

NANYANG JUNIOR COLLEGE JC 2 PRELIMINARY EXAMINATION Higher 2

CANDIDATE NAME Answers

CLASS

TUTOR'S NAME

CHEMISTRY

Paper 2 Structured

Candidates answer on the Question Paper

Additional Materials:

Answer Paper Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in. Write in dark blue or black pen on both sides of the paper. 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.

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

For Examiner's
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1 hour 30 minutes

9746/02

17 September 2008

Answer all questions.

1 Aluminium chloride sublimes at 178°C at standard pressure. The diagrams below show how the volume of aluminium chloride varies with temperature as well as how its electrical conductivity varies with temperature at the stated constant pressures.



(a) Explain why aluminium chloride has zero electrical conductivity at regions D and E. For region D and E, aluminium chloride exists as <u>simple molecules</u> with no <u>mobile</u> <u>electrons</u>, hence do not conduct electricity.

[2]

(b) Draw the displayed formula of the aluminium chloride molecule at regions A and B.

Region A	Region B
$\begin{array}{c} Cl \\ Cl \end{array} \xrightarrow{Cl} Cl \\ Cl \end{array} \xrightarrow{Cl} Cl \\ Cl \end{array} \xrightarrow{Cl} Cl \\ Cl \end{array}$	Cl Al Cl

[2]

(c) Suggest the physical state of the aluminium chloride at region **C**. Explain your answer and hence state the significance of 195°C.

Liquid state because at 2.5 atm, the higher pressure prevents the molecules from vaporizing. Hence 195°C is the boiling point.

[2]

[Total: 6]

2(a) The following table shows the first ionisation energies of phosphorus, sulphur and chlorine.

Element	Ionisation Energy / kJ mol-1
Р	1060
S	1000
CI	1260

(i) Write an equation to represent the first ionization energy of chlorine.

 $CI(g) \rightarrow CI^{+}(g) + e^{-}$ [1]

(ii) Why is the ionisation energy of sulphur lower than that of phosphorus?

P: $1s^2 2s^2 2p^6 3s^2 3p_x^{-1} 3p_y^{-1} 3p_z^{-1}$; S: $1s^2 2s^2 2p^6 3s^2 3p_x^{-2} 3p_y^{-1} 3p_z^{-1}$

Less energy required to remove an electron from 3p_x orbital of S because of interelectron repulsion arising from two electrons occupying the same orbital.

(b) The graphs below show the pH of the solutions obtained after reaction (if any) of chlorides and oxides of some Period 3 elements with water.



(i) Explain why aqueous sodium chloride has a pH of 7. Include any relevant equations in your answer.

NaCl(s) dissolves to form hydrated ions; Na⁺(aq) has low charge density;

does not undergo hydrolysis.

 $NaCl(s) + aq \rightarrow Na^{+}(aq) + Cl^{-}(aq)$ [2]

(ii) Use the graph above and data from the *Data Booklet* to predict the pH of aqueous BeCl₂.

 $pH \approx 3$ or any pH < 7 with reasoning/data (any **one**: diagonal relationship; charge density; Group II)

[2]

For Examiner's

(iii) Give the formula of an oxide of sulphur and give the oxidation state of sulphur in this oxide. Give a balanced equation to account for the pH of its aqueous solution. Formula of oxide: SO_2 or SO_3 Oxidation state of sulphur in oxide: +4 or +6 Equation: $SO_2 + H_2O \rightarrow H_2SO_3$ or $SO_3 + H_2O \rightarrow H_2SO_4$ [3] [Total: 10]

5 For Examiner's Use 3 Silver chromate(VI), Ag_2CrO_4 is only sparingly soluble in water. Write an expression for the solubility product, K_{sp} , of silver chromate(VI). (a) $K_{\rm sp} = [Ag^+]^2 [CrO_4^{2-}]$[1] The solubility of silver chromate(VI) in water at 25 °C is 0.0302 g dm⁻³. (b) For a saturated solution of silver chromate(VI) at 25 °C, calculate the concentration, in mol dm⁻³, of chromate(VI) ions, (i) $[\mathrm{CrO_4}^{2\text{-}}] = \frac{0.0302}{332.0}$ = $9.096 \times 10^{-5} \text{ mol dm}^{-3}$ = $9.10 \times 10^{-5} \text{ mol dm}^{-3}$ (3 sf) the concentration, in mol dm⁻³, of silver ions, (ii) $[Ag^{+}] = 2 \times 9.10 \times 10^{-5} \\ = 1.82 \times 10^{-4} \text{ mol dm}^{-3}$ the value of K_{sp} of silver chromate(VI), stating the units. (iii) $\mathcal{K}_{sp} = [Ag^+]^2 [CrO_4^{2-}] = (1.82 \times 10^{-4})^2 (9.10 \times 10^{-5})$ $= 3.014 \times 10^{-12}$ $= 3.01 \times 10^{-12} \text{ mol}^3 \text{ dm}^{-9} (3 \text{ sf})$ [4] Will a precipitate form when equal volumes of solutions containing 3×10^{-3} mol dm⁻³ silver nitrate and 5×10^{-3} mol dm⁻³ of potassium chromate(VI) are mixed together? (b) Explain your answer, with the aid of relevant calculations. lonic product, $[Ag^+]^2 [CrO_4^{2^-}] = (3 \times 10^{-3}/2)^2 (5 \times 10^{-3}/2)$ = 5.625 x 10⁻⁹ mol³ dm⁻⁹

Since ionic product > K_{sp} , hence ppt will be formed.

[2] [Total: 7]

- 4(a) (i) Write a balanced equation for the reaction of heat on calcium nitrate. $Ca(NO_3)_2 \rightarrow CaO + 2NO_2 + \frac{1}{2}O_2$
 - (ii) Explain, with the help of equations including state symbols, what happens when a small amount of water is added initially to the white solid obtained after heating in (a)(i), followed by an excess of water.

 $CaO(s) + H_2O(I) \rightarrow Ca(OH)_2(s)$

When a small amount of water is added, solid calcium hydroxide is formed initially. When excess water is added, limewater, or aqueous calcium hydroxide is formed.

 $Ca(OH)_2(s) + aq \rightarrow Ca(OH)_2(aq)$

[3]

(b) A 4.50 g sample of a carbonate of a Group II metal, **X**, lost 1.34 g in mass when heated strongly. Identify the metal.

 $\begin{array}{rcl} XCO_3(s) & \rightarrow & XO(s) \ + \ CO_2(g) \\ \text{Original mass} & \text{loss in mass} \\ \text{Amount of } CO_2 \ = \ 1.34/44.0 \ = \ 0.03045 \ \text{mol} \\ \text{Ratio of } XCO_3 \ : \ CO_2 \ = \ 1 \ : \ 1 \\ \text{Amount of } XCO_3 \ = \ 0.03045 \ = \ 4.50/M_r \ \text{of } XCO_3 \\ \text{M}_r \ \text{of } XCO_3 \ = \ 147.8 \\ \text{Or} & 147.8 \ = \ A_r \ \text{of } X \ + \ 12.0 \ + \ 3(16.0) \\ \text{A}_r \ \text{of } X \ = \ 87.8 \ \Rightarrow \ \underline{X} \ \text{is strontium}. \end{array}$

[3]

[Total: 6]

5 J (Cr₂H₈N₂O₇) is an orange crystalline solid that is readily soluble in water to give an orange solution. When aqueous sodium hydroxide is added to a sample of the solution, the solution turns yellow and gives off an alkaline pungent gas, K.

When a solution of **J** is acidified with sulphuric acid and treated with zinc powder, the solution turns green. On addition of sodium hydroxide to this green solution, a green precipitate, L, forms which dissolved in excess sodium hydroxide.

On heating a sample of **J**, a violent reaction takes place with the evolution of steam and a diatomic gas **M** ($M_r = 28.0$). The residue from the reaction is a green powder that does not dissolve in water but dissolves in sulphuric acid to give a green solution. The addition of aqueous sodium hydroxide to this green solution gives the precipitate **L** that had been produced in an earlier test.

(a) Identify J, K and L.

	7	For Examiner's
	J is $(NH_4)_2Cr_2O_7$	Use
	K is NH ₃	
	L is Cr(OH) ₃ [3]	
(b)	The solution of ${\bf J}$ turns yellow when aqueous sodium hydroxide is added. Explain whether this is a redox reaction.	
	This is not a redox reaction as the oxidation no. of Cr remains at +6	
	[1]	
(c)	Write a balanced ionic equation for the reaction of solution J with zinc powder. [1]	
	$[R]: Cr_2O_7^{2^-} + 14H^+ + 6e \rightarrow 2Cr^{3^+} + 7H_2O$	
	$[O]: 2n \rightarrow 2n^{-} + 2e$ Overall: $Cr_2O_7^{2^-} + 14H^+ + 3Zn \rightarrow 2Cr^{3^+} + 7H_2O + 3Zn^{2^+}$ [1]	
(d)	Suggest the identity of gas ${\bf M}$ hence write a balanced equation for the action of heat on ${\bf J}.$	
	M is N ₂	
	$(NH_4)_2Cr_2O_7 (s) \rightarrow Cr_2O_3(s) + N_2 (g) + H_2O (g)$ [2]	
	[Total: 7]	

7



For Examiner's (b) Part of the reaction scheme for the formation of Atenolol involves the synthesis of the ether functional group via two possible routes:



Use

10

7 Below is a reaction scheme for the formation of Compound X from Compound Y.



Compound X

(a) State the reagents and conditions required for **Steps 1** to **3**.

Step	Reagent	Condition
1	Cl ₂ gas	UV light
2	NaOH (aq)	Heat under reflux
3	Acidified K ₂ Cr ₂ O ₇ (aq)	Heat under reflux

(b) Alkenes undergo catalytic oxidation to produce aldehydes and ketones. H2 Chemistry 9746/02/NYJC J2/08 PX

[Turn Over

[3]

e.g.

$$H_2C$$
 \longrightarrow CH_2 $+$ $\frac{1}{2}$ O_2 $\xrightarrow{catalyst}$ CH_3CHO

Acetals (molecules that contain 2 –OR groups bonded to the same carbon) can be formed from aldehydes and ketones in an acid catalysed process. e.g.



Predict the structure of the final product derived from Compound Y by catalytic oxidation, followed by HOCH₂CH₂OH in an acidic medium.



- (c) In Step 4, due to the presence of NaHCO₃(aq), I₂ does not add across the double bond as expected. Instead Compound **X** was obtained.
 - (i) Suggest the type of reaction which occurred in Step 4.

Electrophilic addition......[1]

 (ii) Hence, suggest a mechanism to explain the formation of Compound X in Step 4. In your answer, show any relevant charges, lone pairs of electrons and movement of electrons.

Step 1



Step 2



Step 3





+ I

For Examiner's Use

8(a) A polypeptide P was analysed and contained the following amino acids, [RCH(NH₂)CO₂H].

Amino acid	Abbreviation	Formula of R group
aspartic acid	asp	CH ₂ CO ₂ H
glycine	gly	—Н
serine	ser	—CH₂OH
phenylalanine	phe	-CH ₂
valine	val	—CH(CH ₃) ₂
cysteine	cys	—CH₂SH

Enzyme **A** digests proteins or polypeptides at the carboxylic acid end of the amino acid valine, val. The following peptides were identified after digestion of the polypeptide **P** with enzyme **A**, and subsequent separation.

asp – ser – gly – val ser – phe – cys phe – val

Another enzyme **B** digests at the carboxylic acid end of serine, ser. The following peptides were identified after digestion of the same polypeptide **P** with enzyme **B**, and subsequent separation.

gly – val – ser phe – cys phe – val – asp – ser

Use the information to determine the primary structure of polypeptide **P**. Justify your answer.

From the partial hydrolysis by enzyme A, ser – phe – cys is the last fragment of the polypeptide since it cleaved at the carboxyl end of the val.

From the partial hydrolysis by enzyme **B**, phe – cys is the last fragment of the polypeptide since it cleaved at the carboxyl end of the ser. Hence cys is the C-terminus.

From the fragments obtained with **A** and **B**, there is overlapping amino acid sequence.

Hence the sequence is **phe-val-asp-ser-gly-val-ser-phe-cys**.

[3]

(b) Draw a displayed formula for the phe – cys dipeptide.



[2]

(c) State what R group interactions are possible for the five amino acids in A at pH 7.

Amino acid	Formula of R group	R group interactions
aspartic acid	CH ₂ CO ₂ H	ionic bonding
serine	—CH₂OH	hydrogen bonding
phenylalanine	— CH ₂ -	van der Waals'
valine	—CH(CH ₃) ₂	van der Waals'
cysteine	—CH₂SH	disulphide bond

[3] [Total: 8]