OCR

RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

2815/01

Trends and Patterns

Tuesday **28 JUNE 2005** 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	16	
2	17	
3	12	
TOTAL	45	

For Examiner's Use

Answer **all** the questions.

1 The question below relates to chlorides of some of the elements in Period 3 of the Periodic Table.

(a) Draw '*dot and cross*' diagrams to show the bonding in magnesium chloride and silicon(IV) chloride. Only draw the outer shell electrons.

[3]

(b) Describe the difference in behaviour when magnesium chloride and silicon(IV) chloride are added separately to cold water.

You may include in your answer

- the pH of any resulting solution,
- relevant chemical equations,
- experimental observations,
- the name of the process taking place.

[6]

(c) The melting point of magnesium chloride is much higher than that of silicon(IV) chloride.

Explain this difference in terms of structure and bonding.

[3]

(d) Hot aluminium reacts with dry chlorine to give a white compound which has a relative molecular mass of 267.

(i) Deduce the molecular formula for the white compound.

answer ..... [1]

(ii) Write an equation for the reaction between aluminium and dry chlorine.

..... [1]

(iii) Explain why solid aluminium chloride does not conduct electricity, but when aluminium chloride is added to water, the resulting solution will conduct electricity.

..... [1]

(e) Phosphorus reacts with excess chlorine to form a compound with an empirical formula PCl_5. The solid compound has positive and negative ions.

The positive ion has the formula PCl_4^+.

The formula of the negative ion includes one phosphorus atom.

Suggest the formula of the negative ion.

..... [1]

[Total: 16]

2 The carbonates and nitrates of Group 2 elements decompose when heated.

(a) Calcium oxide is manufactured by the decomposition of calcium carbonate.

(i) Write the equation for this decomposition.

[1]

(ii) Explain why the decomposition temperature of calcium carbonate is much lower than that of barium carbonate.

_____

_____

_____ [2]

(b) Barium nitrate decomposes when heated to make barium oxide, nitrogen dioxide and oxygen.

$$2Ba(NO_3)_2(s) \longrightarrow 2BaO(s) + 4NO_2(g) + O_2(g) \qquad \textbf{Equation 2.1}$$

(i) Use oxidation states to explain why this decomposition reaction involves both oxidation **and** reduction.

.....

.....

.....

..... [3]

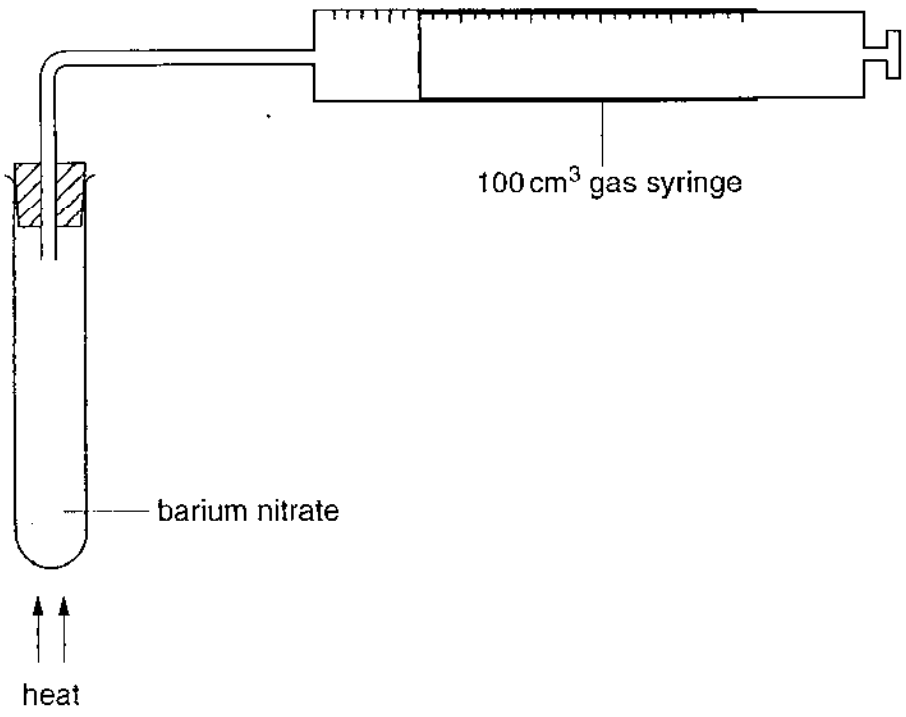
(ii) Calculate the enthalpy change of reaction, ΔH_r, in kJ mol^{-1}, for the thermal decomposition of barium nitrate using the enthalpy changes of formation, ΔH_f, given in the table.

compound	ΔH_f / kJ mol^{-1}
$Ba(NO_3)_2(s)$	−992
$BaO(s)$	−558
$NO_2(g)$	+33

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

(c) A student investigates the volume of gas formed when barium nitrate is heated.

The diagram shows the apparatus the student uses.



(i) A 1.31 g sample of barium nitrate is completely decomposed.

Use **Equation 2.1** to calculate the volume, in cm^3, of gas formed at room temperature and pressure.

1 mol of gas molecules occupies 24 000 cm^3 at room temperature and pressure.

answer ..... cm^3 [3]

(ii) Suggest **one** problem that the student may encounter when carrying out the investigation.

.....

..... [1]

(d) Barium nitrate has a higher decomposition temperature than calcium nitrate. One of the reasons for this is the difference between the lattice enthalpy of barium oxide and that of calcium oxide.

(i) Explain what is meant by the term *lattice enthalpy*.

.....

.....

..... [2]

(ii) Explain why the lattice enthalpy of barium oxide is much **less exothermic** than that of calcium oxide.

.....

.....

.....

..... [2]

[Total: 17]

For Examiner's Use

3 In this question, one mark is available for the quality of use and organisation of scientific terms.

Copper and iron are typical transition elements. One of the characteristic properties of a transition element is that it can form complex ions.

- Explain in terms of electronic configuration why copper is a transition element.
- Give an example of a complex ion that contains copper. Draw the three dimensional shape of the ion and describe the bonding within this complex ion.
- Transition elements show typical metallic properties. Describe **three other** typical properties of transition elements. Illustrate each property using copper or iron or their compounds.

For Examiner's Use

[11]

Quality of Written Communication [1]

[Total: 12]

END OF QUESTION PAPER

Mark Scheme 2815/01
June 2005

Mark Scheme Page 1 of 6	Unit Code 2815/01	Session June	Year 2005	Version Final Post-Standardisation

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	Additional guidance
1 (a)	Correct electronic structures magnesium either 8 electrons in outer shell or none and **both** chloride ions with 8 electrons in the outer shell (1); Correct charge on the ions, Mg^{2+} and Cl^- (1); Correct 'dot-and-cross' diagram for $SiCl_4$ with four covalent Si—Cl bonds and all lone pairs for chlorine (1)	3	
(b)	$MgCl_2$ dissolves / dissociates / ionises / forms a colourless solution / equation showing dissociation (1); With a pH of (almost) 7 (1); $SiCl_4$ is hydrolysed / reacts with water (1); to give a white precipitate / steamy fumes / white fumes / misty fumes (1); and a pH of 3 or below (1); $SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$ (1)	6	**Not** $MgCl_2$ fizzes or forms a white ppt **Allow** for $MgCl_2$ any pH between 6 and 7 **Ignore** state symbols in the equation **Allow** $Si(OH)_2Cl_2$ or $Si(OH)_4$ in the equation
(c)	$MgCl_2$ is giant ionic and $SiCl_4$ is a simple molecule (1) $MgCl_2$ – (Electrostatic) attraction between **ions** / attraction between (positive and negative) **ions** / aw (1); $SiCl_4$ - intermolecular attraction / van der Waals forces of attraction (1); Force of attraction in $MgCl_2$ is **stronger** than in $SiCl_4$ / ora (1)	3	The comparison of the strengths of forces/bonding must refer to the correct type of bonding e.g. strong ionic bonding and weak van der Waals (1) **Not** ionic bonds are stronger than covalent bonds

Mark Scheme Page 2 of 6	Unit Code 2815/01	Session June	Year 2005	Version Final Post-Standardisation

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	Additional guidance
1 (d) (i)	Al_2Cl_6 (1)	1	
(ii)	$2Al + 3Cl_2 \rightarrow Al_2Cl_6$ (1)	1	**Allow** any correct multiple of equation **Allow** ecf from wrong formula in (i)
(iii)	(Solid aluminium chloride is covalent but) in solution has **ions** that can **move** / (solid aluminium chloride has no ions but) in solution **ions** can **move** (1)	1	**Not** ions cannot move in solid **Not** reference to ionic solid
(e)	PCl_6^- (1)	1	
		Total = 16	

Mark Scheme Page 3 of 6	Unit Code 2815/01	Session June	Year 2005	Version Final Post-Standardisation

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	Additional guidance
2 (a) (i)	$CaCO_3 \rightarrow CaO + CO_2$ (1)	1	**Ignore** state symbols
(ii)	Calcium ion has a larger charge density than barium ion / Ca^{2+} has a smaller ionic radius than Ba^{2+} / ora (1); So calcium ion polarises the carbonate (ion) **more** than the barium ion / so Ca^{2+} distorts the CO_3^{2-} **more** than Ba^{2+} / ora (1)	2	Particles referred to must be correct **Not** Ca has a higher charge density **Not** calcium has a higher charge density **Allow** calcium has a smaller ionic radius **Allow** correct description of **more** polarisation **Allow** CO_3 **Not** Ca^{2+} polarises CO_3
(b) (i)	Oxidation state of nitrogen goes from +5 to +4 (1); Oxidation state of oxygen goes from -2 to 0 (1); Correct linking of changes of oxidation state with reduction **and** with oxidation (1)	3	If oxidation state of barium given is incorrect **max 1** for the oxidation numbers. **Allow** ecf from wrong oxidation states for the correct linking mark **Both** oxidation **and** reduction needed
(ii)	Correct use of molar ratios (1); Correct cycle (1); (+)1000 (kJ mol^{-1}) (1)	3	**Award** full marks for (+) 1000 (kJ mol^{-1}) **Only allow** ecf for final lattice energy answer from a correct cycle **Allow** -1000 (1) + 467 (1) + +155

Mark Scheme Page 4 of 6	Unit Code 2815/01	Session June	Year 2005	Version Final Post-Standardisation

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	Additional guidance
2 (c) (i)	Moles of $Ba(NO_3)_2$ = 0.005 or 0.00502 (1); Moles of gas made = 0.0125 / 0.0126 (1); Volume of gas = 300 cm^3 to 302 cm^3 (1)	3	**Allow** ecf within question **Ignore** significant figures
(ii)	Decomposition temperature may be too high / too much gas will be produced / to fill a gas syringe need a smaller amount of solid / gas syringe too small (1)	1	**Allow** NO_2 is toxic / barium compounds are toxic Answer is **consequential** on answer to (i)
(d) (i)	Enthalpy change when one mole of a solid / energy released when one mole of solid (1); Is made from its gaseous ions (1)	2	**Not** energy required **Allow** marks via an equation **Allow** ionic compound / crystals instead of solid
(ii)	Calcium (ion) has a higher charge density / smaller (ionic) radius / ora (1); So it is **more** strongly attracted to the oxide (ion) / ora (1)	2	**Allow** calcium oxide has stronger ionic bond / ora
		Total = 17	

Mark Scheme Page 5 of 6	Unit Code 2815/01	Session June	Year 2005	Version Final Post-Standardisation

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	Additional guidance
3		11	
	Transition element Cu^{2+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$ (1); Transition elements have one oxidation state that has an incomplete set of 3d electrons / have one ion with a half-filled 3d orbital (1)		**Allow** has at least one half-filled d orbital / partially filled 3d sub-shell
	Complex ion Example of a **copper** complex ion e.g. $[Cu(H_2O)_6]^{2+}$ or $CuCl_4^{2-}$ (1); Diagram of the copper complex showing three dimensions e.g. use of wedges or dotted lines (1); Correct bond angle to match the complex / correct name of the shape of the complex (1);		If a copper complex that does not exist is used then first three marks not available If a correct iron complex is given then example mark cannot be awarded **Allow** square planar where appropriate
	Ligand is an electron **pair** donor (1); Copper(II) ion is an electron **pair** acceptor (1); Dative bond exists between ligand and the copper(II) ion (1)		Electron pair donor, electron pair acceptor and dative bond marks can awarded from an appropriate diagram
	Properties Several oxidation states e.g. copper has +1 and +2 or iron has +2 and +3 (1);		Ignore copper has a +3 Ignore iron has a +6 oxidation state
	Forms coloured compounds e.g. copper(II) chloride is green or iron(II) sulphate is pale green (1); Element or compound has catalytic properties e.g. Iron is a catalyst in the Haber process (1)		

Mark Scheme Page 6 of 6	Unit Code 2815/01	Session June	Year 2005	Version Final Post-Standardisation
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	Additional guidance
3	**Quality of written communication** Use of technical terms – at least three terms from the following list are used in the correct context • ligand • dative bond • coordinate bond • tetrahedral • square planar • octahedral • oxidation (state) • catalyst • electron pair • lone pair • orbital • sub-shell (1)	1	Put a ring around the technical terms
		Total = 12	