OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY A

Atoms, Bonds and Groups

F321

Candidates answer on the question paper.

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

Other materials required:
- Scientific calculator

Thursday 13 January 2011
Morning

Duration: 1 hour

OCE/25757

F 3 2 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The insert will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- 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. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Answer **all** the questions.
- 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 **12** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Sir Humphrey Davy, the inventor of the miners' safety lamp, was the first person to isolate the element strontium. Robert Bunsen, the inventor of the Bunsen burner, was partly responsible for the discovery of the element rubidium. Rubidium and strontium occur next to each other in the Periodic Table.

A sample of rubidium was analysed and found to consist of two isotopes, rubidium-85 and rubidium-87. Information about these isotopes is given in the table.

isotope	relative isotopic mass	abundance (%)
rubidium-85	85.00	72.15
rubidium-87	87.00	27.85

(a) In terms of sub-atomic particles, what is the difference between these isotopes of rubidium?

.....

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

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

.....

.....

.....

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

(c) Calculate the relative atomic mass of the sample of rubidium.

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

answer = ... **[2]**

(d) Both rubidium, a Group 1 element, and strontium, a Group 2 element, have their outermost electrons in the 5s orbital.

What 3-D shape is the 5s orbital?

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

(e) Ionisation energies allow chemists to determine electron structures. The first two ionisation energies of rubidium and strontium are shown in the table.

element	first ionisation energy / kJ mol^{-1}	second ionisation energy / kJ mol^{-1}
rubidium	403	2632
strontium	550	1064

(i) Write an equation to represent the **second** ionisation energy of strontium.

Include state symbols.

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

(ii) Why is the **first** ionisation energy of strontium larger than the **first** ionisation energy of rubidium?

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

.....

.....

.....

.....

.....

.....

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

(iii) Why is the **second** ionisation energy of rubidium larger than the **second** ionisation energy of strontium?

.....

.....

.....

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

[Total: 13]

2 Sodium tartrate and copper(II) nitrate are both salts.

(a) Sodium tartrate is a salt of tartaric acid. The formula of tartaric acid can be represented as H_xA. In this formula, x is the number of H^+ ions that can be replaced by metal ions to form salts.

A student carries out a titration to find the value of x in the formula of tartaric acid, H_xA.
In the titration, 25.00 cm^3 of 0.0500 mol dm^{-3} tartaric acid, H_xA, exactly reacts with 12.50 cm^3 of 0.200 mol dm^{-3} sodium hydroxide, NaOH. A solution of sodium tartrate is produced.

(i) Calculate the amount, in mol, of H_xA used.

amount = ... mol **[1]**

(ii) Calculate the amount, in mol, of NaOH used.

amount = ... mol **[1]**

(iii) Deduce the value for x in the formula of tartaric acid, H_xA.

x = ... **[1]**

(b) Copper(II) nitrate is a salt of nitric acid.

(i) A student prepares a solution of copper(II) nitrate, $Cu(NO_3)_2$, by adding, with stirring, an excess of copper(II) oxide to some hot dilute nitric acid.

Construct the equation for this reaction.

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

(ii) Copper(II) nitrate has ionic bonding.

What is meant by the term *ionic bonding*?

.....

.....

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

(iii) Explain why a solution of copper(II) nitrate conducts electricity.

.....

.....

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

(iv) What is the oxidation number of nitrogen in $Cu(NO_3)_2$?

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

(c) Hydrated crystals of copper(II) nitrate can be prepared by allowing water to evaporate from a solution of copper(II) nitrate.

Hydrated copper(II) nitrate has the empirical formula $CuN_2O_{12}H_{12}$.

Write the formula of hydrated copper(II) nitrate to show its water of crystallisation.

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

[Total: 9]

3 Linus Pauling was a Nobel prize winning chemist who devised a scale of electronegativity.

Some Pauling electronegativity values are shown in the table.

element	electronegativity
B	2.0
Br	2.8
N	3.0
F	4.0

(a) What is meant by the term *electronegativity*?

.....

.....

.....

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

(b) Show, using $\delta+$ and $\delta-$ symbols, the permanent dipoles on each of the following bonds.

N—F N—Br

[1]

(c) Boron trifluoride, BF_3, ammonia, NH_3, and sulfur hexafluoride, SF_6, are all covalent compounds. The shapes of their molecules are different.

(i) State the shape of a molecule of SF_6.

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

(ii) Using outer electron shells only, draw *'dot-and-cross'* diagrams for molecules of BF_3 and NH_3.

Use your diagrams to explain why a molecule of BF_3 has bond angles of 120° and NH_3 has bond angles of 107°.

BF_3	**NH_3**

.....

.....

.....

.....

.....

.....

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

(iii) Molecules of BF_3 contain polar bonds, but the molecules are non-polar.

Suggest an explanation for this difference.

.....

.....

.....

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

[Total: 11]

4 Calcium hydroxide is used in agriculture but the amounts used must be carefully controlled.

(a) State **one** use of calcium hydroxide in agriculture **and** suggest why the amount of calcium hydroxide used should not be excessive.

.....

.....

.....

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

(b) A student knew that calcium hydroxide could be made by adding calcium to water.

The student added 0.00131 mol of calcium to a beaker containing about 100 cm^3 of water.
A reaction took place as shown by the equation below.
All the calcium hydroxide formed was soluble.

$$Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$$

(i) Calculate the mass of calcium that the student added.

mass of calcium = ... g **[1]**

(ii) Calculate the volume of hydrogen gas, in dm^3, produced in this reaction at room temperature and pressure, RTP.

volume of hydrogen gas = ... dm^3 **[1]**

(iii) The student transferred the contents of the beaker to a 250 cm^3 volumetric flask and water was added to make the solution up to 250 cm^3.

Calculate the concentration, in mol dm^{-3}, of **hydroxide ions** in the 250 cm^3 solution.

concentration = ... mol dm^{-3} **[2]**

(c) The student repeated the experiment using the same mass of pure barium.

The student found that a smaller volume of hydrogen gas was produced, measured at RTP.

(i) Explain why.

.....

.....

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

(ii) Suggest **one** other difference the student would observe between the reactions of water with calcium and of water with barium.

.....

.....

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

[Total: 8]

5 Chlorine, bromine and iodine are halogens commonly used in school and college experiments.

(a) Halogens have van der Waals' forces between their molecules.

(i) Describe how van der Waals' forces arise.

.....

.....

.....

.....

.....

.....

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

(ii) State **and** explain the trend in the boiling points of chlorine, bromine and iodine.

.....

.....

.....

.....

.....

.....

.....

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

(b) The halogen astatine does **not** exist in large enough quantities to observe any of its reactions.

Why would astatine be expected to react similarly to other halogens?

.....

.....

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

(c) A student investigated the reactivity of halogens by attempting some redox reactions.

(i) The student added bromine water to aqueous solutions of sodium chloride and sodium iodide in separate test-tubes. The student then added an organic solvent, cyclohexane, to each test-tube and these were shaken.

- State what colour you would see in the cyclohexane in each test-tube after shaking.
- Write **ionic** equations for any chemical reactions that take place.
- State and explain the trend in reactivity shown by these observations.

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[6]**

(ii) Suggest why the student carried out the reactions in a well ventilated area.

.....

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

(d) The halogen fluorine is too reactive to use in a school or college laboratory. Fluorine is a powerful oxidising agent. It will react with water as shown below.

(i) Complete and balance the equation for the reaction of fluorine with water.

$F_2(g)$ + $H_2O(l)$ → ..... + $O_2(g)$ **[1]**

(ii) Using oxidation numbers, show what has been oxidised and what has been reduced in this reaction.

.....

.....

.....

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

(e) Fluorine will react violently with gallium to produce gallium fluoride.

Mendeleev originally called gallium 'eka-aluminium' as he predicted that gallium would have similar properties to aluminium.

(i) Complete the electron structure of the gallium atom.

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

(ii) Use Mendeleev's prediction to suggest the empirical formula of gallium fluoride.

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

[Total: 19]

END OF QUESTION PAPER