OCR

RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY

Trends and Patterns

2815/01

Wednesday **25 JANUARY 2006** Afternoon 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 blue or black ink, in the spaces provided on the question paper.
- Pencil may be used for diagrams and graphs **only**.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do not write in the bar code. Do not write in the grey area between the pages.
- **DO NOT** WRITE IN THE AREA **OUTSIDE** THE BOX BORDERING EACH PAGE. ANY WRITING IN THIS AREA WILL NOT BE MARKED.

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	9	
2	8	
3	7	
4	8	
5	13	
TOTAL	45	

This question paper consists of 8 printed pages.

SPA (KN) S97889/2

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[Turn over

Answer **all** the questions.

1 All the carbonates of the elements in Group 2 thermally decompose to form oxides.

(a) Write the equation, including state symbols, for the thermal decomposition of magnesium carbonate.

.....[2]

(b) What is the trend in the ease of thermal decomposition of Group 2 carbonates?

.....

.....**(1)**

(c) Arrange the following compounds in order of their lattice enthalpy. Put the **most** exothermic first.

barium carbonate
barium oxide
magnesium oxide

.....

Explain your answer.

.....

.....

.....

.....[4]

(d) Aluminium carbonate does not exist at room temperature.
Suggest why in terms of polarisation.

.....

.....

.....

.....[2]

[Total: 9]

2 One of the largest uses of phosphorus is in boxes of safety matches. A safety match ignites when it is rubbed against the striking surface of the match box.

The friction between the match head and the striking surface generates enough heat for the phosphorus to burn. This in turn provides enough energy for the decomposition of potassium chlorate(V), $KClO_3$, on the match head.

$$2KClO_3(s) \longrightarrow 2KCl(s) + 3O_2(g)$$

Sulphur on the match stick ignites and sufficient heat is generated to ignite paraffin wax and then the wood in the match.

(a) When the phosphorus burns, phosphorus(V) oxide forms. What is the formula of phosphorus(V) oxide?

.....[1]

(b) Calculate the volume of oxygen, measured at room temperature and pressure, that forms when 0.368 g of potassium chlorate(V) is decomposed.
One mole of any gas occupies 24 000 cm^3 at room temperature and pressure.

volume .....[3]

(c) Suggest why the match head contains potassium chlorate(V).

.....

.....[1]

(d) Write the equation for the reaction between sulphur and oxygen.

.....[1]

(e) Phosphorus(V) oxide is a simple molecular oxide.

(i) Suggest a physical property of phosphorus(V) oxide.

.....[1]

(ii) Suggest a chemical property of phosphorus(V) oxide.

.....[1]

[Total: 8]

3 The compound $FeSO_4.7H_2O$ can be used to kill moss in grass. Iron(II) ions in a solution of $FeSO_4.7H_2O$ are slowly oxidised to form iron(III) ions.

(a) Describe a test to show the presence of iron(III) ions in a solution of $FeSO_4.7H_2O$.

.....

.....[1]

(b) The percentage purity of an impure sample of $FeSO_4.7H_2O$ can be determined by titration against potassium dichromate(VI), $K_2Cr_2O_7$, under acid conditions, using a suitable indicator.

During the titration, $Fe^{2+}(aq)$ ions are oxidised to $Fe^{3+}(aq)$ ions.

- Stage 1 – A sample of known mass of the impure $FeSO_4.7H_2O$ is added to a **concial** flask.
- Stage 2 – The sample is dissolved in an excess of dilute sulphuric acid.
- Stage 3 - The contents of the flask are titrated against $K_2Cr_2O_7(aq)$.

(i) The reduction half equation for acidified dichromate(VI) ions, $Cr_2O_7^{2-}$, is as follows.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \longrightarrow 2Cr^{3+}(aq) + 7H_2O(l)$$

Construct the balanced equation for the redox reaction between $Fe^{2+}(aq)$, $Cr_2O_7^{2-}(aq)$ and $H^+(aq)$.

.....

.....

.....[2]

(ii) In Stage 1, a student uses a 0.655 g sample of impure $FeSO_4.7H_2O$.

In Stage 3, the student uses 19.6 cm^3 of 0.0180 mol dm^{-3} $Cr_2O_7^{2-}$ to reach the end-point.

One mole of $Cr_2O_7^{2-}$ reacts with 6 moles of Fe^{2+}.

Calculate the percentage purity of the impure sample of $FeSO_4.7H_2O$.

percentage purity ..... [4]

[Total: 7]

4 Dilute aqueous copper(II) sulphate contains $[Cu(H_2O)_6]^{2+}$ ions.

(a) Concentrated hydrochloric acid is added drop by drop to a small volume of dilute aqueous copper(II) sulphate. The equation for the reaction taking place is as follows.

$$[Cu(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \longrightarrow [CuCl_4]^{2-}(aq) + 6H_2O(l)$$

(i) Describe the observations that would be made during the addition of the concentrated hydrochloric acid.

.....[1]

(ii) Describe the bonding within the complex ion, $[CuCl_4]^{2-}$.

.....

.....

.....[2]

(b) Concentrated aqueous ammonia is added drop by drop to aqueous copper(II) sulphate until present in excess. Two reactions take place, one after the other, to produce the complex ion $[Cu(NH_3)_4(H_2O)_2]^{2+}(aq)$.

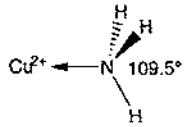
Describe the observations that would be made during the addition of concentrated aqueous ammonia.

.....

.....

.....[2]

(c) Ammonia is a simple molecule. The H—N—H bond angle in an isolated ammonia molecule is 107°.
The diagram shows part of the $[Cu(NH_3)_4(H_2O)_2]^{2+}$ ion and the H—N—H bond angle in the ammonia ligand.



Explain why the H—N—H bond angle in the ammonia ligand is 109.5° rather than 107°.

.....

.....

.....

.....[3]

[Total: 8]

5 In this question, one mark is available for the quality of spelling, punctuation and grammar.

The elements sodium, aluminium and phosphorus react with chlorine to form chlorides. The action of water on these chlorides is related to their structure and bonding.

Using only the elements sodium, aluminium and phosphorus,

- describe, with the aid of equations, the reactions of **two** of these elements with chlorine and use **one** of the reactions to explain what is meant by a redox reaction;
- describe and explain the action of water on the chlorides of sodium, aluminium and phosphorus.

Question	Expected answers	Marks	Additional guidance
1 (a)	$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$ Equation (1); State symbols (1)	2	State symbols mark dependent on correct formulae
(b)	Decreases down the group / decomposition temperature increases down the group / ora (1)	1	
(c)	Magnesium oxide, barium oxide and barium carbonate (1); Magnesium ion has a smaller ionic radius than barium ion / magnesium ion has a larger charge density than barium ion / ora (1); Oxide ion has a smaller ionic radius than carbonate ion / oxide ion has a higher charge density than a carbonate ion / ora (1); Link between stronger attraction between ions and the smaller ionic radii / link between stronger attraction between ions and higher charge density / ora (1)	4	**Allow** use of correct formulae for ions **Not** oxygen is smaller than carbonate **Not** Mg is smaller than Ba **Not** Mg^{2+} has a smaller atomic radius
(d)	**Any two from** Aluminium ion is very small / aluminium ion is highly charged / aluminium ion has a large charge density (1); Aluminium ion is highly polarising (1); So aluminium ion polarises the electron cloud around carbonate ion (very easily) / aluminium ion distorts the electron cloud around carbonate ion (very easily) (1)	2	**Allow** mention of Al^{3+} **Allow** lattice enthalpy of aluminium oxide is extremely exothermic (1) and this drives the reaction to the right hand side (1)
		Total = 9	
2 (a)	P_2O_5 / P_4O_{10} (1)	1	
(b)	M_r of $KClO_3$ = 122.5 Moles of $KClO_3$ = 3.00×10^{-3} (1); Moles of oxygen = 4.50×10^{-3} (1); Volume of oxygen = 108 cm^3 / 0.108 dm^3 (1)	3	**Allow** ecf from wrong moles of $KClO_3$ **Allow** ecf from wrong number of moles of oxygen **Unit essential** for full marks
(c)	Provides oxygen / as an oxidant / aw (1)	1	
(d)	$S + O_2 \rightarrow SO_2$ (1)	1	
(e) (i)	Does not conduct electricity / low melting point / low boiling point (1)	1	
(ii)	Acidic oxide / reacts with bases / forms an acid with water (1)	1	**Allow** gives a pH value less than 7
		Total = 8	

3	(a)		Add (aqueous) sodium hydroxide which will give a brown/rusty ppt (1)	1	**Allow solid for precipitate or (s) in equation Allow Use aqueous thiocyanate ions which gives a (blood) red colouration**
	(b)	(i)	$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$ Correct reactants and products (1); Correct balancing (electrons cancelled out) (1)	2	
		(ii)	Moles of dichromate(VI) = 3.53 x 10-4 (1); Moles of iron(II) = 2.12 x 10-3 (1): Moles of impure iron(II) sulphate = 2.36 x 10-3 (1); Percentage purity = 89.8 / 89.8 – 90.0 (1)	4	**Allow alternative working out via mass instead of moles e.g. mass of iron in hydrated FeSO4 from percentage composition compared to mass of iron from moles of iron(II). Allow ecf throughout unless percentage is above 100%**
				Total = 7	
4	(a)	(i)	(Blue to) yellow (solution) / (blue to) green (solution) (1)	1	
		(ii)	Lone pair on chloride ion (1); Donated to copper(II) ion (1)	2	**Allow dative bond / coordinate bond (1) Allow marks via a diagram that must show lone pairs and the dative bond**
	(b)		(Light) blue precipitate / blue solid (1); With excess (dark) blue solution (1)	2	**Not just goes blue**
	(c)		Any three from Ammonia molecule 1 lone pair (and 3 bond pairs) (1); Ammonia ligand 4 bond pairs / lone pair is now a bond pair / ligand does not have a lone pair (1); Lone pairs repel more than bond pairs (1): In complex equal repulsion between electron pairs (1)	3	**Not bonds repel / atoms repel**
				Total = 8	

Question	Expected answers	Marks	Additional guidance
5	**Reaction of elements** **Any two elements reaction with chlorine – maximum four marks** Sodium burns with a yellow flame / gives a white solid formed (1); $2Na + Cl_2 \rightarrow 2NaCl$ (1); Aluminium makes a white solid (1); $2Al + 3Cl_2 \rightarrow 2AlCl_3$ or Al_2Cl_6 (1); (In excess chlorine) Phosphorus give a white flame / makes a white or pale yellow solid (1); $P_4 + 10Cl_2 \rightarrow 4PCl_5$ / $2P + 5Cl_2 \rightarrow 2PCl_5$ (1) (In limited supply of chlorine) gives a white flame / makes a colourless (fuming) liquid (1); $P_4 + 6Cl_2 \rightarrow 4PCl_3$ / $2P + 3Cl_2 \rightarrow 2PCl_3$ (1) **Chosen redox reaction – two marks** Correct electron loss for oxidation / correct change in oxidation number for oxidation (1); Correct electron gain for reduction / correct change in oxidation number for reduction (1) **Action of water – six marks** Sodium chloride dissolves in water / NaCl + aq → $Na^+(aq) + Cl^-(aq)$ (1); NaCl gives a solution which is neutral (1); **Any two from** Aluminium chloride is hydrolyses / reacts with water / aluminium ion polarises water molecules (1); Makes an acidic solution (1); **Any two from** Phosphorus(V) chloride is hydrolysed by water / reacts with water (1); $PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$ (1); Acidic solution is formed / steamy fumes produced (1) **And QWC** One mark for correct spelling, punctuation and grammar in at least two sentences (1)	12 1	**Allow** a white flame **Allow** ecf from a wrong equation **Allow** equations showing polarisation by Al^{3+} or equation of $AlCl_3$ with water **Allow** PCl_3 is hydrolysed / reacts with water (1) $PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$ (1) Acidic solution is formed / steamy fumes produced (1) **Allow** $P(OH)_3O$ etc
		Total = 13	