5: Chemical trends – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
2	2017	June	23
3	2017	June	21
2	2017	November	21

The mark scheme for each question is provided at the end of the document.

2 The halogens, chlorine, bromine and iodine, and their compounds, show a variety of similarities and trends in their physical and chemical properties.

(a) (i) Give the colours and states of chlorine, bromine and iodine at room temperature and pressure.

halogen	colour	state
chlorine		
bromine		
iodine		

[2]

(ii) The halogens become less volatile down the group.

Explain this trend in volatility.

.....

.....

..... [2]

(b) The halogens are oxidising agents.

State and explain the trend in oxidising power of the halogens.

.....

.....

.....

..... [3]

(c) Concentrated sulfuric acid reacts with solid sodium halides.

(i) State any observations that would be made on addition of concentrated sulfuric acid to

- solid sodium chloride, ...

.....

- solid sodium iodide. .....

.....

[2]

(ii) Give reasons for the difference in the observations in **(i)**.

.....

.....

..... [2]

(iii) The addition of concentrated sulfuric acid to solid sodium bromide, NaBr, produces brown fumes and an acidic gas that decolourises acidified potassium manganate(VII) solution. This acidic gas is a significant contributor to acid rain.

Write the equation for the reaction of concentrated sulfuric acid with sodium bromide.

..... [2]

(d) An aqueous solution, **Z**, contains a mixture of sodium chloride and sodium iodide.

(i) Excess aqueous silver nitrate is added to **Z** in a test-tube. A yellow precipitate forms.

Explain the colour of this precipitate.

.....

..... [1]

(ii) Aqueous ammonia is then added to the test-tube in **(i)**. The mass of precipitate decreases.

Explain this observation.

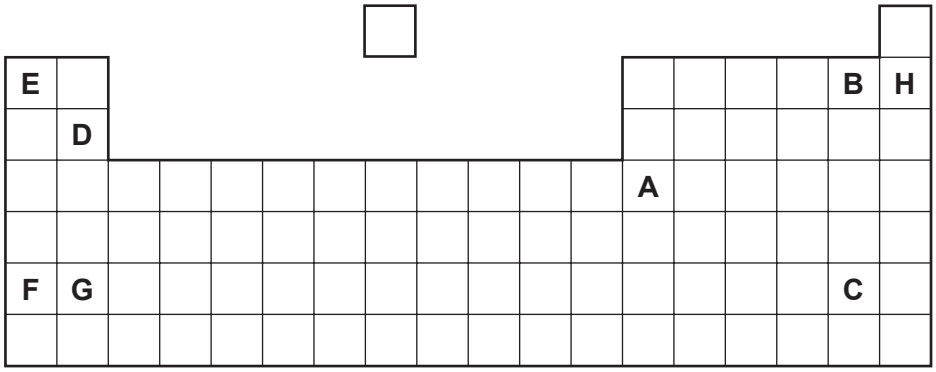
.....

..... [1]

[Total: 15]

3 The properties of elements and their compounds show similarities, differences and trends depending on the positions of the elements in the Periodic Table.

(a) The positions of some elements are indicated. The letters used are **not** the symbols of the elements.



From the elements labelled, give the letter for;

(i) the element that forms an amphoteric oxide, ... [1]

(ii) the element with the highest first ionisation energy, ... [1]

(iii) the element that forms a soluble hydroxide and an insoluble sulfate, ... [1]

(iv) the most volatile element in a group that contains elements in all three states of matter at room temperature and pressure,

..... [1]

(v) the element that forms the largest cation. ..... [1]

(b) The elements in Group 2 all react with oxygen and with water.

(i) State and explain the conditions needed for magnesium to react with oxygen.

.....

..... [2]

(ii) State what would be seen during the reaction in **(b)(i)**.

.....

..... [1]

(iii) Write an equation for the reaction of magnesium with cold water.
Include state symbols.

..... [2]

(c) The carbonates and nitrates of the elements in Group 2 can all be decomposed by heating.

(i) Write an equation for the thermal decomposition of magnesium nitrate.

..... [1]

(ii) The thermal decomposition of calcium carbonate forms a solid product that is industrially important. This solid product reacts with water to form a compound commonly known as slaked lime.

Write equations for the thermal decomposition of calcium carbonate and the reaction of the solid product to form slaked lime.

thermal decomposition .....

formation of slaked lime .....
[2]

(d) Calcium carbonate and calcium hydroxide both have an important use in agriculture.

(i) Describe this use and explain what makes these two compounds suitable for it.

.....

.....

..... [2]

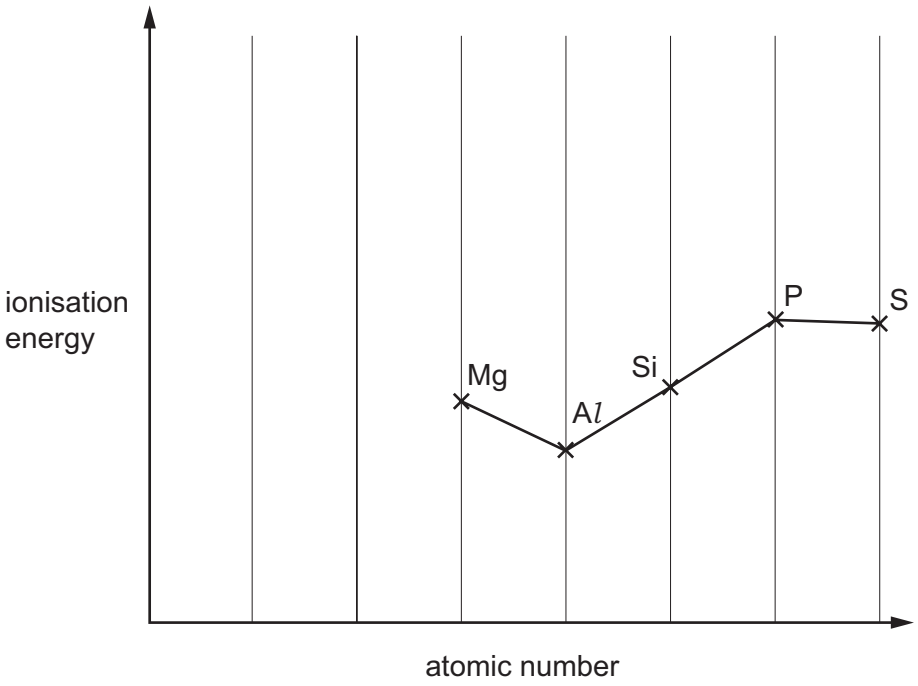
(ii) Write an ionic equation to illustrate this use of calcium carbonate.

..... [1]

[Total: 16]

2 The elements in the third period, and their compounds, show trends in their physical and chemical properties.

(a) A sketch graph of the first ionisation energies of five successive elements in the third period is shown.



(i) Explain why there is a general increase in the first ionisation energy across the third period.

.....

.....

..... [2]

(ii) Sketch, on the graph, the position of the ionisation energies of the two elements that come before Mg in this sequence. [2]

(iii) Explain, with reference to electron arrangements, the decreases in first ionisation energy between Mg and Al and between P and S.

Mg and Al .....

.....

.....

P and S .....

.....

.....
[4]

(b) The chlorides of the elements in the third period behave in different ways when added to water, depending on their structure and bonding.

L and **M** are each a chloride of an element in Period 3. A student investigated **L** and **M** and their results are given.

L is a white crystalline solid with a melting point of 987 K. **L** dissolves in water to form an approximately neutral solution. Addition of NaOH(aq) to an aqueous solution of **L** produces a white precipitate.

M is a liquid with a boiling point of 331 K. **M** is hydrolysed rapidly by cold water to form a strongly acidic solution, a white solid and white fumes.

Identify **L** and **M**.
Explain any properties and observations described.
Give equations where appropriate.

(i) **L** is .....

.....

.....

.....

..... [3]

(ii) **M** is .....

.....

.....

.....

..... [3]

[Total: 14]

Question	Answer	Marks
2 (a) (i)	<table><tr><td>halogen</td><td>colour</td><td>state</td></tr><tr><td>chlorine</td><td>yellow / green</td><td>gas</td></tr><tr><td>bromine</td><td>red / brown / orange</td><td>liquid</td></tr><tr><td>iodine</td><td>grey / black</td><td>solid</td></tr></table>	**2**
2 (a) (ii)	increasing number of electrons	**1**
	(gives) increasing strength of van der Waals' / id-id forces / London / dispersion forces	**1**
2 (b)	oxidising power decreases down the group. *ora*	**1**
	ability to accept electrons decreases (down the group) *ora*	**1**
	because (outer shell experiences) more shielding OR increased distance from nucleus (to outer shell) (outweighs the increasing nuclear charge down the group) *ora*	**1**
2 (c) (i)	solid sodium chloride: steamy / misty / white fumes	**1**
	solid sodium iodide: purple fumes	**1**
2 (c) (ii)	(conc sulfuric) not powerful enough oxidising agent (to oxidise chloride) OR chloride not powerful enough reducing agent (to reduce sulfuric acid)	**1**
	iodide reduces sulfuric acid OR iodide / I^- is oxidised OR sulfuric acid oxidises iodide	**1**
2 (c) (iii)	$2NaBr + 2H_2SO_4 \rightarrow Br_2 + SO_2 + Na_2SO_4 + 2H_2O$ OR $NaBr + H_2SO_4 \rightarrow NaHSO_4 + HBr$ AND $2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$ OR $2NaBr + H_2SO_4 \rightarrow Na_2SO_4 + 2HBr$ AND $2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$	**2**
2 (d) (i)	AgI (and AgC*l* solid) / silver ions reacting with iodide ions	**1**
2 (d) (ii)	AgC*l* (precipitate) dissolves (in ammonia) owtte	**1**
		Total: 15

Question	Answer	Marks
3 (a) (i)	A	**1**
3 (a) (ii)	H	**1**
3 (a) (iii)	G	**1**
3 (a) (iv)	B	**1**
3 (a) (v)	F	**1**
3 (b) (i)	(strong) heating	**1**
	(to provide / overcome) high activation energy	**1**
3 (b) (ii)	**white** flame / **white** light / **white** smoke / **white solid**	**1**
3 (b) (iii)	$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(s) + H_2(g)$	**1**
3 (c) (i)	$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$	**1**
3 (c) (ii)	$CaCO_3$ $CaO + CO_2$	**1**
	$CaO + H_2O$ $Ca(OH)_2$	**1**
3 (d) (i)	reduce acidity in soil / increase pH of soil	**1**
	(both) basic / base(s)	**1**
3 (d) (ii)	$CaCO_3 + 2H^+ \rightarrow Ca^{2+}$ $CO_2 + H_2O$ OR $CaCO_3 + 2H^+ \rightarrow Ca^{2+} + H_2CO_3$	**1**
		Total: 16

Question	Answer	Marks
2 (a) (i)	due to increasing nuclear attraction (for electrons)	**1**
	due to increasing nuclear charge / atomic / proton number AND similar shielding / same (outer/number of) shell / energy level	**1**
2 (a) (ii)	Cross shown on first vertical line from the y-axis (Group 0 / Ne) is clearly higher than all shown	**1**
	Cross shown on second vertical line from the y-axis (Group 1 / Na) lower than all shown	**1**
2 (a) (iii)	A*l* (the outer / valence) electron (which is lost) is in (3)p sub-shell (Mg is in (3)s subshell) OR A*l* (the outer / valence) electron (which is lost) is in higher energy sub-shell	**1**
	(electron to be removed) is more shielded / experiences greater screening effect	**1**

Question	Answer	Marks
2 (b) (i)	(**L**=) $MgCl_2$ / magnesium chloride	**1**
4 (b) (ii)	Any two from: • (giant) ionic (with strong attractions) • $Mg^{2+}(aq)$ / $Mg(H_2O)_6^{2+}(aq)$ is neutral / undergoes (partial) hydrolysis • $Mg(OH)_2$ is the white precipitate / solid / insoluble / partially soluble • $MgCl_2 + 2NaOH \rightarrow Mg(OH)_2 + 2NaCl$	**2**
2 (b) (iii)	(**M**=) $SiCl_4$ / silicon chloride	**1**
	Any two from: • (simple) molecular / simple covalent • hydrolysis possible due to available d orbitals • forms HCl (aq) / hydrochloric acid / solution and / or HCl gas / fumes • white solid is (hydrated) SiO_2 • $SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$	**2**
		Total: 12

Notes about the mark scheme are available separately.