

Example Candidate Responses (Standards Booklet)

Cambridge O Level
Chemistry
5070

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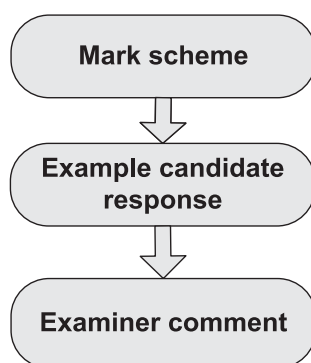
Introduction

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 3 and Paper 4 have been chosen as far as possible to exemplify grades A, C and E. 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 and the candidate answers do not require examiner commentary to expand on how the marks were gained.

Grades are given to each answer in this booklet, however in the examination the whole candidate script is graded on the overall mark awarded, not on each question. It is therefore possible that, for some questions, lower grade candidate answers are awarded the same or similar marks to higher grade candidate answers.

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



The mark scheme, 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.

Past papers, examiner reports and other teacher support materials are available on Teacher Support at <http://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
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		1 hour 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 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 cm³:

(d) Number of moles of HCl in 23.0 cm³ of **P**

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

$$= 0.0345 \text{ (1)}$$

[1]

(e) Number of moles of NaOH which react

$$= 0.0345 \text{ (1)}$$

[1]

(f) Concentration in mol/dm³ of **Q**

Volume of **Q**

$$50.0 - 23.0 = 27.0 \text{ (1)}$$

Concentration of **Q**

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

$$= 1.28 \text{ (1)}$$

[2]

[Total: 21]

Example candidate response – grade A

- 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.

Sup

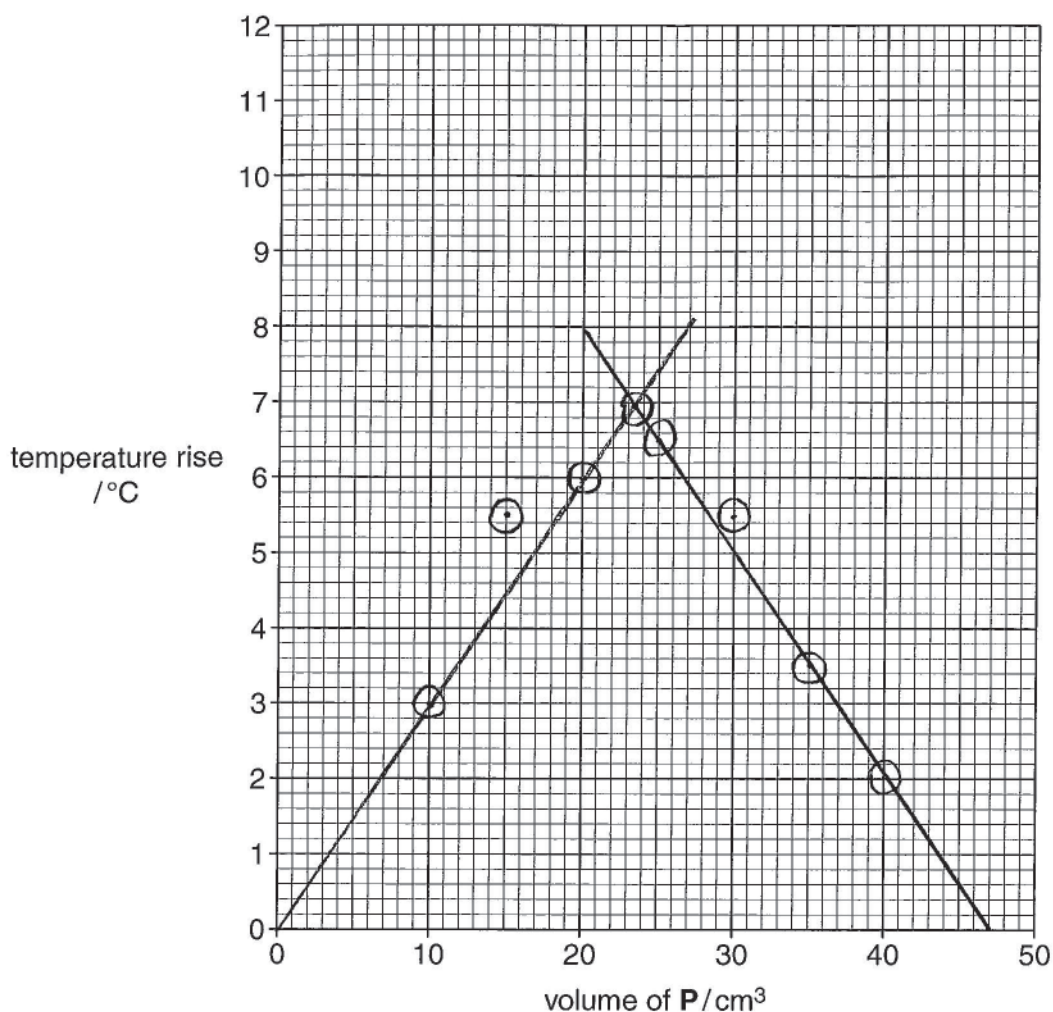
	A	B	C	D	E	F
	experiment number	volume of P / cm^3	volume of Q / cm^3	initial temperature of P / $^\circ\text{C}$	highest temperature of mixture / $^\circ\text{C}$	temperature rise / $^\circ\text{C}$
3.5	1	10	40	31.0	34.0	3.0 ✓
5.0	2	15	35	30.5	36.0	5.5 ✓
7.0	3	20	30	31.0	37.0	6.0 ✓
6.5	4	25	25	31.0	37.5	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] 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] 2



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

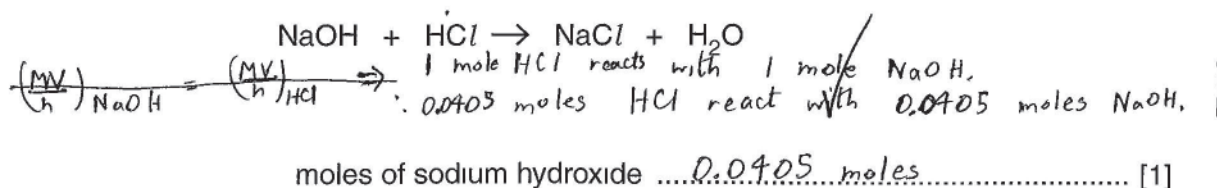
volume of **P** 27.0 cm³ [1]

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

$$\begin{aligned}
 \text{no. of moles of HCl} &= \text{concentration of HCl (in mol/dm}^3\text{)} \times \text{volume of HCl (in dm}^3\text{)} \\
 &= 1.50 \times \frac{27.0}{1000} \\
 &= 0.0405 \text{ moles}
 \end{aligned}$$

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).



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

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

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

$$= \frac{40.5}{23}$$

$$= \cancel{17.6} \quad 1.76 \text{ mol/dm}^3 \quad \checkmark$$

concentration of Q 1.76 mol/dm^3 [2]

[Total: 21]

20
✓

Examiner comment – grade A

- (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 cm^3 .

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 cm^3 is the volume of **Q** which reacts with 27 cm^3 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 – grade C

- 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/dm³ hydrochloric acid.

Q is aqueous sodium hydroxide.

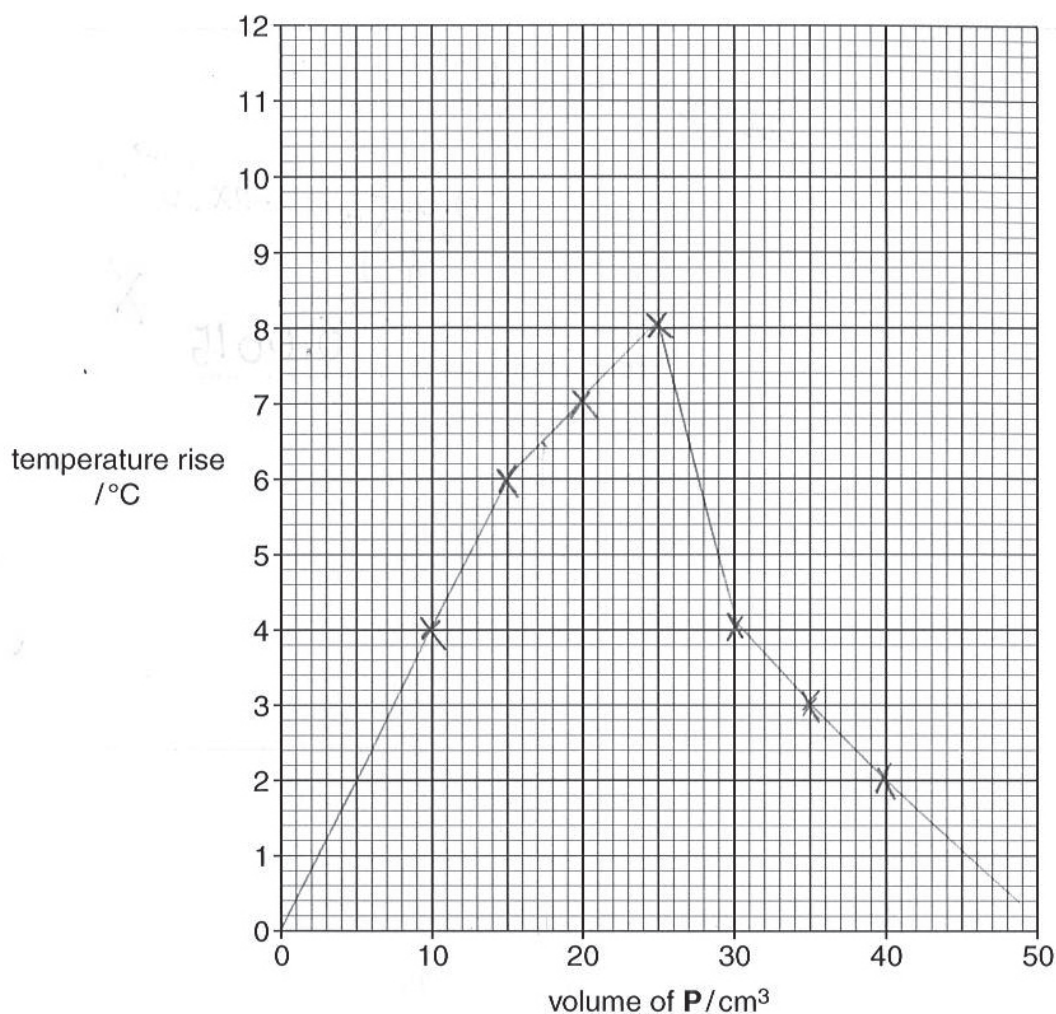
- (a) (i) Put **P** into a burette and use it to measure 10 cm³ of **P** into a plastic cup. Measure the temperature of **P** to the nearest 0.5 °C and record the value in column D of the table.
- (ii) Using a measuring cylinder, measure 40 cm³ of **Q** as accurately as possible. Pour this volume of **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							
4.0	1	10	40	28°C	32°C	4°C	✓
5.5	2	15	35	28°C	34°C	6°C	✓
7.5	3	20	30	29°C	36°C	7°C	✓
7.0	4	25	25	29°C	37°C	8°C	✓
5.5	5	30	20	29°C	35°C	4°C sub	6°C ✓
4	6	35	15	29°C	32°C	3°C	✓
2.5	7	40	10	29°C	31°C	2°C	✓
				✓ x ✓ x ✓✓✓			

(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.

[14] 12

[2] 1



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

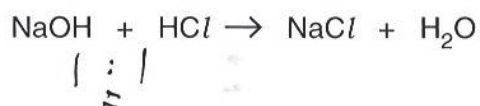
volume of **P** 18 X cm³ [1] 0

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

$$0.0015 \times 18 \text{ ecf} = 0.027$$

moles of hydrochloric acid 0.027 ✓ [1] 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).



moles of sodium hydroxide 0.027 ✓ [1] 1

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

~~0.027~~

$$C = \frac{n}{V}$$

$$0.027 = 1.5 \times 10^{-3}$$

$$\frac{0.027}{18}$$

$$0.0015$$

concentration of Q mol/dm^3 [2]

[Total: 21]

15

Examiner comment – grade C

- (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 – grade E

- 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.

^{HCl}
P is 1.50 mol/dm³ hydrochloric acid.

^{NaOH}
Q is aqueous sodium hydroxide.

- (a) (i) Put P into a burette and use it to measure 10 cm³ 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 cm³ 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.

S U P

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

F ✓

R ✓

S ✓✓

P

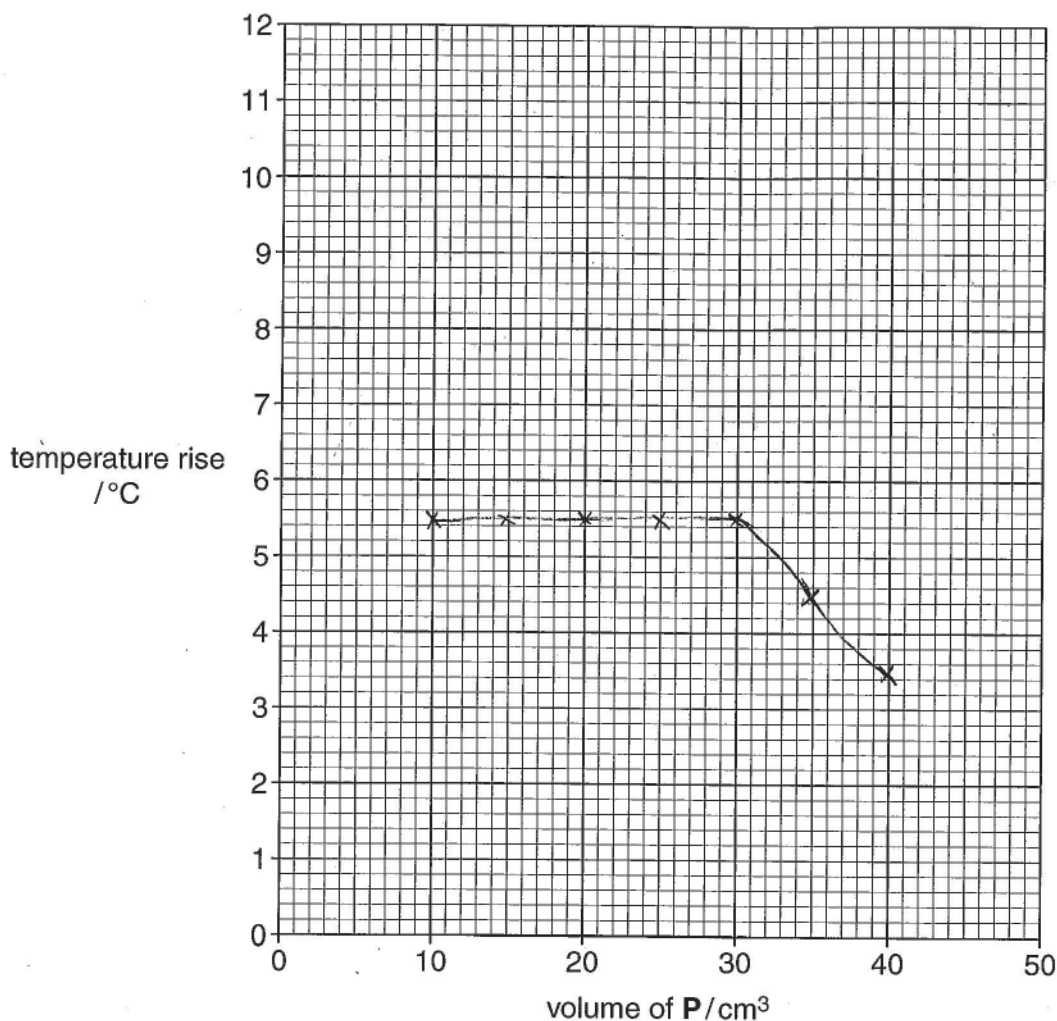
X

X

X

[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]



- (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).

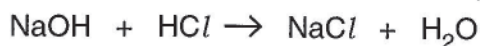
$$\text{mol} = \frac{\text{volume}}{24 \text{ dm}^3}$$

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

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

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).



$$1 \text{ mol of HCl} \rightarrow 1.25 \times 10^{-3}$$

$$1 \text{ mol of NaOH} \rightarrow 1$$

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

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

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

X

0

$$40x = 15$$

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

$$= 0.375$$

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

[Total: 21]

10

Examiner comment – grade E

- (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 cm³ 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]	

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]

ConclusionsCation 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 – grade A

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 2cm depth of R in a test-tube, add a piece of magnesium.	Gas is evolved vigorously. Effervescence is seen. Solid magnesium dissolves and the 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. (b) To the mixture from (a), add dilute nitric acid.	White precipitate is formed. White precipitate remains insoluble. White precipitate does not dissolve.	2
3	To 2cm 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. Acidified KMnO_4 is decolourised.	1
4	To 1 cm depth of aqueous iodine in a test-tube, add S .	Brown solution turns colourless. Aqueous 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



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

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 – grade C

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. (b) To the mixture from (a), add dilute nitric acid.	White precipitate/forms. The precipitate remains insoluble. No further reaction or change occurs.	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).	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

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

[Total: 19]

13

Examiner comment – grade C

- 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 – grade E

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. 1 0



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

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

[3]

[Total: 19]

8

Examiner comment – grade E

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

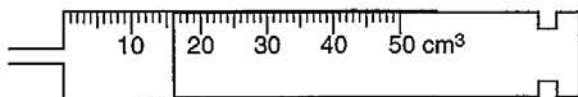
Mark scheme

- 1 (a) (i) (gas) syringe (1) [1]
- (ii) 16 (1)cm³ [1]
- (b) (i) carbon dioxide / CO₂ (1)
 limewater turns milky (1)
 $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$ (1) [3]
- (ii) Hydrogen / H₂ (1) pops in a flame (1)
 $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$ (1) [3]

[Total: 8]

Example candidate response – grade A

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 Carbon dioxide

test bubble gas through limewater. It turns milky

equation for the reaction $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$

[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 $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$

[3]

[Total: 8]

Examiner comment – grade A

- (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.

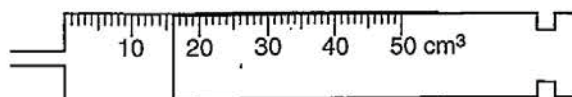
In both of the answers the candidate gave a perfect description of each test and a balanced equation.

Mark awarded = 6 out of 6

Total mark awarded = 8 out of 8

Example candidate response – grade C

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 $\text{CaCO}_3 + \text{HCl} \rightarrow \text{CaCl}_2 + \text{CO}_2$

[3]

- (ii) zinc and dilute sulfuric acid

gas Hydrogen
 test "pops" with a lighted splint
 equation for the reaction $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$

[3]

[Total: 8]

Examiner comment – grade C

- (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.

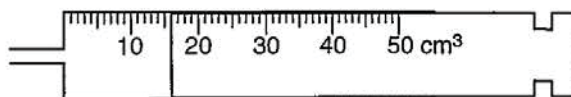
- (ii) The candidate named the gas as hydrogen and gave a correct test, a lighted splint producing a pop, to confirm its presence. A correct equation was given.

Mark awarded = 5 out of 6

Total mark awarded = 7 out of 8

Example candidate response – grade E

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 ~~Carbon dioxide~~ Hydrogen

test Turns lime water milky produces a pop sound

equation for the reaction $\text{CaCO}_3 + \text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$

[3]

- (ii) zinc and dilute sulfuric acid

gas Hydrogen

test makes a pop sound when a glowing splint is placed

equation for the reaction $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$

[3]

[Total: 8]

Examiner comment – grade E

- (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)** $0.05 (1) \times 188 = 9.4\text{g} (1)$ [2]
- (d)** $0.03 (1) \times 188 = 5.64\text{g} (1)$ [2]
- [Total: 8]**

Example candidate response – grade A

- 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.

Cream colour. [1]

- (ii) How is the precipitate separated from the reaction mixture?

By filtration. [1]

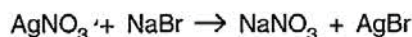
- (b) (i) Calculate the number of moles of silver nitrate in 50.0 cm^3 of 1.0 mol/dm^3 silver nitrate.

$$\begin{aligned} \text{no. of moles} &= \text{concentration} \times \text{volume} \\ &= 1.0\text{ mol/dm}^3 \times 0.050\text{ dm}^3 = 0.05\text{ mol} \end{aligned} \quad \dots\dots\dots 0.05\text{ mol} \quad \dots\dots\dots \text{moles [1]}$$

- (ii) Calculate the number of moles of sodium bromide in 40.0 cm^3 of 1.5 mol/dm^3 sodium bromide.

$$\begin{aligned} \text{no. of moles} &= \text{concentration} \times \text{volume} \\ &= 1.5\text{ mol/dm}^3 \times 0.040\text{ dm}^3 \\ &= 0.06\text{ mol} \end{aligned} \quad \dots\dots\dots 0.06\text{ mol} \quad \dots\dots\dots \text{moles [1]}$$

- (c) The equation for the reaction is



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]

$$\text{molar ratio} \Rightarrow \text{AgNO}_3 : \text{AgBr} \Rightarrow \text{moles} = 0.05\text{ mol} \quad \dots\dots\dots 1:1$$

$$\text{molar mass} = 108 + 80 = 188\text{ g mol}^{-1}$$

$$\begin{aligned} \text{mass} &= \text{molar mass} \times \text{moles} \\ &= 188\text{ g mol}^{-1} \times 0.05\text{ mol} = 9.4\text{ g} \end{aligned} \quad \dots\dots\dots 9.4\text{ g} \quad \dots\dots\dots \text{g [2]}$$

- (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.

$$\begin{aligned} \text{moles of AgNO}_3 \text{ (silver nitrate)} &= \text{volume} \times \text{concentration} \\ &= 0.050\text{ dm}^3 \times 1.0\text{ mol/dm}^3 \\ &= 0.05\text{ mol} \end{aligned}$$

$$\begin{aligned} \text{moles of NaBr (sodium bromide)} &= \text{volume} \times \text{concentration} \\ &= 0.060\text{ dm}^3 \times 0.5\text{ mol/dm}^3 \Rightarrow 0.03\text{ mol} \end{aligned}$$

$$\text{molar ratio} \Rightarrow \text{NaBr} : \text{AgBr} \Rightarrow 0.03\text{ moles} \quad \dots\dots\dots 1:1 \quad \dots\dots\dots 5.64\text{ g} \quad \dots\dots\dots \text{g [2]}$$

$$\begin{aligned} \text{mass} &= \text{molar mass} \times \text{moles} \\ &= 188\text{ g mol}^{-1} \times 0.03\text{ mol} \Rightarrow 5.64\text{ g} \end{aligned}$$

[Total: 8]

Examiner comment – grade A

(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 cm³ of 0.5 mol / dm³ 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 – grade C

- 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.

.....white.....

[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.

$$n = c \times v \quad \dots\dots\dots 0.05 \dots\dots\dots \text{moles [1]}$$

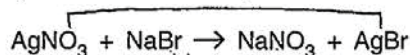
$$= 1.0 \times 0.05 = 0.05$$

(ii) Calculate the number of moles of sodium bromide in 40.0 cm^3 of 1.5 mol/dm^3 sodium bromide.

$$n = c \times v \quad \dots\dots\dots 0.06 \dots\dots\dots \text{moles [1]}$$

$$= 1.5 \times 0.04 = 0.06$$

(c) The equation for the reaction is



Using your answers to (b)(i), (b)(ii) and the equation, calculate the mass of silver bromide produced in the experiment.

[A: Ag, 108; Br, 80]

$$\text{AgBr} = 188$$

$$= 0.05 \times 188 = 9.4$$

$$= 0.06 \times 188 = 11.28$$

$$\text{Mass} = \frac{\text{mole} \times \text{Mr}}{\text{Mr}} \quad \dots\dots\dots 20.68 \dots\dots\dots \text{g [2]}$$

$$9.4 + 11.28 = 20.68$$

(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.

$$0.05 \times 188 = 9.4$$

$$c = \frac{n}{v}$$

$$n = 0.5 \times 0.06$$

$$n = 0.03$$

$$0.03 \times 188 = 5.64$$

$$\dots\dots\dots 15.04 \dots\dots\dots \text{g [2]}$$

$$9.4 + 5.64 = 15.04$$

[Total: 8]

Examiner comment – grade C

(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 – grade E

- 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.

yellow

[1]

- (ii) How is the precipitate separated from the reaction mixture?

Filtration

[1]

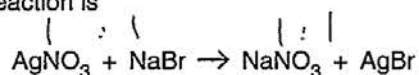
- (b) (i) Calculate the number of moles of silver nitrate in 50.0 cm^3 of 1.0 mol/dm^3 silver nitrate.

$$\text{Moles} = \frac{50.0}{1000} \times 1.0 = 0.05 \quad \dots\dots\dots 0.05 \dots\dots\dots \text{moles [1]}$$

- (ii) Calculate the number of moles of sodium bromide in 40.0 cm^3 of 1.5 mol/dm^3 sodium bromide.

$$\text{Moles} = \frac{40.0}{1000} \times 1.5 = 0.06 \quad \dots\dots\dots 0.06 \dots\dots\dots \text{moles [1]}$$

- (c) The equation for the reaction is



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]

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

$$0.05 = \frac{\text{Mass}}{174}$$

$$8.7 = \text{Mass}$$

$$\frac{0.06}{1} = 0.06$$

$$0.06 \times 80 = \text{Mass}$$

$$4.8$$

$$10.2$$

$$\dots\dots\dots 10.2 \dots\dots\dots \text{g [2]}$$

- (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.

$$\begin{array}{r} 10.2 - 50.0 \\ x - 60.0 \end{array}$$

$$10.2 - 12.24$$

$$\dots\dots\dots 12.24 \dots\dots\dots \text{g [2]}$$

[Total: 8]

Examiner comment – grade E

(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]

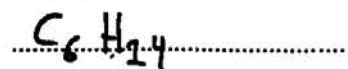
(b) reaction flask with some form of heat indicated (1)
thermometer + cork / bung / closed (1)
condenser with water circulating in the correct direction (1)
receiver flask, not closed (1) [4]

[Total: 5]

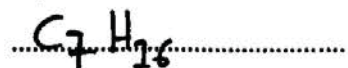
Example candidate response – grade A

- 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



heptane

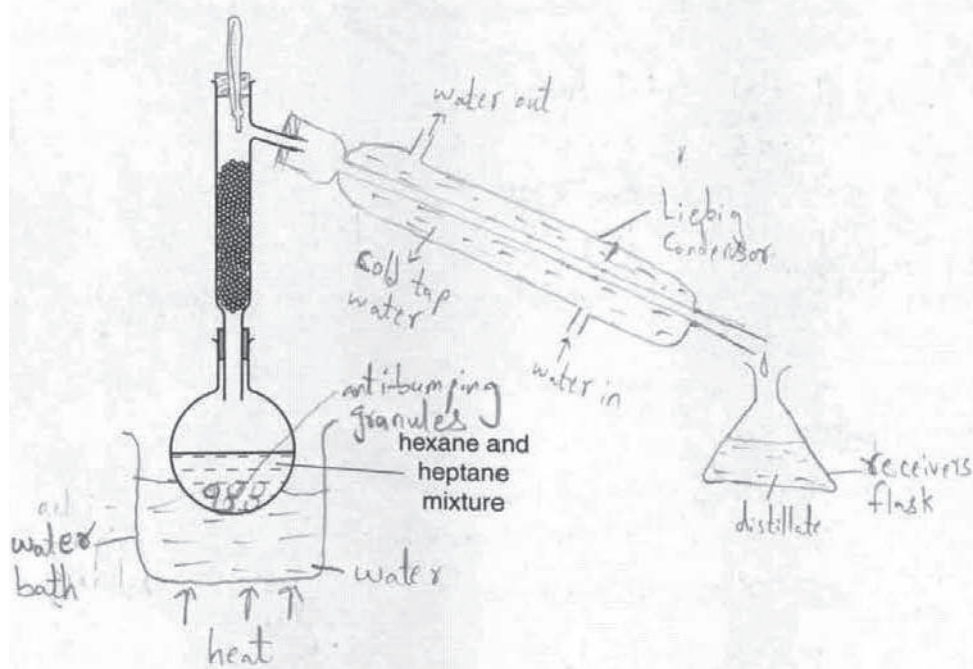


[1]

- (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 – grade A

- (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 – grade C

- 3 (a) Using the general formula for the homologous series of ^{$C_n H_{2n+2}$} alkanes, suggest the formula for both hexane and heptane, the sixth and seventh members of the alkane series respectively.

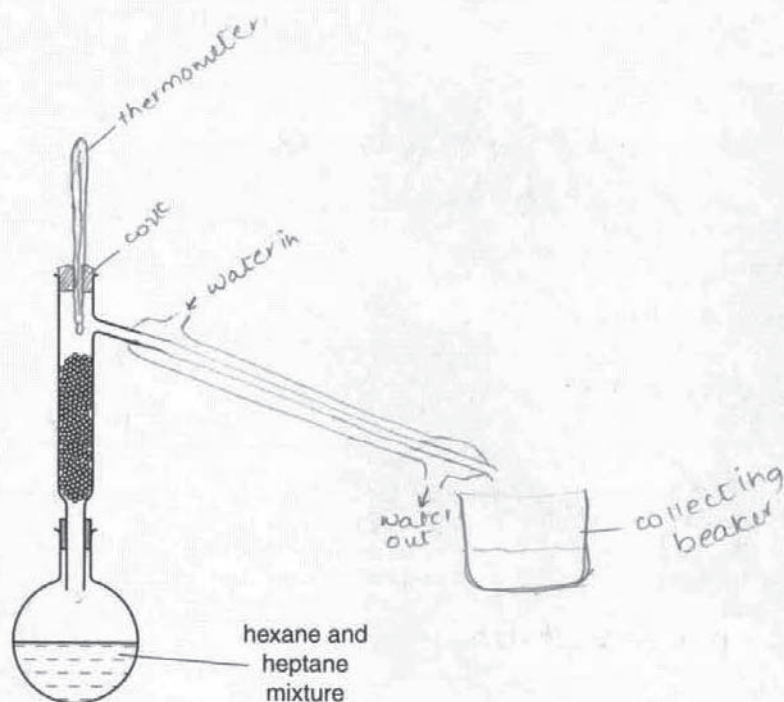
hexane ⁶ $C_6 H_{14}$
 $C_6 H_{14}$
 heptane ⁷ $C_7 H_{16}$
 $C_7 H_{16}$

[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 – grade C

- (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.

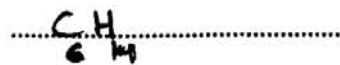
Mark awarded = 2 out of 4

Total mark awarded = 3 out of 5

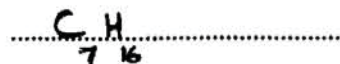
Example candidate response – grade E

- 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



heptane

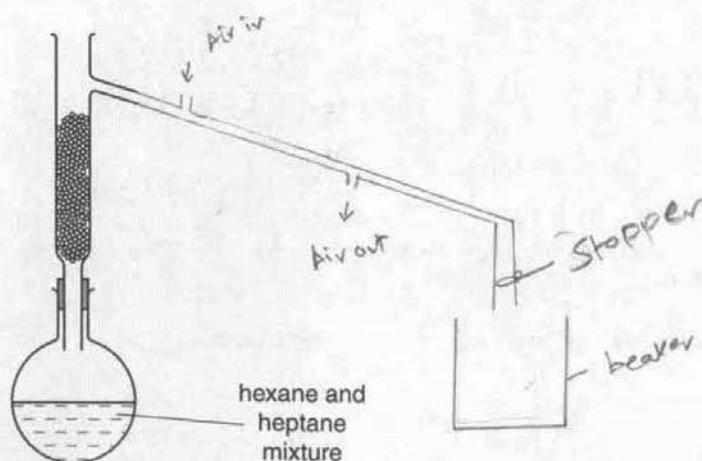


[1]

- (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 – grade E

- (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)** $\text{ZnO} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2\text{O}$ (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 or 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 – grade A

- 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.

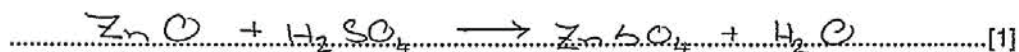
.....3.85.....g [1]

- (b) 50.0 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.



- (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.

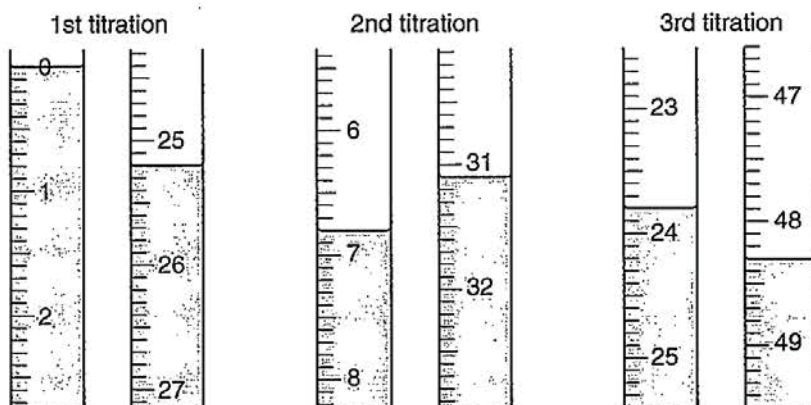
A burette is filled with 0.100 mol/dm³ sodium hydroxide.

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 fromred..... toyellow..... [1]

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.



(d) Use the diagrams to complete the following results table.

titration number	1	2	3
final reading/cm ³	25.2	31.0	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.

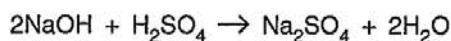
Using these results, the average volume of 0.100 mol/dm³ sodium hydroxide is

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).

$$\text{Moles} = \frac{24.4 \times 0.100}{1000} = 0.00244 \text{ moles} \quad \dots\dots\dots 0.00244 \text{ moles [1]}$$

(f) Sodium hydroxide reacts with sulfuric acid according to the following equation.



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 cm³ of D.

0.00122 moles [1]

- (h) Calculate the number of moles of sulfuric acid in 50.0 cm^3 of 1.00 mol/dm^3 sulfuric acid.

$$\text{Moles} = \frac{50 \times 1}{1000} = 0.05 \quad \dots\dots\dots 0.05 \dots\dots\dots \text{moles [1]}$$

- (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.

$$\text{No. of moles} = 0.05 - 0.0122 = 0.0378 \quad \dots\dots\dots 0.0378 \dots\dots\dots \text{moles [1]}$$

- (j) Using your equation in (b) and your answer in (i), deduce the number of moles of zinc oxide in the sample of C.

$$\dots\dots\dots 0.0378 \dots\dots\dots \text{moles [1]}$$

- (k) Calculate the mass of zinc oxide in the sample of C.
[A_r: Zn, 65; O, 16]

$$\begin{aligned} \text{Mass} &= 0.0378 (65 + 16) \\ &= 0.0378 \times 81 \\ &= 3.0618 \quad \dots\dots\dots 3.0618 \dots\dots\dots \text{g [1]} \end{aligned}$$

- (l) Using your answers in (a) and (k) calculate the percentage by mass of zinc oxide in the sample of C.

$$\% \text{ by mass} = \frac{3.0618}{3.85} \times 100 \quad \dots\dots\dots 79.53 \dots\dots\dots \% [1]$$

[Total: 15]

Examiner comment – grade A

- (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 – grade C

- 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.

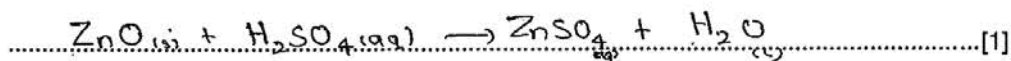
$$\begin{aligned} \text{Mass of C} &= 29.15 - 25.30 \\ &= \underline{3.85} \text{ g} \end{aligned} \quad \dots\dots\dots 3.85 \dots\dots\dots \text{g [1]}$$

- (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.



- (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.

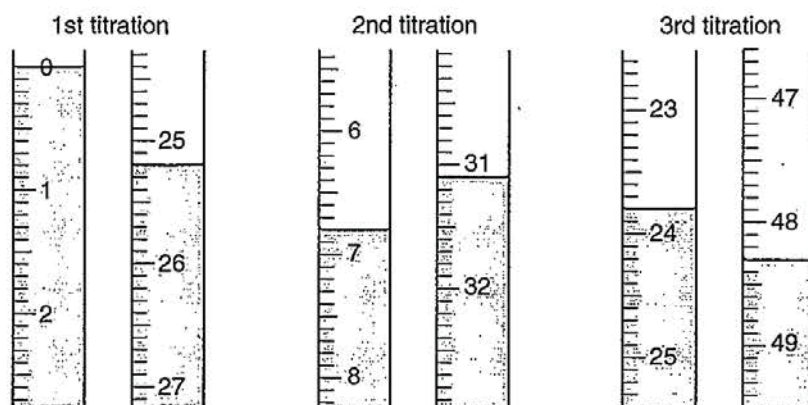
A burette is filled with 0.100 mol/dm³ sodium hydroxide.

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]

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.



(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 23.9
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/dm³ sodium hydroxide is

$$\frac{24.3 + 24.5}{2} = \underline{\underline{24.4 \text{ cm}^3}}$$

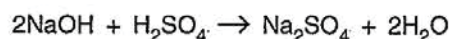
.....24.4.....cm³. [4]

(e) Calculate the number of moles of sodium hydroxide in the average volume of 0.100 mol/dm³ sodium hydroxide in (d).

$$\begin{aligned} n &= VC \\ &= 0.100 \times 24.4 \\ &= \underline{\underline{2.44 \times 10^{-3}}} \end{aligned}$$

.....2.44 × 10⁻³ moles [1]

(f) Sodium hydroxide reacts with sulfuric acid according to the following equation.



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 cm³ of D.

$$\begin{aligned} n &= VC \\ &= 0.100 \times 250 \\ &= \underline{\underline{2.5 \times 10^{-2}}} \end{aligned}$$

.....0.0125..... moles [1]

- (h) Calculate the number of moles of sulfuric acid in 50.0 cm^3 of 1.00 mol/dm^3 sulfuric acid.

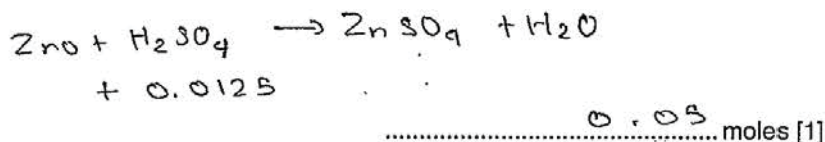
$$\begin{aligned} n &= \frac{q}{e} \\ &= \frac{0.05 \times 1}{1.6 \times 10^{-19}} \\ &= 0.03 \text{ moles} \end{aligned}$$

- (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.

$$\frac{0.08}{0.0125} = 4 \text{ moles}$$

..... 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.



- (k) Calculate the mass of zinc oxide in the sample of C.

$[A_r: \text{Zn}, 65; \text{O}, 16]$

$$r = \frac{\text{Mass}}{mr} \quad 0.08 = \frac{81}{g}$$

..... 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 – grade C

- (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 – grade E

- 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.

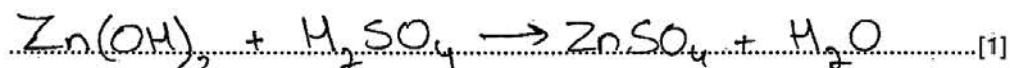
.....3.85.....g [1]

- (b) 50.0 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.



- (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.

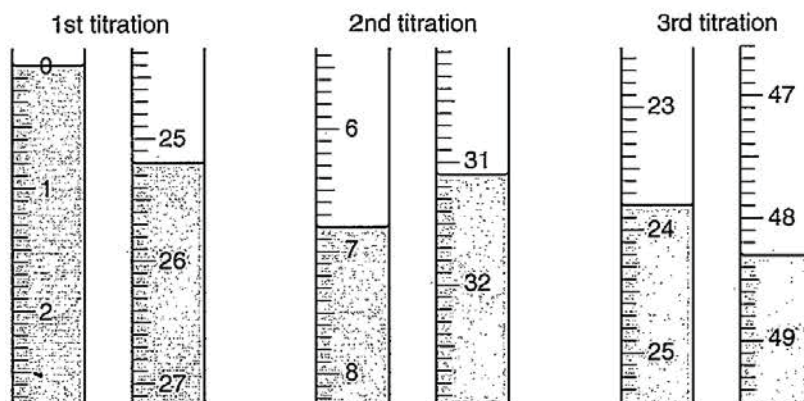
A burette is filled with 0.100 mol/dm³ sodium hydroxide.

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]

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.



(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/dm³ sodium hydroxide is

$$\frac{24.3 + 24.5}{2}$$

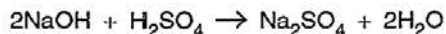
24.4 cm³. [4]

(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.



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.

$$n = CV \\ = 0.00122 \times \frac{250}{1000}$$

0.000305 moles [1]

- (h) Calculate the number of moles of sulfuric acid in 50.0 cm³ of 1.00 mol/dm³ sulfuric acid.

0.00061 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
0.00024 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 – grade E

- (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]

Example candidate response – grade A

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 – grade A

- (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 from 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 – grade C

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 – grade C

(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 – grade E

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.	<i>Pink to colourless</i>	X is an oxidising agent.
(b) Y is passed through acidified potassium dichromate(VI).	<i>Orange to green</i>	Y is a reducing agent.
(c) Y is passed through acidified potassium manganate(VII).	<i>colourless to purple</i>	Y is a reducing agent.

[Total: 6]

Examiner comment – grade E

- (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 cm³ **AND J** = 26 cm³ (1)
 mixture 2: **H** = 34 cm³ **AND J** = 66 cm³ (1) [2]
- (ii)** 9.8 °C (1) [1]
- (iii)** **H** = 56 cm³ **AND J** = 44 cm³ (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 cm³.
- (d)** No. of moles of **J** (1)
 $M = 44 \times 1.00 / 56 \times 2 = 0.393$ (0.39) mol/dm³ (1) [2]
- (e) (i)** 4.9 °C (1) [1]
- (ii)** 56 cm³ **H AND** 44 cm³ **J** (1) [1]

[Total: 13]

Example candidate response – grade A

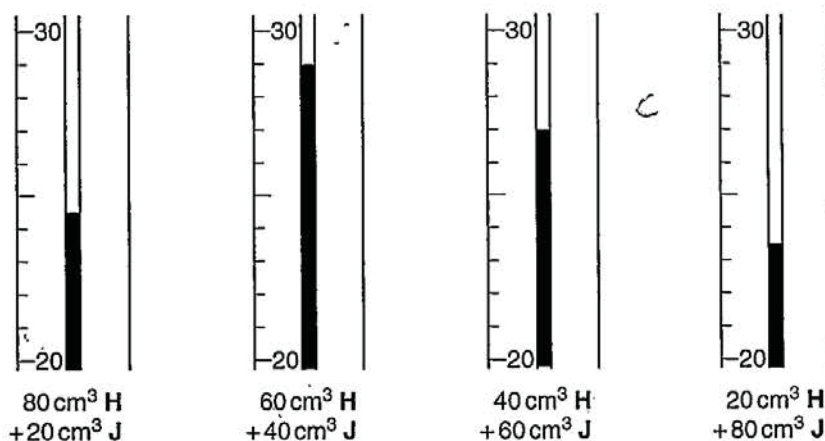
11 The addition of an acid solution to aqueous sodium hydroxide produces a rise in temperature.

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.

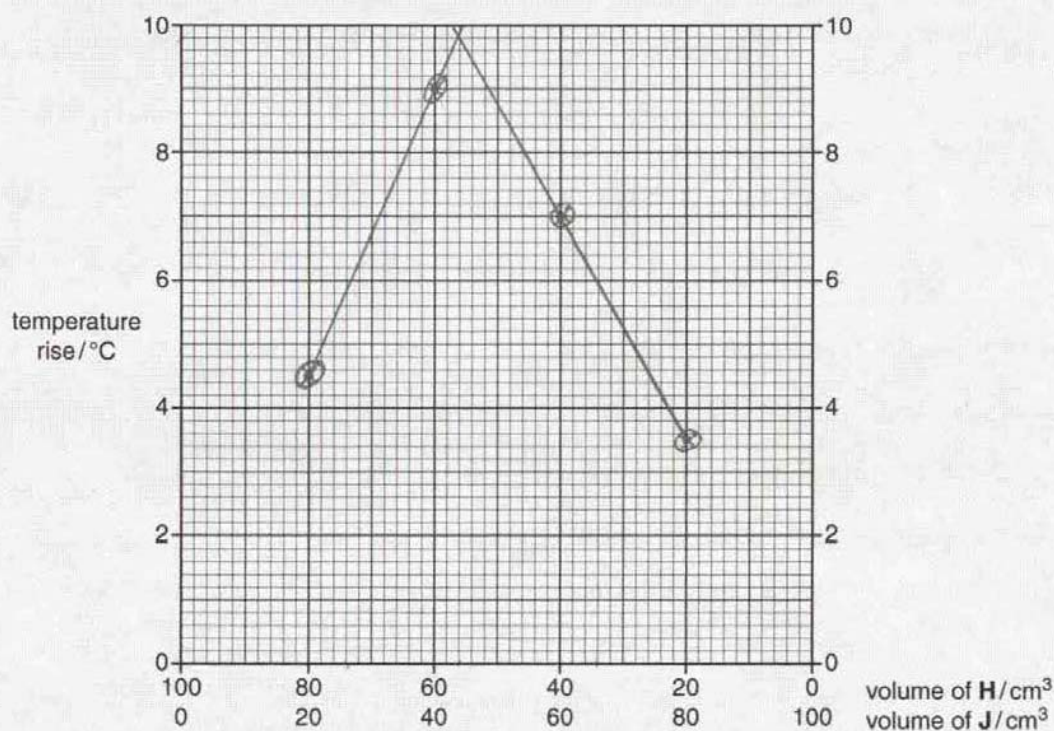


(a) Record these temperatures in the table below and then calculate the rise in temperature in each case.

volume of H/cm ³	volume of J/cm ³	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]

- (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,

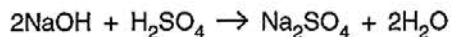
..... 9.8°C [1]

- (iii) the volumes of H and J which produce this temperature rise.

H 56 cm³
J 44 cm³
[1]

- (d) Solution J is 1.00 mol/dm^3 sodium hydroxide.
H is aqueous sulfuric acid.

Sodium hydroxide reacts with sulfuric acid according to the following equation.



Using this equation and your answers to (c)(iii), calculate the concentration of H.

$$\text{Moles} = \frac{44 \times 1}{1000} \\ = 0.044 \text{ moles}$$

$$\text{Moles of } \text{H}_2\text{SO}_4 = 0.022 \text{ moles}$$

$$\text{Concentration} = \frac{0.022 \times 1000}{56} \\ = 0.39 \text{ mol/dm}^3$$

$$\dots\dots\dots 0.39 \dots\dots\dots \text{mol/dm}^3 [2]$$

- (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,

$$\dots\dots\dots 4.9 \dots\dots\dots ^\circ\text{C} [1]$$

- (ii) the volumes of both H and J that would produce this temperature rise.

$$\text{H} \dots\dots\dots 56 \dots\dots\dots \text{cm}^3$$

$$\text{J} \dots\dots\dots 44 \dots\dots\dots \text{cm}^3 \\ [1]$$

[Total: 13]

Examiner comment – grade A

- (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 cm³ of **H** and 44 cm³ 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 – grade C

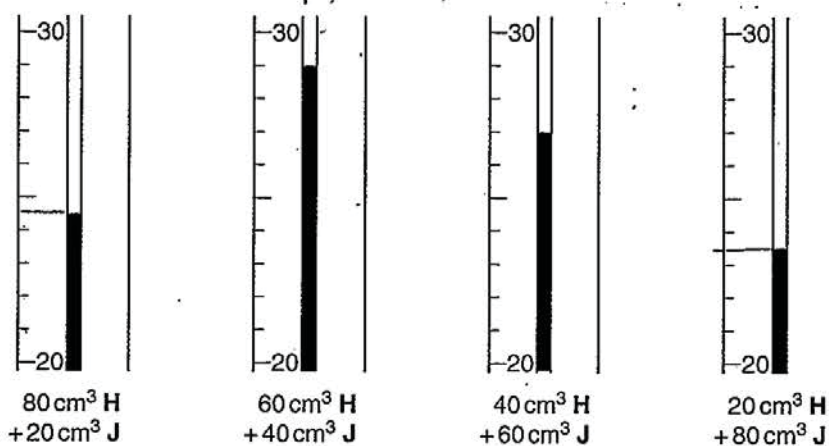
- 11 The addition of an acid solution to aqueous sodium hydroxide produces a rise in temperature.

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.

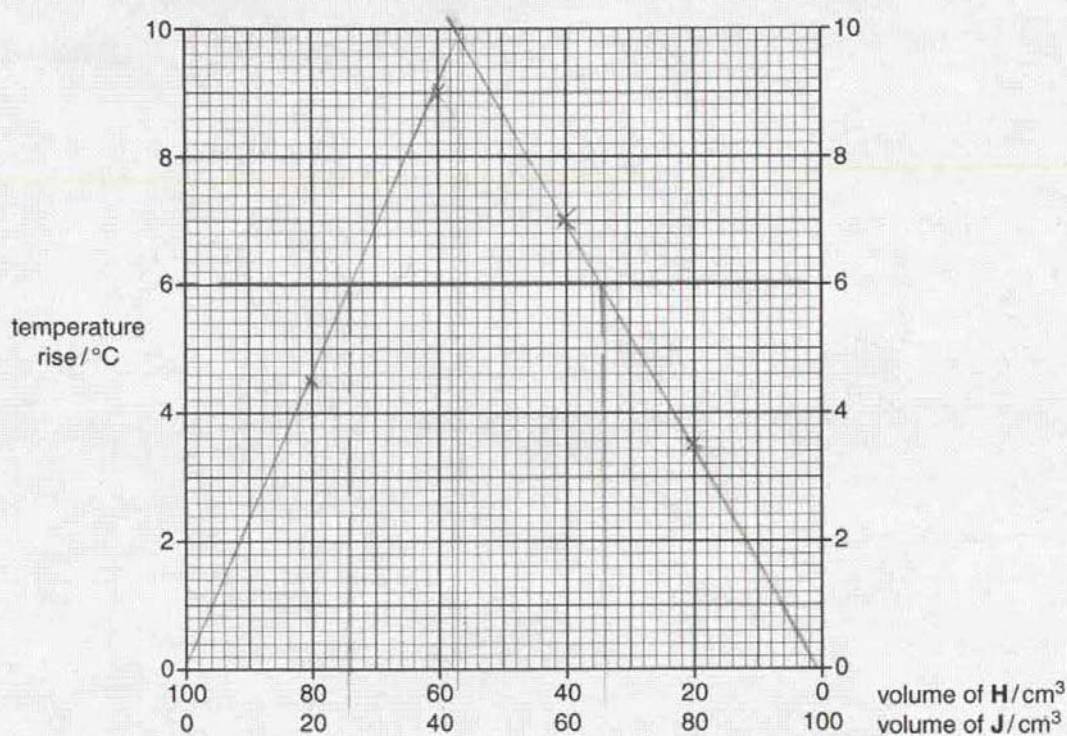


- (a) Record these temperatures in the table below and then calculate the rise in temperature in each case.

volume of H/cm ³	volume of J/cm ³	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]

- (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,

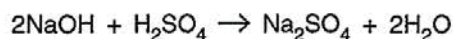
..... 9.9 °C [1]

- (iii) the volumes of H and J which produce this temperature rise.

H 57 cm³
J 43 cm³
[1]

- (d) Solution J is 1.00 mol/dm^3 sodium hydroxide.
H is aqueous sulfuric acid.

Sodium hydroxide reacts with sulfuric acid according to the following equation.



Using this equation and your answers to (c)(iii), calculate the concentration of H.

Moles = Volume $\times$ concentration : 1
 $1 = 57 \times \text{concentration}$
 $\frac{57}{1000} = 0.057$

~~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 – grade C

- (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 – grade E

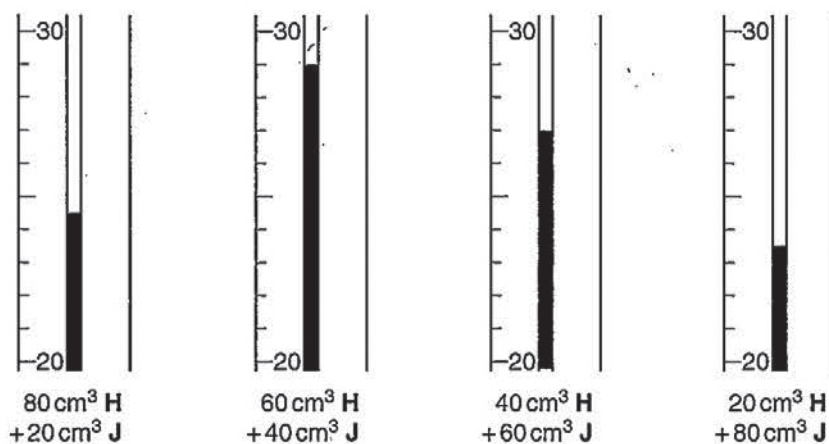
- 11 The addition of an acid solution to aqueous sodium hydroxide produces a rise in temperature.

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.

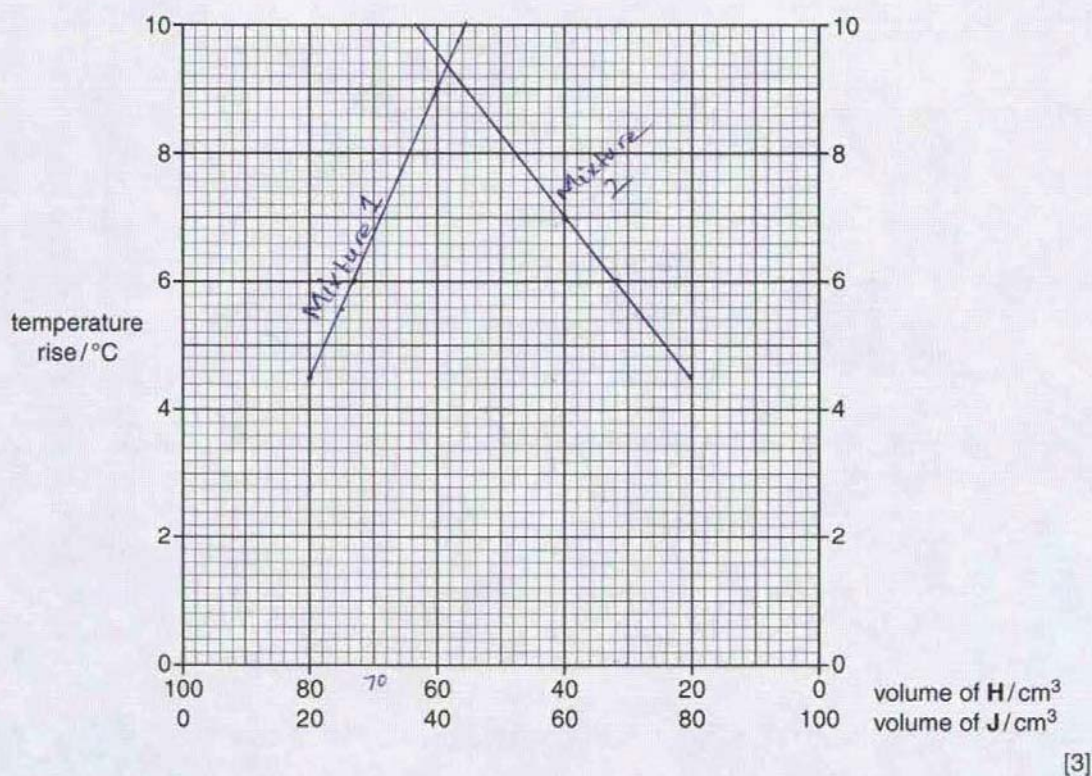


- (a) Record these temperatures in the table below and then calculate the rise in temperature in each case.

volume of H/cm ³	volume of J/cm ³	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]

- (b) Plot these results on the grid below.
Using the points, draw two intersecting straight lines.



- (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,

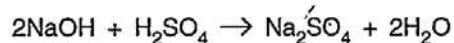
..... 11 °C °C [1]

- (iii) the volumes of H and J which produce this temperature rise.

H 50 cm³
J 50 cm³
[1]

- (d) Solution J is 1.00 mol/dm^3 sodium hydroxide.
H is aqueous sulfuric acid.

Sodium hydroxide reacts with sulfuric acid according to the following equation.



Using this equation and your answers to (c)(iii), calculate the concentration of H.

$$\begin{aligned} \text{moles} &= \frac{\text{conc} \times \text{volume}}{1000} \\ 1 \times 1000 &= \text{conc} \times 50 \\ \frac{20}{50} &= \text{conc} \\ \text{conc} &= 20 \text{ mol/dm}^3 \end{aligned}$$

.....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.

H25..... cm³
J25..... cm³
[1]

[Total: 13]

Examiner comment – grade E

- (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 cm³ of **H** and 42 cm³ 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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