OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

CHEMISTRY   **2811**

Foundation Chemistry

| Friday | **17 JANUARY 2003** | Morning | 1 hour |

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

Candidate Name	Centre Number	Candidate Number

TIME   1 hour

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 may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	12	
2	17	
3	14	
4	8	
5	9	
TOTAL	60	

This question paper consists of 10 printed pages and 2 blank pages.

Answer **all** the questions.

1 Gallium, atomic number 31, exists naturally as a mixture of its isotopes, ^{69}Ga and ^{71}Ga.

(a) Complete the table below to show the atomic structure of each isotope of gallium.

isotope	number of		
	protons	neutrons	electrons
^{69}Ga			
^{71}Ga			

[2]

(b) A mass spectrometer can be used to identify the isotopes in a sample of an element. The diagram below shows a mass spectrometer.

Complete the diagram by adding the names of the processes that take place in each of the four labelled regions.

to the pump

vapour of
element
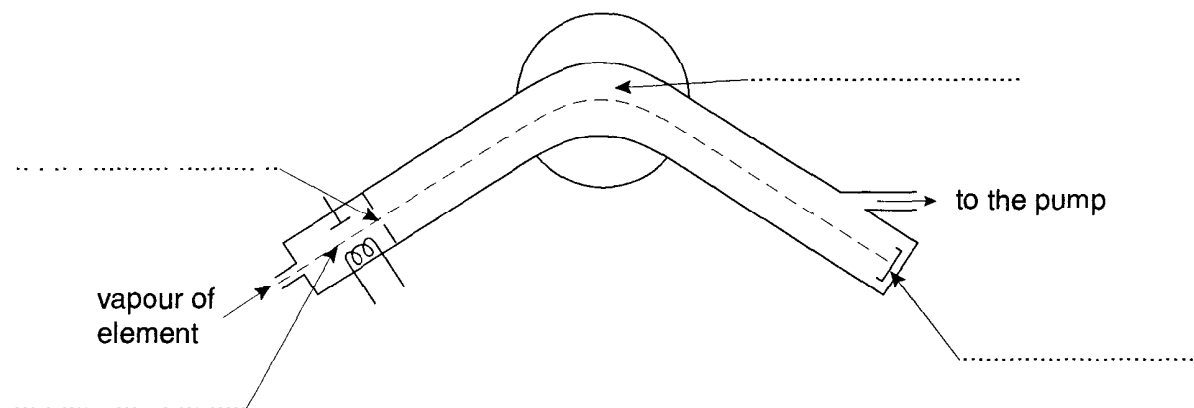
[4]

(c) A sample of gallium was analysed in a mass spectrometer to produce the mass spectrum below. The relative atomic mass of gallium can be calculated from this mass spectrum.

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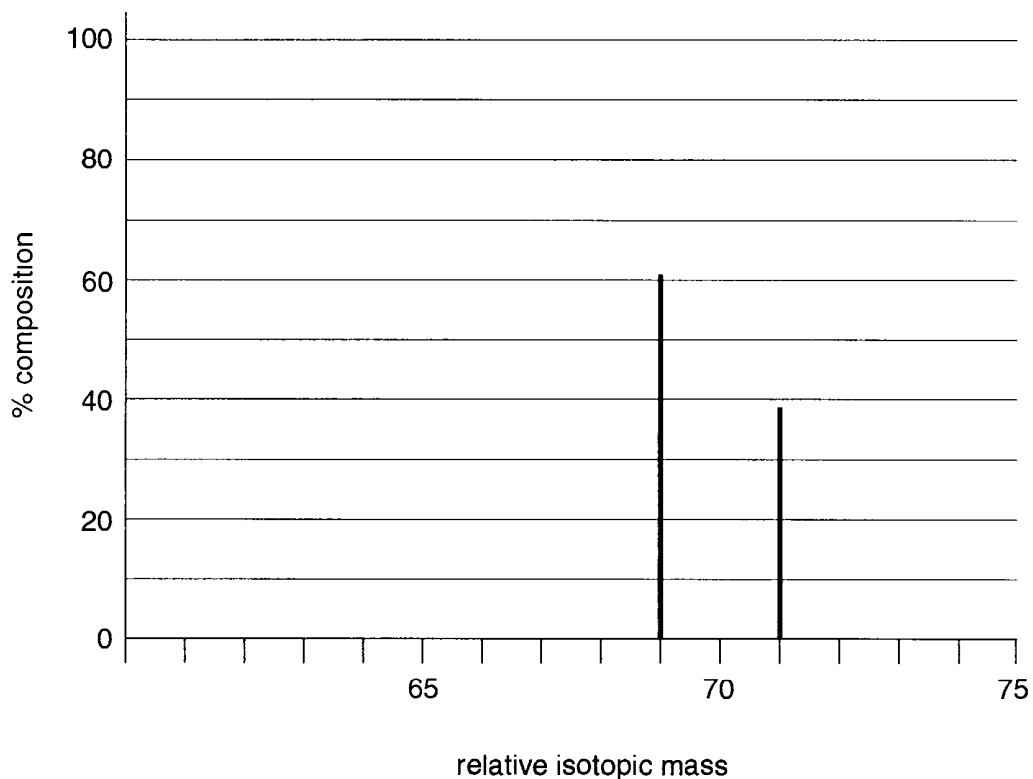
(i) Define the term *relative atomic mass*.

....

....

....

.... [3]

(ii) Estimate the percentage composition of each isotope present in the sample.

[1]

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

answer .... [2]

[Total : 12]

2 When magnesium is heated in air, it reacts with oxygen to form magnesium oxide.

$$2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$$

(a) Complete the electronic configuration of a magnesium atom.

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

(b) What is the oxidation state of magnesium in

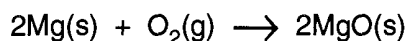 **(i)** Mg .... [1]

  (ii) MgO? .... [1]

(c) When magnesium is heated in air, it also reacts with nitrogen to form solid magnesium nitride, Mg_3N_2.

  (i) Construct an equation, with state symbols, for this reaction between magnesium and nitrogen.

  .... [2]

  (ii) Suggest why magnesium reacts with air to form much more MgO than Mg_3N_2.

  ....

  .... [1]

(d) Magnesium oxide has an extremely high melting point which makes it suitable as a lining for furnaces.

Explain, in terms of its structure and bonding, why magnesium oxide has this property.

....

....

....

.... [3]

(e) When magnesium oxide is added to warm dilute nitric acid, a reaction takes place forming a solution of magnesium nitrate.

$$MgO(s) + 2HNO_3(aq) \longrightarrow Mg(NO_3)_2(aq) + H_2O(l)$$
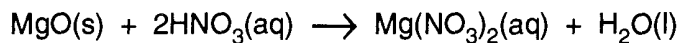
A student reacted 0.0500 mol MgO with 0.400 mol dm^{-3} nitric acid.

(i) What would you see during this reaction?

....

.... [1]

(ii) Calculate the mass of MgO that reacted.

[2]

(iii) Calculate the volume of 0.400 mol dm^{-3} HNO$_3$ required to react exactly with this amount of MgO.

[2]

(f) The solution formed in this reaction contains ions.

(i) Why does this solution conduct electricity?

....

.... [1]

(ii) State the formulae of **two** ions present in this solution.

.... [2]

[Total : 17]

3 This question is about chlorine and chlorine compounds.

(a) Chlorine reacts with water to form a solution.

$$Cl_2(g) + H_2O(l) \longrightarrow HCl(aq) + HOCl(aq)$$
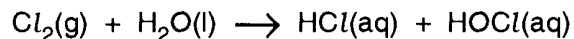
(i) Why is chlorine added to water on a large scale?

.... [1]

(ii) Green universal indicator is added to this solution.

What colour changes would you see

immediately .... [1]

after some time? .... [1]

(b) Describe a simple test that you could carry out to show that chloride ions are present in a sample of sea water.

reagent ....

observation ....

equation ....
[3]

(c) Some dry-cleaning solvents include the chlorine compound *Perc.*

Perc has the following percentage composition by mass: Cl, 85.6%; C, 14.4%.

The relative molecular mass of *Perc* is 166.

(i) Calculate the molecular formula of *Perc.*

[3]

(ii) Suggest why *Perc* would **not** react in the test in **(b)**.

....

.... [1]

(d) Sodium chlorate, $NaClO_3$, is a chlorine compound used as a weed killer.

When heated, $NaClO_3$ releases oxygen gas.

$$2NaClO_3(s) \longrightarrow 2NaCl(s) + 3O_2(g)$$
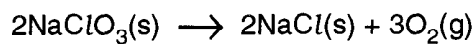
Calculate the volume of O_2 that can be formed at room temperature and pressure by heating 4.26 g of $NaClO_3$.

1 mol of gas molecules occupies 24.0 dm^3 at room temperature and pressure.

[4]

[Total : 14]

4 The first six successive ionisation energies of an element **D** are shown in Table 4.1 below.

Table 4.1

element	ionisation energy / kJ mol^{-1}					
	1st	2nd	3rd	4th	5th	6th
D	1086	2353	4621	6223	37832	47278

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

....

....

....

.... [3]

(b) Write an equation, with state symbols, to represent the **third** ionisation energy of element **D**.

.... [2]

(c) Use Table 4.1 to deduce which group of the Periodic Table contains element **D**. Explain your answer.

group ....

explanation ....

....

.... [3]

[Total : 8]

5 In this question, one mark will be awarded for the quality of written communication.

In the Periodic Table, describe and explain the trend in atomic radii shown by

- the Group 2 elements Be-Ra

- the Period 3 elements, Na-Ar.

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....[8]

Quality of Written Communication [1]

[Total : 9]

Subject: Chemistry Foundation

Code: 2811

Session: January

Year: 2003

Final Mark Scheme

25/1/2003

MAXIMUM MARK	**60**

Abbreviations, annotations and conventions used in the Mark Scheme	/	= alternative and acceptable answers for the same marking point
	;	= separates marking points
	NOT	= answers which are not worthy of credit
	( )	= words which are not essential to gain credit
	——	= (underlining) key words which **must** be used to gain credit
	ecf	= error carried forward
	AW	= alternative wording
	ora	= or reverse argument

1. **(a)**

	isotope	number of		
		protons	neutrons	electrons
✓	^{69}Ga	31	38	31
✓	^{71}Ga	31	40	31

[2]

(b)

acceleration/
accelerator ✓
ignore *'atoms' beyond 1st stage*

ionisation/
electron bombardment/
ioniser ✓
not *electron gun*

deflection/
deflector ✓
ignore *'what deflects'*

to the pump

detection/
detector ✓
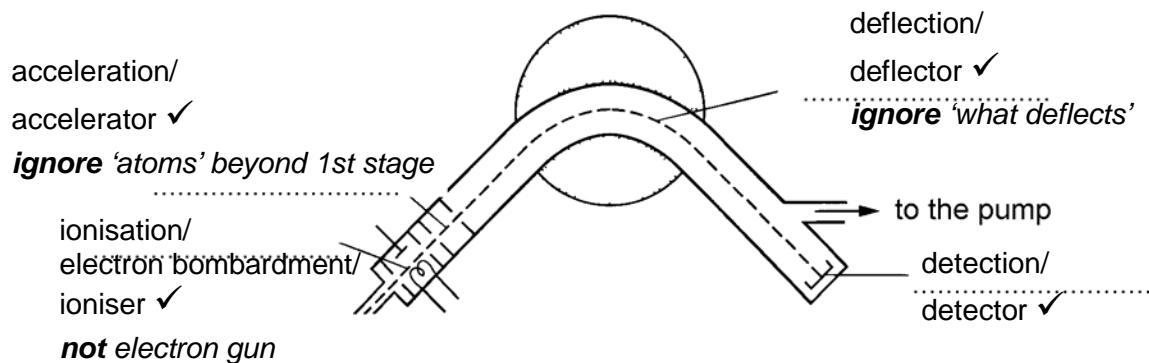
[4]

(c) **(i)** average mass/weighted mean/average mass of an **atom / the isotopes** ✓

compared with carbon-12 ✓

1/12th of mass of carbon-12/on a scale where carbon-12 is 12 ✓

not *12 **g***

or... mass of 1 mole of atoms ✓
compared with carbon-12 ✓

1/12th of mass of 1 mol of carbon-12/on a scale where carbon-12 is 12 **g** ✓ [3]

(ii) ^{69}Ga: 61%; ^{71}Ga: 39% ✓ (*allow 62/38 $\longrightarrow$ 69.76 below*)

[1]

(iii) A_r = 69 x 61/100 + 71 x 39/100 = 69.78 ✓ = 69.8 ✓

ignore g / grammes [2]

[Total: 12 marks]

2 (**a**) $1s^2 2s^2 2p^6 3s^2$ ✓

[1]

(**b**) (**i**) Mg: 0 ✓

[1]

(**ii**) MgO: +2 / 2 / II ✓

[1]

(**c**) (**i**) $3Mg(s) + N_2(g) \longrightarrow Mg_3N_2(s)$ ✓✓
1 for correct formulae and balancing; 1 for correct state symbols

[2]

(**ii**) N_2 is less reactive than O_2 /

bond between N atoms is stronger than bond between O atoms /

nitrogen has a triple bond **and** oxygen has a double bond

activation energy of N > activation energy of O ✓

The emphasis here should be a comparison for the mark

[1]

(**d**) MgO has a giant structure ✓

MgO is ionic / charged magnesium **and** oxide ions shown ✓

strong forces ✓

[3]

(**e**) (**i**) MgO dissolves/disappears ✓

[1]

(**ii**) m(MgO) = 24.3 + 16 = 40.3 (g mol^{-1}) ✓ *(accept 40)*

mass MgO = 0.0500 x 40.3 = 2.015 **g** / 2.02 **g** / 2.01 **g** / 2 **g** ✓

g is needed here

[2]

(**iii**) moles HNO_3 = 2 x 0.0500 = 0.100 mol ✓

right or wrong for 1st mark

volume HNO_3 = 0.25 dm^3 / 250 cm^3 ✓

*i.e. moles HNO$_3$/0.400 **dm^3** / 1000 x moles HNO$_3$/0.400 **cm^3***

0.05/0.400 $\longrightarrow$ 0.125 dm^3 / 125 cm^3 would score 1 mark as molar ratio not used

[2]

(**f**) (**i**) ions move / free ions ✓

[1]

(**ii**) Mg^{2+} /NO_3^- / H^+/OH^- ✓✓ 2 max

[2]

[Total: 17 marks]

3. (a) (i) purification/sterilisation/kills *or* removes germs/disinfects ✓

      not 'to make bleach'   **not** 'cleans the water'

[1]

(ii) turns red / yellow / orange ✓

then colourless / bleaches ✓
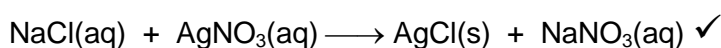
colourless then 'nothing' scores 1 mark

*colourless then 'red' does **not** score because overall bleaching is not implied.*

[2]

(b) *reagent*   silver nitrate/Ag⁺ ions ✓

observation   white (precipitate) / goes white ✓   mark independently

equation $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$ /

           $NaCl(aq) + AgNO_3(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$ ✓

(state symbols not required)

Fluorine for reagent + 'correct' displacement equation scores 1 mark)

[3]

(c) (i)   Cl : C = 85.6/35.5 : 14.4/12 ✓ = 2.4 : 1.2

              = 2 : 1 ✓

Cl_2C has mass of 83. 166 = 2 x 83

molecular formula = Cl_4C_2 ✓

         Cl : C = 85.6/17 : 14.4/12 $\longrightarrow$ Cl_4C scores 1 mark /

         Cl : C = 85.6/17 : 14.4/6 $\longrightarrow$ Cl_2C scores 1 mark

         Cl : C = 85.6/35.5 : 14.4/6 $\longrightarrow$ ClC scores 1 mark

[3]

(ii) perc is covalent / perc is **not** ionic / C–Cl bond in perc is covalent

/ no Cl^- ions / perc is molecular ✓

[1]

(d) $m(NaClO_3) = 106.5$ g mol⁻¹ ✓

moles $NaClO_3 = 4.26/106.5 = 0.04$ mol ✓

moles $O_2 = 0.06$ mol ✓

volume $O_2 = 0.06$ x 24 = 1.44 (dm³) ✓

     If no molar ratio has been used, ans $\longrightarrow$ 0.96 dm³ : worth 3 marks
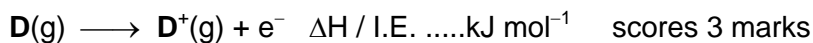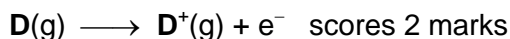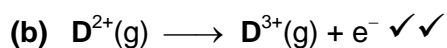
[4]

[Total:14 marks]

4. (a) Energy change when **each atom in 1 mole** ✓

        of **gaseous atoms** ✓

        loses an electron ✓ (to form 1 mole of gaseous 1+ ions).

        1 mole of gaseous atoms loses 1 mole of electrons would score all 3 marks

        $D(g) \longrightarrow D^+(g) + e^-$ scores 2 marks

        $D(g) \longrightarrow D^+(g) + e^-$ ΔH / I.E. .....kJ mol^{-1} scores 3 marks

                                                                                    [3]

    (b) $D^{2+}(g) \longrightarrow D^{3+}(g) + e^-$ ✓✓

        (1st mark for equation; 2nd mark for state symbols

        *'⁻' **not** required in e⁻ ; ignore wrong 'D' except if H or He used; X is acceptable*

                                                                                    [2]

    (c) Group 4 ✓

        Sharp rise in successive ionisation energy between 4th and 5th IE ✓

        marking a change to a new shell/energy level / there are 4 electrons in the outer shell✓

            mention of 'orbital' or 'sub-shell cancels the 'shell mark'

        Each marking point in (c) is independent

                                                                                    [3]

                                                                       [Total: 8 marks]

5. **Group 2**

atomic radii increases down group ✓

down group, electrons added to a new shell / more shells ✓

down group, **more** shielding ✓ : *'more' is essential*

increased nuclear charge outweighed / despite increased nuclear charge ✓

Period 3

atomic radii decrease across period ✓

number of protons/nuclear charge increases ✓

across period, electrons added to same shell / same or similar shielding ✓

nuclear attraction increases / shell drawn in by increased nuclear charge ✓

*watch for distinction between nuclear **attraction** and nuclear **charge** in candidates' scripts.*

[8]

Quality of Written Communication

At least **two** complete sentences that are legible and where the spelling, punctuation and grammar allow the meaning to be clear. ✓

[1]

[Total: 9 marks]