OCR
RECOGNISING ACHIEVEMENT

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Advanced Subsidiary GCE**

# CHEMISTRY 2811

Foundation Chemistry

Friday **12 JANUARY 2001** Morning 1 hour 30 minutes

Additional materials:
Scientific calculator
Data Sheet for Chemistry
Candidates answer on the question paper.

| Candidate Name | Centre Number | Candidate Number |
|---|---|---|
| | | |

**TIME** 1 hour 30 minutes

## INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

## INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You are advised to show all the steps in any calculations.
- You may use a scientific calculator.
- You may use a Data Sheet for Chemistry.

| FOR EXAMINER'S USE | | |
|---|---|---|
| Qu. | Max. | Mark |
| 1 | 15 | |
| 2 | 12 | |
| 3 | 9 | |
| 4 | 12 | |
| 5 | 7 | |
| 6 | 9 | |
| 7 | 10 | |
| 8 | 16 | |
| TOTAL | 90 | |

**This question paper consists of 12 printed pages, 2 lined pages and 2 blank pages.**



Registered Charity Number 1066969

Answer **all** the questions.

**1** Lithium was discovered in 1817 by the Swedish chemist Arfvedson. Lithium exists naturally as a mixture of isotopes.

**(a)** Explain the term *isotopes*.

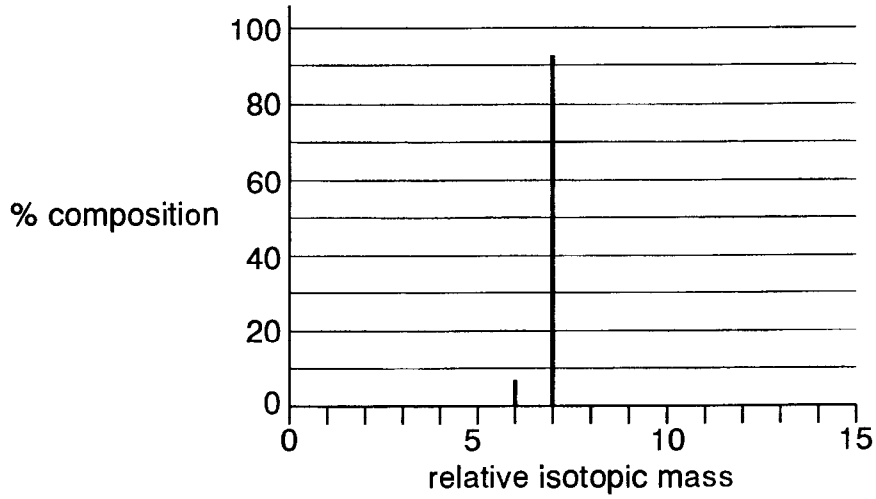
.....

.....[1]

**(b)** Which isotope is used as the standard against which relative atomic masses are measured?

.....[1]

**(c)** The mass spectrum below shows the isotopes present in a sample of lithium.




**(i)** Use this mass spectrum to help you complete the table below for each lithium isotope in the sample.

| isotope | percentage composition | number of | |
|---|---|---|---|
| | | protons | neutrons |
| $^{6}Li$ | | | |
| $^{7}Li$ | | | |

[3]

**(ii)** Calculate the relative atomic mass of this lithium sample. Your answer should be given to three significant figures.

[2]

**(d)** The species responsible for the peaks in this mass spectrum are lithium ions, produced and separated in a mass spectrometer.

**(i)** How are the electrons removed from lithium atoms to form lithium ions in a mass spectrometer?

.....

.....[1]

**(ii)** How does a mass spectrometer separate the ions?

.....

.....[1]

**(e)** The first ionisation energy of lithium is $+520\,kJ\,mol^{-1}$.

**(i)** Define the term *first ionisation energy*.

.....

.....

.....

.....[3]

**(ii)** The first ionisation energy of sodium is $+496\,kJ\,mol^{-1}$.

Explain why the first ionisation energy of sodium is less than that of lithium. Your answer should compare the atomic structures of each element.

.....

.....

.....

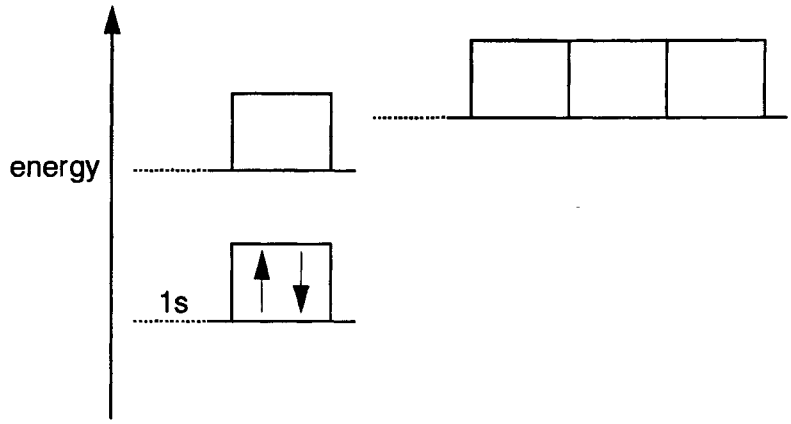
.....

.....

.....[3]

[Total : 15]

**2** Electrons are arranged in energy levels. The diagram below for the 7 electrons in a nitrogen atom is incomplete. It shows two electrons in the 1s level.




**(a)** Complete the diagram for the 7 electrons in a nitrogen atom by

**(i)** adding labels for the other sub-shell levels, [1]

**(ii)** showing how the electrons are arranged. [2]

**(b)** Magnesium reacts with nitrogen forming magnesium nitride, which is an ionic compound.

**(i)** Complete the electronic configuration for the 12 electrons in a magnesium atom.

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

**(ii)** What is the charge on each ion in magnesium nitride?

*magnesium ion* .....

*nitride ion* .....[2]

**(iii)** Complete the electronic configuration of each **ion** in magnesium nitride.

*magnesium ion* $1s^2$.....

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

**(iv)** Deduce the formula of magnesium nitride.

.....[1]

**(c)** Magnesium reacts with carbon dioxide forming a mixture of magnesium oxide, MgO, and carbon.

**(i)** Write an equation, with state symbols, for this reaction.

.....[2]

**(ii)** When water is added to the mixture containing magnesium oxide, some of the magnesium oxide reacts to form a solution of magnesium hydroxide.

$$MgO(s) + H_2O(l) \longrightarrow Mg(OH)_2(aq)$$

Predict the pH of this solution.

.....[1]

[Total : 12]

**3** Calcium carbonate is added to an excess of hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

**(a)** Deduce **two** observations that you would expect to see during this reaction.

*observation 1* .....

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

**(b)** In this experiment, 0.040 g $CaCO_3$ is added to 25 $cm^3$ of 0.050 mol $dm^{-3}$ HCl.

**(i)** Explain what is meant by 0.050 mol $dm^{-3}$ HCl.

.....

.....

.....[2]

**(ii)** Calculate how many moles of $CaCO_3$ were used in this experiment.

[2]

**(iii)** Calculate how many moles of HCl are required to react with this amount of $CaCO_3$.

[1]

**(iv)** Hence show that the HCl is in excess.

[1]

**(c)** State **one** large-scale use of a named Group 2 compound that is being used to reduce acidity.

.....[1]

[Total : 9]

**4** Water is the most abundant compound on Earth. Much of the chemistry of water is influenced by its polarity and its ability to form hydrogen bonds.

**(a)** Polarity can be explained in terms of electronegativity.

**(i)** Explain the term *electronegativity*.

.....

.....

.....[2]

**(ii)** Why are **water** molecules polar?

.....

.....[1]

**(b)** The polarity of water molecules results in the formation of hydrogen bonds.

**(i)** Draw a diagram to show hydrogen bonding between two molecules of water. Your diagram must include dipoles and lone pairs of electrons.

[4]

**(ii)** State the bond angle in a water molecule.

.....[1]

**(c)** State and explain **two** properties of **ice** that are a direct result of hydrogen bonding.

*property* .....

*explanation* .....

.....

*property* .....

*explanation* .....

.....[4]

[Total : 12]

5 Well over 2 000 000 tonnes of sulphuric acid, $H_2SO_4$, are produced in the UK each year. This is used in the manufacture of many important materials such as paints, fertilisers, detergents, plastics, dyestuffs and fibres.

The sulphuric acid is prepared from sulphur in a 3 stage process.

Stage 1:
The sulphur is burnt in oxygen to produce sulphur dioxide.
$S + O_2 \longrightarrow SO_2$

Stage 2:
The sulphur dioxide reacts with more oxygen using a catalyst to form sulphur trioxide.
$2SO_2 + O_2 \longrightarrow 2SO_3$

Stage 3:
The sulphur trioxide is dissolved in concentrated sulphuric acid to form 'oleum', $H_2S_2O_7$, which is then diluted in water to produce sulphuric acid.

**(a)** 100 tonnes of sulphur dioxide were reacted with oxygen in stage 2.

Assuming that the reaction was complete, calculate

**(i)** how many moles of sulphur dioxide were reacted;
$M_r$: $SO_2$, 64.1. [1 tonne = $1 \times 10^6$ g]

[1]

**(ii)** the mass of sulphur trioxide that formed.
$M_r$: $SO_3$, 80.1

[1]

**(b)** Construct a balanced equation for the formation of sulphuric acid from oleum.

.....[1]

**(c)** The concentration of the sulphuric acid can be checked by titration. A sample of the sulphuric acid was analysed as follows.

- $10.0\,cm^3$ of sulphuric acid was diluted with water to make $1.00\,dm^3$ of solution.
- The diluted sulphuric acid was then titrated with aqueous sodium hydroxide, NaOH.

$$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$$

- In the titration, $25.0\,cm^3$ of $0.100\,mol\,dm^{-3}$ aqueous sodium hydroxide required $20.0\,cm^3$ of the **diluted** sulphuric acid for neutralisation.

**(i)** Calculate how many moles of NaOH were used.

[1]

**(ii)** Calculate the concentration, in $mol\,dm^{-3}$, of the **diluted** sulphuric acid, $H_2SO_4$.

[2]

**(iii)** Calculate the concentration, in $mol\,dm^{-3}$, of the original sulphuric acid sent for analysis.

[1]

[Total : 7]

6 The atomic radii of the elements Li to F and Na to Cl are shown in the table below.

| element | Li | Be | B | C | N | O | F |
|---|---|---|---|---|---|---|---|
| atomic radius/nm | 0.134 | 0.125 | 0.090 | 0.077 | 0.075 | 0.073 | 0.071 |
| element | Na | Mg | Al | Si | P | S | Cl |
| atomic radius/nm | 0.154 | 0.145 | 0.130 | 0.118 | 0.110 | 0.102 | 0.099 |

**(a)** Using **only** the elements in this table, select

**(i)** an element with **both** metallic and non-metallic properties,

.....[1]

**(ii)** the element with the largest first ionisation energy,

.....[1]

**(iii)** an element with a giant molecular structure.

.....[1]

**(b)** Explain what causes the general **decrease** in atomic radii across each period?

.....

.....

.....

.....[3]

**(c)** Predict and explain whether a sodium **ion** is *larger*, *smaller* or the *same size* as a sodium **atom**.

.....

.....

.....

.....[3]

[Total : 9]

**7** Chlorine and its compounds have many uses. Chlorine bleach is used to kill bacteria.

**(a)** Chlorine bleach is made by the reaction of chlorine with aqueous sodium hydroxide.

$$Cl_2(g) + 2NaOH(aq) \longrightarrow NaClO(aq) + NaCl(aq) + H_2O(l)$$

**(i)** Determine the oxidation number of chlorine in

$Cl_2$ .....

NaClO .....

NaCl .....[3]

**(ii)** The actual bleaching agent is the $ClO^-$ ion. In the presence of sunlight, this ion decomposes to release oxygen gas.
Construct an equation for this reaction.

.....[1]

**(b)** The sea contains a low concentration of bromide ions. Bromine can be extracted from sea water by first concentrating the sea water and then bubbling chlorine through this solution.

**(i)** The chlorine oxidises bromide ions to bromine.

Construct a balanced ionic equation for this reaction.

.....[1]

**(ii)** Suggest how bromine could be removed from the sea water after this oxidation.

.....

.....[1]

**(c)** Phosgene is a compound of chlorine, carbon and oxygen, used to make polyurethanes and dyes.
Phosgene has the percentage composition by mass: Cl, 71.7%; C, 12.1%; O, 16.2%.

**(i)** Show that the empirical formula of phosgene is $Cl_2CO$.

[2]

**(ii)** The molecular formula of phosgene is the same as its empirical formula.
Draw a possible structure, including bond angles, for a molecule of phosgene.

[2]

[Total : 10]

*In the following question, 2 marks are available for the quality of written communication.*

*You should use diagrams to illustrate your answer.*

**8** Sodium reacts with chlorine forming sodium chloride.

**(a)** Describe the bonding in Na, $Cl_2$ and NaCl. [8]

**(b)** Relate the **physical** properties of $Cl_2$ and **NaCl** to their structure and bonding. [8]

[Total : 16]