OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

CHEMISTRY 2811

Foundation Chemistry

Wednesday **29 MAY 2002** 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.

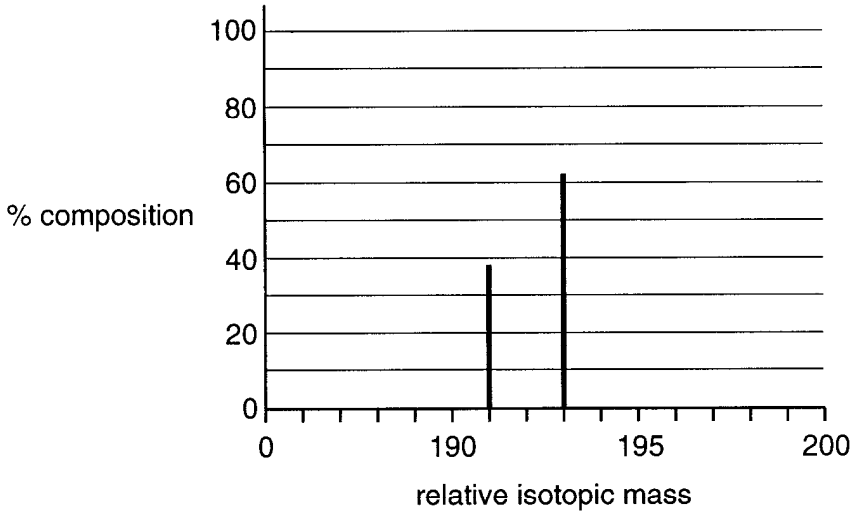
FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	13	
2	8	
3	14	
4	17	
5	8	
TOTAL	60	

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

Registered Charity Number: 1066969
[Turn over

Answer **all** questions

1 Iridium, atomic number 77, is a very dense metal. Scientists believe that meteorites have deposited virtually all the iridium present on Earth. A fragment of a meteorite was analysed using a mass spectrometer and a section of the mass spectrum showing the isotopes present in iridium is shown below.



(a) Explain the term *isotopes*.

.....

.....[1]

(b) Use the mass spectrum to help you complete the table below for each iridium isotope in the meteorite.

isotope	percentage composition	number of	
		protons	neutrons
^{191}Ir			
^{193}Ir			

[3]

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

.....

.....

.....

.....[3]

(ii) Calculate the relative atomic mass of the iridium in this meteorite. Give your answer to **one** decimal place.

[2]

(d) Iridium reacts with fluorine to form a yellow solid **Y** with the percentage composition by mass: Ir, 62.75%; F, 37.25%.

The empirical formula of **Y** can be calculated from this information.

(i) Define the term *empirical formula.*

.....

.....[1]

(ii) Calculate the empirical formula of **Y**.

[2]

(iii) Write a balanced equation for the reaction between iridium and fluorine.

.....[1]

[Total : 13]

2 This question concerns elements and compounds from Group 2 of the Periodic Table.

(a) State the trend in reactivity of the Group 2 elements with oxygen. Explain your answer.

trend in reactivity .....

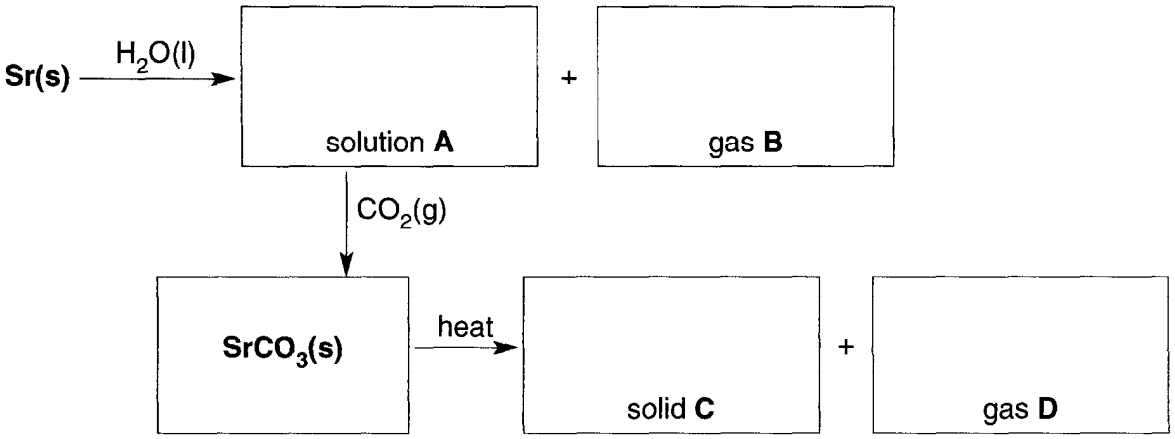
explanation .....

.....

.....

.....[4]

(b) The reactions of strontium are typical of a Group 2 element. Write the formulae for substances **A–D** in the flow chart below.



[4]

[Total : 8]

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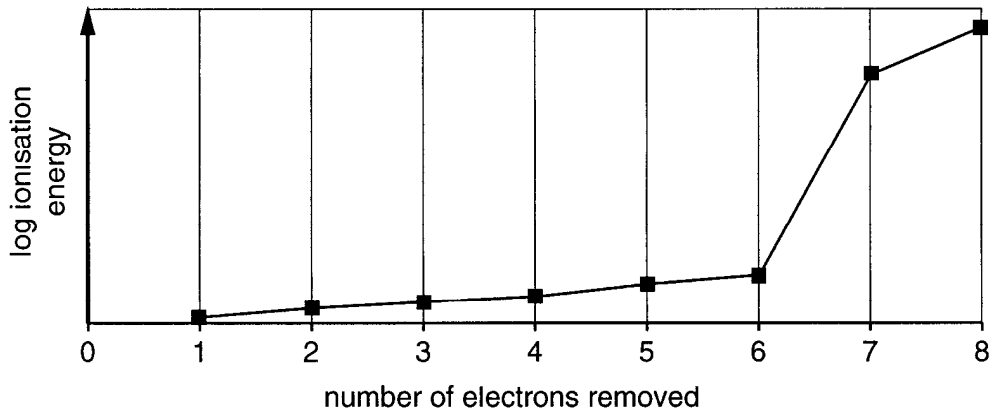
3 This question is about aluminium oxide, Al_2O_3.

(a) Successive ionisation energies provide evidence for the arrangement of electrons in atoms.
The graph below shows the 8 successive ionisation energies of **oxygen**.



(i) Write an equation, including state symbols, to represent the **second** ionisation energy of oxygen.

.....[2]

(ii) How does this graph provide evidence for the existence of two electron shells in oxygen?

.....

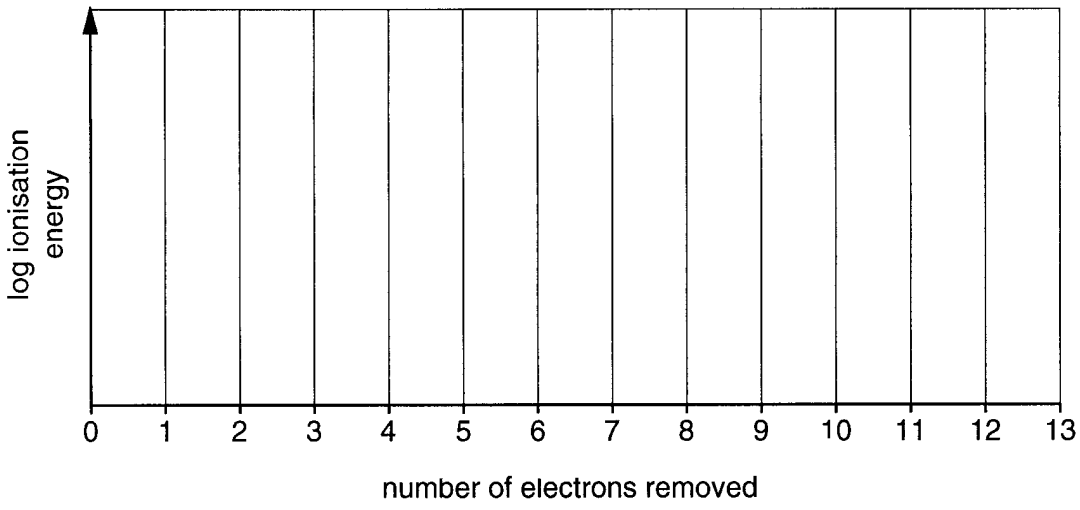
.....

.....[2]

(b) **(i)** Complete the electronic configuration for an **aluminium** atom.

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

(ii) On the axes below, sketch a graph to show the **thirteen** successive ionisation energies of aluminium. [2]



(c) Aluminium oxide can be formed by reacting together aluminium and oxygen.

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

.....[2]

(ii) The bonding in aluminium oxide is intermediate between ionic and covalent bonding. Explain why aluminium oxide has intermediate bonding.

.....

.....

.....

.....

.....[3]

(d) Gemstones such as rubies, sapphires and topaz mainly contain aluminium oxide. Artificial rubies can be made by heating aluminium oxide with very small traces of transition metal oxides and cooling slowly. The traces of these oxides give the rubies their colours.

Calculate how many moles of Al_2O_3 are needed to make a 25.0 g ruby.

Assume that all the mass of this ruby is aluminium oxide.

Answer ..... mol
[2]

[Total : 14]

4 A major use of chlorine is in the purification of drinking water. When chlorine is added to water, the following reaction takes place.

$$Cl_2(g) + H_2O(l) \longrightarrow HOCl(aq) + HCl(aq)$$

(a) Determine the oxidation number of chlorine in

HOCl, ...

HCl. .....[2]

(b) HOCl has covalently bonded molecules.

Draw a '*dot-and-cross*' diagram of a molecule of HOCl.

[2]

(c) **(i)** Outline how the electron pair repulsion theory can be used to predict the shape of a covalent molecule.

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.....

.....[3]

(ii) Using your answers to **(b)** and **(c)(i)**, draw a diagram to show the likely shape of a molecule of HOCl. Predict the bond angle in this molecule and show this clearly on your diagram.

[2]

(d) Chlorine, Cl_2, is a strong oxidising agent and oxidises aqueous iodide ions, $I^-(aq)$, to iodine, I_2.

(i) What is meant by the term *oxidation*?

.....

.....[1]

(ii) Suggest what you would expect to see when $Cl_2(g)$ is bubbled through a solution containing $I^-(aq)$.

.....[1]

(iii) Write a balanced **ionic** equation for the oxidation of $I^-(aq)$ by $Cl_2(g)$.

.....[1]

(e) Industrially, chlorine, $Cl_2(g)$, is prepared by passing an electric current through a concentrated solution of sodium chloride, NaCl, known as brine.

In this question, assume brine has a concentration of NaCl of 4.00 mol dm^{-3}.

(i) Calculate the mass of NaCl dissolved in 1.00 dm^3 of brine.

Answer ..... g
[2]

(ii) Calculate the volume of $Cl_2(g)$ obtained from 1.00 dm^3 of brine.

$$2NaCl(aq) + 2H_2O(l) \longrightarrow Cl_2(g) + 2NaOH(aq) + H_2(g)$$

Assume that 1 mole of $Cl_2(g)$ occupies 24.0 dm^3.

Answer ..... dm^3
[2]

(iii) Every day in the UK 2.5 x 10^9 dm^3 of $Cl_2(g)$ are produced for many uses, including water treatment and the manufacture of plastics.

Assuming that all Cl_2 is produced from brine, calculate the volume of brine required for Cl_2 production each day in the UK.

Assume that 1 mole of $Cl_2(g)$ occupies 24.0 dm^3.

Answer .....
[1]

[Total : 17]

5 Describe the nature of hydrogen bonding and explain **two** anomalous properties of water in terms of this bonding.

In this question, 1 mark is available for the quality of written communication.

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.....[7]

QWC [1]

[Total : 8]

RECOGNISING ACHIEVEMENT

Subject: Chemistry Foundation
Code: 2811

Session: June
Year: 2002

Final Mark Scheme

02/6/2002

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)** **(**Atoms of) the same element / with same protons.... with different masses/different numbers of neutrons ✓ [1]

(b)

isotope	percentage composition	number of	
		protons	neutrons
^{191}Ir	38%	77	114
^{193}Ir	62%	77	116
	✓	✓	✓

*Accept 37-39% for ^{191}Ir; 61-63% for ^{193}Ir but **must** add up to 100.*

[3]

(c) **(i)** average atomic mass/weighted mean/average mass ✓

compared with carbon-12 ✓

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

mass of 1 mole of element/mass of 1 mole of carbon-12 is equivalent to first two marks

"mass of the element that contains the same number of atoms as are in 1 mole of carbon-12" ⟶ 2 marks (mark lost because of mass units)

[3]

(ii) 38 x 191/100 + 62 x 193/100 ✓ = 192.2 ✓

Answers from other percentages above:

37 x 191/100 + 63 x 193/100 ✓ = 192.3 ✓

39 x 191/100 + 61 x 193/100 ✓ = 192.2 ✓

[2]

(d) **(i)** **Simplest (whole number) ratio** of atoms/moles/elements ✓

[1]

(ii) ratio Ir : F = 62.75/192 : 37.25/19 or 0.327 : 1.96 ✓

= 1 : 6 or formula = IrF_6 ✓

(or using answer for Ir from (c)(ii)) [2]

(iii) $Ir + 3F_2 \longrightarrow IrF_6$ ✓ *(consequential on response to (ii))*

[1]

[Total: 13]

2. **(a)** *trend in reactivity*: more reactive down group ✓

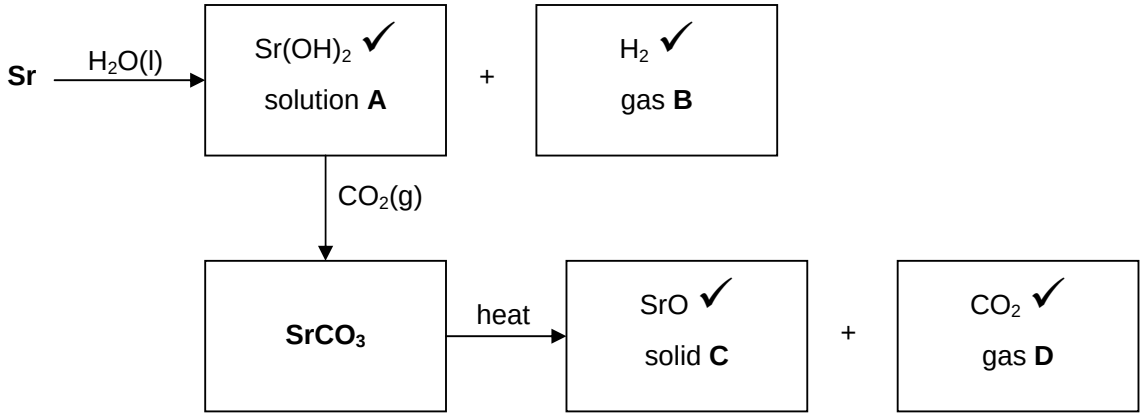
explanation: electrons lost more easily / ionisation energies decrease / less attraction or pull ✓

some attempt to relate this increase in size of atom / more shells / energy levels ✓

and **increase** in shielding ✓

[4]

(b)



[4]

[Total: 8]

3. (a) (i) $O^+(g) \longrightarrow O^{2+}(g) + e^-$ equation ✓;
state symbols **but** an electron must be in the equation somewhere ✓

[2]

(ii) Large difference between 6th and 7th ionisation energies ✓

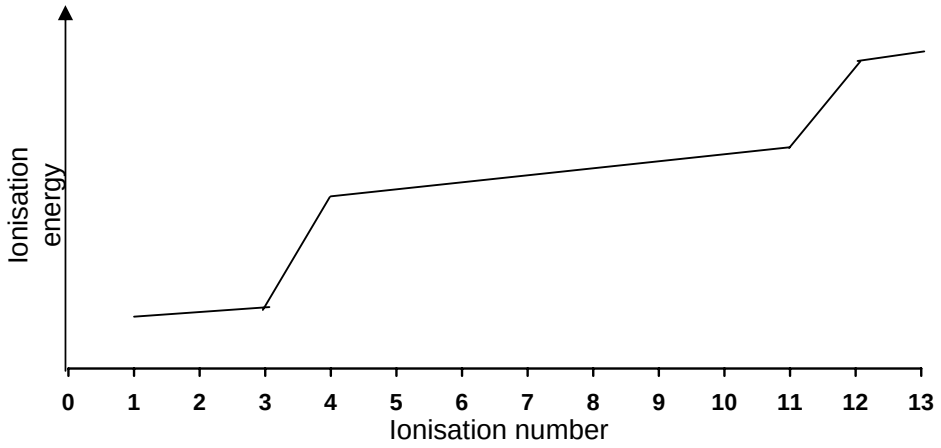
marks a different shell (closer to nucleus) ✓

[2]

(b) (i) $1s^2 2s^2 2p^6 3s^2 3p^1$ ✓

[1]

(ii)



sharp rise between ionisation 3 and ionisation 4 ✓

sharp rise between ionisation 11 and ionisation 12 ✓

i.e. the two steepest rises

(for 2,8,3 pattern the wrong way around, award 1 mark)

[2]

(c) (i) $4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$ equation ✓; state symbols ✓

[2]

(ii) Al^{3+} ions / highly charged aluminium ions ✓ are small ✓;
O^{2-} ions / anions / negative ions are large ✓;
O^{2-} ions / anions / negative ions are polarised / distorted ✓

4 ⟶ [3 max]

(d) $M(Al_2O_3) = 102$ g mol^{-1} ✓

amount of $Al_2O_3 = 25/102 = 0.2451 / 0.245 / 0.25$ ✓

[2]

[Total: 14]

4. **(a)** HOCl: +1 ✓ HCl: –1 ✓

[2]

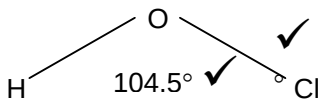
(b) covalent bonds shown correctly ✓
all molecule correct (i.e. chlorine's and oxygen's lone pairs) ✓

[2]

(c) **(i)** electron **pairs** repel ✓
as far apart as possible ✓
the number of electron pairs (surrounding central atom) decides the shape ✓
lone pairs repel more (than bonded pairs) ✓

4 ⟶ [3 max]

(ii)



✓ ✓ allow 104 – 105

[2]

(d) **(i)** loss of electrons / ox number increases / gains oxygen / loses hydrogen ✓

[1]

(ii) brown / orange / yellow colour ✓

[1]

(iii) $Cl_2 + 2I^- \longrightarrow 2Cl^- + I_2$ ✓

[1]

(e) **(i)** *Molar mass* of NaCl = 58.5 g mol^{-1} ✓
mass of NaCl dissolved = 58.5 x 4 g = 234 g ✓

[2]

(ii) 2 mol NaCl ⟶ 1 mol Cl_2

∴ amount of Cl_2 produced = 2 mol ✓ *(i.e. half 1st answer to (e)(i))*

volume of Cl_2 produced = 24 x 2 = 48 dm^3 ✓

[2]

(iii) 1 dm^3 brine ⟶ 48 dm^3 $Cl_2(g)$
2.5 x 10^9/48 dm^3 brine ⟶ 2.5 x 10^9 dm^3 $Cl_2(g)$
∴ 5.2 x 10^7 (dm^3) ✓ (but wrong unit is wrong!)

[1]

[Total: 17]

5. (a) diagram of H bonding between water molecules (O of 1 molecule to H of another) ✓

dipoles shown ✓ with lone pair involved in bond ✓

(could be in words; could describe another molecule such as NH_3.)

[3]

Two properties from:

property higher melting/boiling point than expected ✓

explanation strength of H bonds/H-bonds need to be broken ✓

must imply that intermolecular bonds are broken

property ice is lighter than water/ max density at 4°C ✓

explanation H bonds hold H_2O molecules apart

/ open lattice in ice

/ H-bonds are longer ✓

property high surface tension/viscosity ✓

explanation strength of H bonds/H-bonds need to be broken ✓

4 max ⟶ [4]

Q – legible text with accurate spelling, punctuation and grammar ✓

[1]

[Total: 8]