1. HBr(aq), forms two ions in solution.

Which observation is correct for reactions of HBr(aq)?

A. It effervesces addition of sodium carbonate solution.
B. It forms a white precipitate on addition of silver nitrate solution.
C. It turns orange on addition of silver nitrate solution.
D. It turns brown on addition of potassium chloride solution.

Your answer ☐

[1]

2. Three qualitative tests are carried out on a solution of an unknown compound.

Test 1: On heating with NaOH(aq), a pungent smelling gas evolves which turns red litmus paper blue.

Test 2: On addition of $AgNO_3$(aq), a white precipitate forms which is soluble in dilute NH_3(aq).

Test 3: On addition of Na_2CO_3(aq), there is no visible reaction.

What is the unknown compound?

A. ammonium bromide, NH_4Br
B. ammonium chloride, NH_4Cl
C. hydrochloric acid, HCl
D. sodium chloride, NaCl

Your answer ☐

[1]

3. Haloalkanes can undergo hydrolysis.

A student carries out an experiment to find the relative rate of hydrolysis of 1-chloropropane, C_3H_7Cl, 1-bromopropane, C_3H_7Br, and 1-iodopropane, C_3H_7I.

The student adds 2 cm^3 of ethanol to 2 cm^3 of aqueous silver nitrate to three test tubes labelled **A**, **B** and **C**.

The student adds 5 drops of a different haloalkane to each test-tube in rapid succession and shakes each tube. The student measures the time for a precipitate to form in each test-tube.

The results are shown below.

Test tube	Haloalkane	Time taken for reaction to take place
A	C_3H_7Cl	about half an hour
B	C_3H_7Br	a few minutes
C	C_3H_7I	a few seconds

i. Write an **ionic** equation involving aqueous silver nitrate for formation of **one** of the precipitates.

[1]

ii. What do the experimental results tell you about the carbon–halogen bond enthalpies?

[1]

iii. How could the student modify their experiment so that it could be completed in less time?

[1]

4. Two tests are carried out on an aqueous solution of copper(II) sulfate, $CuSO_4(aq)$.

Test 1: Addition of potassium iodide solution
Test 2: Addition of barium chloride solution

Which of the following statements is / are true?

1: **Test 1** produces an off-white precipitate and a brown solution.

2: **Test 2** produces a white precipitate.

3: **Test 1** and **Test 2** are both redox reactions.

A. 1, 2 and 3
B. Only 1 and 2
C. Only 2 and 3
D. Only 1

Your answer ☐

[1]

5. A student carries out a number of experiments on transition metal compounds.

4.800 g of a green hydrated crystalline solid **A** are heated in a crucible to remove the water of crystallisation. 1.944 g of water are removed to leave 0.0180 mol of solid residue **B**.

Solid **B** contains 32.8%, by mass, of the transition metal.

All of **B** is reacted with $AgNO_3$(aq) to form 7.695 g of a white precipitate, **C**.

The green crystalline solid **A** is dissolved in water to produce a green solution containing a complex ion, **D**.

When aqueous sodium hydroxide is added to solution of **D**, a grey–green precipitate, **E**, is observed, which dissolves in excess aqueous sodium hydroxide to form a green solution.

Determine the formulae of **A, B, D** and **E**.

Show **all** your working.

A = ... **D =** ....

B = ... **C =** .... **[9]**

6. This question looks at ions and complexes.

* You are provided with two boiling tubes containing solutions of the same ionic compound. The compound contains one cation and one anion from the lists below.

- cations: Fe^{2+}, Mn^{2+}, NH_4^+
- anions: Cl^-, CO_3^{2-}, SO_4^{2-}

Solutions of common laboratory reagents are available.

Plan a series of tests that you could carry out on the samples to identify the ionic compound. Your tests should produce at least one positive result for each ion.

For each test,

- include details of reagents, relevant observations and equations
- explain how your observations allow the ions to be identified.

You may include flowcharts or tables in your answer.

[6]

7. A student carries out the following experiment to investigate the reaction between hexane and chlorine. The chlorine is made by reaction of aqueous sodium chlorate(I) with dilute hydrochloric acid.

Procedure	**Observations**
1 cm^3 of hexane is mixed with 1 cm^3 dilute aqueous sodium chlorate(I) in a test-tube.	The mixture forms two colourless layers.
1 cm^3 dilute hydrochloric acid is slowly added to the mixture.	The acid mixes with the lower layer, which turns a pale green colour.
The tube is then stoppered and shaken.	The pale green colour moves to the upper layer, leaving the lower layer colourless.
The tube is placed under a bright light and shaken at regular intervals for about 10 minutes. The stopper is loosened regularly to release any pressure.	The pale green colour slowly disappears leaving two colourless layers after about 10 minutes.

i. The reaction between aqueous sodium chlorate(I) and dilute hydrochloric acid produces aqueous sodium chloride as well as chlorine.

Suggest an equation for this reaction.

[2]

ii. Outline a simple practical test that would confirm the presence of chloride ions in the lower layer, and give the expected result.

test:
....

result:
....

[2]

iii. Name the apparatus that could be used to separate the two liquid layers present at the end of the experiment.

[1]

8.

i. Complete the electron configuration of a bromide **ion**.

$1s^2$
.... **[1]**

ii. A student adds a small volume of aqueous silver nitrate to an aqueous solution of bromide ions in a test-tube. The student then adds a similar volume of dilute aqueous ammonia to the same test-tube.

Describe what the student would see in the test-tube after the addition of aqueous ammonia.

[1]

iii. Write an ionic equation for any precipitation reaction which occurs in the student's tests.

Include state symbols.

[1]

9. A student adds aqueous sodium carbonate to one test-tube and aqueous silver nitrate to a second test-tube.
The student adds dilute sulfuric acid to each test-tube.
Which row has the correct observations?

	Aqueous sodium carbonate	**Aqueous silver nitrate**
A	no change	precipitate
B	no change	no change
C	effervescence	no change
D	effervescence	precipitate

Your answer ☐

[1]

10. Precipitation reactions can be used to distinguish between halide ions.

i. State the reagent needed for these precipitation reactions.

[1]

ii. How would the appearance of the precipitates allow you to distinguish between chloride, bromide and iodide ions?

Chloride ....

Bromide ....

Iodide ....

[1]

11(a). This question is about chemicals used by gardeners.

A garden product contains hydrated ammonium iron(II) sulfate, $(NH_4)_2Fe(SO_4)_2{\bullet}xH_2O$. $(NH_4)_2Fe(SO_4)_2{\bullet}xH_2O$ contains 27.55% by mass of water of crystallisation.

Calculate the value of x in the formula $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$.

Show your working.

x = ... **[3]**

(b). The garden product in the previous question part is a solid mixture of the following ingredients:

- Hydrated ammonium iron(II) sulfate, $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$, which is soluble in water
- Crushed limestone (calcium carbonate)
- Sand.

i. Suggest why crushed limestone has been included in this garden product.

[1]

ii. *Plan a procedure on a test tube scale to show that the solid mixture contains the following ions:
- NH_4^+, Fe^{2+} and SO_4^{2-} present in $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$
- CO_3^{2-} present in crushed limestone.

Show your reasoning, including relevant equations.

[6]

12. Barium chloride, $BaCl_2$, is soluble in water.

i. Compare the electrical conductivities of solid and aqueous barium chloride.

Explain your answer in terms of the particles involved.

[2]

ii. Describe the use of aqueous barium chloride in qualitative analysis.

[2]

iii. Hydrated barium chloride can be crystallised from solution.

Hydrated barium chloride has the formula $BaCl_2 \cdot xH_2O$ and a molar mass of 244.3 g mol $^{-1}$.

Determine the value of ***x*** in the formula of $BaCl_2 \cdot xH_2O$.

Show your working.

x = ... **[2]**

13. Fig. 22.1 shows first ionisation energies for elements across Period 3.

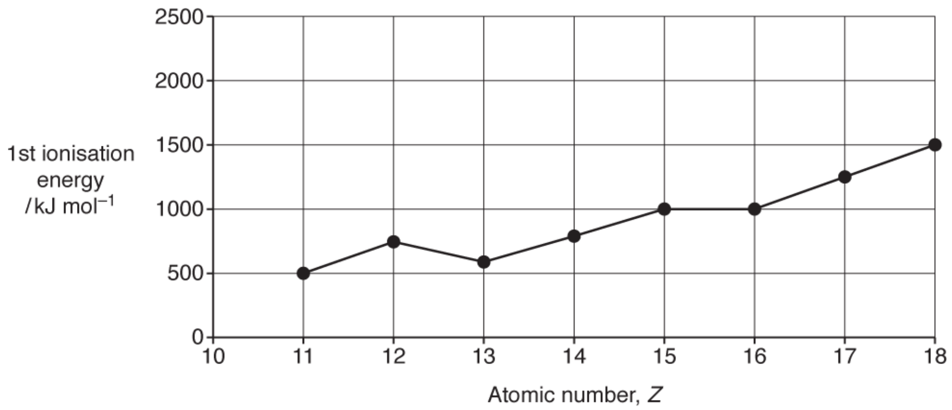


Fig. 22.1

i. Add a point to **Fig. 22.1** for the first ionisation energy of the element with Z = 10.

[1]

ii. Estimate the energy required to form **one** $Na^+(g)$ ion from one Na(g) atom.
Give your answer in kJ, in standard form, and to **two** significant figures.

energy = ... kJ **[1]**

iii. Explain why the first ionisation energies in **Fig. 22.1** show a general increase across Period 3 (Na–Ar).

[3]

iv. Explain why the general increase in first ionisation energies across Period 3 is **not** followed for Mg (Z = 12) to Al (Z = 13).

[2]

14. Two changes are described below.

For each change,

- write an equation, including state symbols,
- state and explain how the entropy changes.

i. The reaction of aqueous barium nitrate with aqueous sodium sulfate.

Full equation with state symbols

Explanation of entropy change

[2]

ii. The change that accompanies the standard enthalpy change of atomisation of iodine.

Equation with state symbols

Explanation of entropy change

[2]

15. Which statement about ammonium carbonate is **not** correct?

A It reacts with $Ba(NO_3)_2(aq)$ to form a white precipitate.
B It effervesces with dilute nitric acid.
C It release an alkaline gas with warm NaOH(aq).
D It has the formula NH_4CO_3.

Your answer ☐ **[1]**

16. You are supplied with a sample of ammonium bromide.

Describe simple tests that would identify the cation and anion present in ammonium bromide.

Include reagents, expected observations and relevant equations.

[5]

17. This question is about nickel and its compounds.

A student is provided with samples of three nickel compounds.

One sample is nickel(II) bromide, another is nickel(II) sulfate and the third is nickel(II) carbonate. The student doesn't know which sample is which.

Describe the tests that the student could carry out to identify the anion (negative ion) in each sample, and write equations for any reactions.

[6]

18. * **B** and **C** are compounds of two different transition elements.

A student carries out test tube reactions on aqueous solutions of **B** and **C**.
The observations of the student's tests are shown below.

	Test	**B(aq)**	**C(aq)**
1	NH_3(aq) added dropwise excess NH_3(aq) added	green precipitate **D** no further change	grey-green precipitate **E** purple solution **F**
2	HNO_3(aq) followed by $Ba(NO_3)_2$(aq)	no change white precipitate **G**	no change no change
3	HNO_3(aq) followed by $AgNO_3$(aq)	no change no change	no change white precipitate **H**

Analyse the results to identify **B** to **H**, and construct ionic equations for the formation of products **D** to **H**.

[6]

19. $NH_4Fe(SO_4)_2{\bullet}12H_2O$ is a hydrated 'double salt'.

A student analyses this double salt using test tube tests.

Which row(s) gives/give correct result(s) for the stated test?

	Test	**Results**
1	Reaction with cold NaOH(aq)	Green precipitate
2	Reaction with $Ba(NO_3)_2(aq)$	White precipitate
3	Reaction with warm NaOH(aq)	Red-brown precipitate and an alkaline gas

A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer **[1]**

20. This question is about some Group 2 elements and their compounds.

A student adds barium oxide, BaO, to water.

A reaction takes place forming a colourless solution.

i. Predict the approximate pH of the colourless solution.

pH = ... **[1]**

ii. A student adds a few drops of dilute sulfuric acid to the colourless solution.

Describe what the student would observe, and give the formula of the barium compound produced.

Observation

Formula of barium compound

[2]

21. An aqueous solution contains a mixture of chloride, bromide and iodide ions.

$AgNO_3$(aq) is added to this mixture, followed by an excess of dilute NH_3(aq).

The resulting mixture is then filtered.

Which compound(s) is/are present in the residue on the filter paper?

A AgC*l* only
B AgC*l* and AgBr
C AgBr only
D AgBr and AgI

Your answer ☐ **[1]**

22. This question is about the reactions of Group 2 metals and their compounds.

A sample of barium oxide is added to distilled water at 25 °C.
A colourless solution forms containing barium hydroxide, $Ba(OH)_2$.

The solution is made up to 250.0 cm^3 with distilled water.
The pH of this solution is 13.12.

i. Determine the mass of barium oxide that was used.

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

mass of barium oxide = ... g **[5]**

ii. 10 cm^3 of dilute sulfuric acid is added to 10 cm^3 of the colourless solution of $Ba(OH)_2$. Write an ionic equation, including state symbols, for the reaction.

[1]

23. This question is about halogens and practical tests

A student is supplied with aqueous solutions of ionic compounds **B** and **C**.

Compound **B** is a chloride, bromide or iodide of a Group 1 element.

Compound **C** is a chloride, bromide or iodide of a Group 2 element.

The molar masses of **B** and **C** are both in the range 100–115 g mol^{-1}.

Use this information and test-tube tests to show how the student could identify the halide present in **B** and **C** and the formulae of **B** and **C**.

Explain your reasoning.

In your answer, include observations, colours and equations.

[5]

24. This question is about some elements in Period 3 and compounds they form.

A student has a 5.00 g mixture of sodium chloride, $NaCl(s)$, and barium nitrate, $Ba(NO_3)_2(s)$.

The student also has a solution of sodium sulfate, $Na_2SO_4(aq)$.

The student uses the method below to determine the percentage by mass of $NaCl(s)$ in the mixture.

Step 1 Dissolve the 5.00g mixture in distilled water.
Step 2 Add an excess of $Na_2SO_4(aq)$ to the solution. A precipitate of barium sulfate forms.
Step 3 Filter off the precipitate, wash with water, and dry.
Step 4 Weigh the dried precipitate.

The molar mass of barium sulfate is 233.4 g mol^{-1}.

i. Write an equation for the formation of barium sulfate in **step 2**.

Include state symbols.

[2]

ii. The student obtains 3.28 g of precipitate.

Calculate the percentage by mass of $NaCl(s)$ in the 5.00 g mixture.

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

percentage by mass of $NaCl$ (s) = ... % **[4]**

iii. The student changes the method in **2(b)**.

In **step 2**, the student adds an excess of silver nitrate solution, $AgNO_3(aq)$, instead of $Na_2SO_4(aq)$.

Explain whether this change would allow the student to determine the percentage by mass of $NaCl(s)$ in the mixture.

[2]

25. A student adds aqueous potassium carbonate to one test tube and aqueous silver nitrate to a second test tube.

The student adds dilute hydrochloric acid to each test tube.

Which row has the correct observations?

	Aqueous potassium carbonate	Aqueous silver nitrate
A	no change	precipitate
B	no change	no change
C	effervescence	no change
D	effervescence	precipitate

Your answer ☐ **[1]**

26. Tutton's salts are 'double salts' with the formula $\mathbf{X}_2\mathbf{Y}(\mathbf{Z}O_4)_2 \cdot 6H_2O$.

A Tutton's salt contains two cations: $\mathbf{X}^+$ and $\mathbf{Y}^{2+}$.

- $\mathbf{X}^+$ can be an ion of the Group 1 elements K, Rb, Cs or Fr, or an ammonium ion.
- $\mathbf{Y}^{2+}$ can be a 2+ ion of magnesium or an ion of most of the transition elements in Period 4.
- **Z** can be S or Cr.

$(NH_4)_2Cu(SO_4)_2 \cdot 6H_2O$ is an example of a Tutton's salt.

The student dissolves their Tutton's salt in water. A pale blue solution forms.

The student carries out two tests on this aqueous solution.

i. The student adds an excess of aqueous ammonia to their aqueous solution of Tutton's salt. A deep blue solution forms.

The complex ion responsible for the deep blue solution has a molar mass of 167.5 g mol^{-1}.

Suggest the formula of this complex ion.

[1]

ii. The student adds NaOH(aq) to the aqueous solution of Tutton's salt and warms the mixture.

A precipitate and a gas are formed.

Write the formulae of the precipitate and gas and suggest a test that could confirm the identity of the gas.

Formula of precipitate

Formula of gas

Test to confirm the identity of the gas

[3]

iii. How could the student carry out a test-tube test to confirm the anion in the Tutton's salt?

[2]

27. Solid ammonia, NH_3, contains hydrogen bonds.

i. Suggest why solid ammonia has a lower melting point than ice.

[2]

ii. When ammonia dissolves in water, ammonium ions, NH_4^+, are formed.

Draw a 'dot-and-cross' diagram to show the bonding in an NH_4^+ ion.

Show outer electrons only.

[2]

iii. Outline how you would test for the presence of NH_4^+ ions in a solution.

Your answer should include observations.

____

____

____

[2]

28. A student analyses a solution of a salt.

The results are shown below.

Test	**Observation**
Reaction with NaOH(aq)	Green precipitate
Reaction with $Ba(NO_3)_2$(aq)	White precipitate

What is the formula of the salt?

A $CuCl_2$
B $CuSO_4$
C $FeCl_2$
D $FeSO_4$

Your answer [ ] **[1]**

29. An unknown compound is tested to identify whether it contains sulfate, carbonate or halide ions.

What is the correct sequence of tests required?

A carbonate, halide, sulfate
B carbonate, sulfate, halide
C halide, carbonate, sulfate
D sulfate, carbonate, halide

Your answer [ ] **[1]**

END OF QUESTION PAPER

Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			A	1	
			Total	**1**	
2			B	1	
			Total	**1**	
3		i	$Ag^+ + Cl^- \rightarrow AgCl$ **OR** $Ag^+ + Br^- \rightarrow AgBr$ **OR** $Ag^+ + I^- \rightarrow AgI$	1	
		ii	Bond enthalpy decreases C−Cl > C−Br > C−I	1	**allow** chlorine–carbon bonds are strongest.
		iii	Heat the test tubes in a water bath.	1	
			Total	**3**	
4			B	1	
			Total	**1**	
5			1. $n(AgCl)$ formed $= \frac{7.695}{143.5} = 0.05362$ (mol) 2. 0.0180 mol of **B** forms 0.05362 mol of Cl^- No of Cl^- ions in formula of **B** $= \frac{0.05362}{0.0180} = 3$ 3. Molar mass of **B** $= \frac{2.856}{0.0180} = 158.7$ (g mol^{-1}) $158.7 - (3 \times 35.5) = 52.2$ which is chromium 4. $n(H_2O) = \frac{1.944}{18} = 0.108$ (mol) 0.0180 mol $CrCl_3$: 0.108 mol H_2O **OR** 1 mol $CrCl_3$: 6 mol H_2O **A** $CrCl_3•6H_2O$ (from points 2, 3 and 4) **B** $CrCl_3$ (from points 2 and 3) **D** $[Cr(H_2O)_6]^{3+}$ (from determination of **A** and understanding of reaction with water) **E** $Cr(OH)_3$ (from understanding of reaction of **D** with aqueous hydroxide)	9	**ALLOW** Alternative working throughout
			Total	**9**	

6			* *Please refer to the marking instruction point 10 for guidance on how to mark this question.* **Level 3 (5–6 marks)** **Develops a plan that allows identification of all six ions** **AND** **includes essential detail and equations for all test procedures and observations, with three anion tests in the correct sequence, CO_3^{2-}, SO_4^{2-} then Cl^-** **AND** **includes cation test with essential detail and all equations** *There is a well-developed, detailed plan which is clear and logically structured. The plan is substantiated with relevant information, e.g. justification of the sequence of anion tests. There is a clear explanation of how the observations allow the ions to be identified.* **Level 2 (3–4 marks)** **Develops a plan that allows identification of at least three ions** **AND** **includes detail of at least three test procedures and observations, and three equations** *There is an appropriate plan presented with some structure. Parts of the fine detail, correct sequence, or reference to use of both samples may be missing. There is some attempt to explain how the observations allow the ions to be identified.* **Level 1 (1–2 marks)** **Develops a plan that allows identification of at least two ions** **AND** **includes detail of at least two test procedures and observations, and one equation**	6	**Indicative scientific points may include:** Use one sample for cation test, other sample for anion tests **Details of tests** *Cation test* add Aqueous sodium hydroxide Positive observations • for Mn^{2+}: pink / buff precipitate • for Fe^{2+}: green precipitate • for NH_4^+: litmus paper held over the opening of the tube turns blue Fine detail: • (gentle) heating for NH_4^+ test Equations: $Mn^{2+} + 2OH^- \rightarrow Mn(OH)_2$ $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$ $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ *Anion tests* CO_3^{2-}: • add nitric acid; positive observation: effervescence SO_4^{2-}: • add aqueous barium nitrate; positive observation: white precipitate Cl^-: • add silver nitrate solution; positive observation: white precipitate Fine detail for Cl^-:

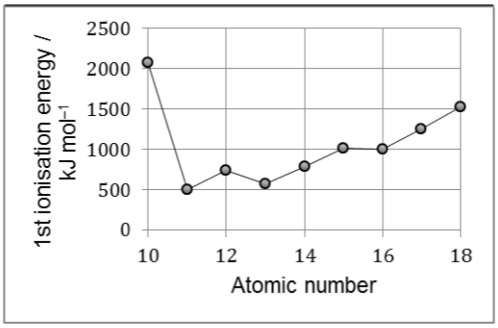
			The plan is basic and communicated in an unstructured way. The response lacks fine detail and no reference to correct sequence of anion tests. There is little or no attempt to explain how the observations allow the ions to be identified. **0 marks** No response or no response worthy of credit.		• subsequent addition of dilute ammonia solution positive observation: precipitate dissolves. Fine detail: correct sequence of all three anion tests • carbonate test followed by sulfate test followed by halide test • justification of sequence • **ALLOW** splitting of solution over three boiling tubes / test tubes and performing each test on a different sample. Equations: $CO_3^{2-} + H^+ \rightarrow CO_2 + H_2O$ $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ $Ag^+ + Cl^- \rightarrow AgCl$
			Total	**6**	
7		i	$NaClO + 2HCl \rightarrow NaCl + Cl_2 + H_2O$ correct formulae of reactants, NaCl and chlorine (1) water and balancing (1)	2	**allow** $NaClO_3 + 6HCl \rightarrow NaCl + 3Cl_2 + 3H_2O$ for 1 mark
		ii	Test: add (a few drops of aqueous) silver nitrate (1) Result: white ppt (1)	2	**ignore** addition of dilute nitric acid before the $AgNO_3$ **ignore** redissolving in excess NH_3 or darkening of the ppt
		iii	separating funnel (1)	1	**allow** dropping pipette
			Total	**5**	
8		i	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$ ✓	1	**ALLOW** … $4s^2\ 3d^{10}4p^6$ **ALLOW** subscripts **AND** 3D **IGNORE** $1s^2$ seen twice **Examiner's Comments** Most candidates were awarded the mark available for the electron configuration of the bromide ion, but weaker responses included the

					electronic configuration of a bromine atom or of the ion, Br^+.
		ii	Cream **AND** precipitate ✓	1	**ALLOW** solid **OR** ppt for precipitate **IGNORE** 'does not dissolve' OR 'partially dissolves' **Examiner's Comments** Many candidates focused exclusively in their answers on the solubility of silver bromide in aqueous ammonia, writing as a result that the precipitate would remain, or that it would not dissolve and so not gaining the mark by omitting the colour of the precipitate.
		iii	$Ag^+(aq) + Br^-(aq) \rightarrow AgBr(s)$ ✓	1	Equation **AND** state symbols required **Examiner's Comments** The majority of candidates answered this question successfully with the only recurring error made being to omit some or all of the state symbols.
			Total	**3**	
9			D	1	**Examiner's Comments** This question demonstrated a lack of practical skills with a many candidates unable to identify the false positive caused by the sulfate ion – the discriminator C was a common incorrect answer. This question proved to be the most difficult multiple choice question.
			Total	**1**	
10		i	Silver nitrate **OR** $AgNO_3$ ✓	1	**ALLOW** Ag^+ **IF** name correct, **IGNORE** an incorrect formula **IGNORE** acidified/HNO_3 **Examiner's Comments** Most candidates responded correctly with either the name of the reagent: silver nitrate, or its formula: $AgNO_3$.

		ii	Chloride: white (precipitate) **AND** Bromide: cream (precipitate) **AND** iodide: yellow (precipitate) ✓	1	All **three** required for the mark **Examiner's Comments** The colours of the silver halide precipitates were well known and very few candidates failed to score here. Where mistakes were made, it was to put the three colours in the wrong order or to show the colours of halogens in solution.
			Total	**2**	
11	a		$n(H_2O)$ = 27.55/18.0 = 1.5306 (mol) ✓ $n((NH_4)_2Fe(SO_4)_2)$ = 72.45/284.0 = 0.2551 (mol) ✓ whole number ratio of $(NH_4)_2Fe(SO_4)2$: H_2O = 0.2551 : 1.5306 = 1 : 6 **OR** x = 6 ✓	3	**If there is an alternative answer, check to see if there is any ECF credit possible** **ALLOW** calculator value or rounding to two significant figures or more but **IGNORE** 'trailing zeroes' if wrong M produces such numbers throughout. **ALLOW ECF** If no working, **ALLOW** 1 mark for x = 6.
	b	i	To neutralise acidic soil ✓	1	
		ii	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Describes practical details of tests and observations that allows all four ions to be identified **AND** Attempts associated equations, with most correct. *There is a well-developed line of reasoning and the method is clear and logically structured. The information presented is relevant and substantiated by observations from the tests described and practical details.* **Level 2 (3–4 marks)** Describes most practical details of tests	6	**Indicative scientific points may include** **Practical details:** • Sample stirred with water and mixture filtered. • SO_4^{2-}, Fe^{2+}, NH_4^+ tests on filtrate. • CO_3^{2-} test on residue or garden product **Tests and associated equations:** CO_3^{2-} test: *Test:* Add nitric acid. *Observation:*effervescence. *Equation:* $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + CO_2 + H_2O$ ***ALLOW*** $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$

			including the observations that allows most ions to be identified **AND** Attempts associated equations, with some correct. *There is a line of reasoning presented and the method has some structure. The information presented is in the most-part relevant and supported by some evidence of observations from the tests described but practical details may be absent.* **Level 1 (1–2 marks)** Describes some of the practical details of tests and observations would only allow some ions to be identified. **OR** Attempts associated equations, with some correct. *The information is basic and the method lacks structure. The information is supported by limited evidence of the observations, the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.		***OR*** overall equation of $CaCO_3$ and an acid. SO_4^{2-} test: Add $BaCl_2(aq)$/$Ba(NO_3)_2(aq)$/$Ba^{2+}(aq)$. Observation: white precipitate. Equation: $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ Fe^{2+} test: Test: Add NaOH(aq) Observation: green precipitate Equation: $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$ NH_4^+ test: *Test:* Add NaOH(aq) and warm *Observation:* gas turns red litmus indicator blue *Equation:* $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$
			Total	**10**	
12		i	Barium chloride does not conduct electricity when solid **AND** because it has ions which are fixed (in position / in lattice) ✓ Barium chloride conducts when in aqueous solution **AND** because it has mobile ions ✓	**2**	**IGNORE** use of 'free' instead of 'mobile' **ALLOW** ions are not free to move **ALLOW ions** are held (in position / in lattice) **ALLOW ions** are not mobile **IGNORE** charge carriers **DO NOT ALLOW** electrons moving **ALLOW** one mark for comparison that does not identify (s) and (aq). **Examiner's Comments** Many precise answers gained full marks by describing the fixed position of ions in a lattice and the mobility of ions in aqueous solution. Delocalised or free electrons were occasionally

					mentioned. Vague answers often used the terms 'free' instead of mobile, 'charge carrier' instead of ion and 'carry a charge' instead of conduct electricity.
		ii	Test for sulfate / SO_4^{2-} ✓ <u>White</u> precipitate forms (when barium chloride solution is mixed with a solution containing sulfate ions) ✓	2	**IGNORE** hydrochloric acid **ALLOW** white solid **IGNORE** cloudy **DO NOT ALLOW** test result linked to incorrect anion **Examiner's Comments** There was some confusion with the displacement reactions of halogens, the test for halide ions and the use of silver nitrate but the majority of students could recall the use of aqueous barium chloride to test for sulfate ions. Occasionally candidates described the use of dilute hydrochloric acid to remove carbonate ions from solution before their creditworthy description of the sulfate test.
		iii	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **IF** answer = 2 award 2 marks $M(BaCl_2)$ = ((137.3 + (35.5 × 2)) = <u>208.3</u> (g mol^{-1}) ✓ 244.3 - 208.3 = 36 **AND** 36/18 = 2 ✓	2	**ALLOW** 208 (g mol^{-1}) **ALLOW ECF** for incorrectly calculated molar mass provided the final answer is rounded to nearest whole number **Examiner's Comments** Very well answered, the majority of candidates scored full marks for this simple calculation.
			Total	**6**	

13		i	 Ne (Z = 10) shown **higher** than 1500 (i.e. > Ar) ✓	**1**	**Look carefully for small dots on the y axis** **IGNORE** no straight line from Ne (10) to Na (11) **Examiner's Comments** This part was poorly attempted with only the most able candidates adding a point on the graph above 1500.
		ii	$\frac{500}{6.02 \times 10^{23}} = 8.3 \times 10^{-22}$ (kJ) ✓ Answer **MUST** be to 2 SF **AND** in standard form.	**1**	**ALLOW** use of IEs close to 500 giving a range: $8.0 \times 10^{-22} - 8.6 \times 10^{-22}$ i.e. $8.3 \pm 0.3 \times 10^{-22}$ **Examiner's Comments** Very few candidates realised the need to use the Avogadro constant, with most candidates responded with 500, or 5.00 $\times 10^{-2}$ in standard form, the energy for one mole. Many candidates did not seem to know the meaning of standard form and there was some confusion between significant figures and decimal places, all basic mathematical concepts and requirements for Chemistry AS. Answer: = 8.3×10^{-22} kJ
		iii	*Nuclear charge* number of protons/proton number increases **OR** greater **nuclear** charge ✓	**3**	**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** Comparison should be used for each mark **IGNORE** atomic number increases **IGNORE** nucleus gets bigger **IGNORE** 'effective nuclear charge increases'

			Distance/shielding (Outer) electrons are in the same shell **OR** (Outer) electrons experience the same/similar shielding **OR** Atomic radius decreases ✓ *Attraction* **Greater** nuclear attraction (on outer electrons) **OR** (outer) electrons are attracted more strongly (to the nucleus) ✓		**IGNORE** same sub-shell **OR** same orbital **IGNORE** 'there is shielding' **ALLOW** 'greater repulsion from inner shells' **ALLOW** 'pull' for 'attraction' **IGNORE** just 'greater attraction' **OR** greater force **IGNORE** 'held' for attracted, *e.g. IGNORE 'held' more strongly* **Examiner's Comments** This part was answered well, with many stock answers seen in terms of atomic size, nuclear charge and attraction. Weaker candidates often produced long responses that lacked focus, which often obtained fewer marks than short concise answers.
		iv	***Sub-shells*** Mg electron is removed from (3)s **AND** Al electron is removed from (3)p ✓ ***Energy levels*** Al electron has a higher **energy** **OR** (3)p has higher energy than (3)s ✓	**2**	**IGNORE** number before s and p *e.g. ALLOW (2)s and (2)p* **ALLOW** response implying that orbitals/sub-shell changes from s to p **IGNORE** comments about distance from nucleus **IGNORE** 'less energy to remove' **DO NOT ALLOW** unpaired electron removed more easily (**ORA**) **Examiner's Comments** Few candidates answered this part well. Candidates were expected to realise that Mg loses an electron from an s orbital, whereas Al loses an electron from a higher energy p orbital.

					There were few clear answers and many candidates were distracted by paired and unpaired electrons or distance from the nucleus. Few candidates responded in terms of the difference in energy between the s and p orbitals.
			Total	**7**	
14		i	*Equation* $Ba(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)$ ✓ *Entropy change **and** explanation* entropy decreases **OR** entropy change negative **AND** ($BaSO_4$) solid / ppt has less disorder / more order / fewer ways of arranging energy / less freedom / less random particles / dispersal of energy ✓	2	**ALLOW** multiples M2 is dependent on $BaSO_4(s)$ (even if formula is incorrect – eg $Ba(SO_4)_2(s)$) seen as a product in the attempted equation as long as reactants are not solid. $BaSO_4$ solid / ppt may be assumed from $BaSO_4(s)$ seen in the attempted equation. **Examiner's Comments** Candidates who correctly identified barium sulfate as a solid product tended to realise that entropy had decreased, although a significant number failed to state that this decrease in entropy was as a result of less disorder being created.
14		ii	*Equation* $\frac{1}{2} I_2(s) \rightarrow I(g)$ ✓ *state symbols required* *Entropy change **and** explanation* entropy increases **OR** entropy change positive **AND** gas has more disorder / less order / more ways of arranging energy / more freedom / more random particles / more dispersal of energy ✓	2	**DO NOT ALLOW** $I_2(s) \rightarrow 2I(g)$ **DEPENDENT** on $\frac{1}{2}I_2(s) \rightarrow I(g)$ **OR** $I_2(s) \rightarrow 2I(g)$ **Examiner's Comments** Most candidates failed to produce a correct equation for the standard enthalpy change of atomisation of

					iodine. Of those who were able to produce the correct equation, a significant number failed to state that the increase in entropy was as a result of increased disorder being created.
			Total	**4**	
15			**D**	**1 (AO 2.3)**	<u>**Examiner's Comments**</u> Most candidates knew that the formula given in D was incorrect.
			Total	**1**	
16			**Test for Br^- (anion) 2 marks** *Reagent **AND** observation* Silver nitrate/$AgNO_3$ **AND** cream (precipitate) ✓ *Equation* $Ag^+ + Br^- \rightarrow AgBr$ ✓ *State symbols not required* --	5 AO3.3×5	FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc. MUST BE USED -- **IGNORE** confusion between cation and anion **IGNORE** nitric acid **ALLOW** 'bromine' for bromide in text **IGNORE** responses about solubility in NH_3 **ALLOW** full equation: e.g. $AgNO_3 + NH_4Br \rightarrow AgBr + NH_4NO_3$ -- **ALLOW displacement by Cl_2** *Reagent* Cl_2/chlorine **AND** *Observation* Orange (solution) ✓ **ALLOW** shade of orange **DO NOT ALLOW** precipitate

			Test for NH_4^+ (cation) **3 marks** *Reagent and conditions* (Heat with) NaOH/KOH/$Ca(OH)_2$/OH^-/hydroxide **BUT NOT** ammonia ✓ *Observation (Independent mark)* pH/indicator paper turns blue / purple / alkaline ✓ *Equation* $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ ✓ *State symbols not required*		*Equation* $2Br^- + Cl_2 \rightarrow Br_2 + 2Cl^-$ ✓ **ALLOW** full equation, e.g. $2NaBr + Cl_2 \rightarrow Br_2 + 2NaCl$ -- **ALLOW** full equation: i.e. $NH_4Br + NaOH \rightarrow NaBr + NH_3 + H_2O$ **ALLOW** $NH_4Br + NaOH \rightarrow NaBr + NH_4OH$ **<u>Examiner's Comments</u>** This question was best discriminator of the paper and rewarded the well-prepared candidates who were competent in writing equations. Most candidates were given the 2 marks for the bromide test with silver nitrate and the related equation (usually shown ionically). Many found the test for the ammonium ion more challenging to describe. The alkaline nature of ammonia was well-known and the indicator colour change to blue was often seen. Many candidates omitted the NaOH reagent and tested the compound with indicator, thinking that the ammonium ion itself is alkaline. Few candidates were able to write the equation for the ammonium test. Lower attaining students often outlined electrolysis as a test and many candidates wrote about the carbonate and sulfate tests prior to the halide test.

			Total	5	
17			*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** The candidate gives a clear description of all three tests with correct observations. **AND** Equations are mostly correct. **AND** Some fine detail included in answer. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** The candidate describes all three tests with correct observations. **OR** Describes two tests with a few omissions. **AND** Includes at least one correct equation. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence* **Level 1 (1–2 marks)** The candidate attempts to describe two tests and observations, but explanations are incomplete. **OR** Gives a thorough description and explanation of one of the tests and attempts one equation. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks**	6 (AO1.2×2) (AO2.7×2) (AO3.4×2)	**Indicative scientific points** Tests for anions *Carbonate test*: Add $HNO_3(aq)$/$HCl(aq)$/$H_2SO_4(aq)$/$H^+(aq)$ fizzing/ forms $CO_2(g)$ → Carbonate identified *Sulfate test*: Add $Ba(NO_3)_2(aq)$ **OR** $BaCl_2(aq)$ White precipitate → Sulfate identified *Bromide test* Add $AgNO_3(aq)$ Cream precipitate → Bromide identified **Equations (ionic or full)** **IGNORE** state symbols (even if wrong) *Carbonate* $2H^+ + CO_3^{2-} \rightarrow CO_2 + H_2O$ **OR** $2H^+ + NiCO_3 \rightarrow Ni^{2+} + CO_2 + H_2O$ **OR** $2HNO_3 + NiCO_3 \rightarrow Ni(NO_3)_2 + H_2O + CO_2$ **OR** $2HCl + NiCO_3 \rightarrow NiCl_2 + H_2O + CO_2$ **OR** $H_2SO_4 + NiCO_3 \rightarrow NiSO_4 + H_2O + CO_2$ *Sulfate* $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ **OR** $Ba(NO_3)_2 + NiSO_4 \rightarrow BaSO_4 + Ni(NO_3)_2$ **OR** $BaCl_2 + NiSO_4 \rightarrow BaSO_4 + NiCl_2$ *Bromide*

			No response or no response worthy of credit.		$Ag^{+} + Br^{-} \rightarrow AgBr$ **OR** $2AgNO_3 + NiBr_2 \rightarrow 2AgBr + Ni(NO_3)_2$ **<u>Fine Detail (NOT inclusive)</u>** *Sequence of tests on samples* Carbonate → Sulfate → Bromide *Solubility of AgBr* Soluble in concentrated ammonia *State symbols in ionic or full equations e,g.* • $2H^{+}(aq) + CO_3^{2-}(aq) \rightarrow CO_2(g) + H_2O(l)$ **OR** $2H^{+}(aq) + NiCO_3(s) \rightarrow Ni^{2+}(aq) + CO_2(g) + H_2O(l)$ • $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ • $Ag^{+}(aq) + Br^{-}(aq) \rightarrow AgBr(s)$ **<u>Examiner's Comments</u>** * Very few candidates managed to score full marks for this question. Even the highest-attaining candidates struggled with writing balanced chemical equations. The most successful candidates used ionic equations with state symbols in their responses. A large proportion of candidates gave unnecessary details such as testing for CO_2 using limewater or the colours of other silver halide precipitates. The best responses broken down their response to cover each test in turn, giving clear and concise details for each.
			Total	**6**	
18			*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5–6 marks)**	6 (AO 3.3×3) (AO 3.4×3)	**Indicative scientific points may include:** **Identification of unknowns** Can be identified within labelled

			All three tests are covered in detail, with at least **six** of **B** to **H** identified correctly and equations mostly correct. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** All three tests are covered with at least **four** of **B** to **H** identified correctly. Some attempt at writing equations, but with several omissions or incorrect formulae. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Only two tests covered with at least **two** of **B** to **H** identified correctly, and little attempt at writing equations. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		equation. **B** is $FeSO_4$ **OR** Iron(II) sulfate • Test 1: Fe^{2+} present • Test 2: SO_4^{2-} present **D** is $Fe(OH)_2$ **OR** $[Fe(H_2O)_4(OH)_2]$ **OR** iron(II) hydroxide **G** is $BaSO_4$ OR barium sulfate **C** is $CrCl_3$ **OR** chromium(III) chloride • Test 1: Cr^{3+} present • Test 3: Cl^- present **E** is $Cr(OH)_3$ **OR** $[Cr(H_2O)_3(OH)_3]$ **OR** chromium(III) hydroxide **F** is $[Cr(NH_3)_6]^{3+}$ **H** is silver chloride OR AgCl **Equations** **D**: $[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow Fe(OH)_2 + 6H_2O$ **OR** $Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$ **OR** $[Fe(H_2O)_6]^{2+} + 2OH^- \rightarrow [Fe(H_2O)_4(OH)_2] + 2H_2O$ **OR** $[Fe(H_2O)6]^{2+} + 2NH_3 \rightarrow [Fe(H_2O)_4(OH)_2] + 2NH_4^+$ **OR** $[Fe(H_2O)_6]^{2+} + 2NH_3 \rightarrow Fe(OH)_2 + 4H_2O + 2NH_4^+$ **E**: $[Cr(H_2O)6]^{3+} + 3OH^- \rightarrow Cr(OH)_3 + 6H_2O$ **OR** $Cr^{3+} + 3OH^- \rightarrow Cr(OH)_3$ **OR** $[Cr(H_2O)_6]^{3+} + 3OH^- \rightarrow [Cr(H_2O)_3(OH)_3] + 3H_2O$ **OR** $[Cr(H_2O)_6]^{3+} + 3NH_3 \rightarrow [Cr(H_2O)_3(OH)_3] + 3NH_4^+$ **OR** $[Cr(H_2O)_6]^{3+} + 3NH_3 \rightarrow Cr(OH)_3 + 3H_2O + 3NH_4^+$ **F**: $[Cr(H_2O)_6]^{3+} + 6NH_3 \rightarrow [Cr(NH_3)_6]^{3+} + 6H_2O$ **OR** $Cr(OH)_3 + 6NH_3 \rightarrow [Cr(NH_3)_6]^{3+} + 3OH^-$ **OR** $[Cr(H_2O)_3(OH)_3] + 6NH_3 \rightarrow [Cr(NH_3)_6]^{3+} + 3H_2O + 3OH^-$ **G**: $Ba^{2+} + SO4^{2-} \rightarrow BaSO_4$ **H**: $Ag^+ + Cl^- \rightarrow AgCl$

			Total	**6**	
19			C	1 (AO2.3)	
			Total	**1**	
20		i	Any value in range: 8–14 ✓	1 (AO1.1)	**Examiner's Comments** Most candidates gained this mark. The most common incorrect response was pH 7 with a few giving a pH value of less than 7.
		ii	White precipitate/white solid ✓ $BaSO_4$ ✓	2 (AO 3.1) (AO 3.2)	**Examiner's Comments** Most candidates were able to give the formula of the barium compound as $BaSO_4$. However, they did not recognise that this would cause a white ppt to be seen, presumably as not in the context of qualitative ions testing. Many candidates said they would see bubbling/fizzing. Some gave a colour change as they were possibly considering what would be seen if an indicator is present. Others mentioned a precipitate but with no colour given. Some candidates gave the incorrect formula, such as Ba_2SO_4 or $Ba(SO_4)_2$, again showing the importance of practising writing formulae. In addition, some candidates wrote out the whole equation for the reaction. **OCR support** We have produced a topic support pack to assist with learning about the reaction of group 2 elements and their compounds: http:/www.ocr.org.uk/Images/364103-chemistry-of-group2.docx

			Total	**3**	
21			**D**	1(AO2.7)	**Examiner's Comments** This question proved to be difficult, with only the most able candidates selecting the correct answer of D. A was often given as an incorrect answer as candidates recognised that AgCl would be the only halide precipitate to show a change with dilute ammonia but did not realise that as it would redissolve, it would be the only one not in the filtrate.
			Total	**1**	
22		i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.53(g) award 5 marks** **--** **[H⁺]** = $10^{-13.12}$ **OR** 7.58..... × 10^{-14} (mol dm^{-3}) ✓ $[OH^-] = \frac{1 \times 10^{-14}}{7.58 \ldots \times 10^{-14}}$ **OR** 0.1318 .... (mol dm^{-3}) ✓ $n(OH^-)$ in 250 cm^3 = $\frac{0.1318\ldots}{4}$ **OR** 0.0329...... (mol) ✓ $n(Ba(OH)_2)$ or $n(BaO)$ = $\frac{0.0329\ldots}{2}$ **OR** 0.0164..... (mol) ✓ **Mass of BaO** = 0.0164..... × 153.3 = 2.53 (g) **3SF** ✓	5 (AO2.4×5)	**ALLOW ECF and 3SF throughout.** **ALLOW** calculation process in any order. **IGNORE** rounding errors past **3SF** **---** Calculator: 7.58577575 × 10^{-14} Calculator: 0.1318256739 **ALLOW** alternative approach using pOH for first 2 marks. $p[OH^-]$ = 14 − 13.12 = 0.88 $[OH^-] = 10^{-0.88}$ = 0.1318..... Calculator: 0.03295641846 0.033(0) comes from $[OH^-]$ = 0.132 Calculator: 0.01647820923 Calculator: 2.526109475 **Common errors 4 marks** 5.05g Not dividing by 2 2.82g Use of M_r for $Ba(OH)_2$ 5.06g rounds to 0.132 in M2 then not dividing by 2

					3 marks 5.65g not dividing by 2 and using Mr for $Ba(OH)_2$ **Examiner's Comments** Although few candidates got the correct final answer, however almost all achieved some marks from this calculation through error carried forward, with marks spread across the available range. Almost all candidates were able to find the concentrations of hydrogen and hence hydroxide ions. A few candidates successfully used $p[OH^-]$ method. Most were able to calculate the moles of hydroxide ions in 250cm^3. Many then did not realise the need to half this number to find the moles of barium, and/or used the Mr for barium hydroxide instead of barium oxide.
		ii	$Ba^{2+}(aq) + 2H^+(aq) + SO_4^{2-}(aq) + 2OH^-(aq)$ $\rightarrow BaSO_4(s) + 2H_2O(l)$✓	1 (AO3.2)	**ALLOW** multiples **ALLOW** $H^+(aq) + OH^-(aq) \rightarrow H2O(l)$ **OR** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ **Examiner's Comments** This question was answered well, with many candidates giving one of the equations in the 'ALLOW' part of the mark scheme. Those candidates who did not gain this mark gave full equations or missed out state symbols.
			Total	**6**	
23			**Identification of halide** Add (aqueous) silver nitrate **OR** $AgNO_3$ **OR** Ag^+/silver ions ✓ **Observations - mark independently** Chloride/Cl^- gives white precipitate Bromide/Br^- gives cream precipitate Iodide/I^- gives yellow precipitate ✓ **Precipitate/solid seen at least once** **Equation for at least one halide**	5 (AO3.3×3 AO3.2×2)	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **IGNORE** addition of HNO_3 but HCl **CONs** $AgNO_3$ **IGNORE** references to solubility in NH_3 (dil or conc), even if incorrect **ALLOW** chlorine for chloride, etc **ALLOW** equation with Br^- **OR** I^- e.g. $Ag^+ + Br^- \rightarrow AgBr$

			e.g. $Ag^+ + Cl^- \rightarrow AgCl$ **ALLOW** $Ag^+ + X^- \rightarrow AgX$ ✓ ***IGNORE*** *state symbols (ppt already assessed)* **Identification of B and C** **B**: NaBr **OR** sodium bromide ✓ **C**: $CaCl_2$ **OR** calcium chloride ✓		**ALLOW** full/partial equations, e.g. $AgNO_3 + Cl^- \rightarrow AgCl + NO_3^-$ **ALLOW** explanation for identification: i.e. **B (Group 1):** Subtract molar/atomic mass of halide/Br from number in range 100–115/molar mass of B ✓ **C (Group 2):** Subtract **2** × molar/atomic mass of halide/Cl from number in range 100–115/molar mass of **C** ✓ **ALLOW** displacement by addition of halogen ✓ 2 correct colours in water or organic solvent ✓ Equation, e.g. $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$ ✓ **<u>Examiner's Comments</u>** Candidates generally answered the first part of this question well. Most candidates were able to identify silver nitrate (or a halogen displacement method), to describe the expected observations, supported with mainly correct ionic equations. Candidates found it much harder to identify B and C as NaBr and $CaCl_2$. They could do this in various ways by matching possible formula with the provided molar mass ranges. The mark scheme did allow marks to be given when candidates described the identification process, although this was often very muddled, so, only the most able few candidates fully identified the unknown B and C.
			Total	**5**	
24		i	$Ba(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)$ Balanced equation ✓ State symbols ✓	2 (AO 2.5 x 2)	**ALLOW** ionic equation $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ **M2 dependent on M1** **IGNORE** NaCl balanced on both sides **<u>Examiner's Comments</u>**

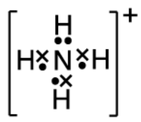
					Less than half the candidates gained credit for this challenging question. There was lots of information to process. Many struggled to give the correct formula for the products, e.g. $NaNO_3$, Ba_2SO_4, or had issues with balancing. Some tried to involve the NaCl in the reaction, either recognising that it didn't react (acceptable on the mark scheme) or forming barium chloride or even Cl_2. Lots of candidates lost the mark for state symbols as they left $Ba(NO_3)_2$ as (s), not recognising that in step 1 the mixture was dissolved in water so should now be (aq).
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 26.6 % award 4 marks** --- $n(BaSO_4)$ = $\frac{3.28}{233.4}$ **OR** 0.014053… (mol) ✓ mass $Ba(NO_3)_2$ = 0.014053… × 261.3 **OR** 3.672.......(g) ✓ mass NaCl = 5.00 – 3.672.. **OR** 1.3279… (g) ✓ % NaCl = $\frac{1.3279 \times 100}{5.00}$ = 26.6(%) **3 SF** ✓	4 (AO 3.1 ×3) (AO 3.2)	**ALLOW ECF** from incorrect equation in 2(b)(i) and throughout **ALLOW 3SF** up to calculated value throughout **IGNORE** rounding errors past **3SF** *Calculator:* 0.01405312768 *Calculator:* 3.672082262 *Calculator:* 1.327917738 **ALLOW ECF** for use of calculated mass NaCl e.g. 0.014053…x 58.5 = 0.8221…. to give final % 16.4 to 3SF --- **Alternative approach for last 2 marks** % $Ba(NO_3)_2$ = $\frac{3.672 \times 100}{5.00}$ = 73.44 … ✓ % NaCl = 100 – 73.44 = 26.6 % ✓ **<u>Examiner's Comments</u>** This was a tricky calculation, made more challenging if candidates hadn't been able to successfully complete (i). Many were able to calculate the moles of $BaSO_4$ but often rounded their answer to only 2 significant

					figures at this stage i.e. 0.014. Many assumed a direct ratio between $BaSO_4$ and NaCl so mass was found by multiplying moles by 58.5 (molar mass for NaCl) - if this was done then credit was given for ECF for the final marking point. **OCR support** The M1 section of the Mathematical Skills handbook contains useful information on handling data, including M1.1 use of significant figures.
		iii	Silver chloride/Ag*Cl* would be produced (as a precipitate) ✓ (Mass of Na*Cl*) can be calculated from the mass/moles of Ag*Cl* ✓	2 (AO 3.4 × 2)	**ALLOW** Chlor**ide** reacts to give (white) ppt **IGNORE** incorrect formula of silver chloride **ALLOW** equation showing formation of AgCl(s) **ALLOW** Weigh Ag*Cl* and use to calculate %/mass/moles **Examiner's Comments** Another tricky question with less than half gaining credit. Many were able to recognise the addition of silver nitrate as the test for halide ions but did not realise that it could be used quantitatively. Many didn't read the question carefully and assumed Na_2SO_4 was still present, giving a mixture of two precipitates. Some, despite recognising the formation of AgCl, could not then see how to calculate the mass of NaCl i.e. "you won't have formation of $BaSO_4$". Some suggested that barium nitrate would also form a precipitate, perhaps confused by the (s) state symbol in the question.
			Total	**8**	

25			**D**	1 (AO 2.3)	**<u>Examiner's Comments</u>** Most candidates answered this correctly with D. Errors came from candidates not realising HCl provided Cl^- ions that would react with $AgNO_3$ and therefore they did not recognise the formation of the white precipitate.
			Total	**1**	
26		i	[$Cu(NH_3)4(H_2O)_2$] $^{2+}$ ✓ **TAKE CARE** with correct brackets, numbers and 2+ charge	1 (AO 2.4)	**ALLOW** +2 for charge **IGNORE** $[Cu(NH_3)_4]^{2+}$ H_2O and NH3 can be in either order, i.e. [$Cu(H_2O)_2(NH_3)_4$]$^{2+}$ **<u>Examiner's Comments</u>** This reaction of copper(II) ions with aqueous ammonia and the formula of the complex ion formed are part of the specification. Within this novel context, the molar mass had been provided as a clue. Less than half the candidates correctly gave the correct formula and it was noticeable how well this part discriminated across abilities. This was another example of many candidates being unable to apply their knowledge and understanding to a novel context.
		ii	**Formula of precipitate** $Cu(OH)_2$ ✓ **IGNORE** name: copper(II) hydroxide -- **Formula of gas** ;NH_3 ✓ **IGNORE** name: ammonia -- **Test for ammonia** Available only from a reasonable attempt for identifying the gas as NH_3, e.g. NH_4, NH_4+, NH_2, ammonia, ammonium	3 (AO 2.3 ×3)	ALLOW $Cu(OH)_2(H_2O)_4$ **ALLOW** charges on Cu **AND** OH e.g. $Cu^{2+}(OH^-)_2$ ✓ **DO NOT ALLOW** unbalanced charges. e.g. $Cu(OH^-)_2$ ✗ -- **DO NOT ALLOW** correct test for NH_3 based on incorrect ID of the gas **NO ECF** for a test on the wrong gas (has to be test for NH_3) **DO NOT ALLOW** bleaches indicator

			(Moist/damp) indicator/litmus (paper) turns blue ✓ Moist/damp **NOT** required. Initial colour of litmus **NOT** required but *blue* is **CON**		**CON** **Examiner's Comments** Addition of NaOH(aq) to the Tutton's salt results in two reactions: precipitation of copper(II) hydroxide and a reaction of an ammonium ion, used to show its presence as a qualitative test. As with Question 4 (c) (i), this part discriminated very well with many candidates able to be rewarded with some of the marks. The formula of copper(II) hydroxide, as $Cu(OH)_2$ or $Cu(OH)_2(H_2O)_2$ were both acceptable. This was correct more often than the responses related to the ammonium ion. The formula of the gas formed in the reaction of NaOH(aq) with the ammonium ion caused problems, with NH_3 and its subsequent test with moist indicator turning blue seen much less than the reaction of Cu^{2+}(aq) ions. Hydrogen (the 'squeaky pop test) and oxygen (relighting a glowing split) were common incorrect responses. This was another question in which referring back to the formula of the Tutton's salt would have revealed important clues.
		iii	**Reagent** $BaCl_2$ / barium chloride (solution) **OR** $Ba(NO_3)_2$ / barium nitrate (solution) **OR** Ba^{2+} (solution/aq) / barium ions ✓ **Observation**	2 (AO 2.3 ×2)	**ALLOW** $Ba(OH)_2$ or other **soluble** Ba^{2+} compounds --- **IGNORE** test for other anions provided they do **NOT** interfere with SO_4^{2-} test **e.g.** **IGNORE** addition of $HCl/HNO_3/H^+$ **BUT DO NOT ALLOW** H_2SO_4 *Interferes with SO_4^{2-} test* **IGNORE** $Ag^+/AgNO_3$ **after** SO_4^{2-} test **DO NOT ALLOW before** SO_4^{2-}

			white precipitate/ppt ✓ Only available from soluble Ba^{2+} reagent **ALLOW** minor slips in formula of Ba^{2+} reagent, e.g. BaCl, $BaNO_3$		test **IGNORE** bubbling any gas through limewater **IGNORE** responses linked to CrO_4^{2-} *Not in Tutton's salt that student prepares* **<u>Examiner's Comments</u>** Th final part of Question 4 required candidates to identify the anion in the Tutton's salt as sulfate, and to recall that Ba^{2+} ions is used for the sulfate test to form a white precipitate. Any soluble barium compound was credited with barium chloride and nitrate being the commonest seen. As with earlier parts, this part discriminated very well. Most candidates who knew that barium ions were needed also collected the mark for the white precipitate observation. Over half the candidates did not score here, the most common errors being to repeat the test for the ammonium ion, or to use silver nitrate, clear confusion with the halide test.
			Total	**6**	
27		i	(Ammonia has) weaker hydrogen bonds (than ice/water) ✓ N has **one** lone pair **AND** O has **two** **OR** N less electronegative than O ✓	2	**ORA** but assume 'it' refers to ammonia Answer must be comparative between hydrogen bonding in ammonia and ice **ALLOW** Ammonia has less hydrogen bonds **ALLOW** response in terms of energy required to break hydrogen bonds e.g. less energy needed to break hydrogen bonds (in ammonia) **DO NOT ALLOW** reference to breaking N-H and O-H bonds i.e. covalent bonds **IGNORE** reference to other intermolecular forces e.g. London forces, dipole-dipole interactions.

					ALLOW ammonia has **one** lone pair **AND** water/ice has **two** **Examiner's Comments** Despite being told in the question that ammonia contains hydrogen bonds, many gave responses in terms of ammonia having either London forces and permanent dipole-dipole forces which are weaker than hydrogen bonds. For example, 'ammonia consists of permanent dipole-dipole interactions which are weaker than hydrogen bonding in ice' and 'NH_3 has 17 electrons and H_2O has 18 electrons. Due to NH_3 having fewer electrons, there are fewer London forces'. Lower-scoring candidates often confused hydrogen bonds and covalent bonds, consistent with what was seen in 1(b)(i). For example, 'O-H bond is stronger than N-H bond' and 'more energy needed to break O-H bonds rather than N-H bonds'. Some of these candidates did score a mark for recognising that N is less electronegative than O. For others they understood that ammonia has weaker hydrogen bonds but then struggled to give a reason either in terms of lone pairs or electronegativity.
		ii	 **Bonded pairs** Electron pairs in 3 x N-H covalent bonds shown correctly using dots and crosses ✓	2	**ALLOW** shell circles **IGNORE** inner shell in N **Charge and brackets not required** **DO NOT ALLOW** additional electrons on either N or H for dative bond mark **Examiner's Comments** Less than half of the candidates scored both marks. Most candidates

			Dative bond shown with two crosses or two dots ✓		drew 4 x N-H shared covalent bonds and therefore lost the dative bond mark. Some added an additional electron to either N or H. Some drew an additional shaped electron (e.g. using a triangle) on one of the bonding pairs, obviously not realising that both electrons in dative bond originate from N, so have the same symbol. Many diagrams were unclear making it hard distinguish between dots and crosses especially if adding circles for electron shells. A few lower-attaining candidates attempted to draw an ionic dot-cross diagrams.
		iii	**Reagent and conditions** (Heat with) hydroxide ✓ **Observation** ***(Independent mark)*** pH/litmus/indicator paper turns blue/purple ✓	2	**ALLOW** NaOH/KOH/$Ca(OH)_2$/OH^- **DO NOT ALLOW** Ammonium hydroxide OR ammonia **<u>Examiner's Comments</u>** Higher-attaining candidates often gave a very detailed responses with all stages, including warming the NaOH, use of damp litmus paper and some included an ionic equation. Quite a few lost a mark as they missed the addition of hydroxide, just warmed, but they still gained mark for testing with indicator paper. Some thought that the indicator paper would turn red or be bleached and a few gave incorrect ion test e.g. add silver nitrate, add acid. Over a third of candidates did not score on this question, with a significant proportion not even attempting it.
			Total	**6**	
28			**D**	1	**<u>Examiner's Comments</u>** The correct answer was D. Many

					candidates were able to identify the green precipitate as $Fe(OH)_2$ and the white precipitate as $BaSO_4$. A few candidates suggested C, identifying $BaCl_2$ as the white precipitate, or B, identifying $Cu(OH)_2$ as the green precipitate.
			Total	**1**	
29			**B**	1	**<u>Examiner's Comments</u>** This question was answered well with most candidates correctly selecting the sequence shown in B.
			Total	**1**	