Thursday 23 May 2013 – 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

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. 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 space is required, you should use the lined pages 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 Silicon and potassium are two elements found in the Earth's crust.

(a) Silicon and potassium both exist as several isotopes.

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

....

....

.... **[2]**

(ii) Complete the table below for an atom and an ion of two different isotopes of potassium.

	Protons	**Neutrons**	**Electrons**
^{39}K	....	....	19
....	....	22	18

[2]

(b) Complete the electron configuration of a silicon atom.

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

(c) **(i)** Silicon reacts with chlorine to form molecules of silicon tetrachloride, $SiCl_4$.

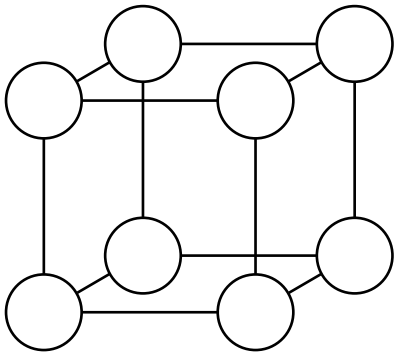
How many molecules are present in 8.505 g of $SiCl_4$?

answer = ... molecules **[3]**

(ii) Potassium reacts with chlorine to form an ionic lattice of potassium chloride, KCl.

A diagram of part of the potassium chloride lattice is shown below.

Add labels to each circle in the diagram to show the particles present in the lattice. The diagram assumes all particles have the same size.



[2]

[Total: 10]

2 Hydrated aluminium sulfate, $Al_2(SO_4)_3\bullet \boldsymbol{x}H_2O$, and chlorine, Cl_2, are used in water treatment.

(a) A student attempts to prepare hydrated aluminium sulfate by the following method.

- The student heats dilute sulfuric acid with an excess of solid aluminium oxide.
- The student filters off the excess aluminium oxide to obtain a colourless solution of $Al_2(SO_4)_3$.

(i) State the formulae of the two **main** ions present in the solution of $Al_2(SO_4)_3$.

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

(ii) Write an equation for the reaction of aluminium oxide, Al_2O_3, with sulfuric acid.

Include state symbols.

.... **[2]**

(iii) What does '$\bullet \boldsymbol{x}H_2O$' represent in the formula $Al_2(SO_4)_3\bullet \boldsymbol{x}H_2O$?

....

.... **[1]**

(iv) The student heats 12.606 g of $Al_2(SO_4)_3\bullet \boldsymbol{x}H_2O$ crystals to constant mass.

The anhydrous aluminium sulfate formed has a mass of 6.846 g.

Use the student's results to calculate the value of ***x***.

The molar mass of $Al_2(SO_4)_3 = 342.3\,g\,mol^{-1}$.

x = ... **[3]**

(b) A student tests chlorine gas with damp blue litmus paper. The litmus paper first turns a red colour and is then bleached. A reaction takes place between chlorine and water in the damp litmus paper.

(i) Write the equation for the reaction between chlorine and water.

Explain why the damp litmus paper turns a red colour as a result of this reaction.

....

....

.... **[2]**

(ii) Bleach is made by reacting chlorine with cold dilute aqueous sodium hydroxide.

Suggest the formula of the **ion** responsible for bleaching.

.... **[1]**

[Total: 11]

3 The hydrides of Group 5 elements all exist as gases at room temperature.

(a) Phosphine gas, PH_3, can be prepared by adding phosphorus, P_4, to warm concentrated aqueous sodium hydroxide as shown in the equation below.

$$P_4(s) + 3NaOH(aq) + 3H_2O(l) \rightarrow PH_3(g) + 3NaH_2PO_2(aq)$$

(i) Using oxidation numbers, explain why this is a disproportionation reaction.

....

....

....

....

.... **[3]**

(ii) A chemist reacts 1.86 g of P_4 with excess NaOH(aq).

Calculate the volume of phosphine gas, in cm^3, produced at room temperature and pressure, RTP.

volume of phosphine gas = ... cm^3 **[2]**

(b) Phosphine gas burns in air to form an oxide of phosphorus, P_4O_{10}, and water.

Write the equation for this reaction.

.... **[1]**

(c) Phosphoric acid, H_3PO_4, can be made by reacting P_4O_{10} with water.

Sodium phosphate, Na_3PO_4, is a salt that can be prepared by reacting H_3PO_4 with sodium hydroxide, NaOH.

A student prepared a solution of Na_3PO_4 by reacting 15.0 cm^3 of 0.100 mol dm^{-3} H_3PO_4 with 0.200 mol dm^{-3} NaOH.

(i) Why is Na_3PO_4 described as a salt of H_3PO_4?

....

.... **[1]**

(ii) Calculate the amount, in moles, of H_3PO_4 in 15.0 cm^3 of 0.100 mol dm^{-3} H_3PO_4.

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

(iii) The equation for the preparation of Na_3PO_4 from NaOH and H_3PO_4 is shown below.

$$3NaOH(aq) + H_3PO_4(aq) \rightarrow Na_3PO_4(aq) + 3H_2O(l)$$

Calculate the volume of 0.200 mol dm^{-3} NaOH that reacts exactly with 15.0 cm^3 of 0.100 mol dm^{-3} H_3PO_4.

volume = ... cm^3 **[1]**

(d) Ammonia, NH_3, is another gaseous Group 5 hydride.

NH_3 and PH_3 are both simple molecules. The boiling points of NH_3 and PH_3 are shown in the table below.

Group 5 hydride	Boiling point / °C
NH_3	–33
PH_3	–88

(i) Complete the table below to show the main intermolecular forces present in NH_3 and PH_3.

Group 5 hydride	Main intermolecular force
NH_3	
PH_3	

[2]

(ii) Suggest why PH_3 has a lower boiling point than NH_3.

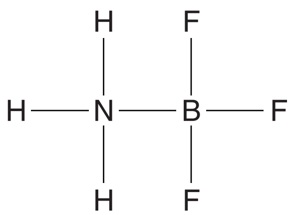
....

....

.... **[1]**

(e) NH_3 reacts with molecules of BF_3 to form H_3NBF_3, shown below.

One of the bonds in H_3NBF_3 is a dative covalent bond.



(i) A covalent bond is a shared pair of electrons.

What is a *dative* covalent bond?

....

....

.... **[1]**

(ii) Draw a '*dot-and-cross*' diagram to show the bonding in H_3NBF_3.

Label the dative covalent bond in your diagram.

Show **outer** electrons only.

[2]

(iii) The F–B–F bond angle in BF_3 is different from the F–B–F bond angle in H_3NBF_3.

Complete the table to predict the F–B–F bond angles in BF_3 and in H_3NBF_3.

Molecule	**F–B–F bond angle/°**
BF_3	
H_3NBF_3	

[2]

(iv) The H–N–H bond angle in NH_3 is 107°. A student predicted that the H–N–H bond angle in H_3NBF_3 is larger.

Explain why the student might expect the H–N–H bond angle to be larger in H_3NBF_3 than in NH_3.

....

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....

....

.... **[3]**

[Total: 20]

4 Group 2 elements react with halogens.

(a) Describe and explain the trend in reactivity of Group 2 elements with chlorine as the group is descended.

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

.... **[5]**

(b) A student was provided with an aqueous solution of calcium iodide.

The student carried out a chemical test to show that the solution contained iodide ions. In this test, a precipitation reaction took place.

(i) State the reagent that the student would need to add to the solution of calcium iodide.

.... **[1]**

(ii) What observation would show that the solution contained iodide ions?

.... **[1]**

(iii) Write an ionic equation, including state symbols, for the reaction that took place.

.... **[1]**

(iv) The student is provided with an aqueous solution of calcium bromide that is contaminated with calcium iodide.

The student carries out the same chemical test but this time needs to add a second reagent to show that iodide ions are present.

State the second reagent that the student would need to add.

.... **[1]**

[Total: 9]

5 Periodicity is a repeating pattern across different periods.

(a) First ionisation energy shows a trend across Period 2.

The first ionisation energies of lithium, carbon and fluorine are shown in **Table 5.1** below.

Element	Lithium	Carbon	Fluorine
First ionisation energy / kJ mol^{-1}	520	1086	1681

Table 5.1

(i) Explain the trend across Period 2 shown in **Table 5.1**.

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

....

....

....

....

....

....

....

.... **[3]**

(ii) Solid carbon exists in two forms, diamond and graphite.

Explain why it is unnecessary to refer to carbon as either diamond or graphite in **Table 5.1**.

....

.... **[1]**

(b) Lithium, carbon (in the form of diamond) and fluorine have very different melting points.

These differences in melting points are the result of different types of structure and different forces or bonds between the particles in the structures.

Part of the table below has been filled in.

Complete the table below.

	Lithium	**Carbon (diamond)**	**Fluorine**
Melting point / °C	181	3550	–220
Structure	Giant		Simple
Force or bond overcome on melting	Metallic bond		
Particles between which the force or bond is acting			

[6]

[Total: 10]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

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