OCR
Oxford Cambridge and RSA

Friday 27 May 2016 – Morning

AS GCE CHEMISTRY A

F321/01 Atoms, Bonds and Groups

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour

* F 3 2 1 0 1 *

* 5 9 8 6 7 8 5 8 0 1 *

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional answer space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **60**.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Nitrogen is the most common gas in the atmosphere.

(a) Atoms of nitrogen consist of protons, neutrons and electrons.

Complete the table below.

Particle	Relative mass	Relative charge	Position within the atom
Proton			
Neutron			
Electron			shell

[2]

(b) The electrons in the second shell of a nitrogen atom are found in an s-orbital and three p-orbitals.

(i) State, in words, the 3D shape of an s-orbital and a p-orbital.

s-orbital .....

p-orbital .....

[1]

(ii) Describe the relative energies of the 2s orbital and **each** of the three 2p orbitals in a nitrogen atom.

.....

.....

..... **[2]**

(c) Draw a '*dot-and-cross*' diagram to show the bonding in a nitrogen molecule.

Show **outer** electrons only.

[1]

(d) Calculate the amount, in mol, of nitrogen **atoms** in 5.117×10^{20} nitrogen **molecules**.

Give your answer in standard form.

amount of nitrogen atoms = ... mol **[2]**

(e) N_2O_3 is an unstable oxide of nitrogen that decomposes in a redox reaction.

$$N_2O_3(g) \longrightarrow NO(g) + NO_2(g)$$

(i) State the oxidation number of nitrogen in each oxide in the table below.

Oxide	Oxidation number of nitrogen
N_2O_3	
NO	
NO_2	

[1]

(ii) Name this type of redox reaction.

In your answer you should use appropriate technical terms spelled correctly.

..... **[1]**

(f) N_2O_3 reacts with water to form an acid as the only product. This reaction is **not** a redox reaction. The empirical formula of the acid formed is the same as the molecular formula.

(i) State what is meant by the term *molecular formula*.

.....

..... **[1]**

(ii) Suggest the empirical formula of the acid formed.

empirical formula of acid = ... **[1]**

[Total: 12]

2 This question is about halogens.

(a) Solid chlorine and solid bromine have a similar structure.

Name this structure.

..... **[1]**

(b) The intermolecular attractions in halogens are van der Waals' forces.

(i) Explain how van der Waals' forces arise between halogen molecules.

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..... **[3]**

(ii) The boiling points of chlorine and bromine are shown in the table.

Halogen	Boiling point / °C
chlorine	–34
bromine	59

Explain why bromine has a higher boiling point than chlorine.

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..... **[2]**

(c) A student carries out test-tube experiments to prove the trend in reactivity of halogens.

The student is provided with the following solutions:

- bromine water
- aqueous iodine
- aqueous barium chloride
- aqueous magnesium bromide
- aqueous calcium iodide.

Chlorine gas and chlorine water are **not** available.

The student carries out the **minimum** number of test-tube experiments using these solutions in the presence of cyclohexane (an organic solvent).

- State the solutions that need to be added together in order to prove the trend in reactivity of the halogens, using the **minimum** number of test-tube experiments.

- Describe the colour seen in the organic solvent at the end of each test-tube experiment.

- Write an ionic equation for **one** reaction that takes place.

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..... **[5]**

[Total: 11]

3 The elements of Period 2 and Period 3 of the Periodic Table are shown in **Table 3.1**.

Group	1	2	3	4	5	6	7	0
Period 2	Li	Be	B	C	N	O	F	Ne
Period 3	Na	Mg	A*l*	Si	P	S	C*l*	Ar

Table 3.1

(a) The elements in these two periods show a repeating pattern in chemical and physical properties.

What is the name given to this repeating pattern of properties?

..... **[1]**

(b) State the element in **Table 3.1** with:

- the lowest first ionisation energy .....
- the lowest fourth ionisation energy .....
- the lowest boiling point .....

[3]

(c) Gallium, atomic number 31, is in Period 4 of the Periodic Table. Gallium is a Group 3 element.

Predict the formula of a gallium ion.

..... **[1]**

(d) The melting points of the Period 3 metals sodium and magnesium are shown below.

Metal	Melting point / °C
sodium	98
magnesium	649

Explain the differences in the melting points of sodium and magnesium, using the model of metallic bonding.

In your answer you should use appropriate technical terms spelled correctly.

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..... **[3]**

(e) When magnesium nitrate, $Mg(NO_3)_2$, is heated, it decomposes as shown.

$$2Mg(NO_3)_2(s) \rightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

A student heats 2.966 g of $Mg(NO_3)_2$, which decomposes as above.

Calculate the **total** volume of gas formed, in cm^3, at room temperature and pressure, RTP.

total volume of gas formed = ... cm^3 **[3]**

(f) Fluorine forms several compounds with sulfur and with oxygen.

(i) Give the **formula** and the **name** of the compound formed between fluorine and sulfur which has octahedral molecules.

Formula .....

Name .....

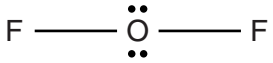
[1]

(ii) Fluorine reacts with aqueous sodium hydroxide to form the oxide F_2O.
Two other products are also formed. One product is an ionic compound with a relative formula mass of 42.0.

Construct a balanced equation for this reaction.

..... **[2]**

(g) (i) Fluorine is the most electronegative element.
Indicate any dipoles on the molecule of F_2O below using partial charges.



[1]

(ii) Suggest the **shape** of the F_2O molecule and the F–O–F **bond angle**.

Shape .....

Bond angle .....

[1]

(iii) What is the oxidation number of oxygen in F_2O?

Include the sign in your answer.

..... **[1]**

[Total: 17]

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Turn over for the next question

4 This question is about the chemistry of the metals zinc, magnesium, aluminium and calcium.

(a) Complete the electron configuration of a zinc atom.

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

(b) A sample of zinc was found to contain four isotopes with the abundances shown in the table.

Isotope	Abundance (%)
^{64}Zn	49.0
^{66}Zn	27.9
^{67}Zn	4.3
^{68}Zn	18.8

(i) Define the term *relative atomic mass*.

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..... **[3]**

(ii) Calculate the relative atomic mass of zinc in this sample.

Give your answer to **two** decimal places.

relative atomic mass of zinc = ... **[2]**

(c) Zinc carbonate, $ZnCO_3$, reacts with dilute hydrochloric acid.

A student reacts a sample of $ZnCO_3$ with an excess of dilute hydrochloric acid in a test-tube.

(i) Describe what the student would see during this reaction.

.....

..... **[1]**

(ii) Write the equation for the reaction between $ZnCO_3$ and dilute hydrochloric acid.

..... **[1]**

(d) Magnesium will undergo redox reactions with aqueous salts of less reactive metals.

(i) A student reacts magnesium with aqueous copper(II) sulfate.

$$Mg(s) + CuSO_4(aq) \longrightarrow Cu(s) + MgSO_4(aq)$$

Explain, in terms of **numbers** of electron transferred, the redox processes taking place in this reaction.

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..... **[2]**

(ii) The student also noticed that the magnesium started fizzing.

The student thought the fizzing was due to the magnesium reacting with water in the mixture.

Write the equation for the reaction of magnesium with water.

Include state symbols.

..... **[2]**

(e) A student reacts 35.0 cm^3 of 3.00×10^{-2} mol dm^{-3} $H_2SO_4(aq)$ with an excess of A*l*.

An equation for this reaction is shown.

$$2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

Calculate the mass, in g, of $Al_2(SO_4)_3$ formed in solution.

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

Show your working.

mass = ... g **[4]**

(f) Compounds of calcium have many uses.

(i) Identify a compound of calcium that could be used to convert a soil pH from 5.8 to 7.5.

..... **[1]**

(ii) Calcium phosphide, Ca_3P_2, is an ionic compound used in rat poison.

Calcium phosphide can be prepared by reacting calcium metal with phosphorus, P_4.

Write the equation for the reaction of calcium with phosphorus to form calcium phosphide.

..... **[1]**

(iii) Draw a '*dot-and-cross*' diagram to show the bonding in calcium phosphide, Ca_3P_2.

Show **outer** electrons only.

[2]

[Total: 20]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).