OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

CHEMISTRY 2811

Foundation Chemistry

Friday **9 JANUARY 2004** Morning 1 hour

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

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 provided 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	15	
3	11	
4	13	
5	9	
TOTAL	60	

This question paper consists of 12 printed pages.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 The Group 7 element bromine was discovered in 1826. Bromine gets its name from the Greek *brōmos* meaning stench because of its strong smell.

(a) Bromine consists of a mixture of two isotopes, ^{79}Br and ^{81}Br.

(i) What is the difference between the atomic structures of ^{79}Br and ^{81}Br?

.....

.....[2]

(ii) State **two** similarities between the atomic structures of ^{79}Br and ^{81}Br.

.....

.....[2]

(b) The electronic configuration of a bromine atom can be written in terms of sub-shells.

(i) Complete the electronic configuration of a bromine atom.

$1s^2 2s^2 2p^6 3s^2 3p^6$ .....[2]

(ii) Why is bromine classified as a p-block element?

.....

.....[1]

(c) Bromine forms three compounds with phosphorus. The compounds have the molecular formulae PBr_3, PBr_5 and P_2Br_4.

(i) Explain what is meant by the term *molecular formula*.

.....

.....[1]

(ii) PBr_3 can be prepared by heating bromine with phosphorus, P_4.

Write a balanced equation for this reaction.

.....[1]

(iii) Compound **A** is one of the three bromides of phosphorus above. It has the following percentage composition by mass: P, 16.2%; Br, 83.8%.

Use this percentage composition to calculate the empirical formula and to determine the identity of compound **A**.

empirical formula .....

identity of compound **A** .....
[3]

[Total: 12]

[Turn over

2 Water and carbon dioxide both consist of covalent molecules.

(a) State what is meant by a *covalent* bond.

.....

.....[2]

(b) Draw '*dot-and-cross*' diagrams for a molecule of water and a molecule of carbon dioxide. Show outer electron shells only.

water	carbon dioxide

[3]

(c) The shape of a water molecule is different from the shape of a carbon dioxide molecule.

(i) Draw the shapes of these molecules and state the bond angles.

water	carbon dioxide
bond angle in water = ...	bond angle in carbon dioxide = ...

[4]

(ii) Explain why a water molecule has a different shape from a carbon dioxide molecule.

.....

.....

.....

.....[2]

(d) An understanding of electronegativity helps to explain why some covalent bonds are polar.

(i) Define the term *electronegativity*.

.....

.....

.....[2]

(ii) Water and carbon dioxide both have polar bonds. Explain why water has polar molecules but carbon dioxide has non-polar molecules.

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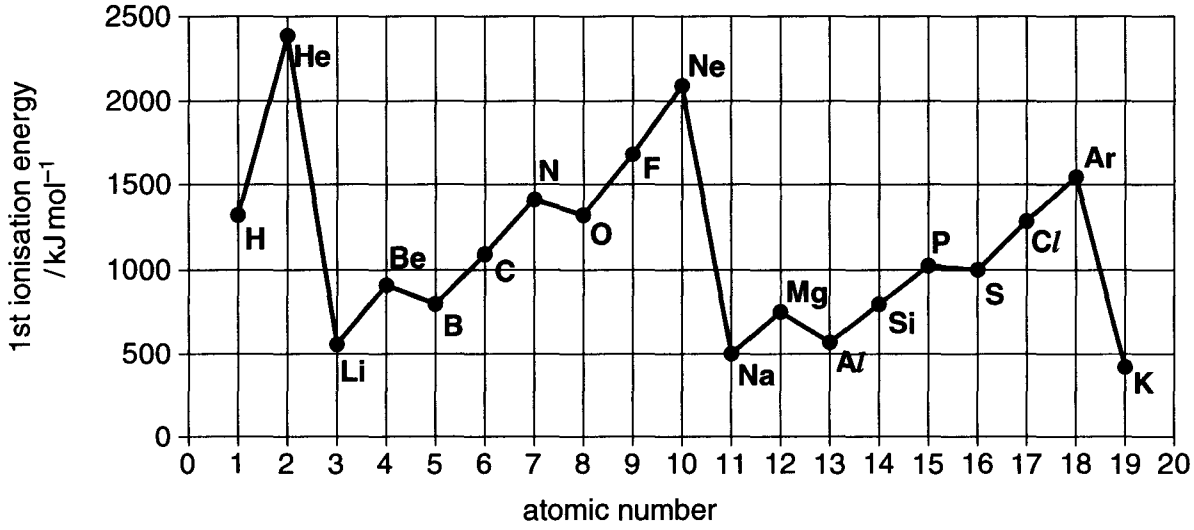
.....[2]

[Total: 15]

3 The first ionisation energies of the elements H to K are shown below. Use this diagram to help with your answers to this question.



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

.....

.....

.....

.....[3]

(b) Explain why the first ionisation energies show a **general** increase across Period 2 (Li to Ne).

.....

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.....[2]

(c) Explain why the first ionisation energy of O is **less** than that of N.

.....

.....

.....[2]

(d) State and explain the trend in first ionisation energies shown by the elements with the atomic numbers 2, 10 and 18.

.....

.....

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.....

.....

.....[4]

[Total: 11]

4 The Group 2 metal strontium, Sr, is very reactive.

(a) Strontium metal is stored under oil and, when exposed to air, the shiny surface of the strontium becomes dull.

Predict, with an equation, what reaction takes place when strontium is exposed to air.

.....

.....

.....[2]

(b) The reaction of strontium with water is a redox reaction. A student reacted 0.438 g of strontium with 200 cm^3 of water.

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

(i) Use oxidation numbers to show that strontium has been oxidised in this reaction.

.....

.....

.....[2]

(ii) Calculate how many moles of Sr were reacted.

A_r: Sr, 87.6

answer ..... mol [1]

(iii) Calculate the volume, in dm^3, of $H_2(g)$ produced. You can assume that, under the experimental conditions, 1.00 mol of $H_2(g)$ has a volume of 24.0 dm^3.

answer ..... dm^3 [1]

(iv) Calculate the concentration, in mol dm^{-3}, of the $Sr(OH)_2$ produced.

answer ..... mol dm^{-3} [1]

(c) An ore of strontium contains strontium carbonate, $SrCO_3$.

To obtain metallic strontium,

- the $SrCO_3$ is converted into strontium oxide, SrO;
- SrO is then reduced to produce strontium.

(i) Suggest how strontium carbonate is converted into strontium oxide.

.....[1]

(ii) Aluminium can be used to reduce strontium oxide.

Balance the equation below for this conversion.

..... SrO(s) + ... Al(s) $\longrightarrow$ ..... Sr(s) + ... Al_2O_3(s) [1]

(iii) A chemical company receives an order to supply 100 tonnes of strontium. The company needs to work out how much ore to process.

The ore typically contains 2% by mass of $SrCO_3$.

Calculate the mass of ore that the company would need in order to produce 100 tonnes of strontium.

1 tonne = 10^6 g

[3]

(iv) Suggest how the company could minimise the environmental impact of strontium production from the ore.

.....

.....[1]

[Total: 13]

[Turn over

For Examiner's Use

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

This question is about the Group 7 elements chlorine, bromine and iodine.

- Explain why chlorine, bromine and iodine have different physical states at room temperature and pressure. [4]
- An aqueous solution of bromine was added to an aqueous solution of chloride ions and also to an aqueous solution of iodide ions.

  State what you would see in each case.

  Include an equation for any chemical reaction that takes place.

  Explain the trend shown by these observations. [4]

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Quality of Written Communication [1]

[Total: 9]

RECOGNISING ACHIEVEMENT

Subject: Foundation Chemistry Code: 2811

Session: January Year: 2004

Mark Scheme

FINAL VERSION

MAXIMUM MARK	60

ADVICE TO EXAMINERS ON THE ANNOTATION OF SCRIPTS

1. Please ensure that you use the **final** version of the Mark Scheme.
   You are advised to destroy all draft versions.

2. Please mark all post-standardisation scripts in red ink. A tick (✓) should be used for each answer judged worthy of a mark. Ticks should be placed as close as possible to the point in the answer where the mark has been awarded. The number of ticks should be the same as the number of marks awarded. If two (or more) responses are required for one mark, use only one tick. Half marks (½) should never be used.

3. The following annotations may be used when marking. No comments should be written on scripts unless they relate directly to the mark scheme. Remember that scripts may be returned to Centres.

   x = incorrect response (errors may also be underlined)
   ^ = omission mark
   bod = benefit of the doubt (where professional judgement has been used)
   ecf = error carried forward (in consequential marking)
   con = contradiction (in cases where candidates contradict themselves in the same response)
   sf = error in the number of significant figures

4. The marks awarded for each part question should be indicated in the margin provided on the right hand side of the page. The mark total for each question should be ringed at the end of the question, on the right hand side. These totals should be added up to give the final total on the front of the paper.

5. In cases where candidates are required to give a specific number of answers, (e.g. 'give three reasons'), mark the first answer(s) given up to the total number required. Strike through the remainder. In specific cases where this rule cannot be applied, the exact procedure to be used is given in the mark scheme.

6. Correct answers to calculations should gain full credit even if no working is shown, unless otherwise indicated in the mark scheme. (An instruction on the paper to 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)

7. Strike through all blank spaces and/or pages in order to give a clear indication that the whole of the script has been considered.

8. An element of professional judgement is required in the marking of any written paper, and candidates may not use the exact words that appear in the mark scheme. If the science is correct and answers the question, then the mark(s) should normally be credited. If you are in doubt about the validity of any answer, contact your Team Leader/Principal Examiner for guidance.

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				
Question			**Expected Answers**		**Marks**
1	**(a)**	**(i)**	^{79}Br has two ✓ less neutrons than ^{81}Br ✓		**[2]**
		(ii)	^{79}Br and ^{81}Br have same number of protons ✓ and same number of electrons ✓		**[2]**
	(b)	**(i)**	$1s^2 2s^2 2p^6 3s^2 3p^6 \ldots\ldots 3d^{10} 4s^2 4p^5$ ✓✓ Award 1 mark for p^5.		**[2]**
		(ii)	Highest energy sub-shell/sub-shell/ being filled is the p sub-shell/outer electrons are in a p (sub-shell/orbital/shell) ✓		**[1]**
	(c)	**(i)**	Number **AND** type of atoms (making up a molecule)/number of atoms of each element ✓ ***Not** ratio*		**[1]**
		(ii)	$P_4 + 6\ Br_2 \longrightarrow 4\ PBr_3$ ✓		**[1]**
		(iii)	ratio P : Br = 16.2/31 : 83.8/79.9 /= 0.52 : 1.05 /= 1 : 2 ✓ Empirical formula = PBr_2 ✓ Correct compound = P_2Br_4 /phosphorus(II) bromide but **not** PBr_2 ✓		**[3]**
					Total: 12

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Question	**Expected Answers**	**Marks**
2 (a)	shared pair ✓ of electrons ✓ *i.e. 'shared electrons' is worth 1 mark. pair of electrons for second marks*	**[2]**
(b)	H_2O: all correct including lone pairs around O ✓ CO_2: correct covalent bonds around carbon ✓ lone pairs added around oxygen atoms ✓ (must be 'dot AND cross' or electron source clearly shown (different coloured for source is OK)	**[3]**
(c) (i)	molecule shown as non-linear ✓ angle: 104 - 105° ✓ molecule shown as linear ✓	**[4]**
(ii)	angle: 180° ✓ shape of H_2O shape of CO_2 Electron pairs repel / groups (or regions) of electrons repel/ electron pairs get as far apart as possible ✓ Oxygen in water surrounded by 4 areas of electron density/2 bonds and 2 lone pairs **AND** Carbon in CO_2 surrounded by 2 regions of electron density/2 double bonds ✓	**[2]**
(d) (i)	Attraction of electrons ✓ in a bond ✓ towards an atom	**[2]**
(ii)	CO_2 is symmetrical/H_2O is not symmetrical ✓ In CO_2, dipoles cancel/in H_2O, the dipoles don't cancel ✓	**[2]**
		Total: 15

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Question	**Expected Answers**	**Marks**
3 (a)	Energy change when each atom in 1 mole ✓ of gaseous atoms ✓ loses an electron ✓ (to form 1 mole of gaseous 1+ ions).	**[3]**
(b)	increasing nuclear charge/number of protons ✓ electrons experience greater attraction or *pull* / atomic radius decreases / electrons added to same shell /same or similar shielding ✓	**[2]**
(c)	N has an single electron in each p orbital/ O has a paired p orbital ✓ in O, this pairing leads to repulsion/higher energy level ✓	**[2]**
(d)	(From 2 ⟶ 10 ⟶ 18 / down group) 1st ionisation energies decrease/easier to remove electrons ✓ electron is further from nucleus/ atomic radius increases/ electron in a different shell/ atoms increase in size ✓ (***not*** *sub-shell or orbital*) electron experiences **more** shielding ✓ (***more*** *is essential here*) distance and shielding outweigh the increased nuclear charge ✓ ***NOT: attraction/pull; effective nuclear charge***	**[4]**
		Total: 11

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Question	**Expected Answers**	**Marks**
4 (a)	Strontium reacts with oxygen/strontium oxide forms/SrO forms ✓ $2Sr + O_2 \longrightarrow 2SrO$ / $Sr + {}^1/_2 O_2 \longrightarrow SrO$ ✓	**[2]**
(b) (i)	In Sr, oxidation number = 0 ✓ In $Sr(OH)_2$, oxidation number = (+)2 ✓ OR Oxidation number increases from $Sr \longrightarrow Sr(OH)_2$ ✓ by 2 ✓	**[2]**
(ii)	0.438/87.6 = 5.00×10^{-3} / 0.00500 mol ✓	**[1]**
(iii)	0.00500 x 24.0 = 0.120 dm^3 ✓ (accept 120 cm^3)	**[1]**
(iv)	0.00500 x 1000/200 = 0.0250 mol dm^{-3} ✓	**[1]**
(c) (i)	heat ✓	**[1]**
(ii)	...3..SrO(s) + ...2..Al(s) $\longrightarrow$ ...3..Sr(s) + ...Al_2O_3(s) ✓	**[1]**
(iii)	Molar mass of $SrCO_3$ = 87.6 + 12 + 16x3 = 147.6 g mol^{-1} ✓ Mass $SrCO_3$ required = 100 x 147.6/87.6 = 168 tonnes ✓ Mass of ore needed = mass $SrCO_3$ x 100/2 = 168 x 100/2 = 8400 tonnes / 8425 tonnes *(from 168.484931507)* ✓ *(answer depends on rounding)* *5000 tonnes is 50 x 100 tonnes: worth 1 mark*	**[3]**
(iv)	98% waste produced which must be disposing of /made into something worthwhile / CO_2 being removed by something sensible/ any sensible comment ✓	**[1]**
		Total: 14

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	
Question	**Expected Answers**	**Marks**
5	***Physical states of halogens*** chlorine gas; bromine liquid; iodine solid/ boiling point increases from $Cl_2 \longrightarrow Br_2 \longrightarrow I_2$ ✓ number of electrons/number of shells increases down group ✓ van der Waals' forces/ induced dipole-dipole interactions/ AW ✓ stronger forces to be broken (between the molecules) ✓ ***Displacement*** with chloride, nothing happens ✓ with iodide, $\longrightarrow$ darker orange/brown/darker yellow /$\longrightarrow$ purple with organic solvent ✓ $Br_2 + 2I^- \longrightarrow I_2 + 2Br^-$ ✓ (or a full equation, e.g. with NaI) The strength of oxidising power is $Cl_2 > Br_2 > I_2$ / Reactivity order is $Cl_2 > Br_2 > I_2$ ✓ ***Quality of written communication*** • organise relevant information clearly and coherently, using specialist vocabulary when appropriate; **Evidence should link together two of the marking points:** e.g. size of the intermolecular forces linked to temperature at which a substance changes state / number of electrons linked to magnitude of intermolecular forces /amount of energy needed to overcome forces order of reactivity linked to observation ✓ The key is a 'because' or 'therefore': i.e bromine doesn't displace chlorine because it is less reactive. Greater intermolecular forces: therefore more energy needed to break them.	**[4]** **[4]** **[1]**
		Total: 9