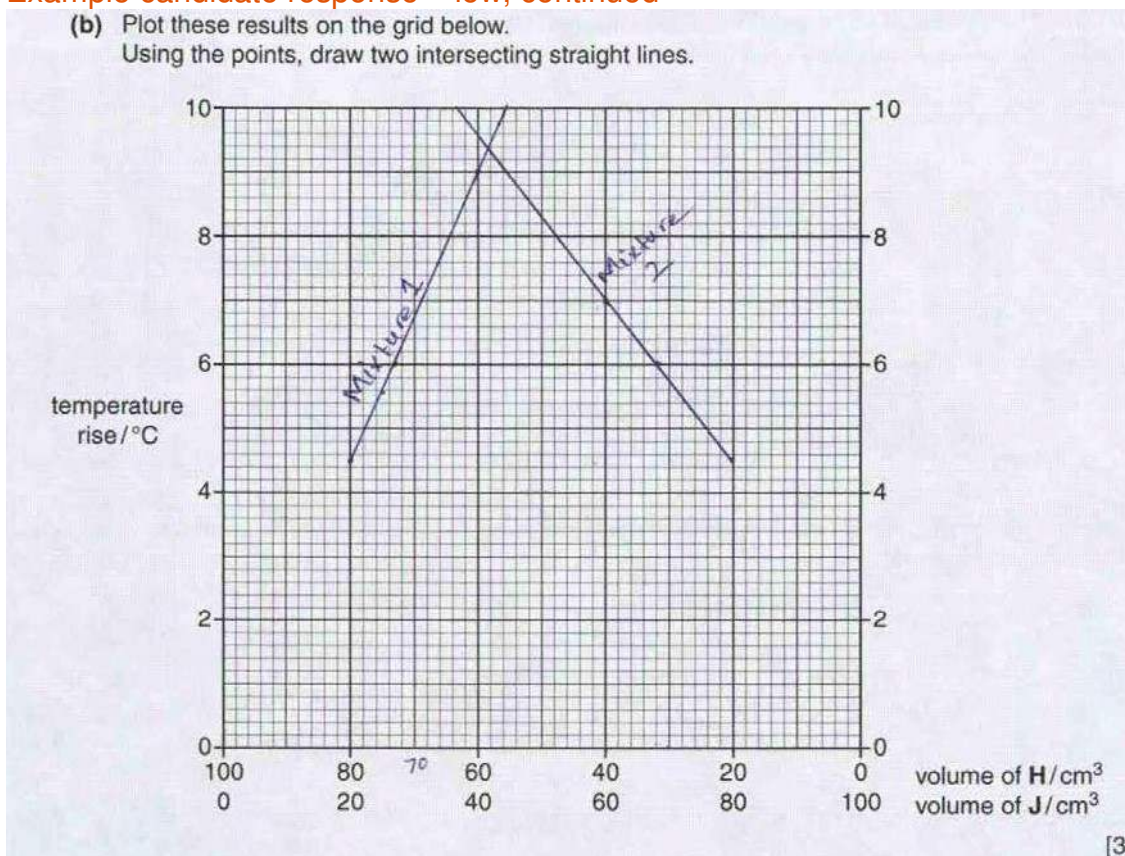
(c) Use your graph to deduce

(i) the volumes of **H** and **J** in two mixtures, each of which produces a final temperature of 26°C,

	volume of **H**/cm^3	volume of **J**/cm^3
mixture 1	73	27
mixture 2	32	68

[2]

(ii) the greatest temperature rise that can occur,

.... 11°C ....°C [1]

(iii) the volumes of **H** and **J** which produce this temperature rise.

H .... 50 .... cm^3

J .... 50 .... cm^3

[1]

Example candidate response – low, continued

(d) Solution **J** is 1.00 mol/dm³ sodium hydroxide.
H is aqueous sulfuric acid.

Sodium hydroxide reacts with sulfuric acid according to the following equation.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$
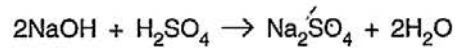
Using this equation and your answers to **(c)(iii)**, calculate the concentration of **H**.

$$moles = \frac{conc \times volume}{1000}$$

$$1 \times 1000 = conc \times 50$$

$$\frac{20}{\cancel{1000}}{\cancel{50}} = conc$$

$$conc = 20 \, mol/dm^3$$

......................20..................mol/dm³ [2]

(e) The student repeats the experiment having first diluted the concentrations of both **H** and **J** to half those used in the original experiment.

Suggest

(i) the greatest temperature rise that would occur,

......................5 °C..................°C [1]

(ii) the volumes of both **H** and **J** that would produce this temperature rise.

H ....25...................... cm³

J ....25...................... cm³
[1]

[Total: 13]

Examiner comment – low

(a) The candidate read the fourth thermometer diagram incorrectly and as a result, lost one mark for the first column in the table. The second mark was consequently awarded.

(b) The candidate accurately plotted all the points on the grid and joined them up with two intersecting straight lines as instructed in the question.

Mark awarded = 4 out of 5

(c) (i) Candidates are asked to read from their graphs the volumes of **H** and **J** in two mixtures each of which produces a final temperature of 26 °C. Thus the candidate should read the volumes corresponding to a temperature rise of 6 °C. The candidate's answers were correct.

(ii) The intersection of the two straight lines represents the maximum temperature rise that can occur. The answer suggested by the candidate of 11° was not correct.

(iii) The candidate's graph suggests that the maximum temperature rise occurs at 58 cm^3 of **H** and 42 cm^3 of **J**. The candidate's answer of 50/50 was not correct.

Mark awarded = 2 out of 4

(d) The candidate was not able to complete the calculation.

Neither the equation nor the volumes of **H** or **J** were used in the calculation.

(e) (i) The candidate's answer of 5 °C was not half of the original temperature rise of 11 °C.
(ii) The candidate also halved the original volumes of **H** and **J**.

No marks were gained for parts **(d)** and **(e)**.

Mark awarded = 0 out of 4

Total mark awarded = 6 out of 13

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