

OCR A-LEVEL CHEMISTRY A • H432

CHEMISTRY



EXAM QUESTION PACK

3.1.4 QUALITATIVE ANALYSIS

SCORE

/34

PERCENTAGE

%

STEMUP

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- (i) Complete the electron configuration of a bromide ion.

1s² [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]

- 2 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]

3 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]

4 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 AgNO₃(aq), a white precipitate forms which is soluble in dilute NH₃(aq).

Test 3: On addition of Na₂CO₃(aq), there is no visible reaction.

What is the unknown compound?

- A ammonium bromide, NH₄Br
- B ammonium chloride, NH₄Cl
- C hydrochloric acid, HCl
- D sodium chloride, NaCl

Your answer ☐

[1]

5 Haloalkanes can undergo hydrolysis.

A student carries out an experiment to find the relative rate of hydrolysis of 1-chloropropane, $\text{C}_3\text{H}_7\text{Cl}$, 1-bromopropane, $\text{C}_3\text{H}_7\text{Br}$, and 1-iodopropane, $\text{C}_3\text{H}_7\text{I}$.

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	$\text{C}_3\text{H}_7\text{Cl}$	about half an hour
B	$\text{C}_3\text{H}_7\text{Br}$	a few minutes
C	$\text{C}_3\text{H}_7\text{I}$	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]

- 6 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]

7 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]

(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 $\text{BaCl}_2 \cdot x\text{H}_2\text{O}$ and a molar mass of 244.3 g mol^{-1} .

Determine the value of x in the formula of $\text{BaCl}_2 \cdot x\text{H}_2\text{O}$.

Show your working.

$$x = \text{-----} [2]$$

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

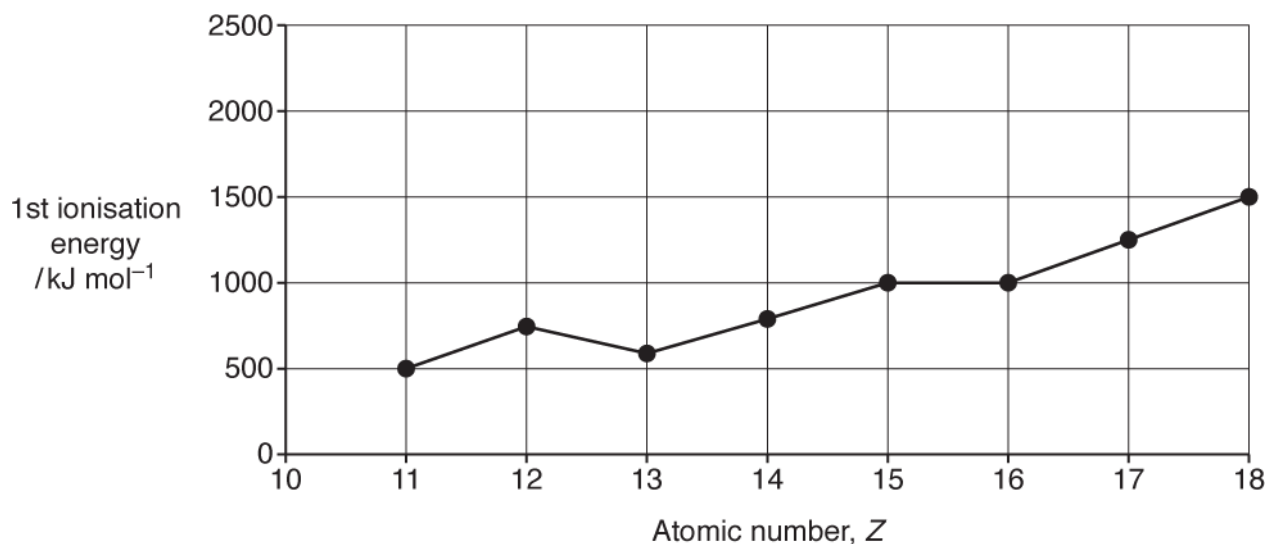


Fig. 22.1

- (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** $\text{Na}^+(\text{g})$ ion from one $\text{Na}(\text{g})$ 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]

Include reagents, expected observations and relevant equations.

[5]

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Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1		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	
2		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

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	5	
3			A	1	
			Total	1	
4			B	1	
			Total	1	
5		i	$\text{Ag}^+ + \text{Cl}^- \rightarrow \text{AgCl}$ OR $\text{Ag}^+ + \text{Br}^- \rightarrow \text{AgBr}$ OR $\text{Ag}^+ + \text{I}^- \rightarrow \text{AgI}$	1	
		ii	Bond enthalpy decreases $\text{C}-\text{Cl} > \text{C}-\text{Br} > \text{C}-\text{I}$	1	allow chlorine–carbon bonds are strongest.
		iii	Heat the test tubes in a water bath.	1	
			Total	3	
6			D	1	<u>Examiner's Comments</u> 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	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
7		i	Silver nitrate OR AgNO_3 ✓	1	ALLOW Ag^+ IF name correct, IGNORE an incorrect formula IGNORE acidified/HNO_3 <u>Examiner's Comments</u> 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 <u>Examiner's Comments</u> 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	

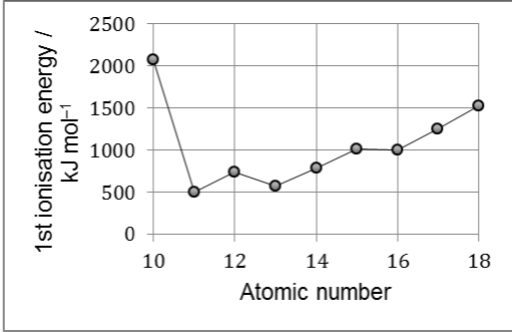
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
8		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.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 2 award 2 marks $M(\text{BaCl}_2) = ((137.3 + (35.5 \times 2))$ ✓ $= \underline{208.3} \text{ (g mol}^{-1}\text{)}$ $244.3 - 208.3 = 36$ 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	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
9	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 $\frac{500}{6.02 \times 10^{23}} = 8.3 \times 10^{-22} \text{ (kJ) } \checkmark$ 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 5.00×10^{-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: $= 8.3 \times 10^{-22} \text{ kJ}$

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	<i>Nuclear charge</i> number of protons/proton number increases OR greater nuclear charge ✓ <i>Distance/shielding</i> (Outer) electrons are in the same shell OR (Outer) electrons experience the same/similar shielding OR Atomic radius decreases ✓ <i>Attraction</i> Greater nuclear attraction (on outer electrons) OR (out) electrons are attracted more strongly (to the nucleus) ✓	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' 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, <i>e.g. IGNORE 'held' more strongly</i> 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.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		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 <i>e.g. ALLOW (2)s and (2)p</i> 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	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
10	Test for Br⁻ (anion) 2 marks <i>Reagent AND observation</i> Silver nitrate/AgNO₃ AND cream (precipitate) ✓ <i>Equation</i> $\text{Ag}^+ + \text{Br}^- \rightarrow \text{AgBr}$ ✓ <i>State symbols not required</i> Test for NH₄⁺ (cation) 3 marks <i>Reagent and conditions</i> (Heat with) NaOH/KOH/Ca(OH)₂/OH⁻/hydroxide BUT NOT ammonia ✓ <i>Observation (Independent mark)</i> pH/indicator paper turns blue / purple / alkaline ✓ <i>Equation</i> $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$ ✓ <i>State symbols not required</i>	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 NH₃ ALLOW full equation: e.g. $\text{AgNO}_3 + \text{NH}_4\text{Br} \rightarrow \text{AgBr} + \text{NH}_4\text{NO}_3$ ALLOW displacement by Cl₂ <i>Reagent</i> Cl₂/chlorine AND <i>Observation</i> Orange (solution) ✓ ALLOW shade of orange DO NOT ALLOW precipitate <i>Equation</i> $2\text{Br}^- + \text{Cl}_2 \rightarrow \text{Br}_2 + 2\text{Cl}^-$ ✓ ALLOW full equation, e.g. $2\text{NaBr} + \text{Cl}_2 \rightarrow \text{Br}_2 + 2\text{NaCl}$ ALLOW full equation: i.e. $\text{NH}_4\text{Br} + \text{NaOH} \rightarrow \text{NaBr} + \text{NH}_3 + \text{H}_2\text{O}$ ALLOW $\text{NH}_4\text{Br} + \text{NaOH} \rightarrow \text{NaBr} + \text{NH}_4\text{OH}$ <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

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					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	