

Section A

- 1 The correct balanced equation for the reaction between heated magnesium and steam, including state symbols, is

- ☐ A $\text{Mg(s)} + \text{H}_2\text{O(l)} \rightarrow \text{MgO(s)} + \text{H}_2\text{(g)}$
☐ B $\text{Mg(s)} + 2\text{H}_2\text{O(g)} \rightarrow \text{Mg(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$
☐ C $\text{Mg(s)} + \text{H}_2\text{O(g)} \rightarrow \text{MgO(s)} + \text{H}_2\text{(g)}$
☐ D $\text{Mg(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Mg(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$

(Total for Question 1 = 1 mark)

- 2 This question concerns the trends in properties on descending Group 2 of the Periodic Table.

(a) What are the trends in solubility of sulfates and hydroxides down Group 2?

(1)

- ☐ A Sulfates increase, hydroxides decrease.
☐ B Sulfates decrease, hydroxides increase.
☐ C Sulfates increase, hydroxides increase.
☐ D Sulfates decrease, hydroxides decrease.

(b) What are the trends in thermal stability of carbonates and nitrates down Group 2?

(1)

- ☐ A Carbonates increase, nitrates decrease.
☐ B Carbonates decrease, nitrates increase.
☐ C Carbonates increase, nitrates increase.
☐ D Carbonates decrease, nitrates decrease.

(c) What are the trends in first ionization energy and electronegativity of the elements down Group 2?

(1)

- ☐ A Ionization energy increases, electronegativity decreases.
☐ B Ionization energy decreases, electronegativity increases.
☐ C Ionization energy increases, electronegativity increases.
☐ D Ionization energy decreases, electronegativity decreases.

(Total for Question 2 = 3 marks)

- 3 Which silver halide is a cream coloured solid which darkens in sunlight and dissolves in concentrated ammonia solution?

- ☐ A AgF
☐ B AgCl
☐ C AgBr
☐ D AgI

(Total for Question 3 = 1 mark)

4 What is the FBF bond angle in boron trifluoride, BF_3 ?

- ☐ A 180°
☐ B 120°
☐ C 109.5°
☐ D 90°

(Total for Question 4 = 1 mark)

5 What is the total number of electrons in the covalent bonds in a beryllium chloride molecule, BeCl_2 ?

- ☐ A 2
☐ B 4
☐ C 6
☐ D 8

(Total for Question 5 = 1 mark)

6 Which of the following molecules is linear?

- ☐ A CO_2
☐ B C_2H_4
☐ C H_2O
☐ D NH_3

(Total for Question 6 = 1 mark)

7 Which of the following molecules is **non-polar**?

- ☐ A CH_3Cl
☐ B CH_2Cl_2
☐ C CHCl_3
☐ D CCl_4

(Total for Question 7 = 1 mark)

8 Methanol dissolves in water mainly due to the formation of new

- ☐ A hydrogen bonds.
☐ B dipole-dipole forces.
☐ C London forces.
☐ D covalent bonds.

(Total for Question 8 = 1 mark)

9)

Which of these bond angles is the **largest**?

- ☐ A Cl—B—Cl in BCl_3
☐ B H—N—H in NH_3
☐ C Cl—Be—Cl in BeCl_2
☐ D H—O—H in H_2O

1 mark)

10)

Which of the following molecules is **not** polar?

- ☐ A HCl
- ☐ B CH₃Cl
- ☐ C CHCl₃
- ☐ D CCl₄

1 mark)

11)

What colour is the vapour which forms when concentrated sulfuric acid is added to solid potassium iodide?

- ☐ A Green
- ☐ B Orange
- ☐ C Brown
- ☐ D Purple

1 mark)

12)

The oxygen atom in a molecule of water has two bonding pairs and two lone pairs of electrons. Based on the electron-pair repulsion theory, the H—O—H bond angle is most likely to be

- ☐ A 180°
- ☐ B 109.5°
- ☐ C 107°
- ☐ D 104.5°

1 mark)

13)

The shape of a molecule of boron trifluoride, BF₃, is

- ☐ A trigonal planar.
- ☐ B pyramidal.
- ☐ C tetrahedral.
- ☐ D T-shaped.

1 mark)

14)

When solid samples of sodium carbonate and magnesium carbonate are strongly heated

- ☐ A both compounds decompose.
- ☐ B sodium carbonate decomposes but magnesium carbonate does not.
- ☐ C magnesium carbonate decomposes but sodium carbonate does not.
- ☐ D neither compound decomposes.

1 mark)

15)

As Group 2 is **descended**

- ☐ A the solubility of hydroxides and of sulfates increases.
- ☐ B the solubility of hydroxides increases and of sulfates decreases.
- ☐ C the solubility of hydroxides decreases and of sulfates increases.
- ☐ D the solubility of hydroxides and of sulfates decreases.

1 mark)

Section B

16)

Fuels of the Future

Concerns about the future availability of fossil fuels, and the fact that their combustion produces greenhouse gases, have led to a search for alternative sources of energy. A great deal of attention has been directed at developing the use of hydrogen as a fuel. Since the only product of its combustion is water, hydrogen is considered to be a clean fuel.

However, the use of hydrogen has major drawbacks. The small size of the hydrogen molecule means that it is difficult to prevent leaks and, to store enough to provide a reasonable amount of fuel for a car, hydrogen must be compressed to around 700 atmospheres. Furthermore, the main source of hydrogen is currently fossil fuels such as methane, which is combined with steam in a series of reactions to form carbon dioxide and hydrogen.

One suggested alternative to hydrogen is ammonia. Ammonia, which is obtained by combining nitrogen and hydrogen at temperatures around 450°C and pressures of about 150 atmospheres, also has serious disadvantages: it is a toxic, corrosive and pungent gas which is difficult to ignite.

However, burning ammonia produces only nitrogen and water and it is relatively easy to liquefy, having a boiling temperature of just -33°C. Furthermore, the technology works: ammonia was used as a fuel for Belgian buses in the Second World War and, in 2007, the 'NH₃ Car' project based in Ann Arbor, Michigan, used a mixture of ammonia and petrol to fuel a 2500 mile journey, from Detroit to San Francisco, in a modified pickup truck.

(a) (i) Explain the term **greenhouse gas**.

(2)

*(ii) State and explain whether or not water (in the gaseous state) is a greenhouse gas. (2)

(iii) Write the equation for the formation of hydrogen from methane and steam. State symbols are **not** required. (2)

(iv) Suggest why using methane to form hydrogen in this way is preferable to burning methane directly. (1)

— (v) Storing hydrogen at a pressure of 700 atmospheres is a disadvantage to its use as a fuel because of the costs involved. Suggest why using such high pressures is so expensive. (1)

(b) (i) Draw a dot and cross diagram for ammonia, showing the outer electrons only. (1)

*(ii) By considering the intermolecular forces involved, explain why methane has a boiling temperature of 109 K while ammonia has a boiling temperature of 240 K, although these two compounds have very similar molar masses. (4)

17)

Metals are good conductors of heat and electricity and usually have high melting temperatures and boiling temperatures.

(a) (i) Describe the **structure** of a metal. (2)

(ii) Describe the **bonding** in a metal. (2)

— (b) Explain why the melting temperature of magnesium (650 °C) is much higher than that of sodium (98 °C). (3)

(c) Explain how metals conduct electricity. (2)

18)

This question is about the element chlorine (atomic number = 17).

(a) Complete the electronic structure of chlorine.

(1)

$1s^2 2s^2$

(b) Chlorine forms compounds with magnesium and with carbon.

(i) Draw a dot and cross diagram to show the electronic structure of the compound magnesium chloride (only the outer electrons need be shown). Include the charges present.

(2)

(ii) Draw a dot and cross diagram to show the electronic structure of the compound tetrachloromethane (only the outer electrons need be shown).

(2)

*(iii) Suggest why the melting temperature of magnesium oxide is higher than that of magnesium chloride, even though both are almost 100% ionic.

(3)

(c) Magnesium chloride may be prepared from magnesium by reaction with chlorine or with hydrochloric acid. Compare these two preparations in terms of the atom economies of the reactions. No calculation is required.

(2)