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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2015

Centre Number

Candidate Number

Chemistry

Assessment Unit AS 1
assessing
Basic Concepts in Physical
and Inorganic Chemistry

MV18

[AC112]

WEDNESDAY 10 JUNE, AFTERNOON

TIME

1 hour 30 minutes, plus your additional time allowance.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all fifteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided.
Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all five** questions in **Section B**. Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **11(c)(ii)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets at the end of each question indicate the marks awarded to each question or part question.
A Periodic Table of Elements, containing some data, is included in this question paper.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Potassium dichromate has the formula $K_2Cr_2O_7$. Which one of the following lists the oxidation numbers of potassium and chromium in potassium dichromate?

	potassium	**chromium**
A	**+**1	**+**3
B	**+**1	**+**6
C	**+**2	**+**3
D	**+**2	**+**6

2 There are three bonding pairs and one lone pair of electrons around the central phosphorus atom in phosphine (PH_3). Which one of the following describes the shape of the phosphine molecule?

A Bent

B Pyramidal

C Tetrahedral

D Trigonal planar

3 Which one of the following statements represents how the visible emission line spectrum of atomic hydrogen arises?

A Energy is given out when hydrogen atoms lose electrons to form ions

B Energy is given out when electrons move from higher energy levels to the n = 1 energy level

C Energy is given out when electrons move from higher energy levels to the n = 2 energy level

D Energy is given out when electrons move from the n = 1 energy level to higher energy levels

4 The table below shows the first six successive ionisation energies for a Period 2 element.

	first	**second**	**third**	**fourth**	**fifth**	**sixth**
Ionisation Energy/ kJ mol^{-1}	1090	2350	4610	6220	37800	47000

Which one of the following elements has these ionisation energies?

A Carbon

B Fluorine

C Nitrogen

D Oxygen

5 Which one of the following elements forms an ion with a double negative charge that has the same electronic configuration as argon?

A Calcium

B Chlorine

C Selenium

D Sulfur

6 Boron trichloride reacts with water to form a strongly acidic solution as shown below.

$$BCl_3 + 3H_2O \rightarrow H_3BO_3 + 3HCl$$

When 21.6 g of BCl_3 is dissolved in 250 cm^3 of water the concentration of the hydrochloric acid in this solution is

A 0.55 mol dm^{-3}.

B 0.74 mol dm^{-3}.

C 2.21 mol dm^{-3}.

D 2.94 mol dm^{-3}.

7 The chlorate(V) ion, ClO_3^-, may be reduced to chlorine.

$$2ClO_3^-(aq) + \boldsymbol{x}H^+(aq) + \boldsymbol{y}e^- \rightarrow Cl_2(aq) + \boldsymbol{z}H_2O(l)$$

Which one of the following represents the correct values of ***x***, ***y*** and ***z***?

	x	***y***	***z***
A	6	6	3
B	6	4	3
C	12	10	6
D	12	12	6

8 Which one of the following is the most powerful reducing agent?

A Bromine atom

B Chlorine atom

C Fluoride ion

D Iodide ion

9 Which one of the following elements would be expected to form the smallest ion with a noble gas configuration?

A Aluminium

B Chlorine

C Sodium

D Sulfur

10 Which one of the following equations represents the first ionisation energy of fluorine?

A $F_2(g) + 2e^- \rightarrow 2F^-(g)$

B $F(g) + e^- \rightarrow F^-(g)$

C $F(g) \rightarrow F^+(g) + e^-$

D $F_2(g) \rightarrow 2F^+(g) + 2e^-$

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(Questions continue overleaf)

Section B

Answer **all five** questions in this section.

11 Beryllium is a hard silver-white metal which was first isolated by Wöhler in 1828 by the reaction of potassium with beryllium chloride. Potassium being more reactive than beryllium gave a metallic solid in a strongly exothermic process.

(a) Write the equation for the reaction of potassium with beryllium chloride. [1 mark]

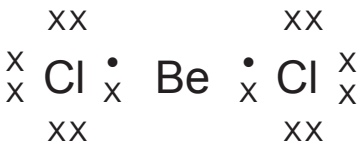
_____

(b) Beryllium chloride can be prepared by the reaction of beryllium with chlorine or hydrogen chloride. Write equations for both of these reactions. [2 marks]

_____

_____

(c) Beryllium chloride is a covalent molecule with a melting point of 400°C. Its electronic structure is shown below.



It reacts vigorously with water.

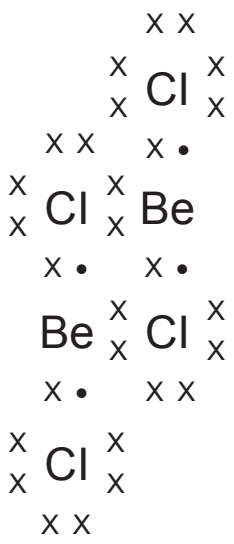
$$BeCl_2 + 2H_2O \rightarrow Be(OH)_2 + 2HCl$$

(i) Name and explain the shape of the beryllium chloride molecule. [3 marks]

(ii) Beryllium chloride and sodium chloride are separately added to water. Describe and explain what is observed when Universal Indicator is added to each solution. [4 marks]

Quality of written communication [2 marks]

(d) The high melting point of beryllium chloride is explained by its polymeric structure. Part of the polymeric structure is shown below:



(i) Explain whether beryllium, in the polymeric structure, obeys the octet rule. [1 mark]

_____

(ii) Explain whether chlorine, in the polymeric structure, obeys the octet rule. [1 mark]

_____

(iii) Some of the chlorine atoms in the polymeric structure are forming **coordinate bonds**. Explain this term. [2 marks]

_____

_____

(iv) Explain why the polymeric structure has a high melting point. [2 marks]

_____

_____

12 A sample of iron from a meteorite was found to contain the following isotopes: ^{54}Fe, ^{56}Fe and ^{57}Fe.

(a) (i) Complete the table to show the number of protons, neutrons and electrons that are present in each of the isotopes. [3 marks]

isotope	**protons**	**neutrons**	**electrons**
^{54}Fe			
^{56}Fe			
^{57}Fe			

(ii) From the mass spectrum the relative abundances of the isotopes in this sample of iron were found to be as follows:

m/z ratio	54	56	57
% abundance	5.8	91.6	2.6

Calculate the relative atomic mass of iron to **one** decimal place. [2 marks]

(iii) Explain the difference, if any, in the chemical properties of the isotopes of iron. [1 mark]

(b) (i) Write the electronic configuration of an Fe^{2+} ion. [1 mark]

(ii) When chlorine gas is bubbled through a solution of Fe^{2+} ions, oxidation to Fe^{3+} ions occurs. Write an equation for this reaction. [2 marks]

(iii) With reference to s,p,d notation explain the stability of the Fe^{3+} ion relative to the Fe^{2+} ion. [2 marks]

13 The combustion of Group I metals forms their oxides. Depending on the reaction conditions sodium can form the peroxide, Na_2O_2.

(a) (i) Write an equation for the reaction of sodium with oxygen to form the peroxide. [1 mark]

(ii) At higher temperatures and pressures a different oxide **Y** is formed. One mole of **Y** contains the Avogadro number of O^{2-} ions and 1.2×10^{24} Na^+ ions. Deduce the formula of **Y**. [1 mark]

(b) If a large amount of energy is supplied to sodium vapour it ionises. The 1st ionisation energy for sodium is 500 kJ mol^{-1}. Calculate the wavelength of energy absorbed in nm by the sodium vapour. [4 marks]

($1\,nm = 1 \times 10^{-9}\,m$ $\quad$ $c = 3.0 \times 10^{8}\,m\,s^{-1}$)

(c) When strongly heated sodium reacts with ammonia to form sodium amide, $NaNH_2$, and hydrogen.

(i) Write the equation for the reaction between sodium and ammonia. [1 mark]

_____

(ii) Use the boxes below to give the electronic configuration of the N atom and the N^- ion. [2 marks]

	1s	2s	2p
N	☐	☐	☐ ☐ ☐
N^-	☐	☐	☐ ☐ ☐

(iii) Draw the shape of an amide ion, NH_2^-, showing any lone pairs of electrons. [1 mark]

(iv) Name the shape of the amide ion. [1 mark]

_____

(v) Explain, in terms of electron pair repulsion, why the bond angle in an amide ion is smaller than the bond angle in an ammonia molecule. [3 marks]

_____

_____

_____

_____

_____

14 Sodium carbonate is manufactured by the Solvay process. This is a two stage process.

STAGE 1
Sodium hydrogencarbonate is formed.

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

STAGE 2
Sodium hydrogencarbonate is then thermally decomposed.

$$2NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

(a) (i) Calculate the number of moles of sodium hydrogencarbonate formed from 234 kg of sodium chloride. [2 marks]

(ii) Calculate the maximum mass of sodium carbonate formed in kg. [2 marks]

(b) Sodium carbonate can form a number of hydrates of formula $Na_2CO_3.xH_2O$. A 6.0 g sample of hydrated sodium carbonate was dissolved in water and the solution made up to 250 cm^3. A 25.0 cm^3 portion of this solution required 24.3 cm^3 of 0.2 mol dm^{-3} sulfuric acid for complete reaction.

$$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$$

(i) Calculate the number of moles of sulfuric acid required for complete reaction. [1 mark]

(ii) Deduce the number of moles of sodium carbonate in 25.0 cm^3 of the solution. [1 mark]

(iii) Calculate the number of moles of sodium carbonate in 250 cm^3 of solution. [1 mark]

(iv) Calculate the relative formula mass of the hydrated sodium carbonate. [1 mark]

(v) Calculate the relative formula mass of anhydrous sodium carbonate. [1 mark]

(vi) Calculate the value of x. [1 mark]

(c) Water and carbon dioxide both contain polar bonds.

(i) Show the polarity of the carbon–oxygen bond and the oxygen–hydrogen bond on the bonds drawn below. [2 marks]

C═O O—H

(ii) Suggest why the carbon dioxide molecule is non-polar. [1 mark]

(iii) Explain why water changes to a gas at 100°C. [2 marks]

15 The table below shows some data about the halogens, Group VII.

element	**electronegativity**	**boiling point of hydrogen halide/K**	**bond energy of hydrogen halide/ kJ mol^{-1}**
fluorine	4.0	293	568
chlorine	3.0	188	431
bromine	2.8	206	366
iodine	2.5	238	299

(a) (i) Define the term **electronegativity**. [2 marks]

(ii) Explain the trend in electronegativity as the group is descended. [2 marks]

(iii) Explain the trend in boiling point from hydrogen chloride to hydrogen iodide. [2 marks]

(iv) Explain why hydrogen fluoride does not follow this trend. [2 marks]

(v) State and explain the order of increasing acid strength of equimolar solutions of the hydrogen halides. [1 mark]

(b) Bromine water reacts with cold, dilute alkali as shown below:

$$Br_2(aq) + 2OH^-(aq) \rightarrow Br^-(aq) + BrO^-(aq) + H_2O(l)$$

(i) State the colour change observed during this reaction. [2 marks]

(ii) State the oxidation states of bromine in the reaction and use them to explain why this reaction is an example of disproportionation. [4 marks]

(iii) Write the ionic equation for the reaction of bromine with hydroxide ions to produce bromate(V), BrO_3^-, ions. [2 marks]

(c) Use the information below to identify N, O, P, Q and R.

(i) When silver nitrate solution is added to a solution of a potassium halide, N, a yellow solid is formed. [1 mark]

N is _____

(ii) When concentrated sulfuric acid is added to a solid potassium halide O, a red-brown gas P and two colourless gases Q and R are formed. [4 marks]

O is _____

P is _____

Q is _____

R is _____

THIS IS THE END OF THE QUESTION PAPER

For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
Total Marks	