Centre Number	Index Number	Name and Class

ANGLO-CHINESE JUNIOR COLLEGE
PRELIMINARY EXAMINATIONS
Advanced Level

CHEMISTRY **9746/02**
Higher 2

Paper 2 Structured **22 August 2008**
1 hour 30 minutes

Candidates answer on the Question Paper
Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, Centre number and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
A Data Booklet is provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
At the end of the examination, fasten all your work securely together including the cover page.

For Examiner's Use	
Question no.	**Marks**
1	
2	
3	
4	
5	
TOTAL	

This document consists of **12** printed pages.

1 **(a)** On heating, Group I metal nitrates such as sodium nitrate(V) decompose giving the metal nitrate(III) and oxygen, while Group II metal nitrates, for example magnesium nitrate(V), decompose giving different products.

(i) Write balanced equations for the decomposition of sodium nitrate(V) and magnesium nitrate(V) respectively.

[2]

15.35 g of a mixture of sodium nitrate(V) and magnesium nitrate(V) was heated in a fume cupboard until no more gases were evolved.

The water soluble part of the residue was dissolved in water to prepare 1.00 dm^3 of solution.

10.00 cm^3 of this solution was reacted with 20.00 cm^3 (in excess) of 0.0200 mol dm^{-3} potassium manganate(VII) solution, acidified with dilute sulphuric acid.

(ii) The nitrate(III) half equation is

$$NO_2^- + H_2O \longrightarrow NO_3^- + 2H^+ + 2e^-$$

Write a balanced equation for the reaction between nitrate(III) ions and manganate(VII) ions.

[1]

The excess potassium manganate(VII) required 12.00 cm^3 of 0.0500 mol dm^{-3} ethanedioic acid solution for complete reaction.

$$[\ 2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O\ ]$$

(iii) Calculate the amount in moles of the nitrate(III) ions in the 10.00 cm^3 solution.

[2]

(iv) Hence, calculate the mass of each nitrate in the mixture.

[2]

(b) Magnesium nitrate(V) and strontium nitrate(V) decompose similarly on heating. However, magnesium nitrate(V) decomposes at a lower temperature than strontium nitrate(V).
Explain why these two nitrates decompose at different temperatures.

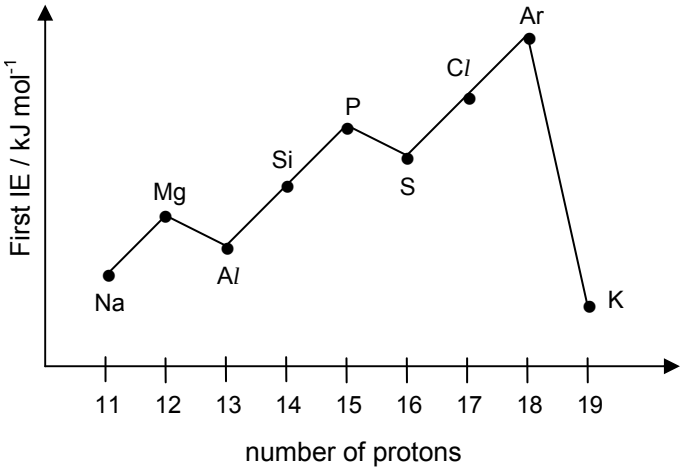
[2]

(c) Ammonium nitrate(V) decompose to produce nitrous oxide, $\mathbf{N_2O}$.
Nitrous oxide is relatively inert at room temperature but at 500^{o}C, it decomposes to oxygen, nitrogen and nitric oxide, **NO**. In the spaces provided, draw the dot and cross diagrams of these two oxides of nitrogen.

Formula	Nitrogen oxidation state	Dot and Cross Diagram
N_2O	+1	
NO	+2	

[2]
[Total: 11]

2 **(a)** The first ionisation energies of nine elements from sodium to potassium are shown in the sketch below.



Give reasons for:

(i) the general trend across the period from Na to Ar.

[2]

(ii) the discontinuity between Mg and Al.

[1]

(iii) the discontinuity between P and S.

[1]

(iv) the difference between the first ionisation energies of Na and K.

[1]

(b) **(i)** Sketch the melting point trend of elements in period 3.

[1]

(ii) Explain the difference in melting points for sodium and silicon in terms of their structures and bonding.

[3]

(c) Sodium was first produced commercially in 1855 by thermal reduction of sodium carbonate with carbon in what is known as the Deville process.

$Na_2CO_3(l) + 2C(s) \rightarrow 2Na(g) + 3CO(g)$

The standard entropy change of reaction, ΔS_r^{θ} is +549 J K^{-1} mol^{-1}

(i) Explain why the entropy change of the above reaction is positive.

[1]

(ii) Determine the range of temperatures for the above reaction to be feasible.

	$Na_2CO_3(l)$	CO(g)	Na(g)
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	-1103	-111	+107

[2]
[Total: 12]

3 **(a)** **(i)** Calcium is a fairly soft, silvery-grey metal which quickly tarnishes in air; hence metallic calcium has no commercial uses. However titanium is a commercially important engineering metal.

State two physical properties which make titanium a very useful material in the aircraft industry and **suggest** another property that allows titanium to be used in artificial hip joints.

[2]

(ii) Calcium can only exist as Ca^{2+} ion in its compounds but titanium forms ions with different charges (+2,+3 and +4) in its solid compounds. $TiCl_3$ is coloured while TiF_4 (an ionic compound) is a white powder.

Unlike calcium, explain why titanium can exhibit several oxidation states in its compounds and suggest why TiF_4 is not coloured.

[2]

(b) Vanadium was named after Vanadis, the Scandinavian goddess of beauty and it forms many coloured compounds. Using the following data, choose a reagent which will convert vanadium(V) to vanadium(IV) but not to vanadium(III). Write a balanced equation for the conversion.

	E^{θ}/V
$VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$	+0.34
$VO_2^+ + 2H^+ + e^- \rightleftharpoons VO^{2+} + H_2O$	+1.00
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$	+0.17
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77

[1]

(c) Some data for iron and ruthenium are given below.

	Proton number	Electronic configuration
Fe	26	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$
Ru	44	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^7 5s^1$

$[Ru(H_2O)_6]^{3+} + e^- \rightleftharpoons [Ru(H_2O)_6]^{2+}$ $\quad E^\theta = + 0.23V$

$[Fe(H_2O)_6]^{3+} + e^- \rightleftharpoons [Fe(H_2O)_6]^{2+}$ $\quad E^\theta = + 0.77V$

(i) Write the electronic configuration of $Ru^{2+}(aq)$ and hence explain why $Ru^{2+}(aq)$ is less stable than $Ru^{3+}(aq)$.

[2]

(ii) $[Ru(H_2O)_6]^{3+}$ can be made from the complex $[Cl_5Ru\text{-}O\text{-}RuCl_5]^{4-}$. What is the oxidation state of ruthenium in $[Cl_5Ru\text{-}O\text{-}RuCl_5]^{4-}$?

[1]

(iii) Cyanide ligands can form a very stable complex with Fe^{2+} ions. How can the formation of this very stable complex explain the highly poisonous nature of the cyanide ion?

[1]

(d) **(i)** 2,3-dihydroxybutanedioate ions are oxidised by hydrogen peroxide to carbon dioxide and water. The reaction is catalysed by $Co^{2+}(aq)$. The solution is pink at the beginning and end of the reaction, but green during it.

The redox reaction between 2,3-dihydroxybutanedioate ions and hydrogen peroxide is represented by the following half-equations:

$(CHOHCO_2^-)_2(aq) + 2H_2O(l) \rightleftharpoons 4CO_2(g) + 8H^+(aq) + 10e^-$

$2H^+(aq) + H_2O_2(aq) + 2e^- \rightleftharpoons 2H_2O(l)$

Suggest the mechanism by which $Co^{2+}(aq)$ ions catalyse this reaction.

[2]

(ii) The typical blue colour of the famous Delft pottery is due to the Co^{2+} ions which are incorporated in the thin layer of glaze on the pottery. Explain why cobalt compounds are usually coloured.

[3]
[Total: 14]

4 (a) 1.00 g of magnesium ammonium phosphate, $MgNH_4PO_4$, was added to 50 cm^3 of a 1.00 mol dm^{-3} aqueous solution of sodium hydroxide. The mixture was then boiled.
(The values of K_{sp} of magnesium hydroxide = 1.0×10^{-11} and of K_b of ammonia = 1.0×10^{-5})

(i) Predict whether a precipitate of magnesium hydroxide would form in the mixture above.

[2]

(ii) If all the ammonia liberated from the mixture were completely dissolved in water to give a 50.0 cm^3 solution, what volume of 0.20 mol dm^{-3} aqueous hydrochloric acid would be needed for complete reaction with the aqueous ammonia solution?

[1]

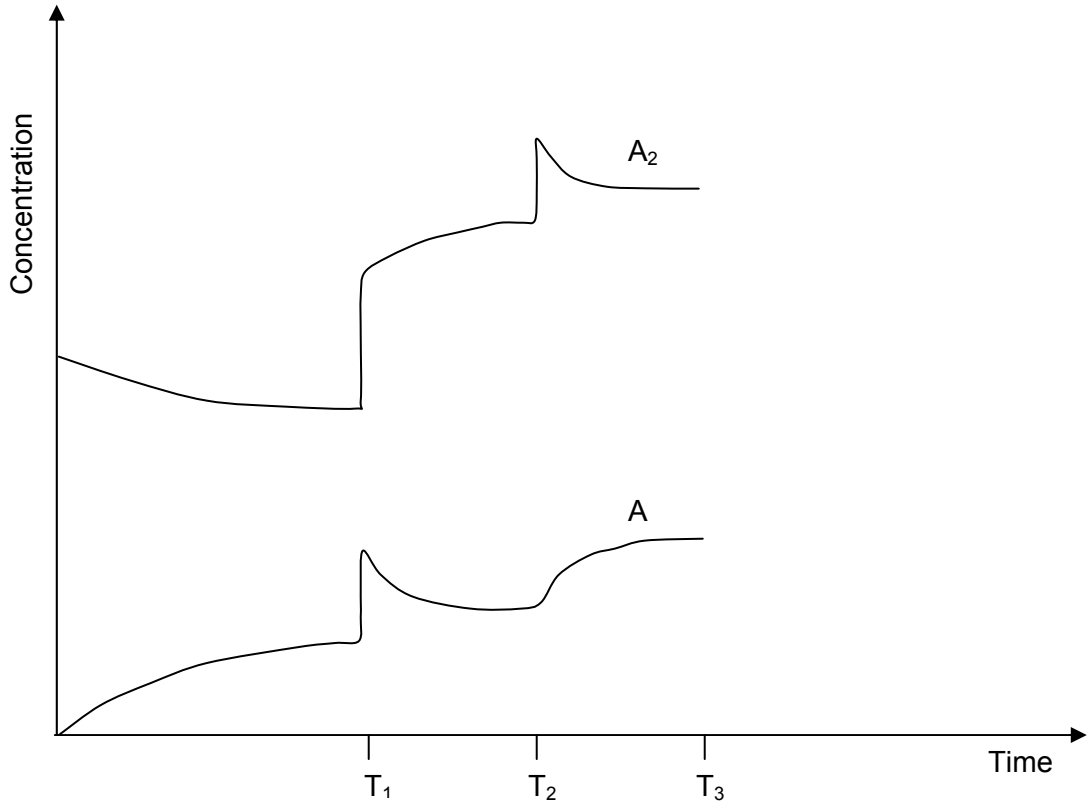
(iii) Hence, calculate the pH value of the mixture in **(ii)** after hydrochloric acid has completely reacted with it.

[3]

(b) The conversion of A_2 is as follows:

$A_2(g) \rightleftharpoons 2A(g)$

The conversion was studied using a fixed amount of A_2 in a reaction vessel. At different times during the experiment, changes were made to the conditions in the reaction vessel. The change in the concentrations in the equilibrium mixture with time is given by the graph below:



Suggest the change in condition that caused the change at time

(i) T_1

[1]

(ii) T_2

[1]

(iii) Explain whether you expect the conversion of A_2 to A to be exothermic or endothermic. Sketch on the graph above the changes in the concentrations of A_2 and A when the mixture was cooled at time T_3.

[2]
[Total: 10]

5 (a) An organic compound **X** (spirit of amber) plays an important biochemical role in the Krebs cycle. It is also produced in the fermentation of sugar and gives wine a characteristic flavour.

(i) Compound **X** has the following composition by mass.

C, 40.7%; H, 5.1%; O, 54.2%

Calculate the empirical formula of **X**.

[2]

(ii) When a 0.204 g sample of compound **X** was vapourised in a suitable apparatus, the vapour occupied 74.2 cm^3 at 250 ºC and 101 kPa. Calculate the M_r of compound **X**.

[1]

(iii) Determine the molecular formula of **X**.

[1]

(b) The following tests are carried out on compound **X**. State all deductions about compound **X** in each case.

(i) When aqueous sodium carbonate is added to compound **X**, effervescence occurs. Colourless gas forms white precipitate in lime water.

[1]

(ii) Compound **X** gives white fumes when treated with thionyl chloride, $SOCl_2$.

[1]

(iii) On heating compound **X** under reflux with potassium manganate (VII), purple colour of solution remains.

[1]

(iv) Compound **X** does not give yellow precipitate with aqueous alkaline iodine.

[1]

(v) Compound **X** does not give orange precipitate with 2,4-dinitrophenylhydrazine.

[1]

(c) **(i)** Draw two possible displayed formulae of compound **X**.

[2]

(ii) Given that compound **X** can be obtained from an alkene, suggest reagents and conditions for the reaction.

[1]

(d) Compound **Y** has the same molecular formula as compund **X**. If compound **Y** undergoes positive tests in **(b)(i) to (b)(v)**, suggest a structural formula for it.

[1]
[Total: 13]