

NANYANG JUNIOR COLLEGE JC 2 PRELIMINARY EXAMINATION Higher 2

## CHEMISTRY

Paper 3

9746/03 16 September 2009 2 hours

Candidates answer on writing paper

Additional Materials: Data Booklet Graph paper

## 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 4 out of 5 questions.

Write your answers on the writing paper provided

Begin each question on a fresh piece of paper.

You are advised to show all working and calculations

- 1 Aluminum is an element in Period 3 of the Periodic Table.
  - (a) The graph below shows the second ionization energies of eight elements with consecutive proton number.



(i) Which of the above elements, A to H, is Aluminium? Explain your answer.

[2]

[1]

[1]

- (b) A 0.400g sample of a mineral, AB(CO<sub>3</sub>)<sub>2</sub> (where A and B are Group II elements) was heated strongly until no further change occurs. A white powder weighing 0.275g was collected and shaken with 200 cm<sup>3</sup> of water. A portion of the white powder remained insoluble and was then filtered. The residue was dried and it weighed 0.057g.
  - (i) Assuming that the products on heating consist of the oxides of A and B and carbon dioxide, write a balanced equation for the decomposition of  $AB(CO_3)_2$
  - (ii) Calculate the mass of carbon dioxide produced.
  - (iii) Hence, or otherwise, identify the metals, **A** and **B**, showing your working clearly.
- (c) Arrange the following molecules in order of increasing boiling points. Explain your choice in term of structure and bonding. [5] NaF, H<sub>2</sub>O, MgO, CO<sub>2</sub>, CH<sub>3</sub>NH<sub>2</sub>

**d(i)** Which of the following amino acid residues is most likely to be found on the outer surface of a water soluble globular protein? Explain your answer.





- (ii) State the type of R group interactions that would occur between these residues.
- (iii) The white of an egg is about 88% water and 12% protein (by mass). When an egg is heated, the white undergoes obvious changes. Name the process responsible for these changes and explain the structural changes which the food components undergo.
- (iv) Amino acids exist as zwitterions in aqueous solutions. Choose any one of the five amino acids, draw the structural formula of its zwitterions formed. [1]
- (v) Write equations to show how it can act as a buffer.

[2]

[1]

[2]

2(a) (i) Using the data given below and other relevant data from the Data Booklet, draw a clearly labelled energy level diagram for Fe<sub>2</sub>O<sub>3</sub>(s) and hence calculate its lattice enegy

## Data:

Enthalpy change of atomization of iron = +414 kJ mol<sup>-1</sup> First electron affinity of oxygen = -141 kJ mol<sup>-1</sup> Second electron affinity of oxygen = +844 kJ mol<sup>-1</sup>  $8Fe(s) + 6O_2(g) \rightarrow 4Fe_2O_3(s) \Delta H = -3288 kJ mol^{-1}$ [4]

- (ii) Explain why the second electron affinity of oxygen is endothermic.
- (iii) Using the data provided below, draw a energy cycle diagram to calculate the enthalpy change,  $\Delta H_r$  of the reaction:

$$3C(s) + 2Fe_2O_3(s) \rightarrow 4Fe(s) + 3CO_2(g)$$

Data:

Enthalpy change of combustion of graphite = -394 kJ mol<sup>-1</sup>

8Fe(s) + 6O<sub>2</sub>(g) 
$$\rightarrow$$
 4Fe<sub>2</sub>O<sub>3</sub>(s)  $\Delta$ H<sub>r</sub> = -3288 kJ mol<sup>-1</sup>

(b) Describe a simple chemical test which would enable you to distinguish the following pairs of compounds. For each test, state the reagents and conditions, and state what would be observed with **each** compound.

Note: The distinguishing of the pair may rely on preliminary breaking up of the compounds and subsequent testing of the reaction products.



[4]

[1]

[4]

(c) Nicotine is a naturally occurring liquid alkaloid, which can be extracted from the leaves of the tobacco plant. It is the compound that is responsible for the potent effect of tobacco on the human body.



- (i) A molecule of nicotine contains two nitrogen atoms, both of which can act as a base by accepting a proton. Draw the structure of nicotine and circle the nitrogen atom which you think is the stronger base. Explain your choice for that nitrogen acting as the stronger base.
- (ii) As a result of the solubility in water, it is readily absorbed both through the watery mucous membrane of the mouth and through the fatty cells that line the lungs. Draw a diagram, including dipoles, to show the hydrogen bonding between a molecule of nicotine and a molecule of water.
- (d) Another organic compound **P** has two different nitrogen atoms in its structure.



**Compound P** 

- (i) Draw an isomer of compound **P** which exhibits optical activity. [1]
- (ii) Draw the structure of the organic compound formed when **P** reacts with hot HCl (aq)

[1]

[3]

[2]

**3(a)** Dinitrogen oxide, N<sub>2</sub>O, is used as an anesthetic. It decomposes when heated as follows.

 $N_2O(g) \rightarrow N_2(g) + \frac{1}{2}O_2(g)$ 

The rate of decomposition of pure dinitrogen oxide may be followed by measuring the total pressure of the system. In an experiment conducted at 1000K, in the presence of a gold surface, the total pressure  $P_T$  increased as follows :

<b>Ρ</b> <sub>7</sub> / kPa	25.0	27.5	30.0	32.5	34.0	35.0
Time / s	0	100	230	420	590	740
<b>P<sub>N20</sub> /</b> kPa	25.0	20.0	*	10.0	*	5.0

- (i) Calculate the partial pressures of  $N_2O$  ( $P_{N2O}$ ) at 230 s and 590 s. [3]
- (ii) By using a graphical method, determine the order of the reaction with respect [4] to  $N_2O$ .
- (iii) Estimate how many half lives would have elapsed for the partial pressure of [3] N<sub>2</sub> to increase to about 18.8 kPa.
- (b) When a mixture of Mg(NO<sub>3</sub>)<sub>2</sub> and Y(NO<sub>3</sub>)<sub>2</sub> is dissolved in water, a blue solution is observed.

An unknown X (aq) is then added dropwise to the blue solution. Precipitation occurs. When excess X (aq) is added, some of the precipitate dissolves. Upon filtration, a dark blue filtrate and white residue are obtained.

- (i) For Y and X (aq), write the electronic configuration (s,p,d,f notation) for cation [2] Y , and identity of X
- (ii) By means of equations, describe the reactions and state the colour of any [4] precipitate formed.
- (c) Propanone reacts with hydrogen cyanide to form a compound with molecular formula C<sub>4</sub>H<sub>7</sub>ON.
  - (i) Draw a displayed formula for the compound obtained.

- [1]
- (ii) The compound in (i) can be used in the synthesis of methyl-2methylpropanoate.



Outline a reaction scheme, stating reagents and conditions for the [3] conversion.

Turn over

- **4(a)** 40.0 mol dm<sup>-3</sup> of 0.120 cm<sup>3</sup> hydrochloric acid solution was placed in a conical flask and titrated against a solution of 0.200 mol dm<sup>-3</sup> ethalyamine,  $CH_3CH_3NH_2$  from a burette. Given the K<sub>b</sub> of ethylamine is 5.6 x 10<sup>-4</sup> mol<sup>2</sup> dm<sup>-6</sup>,
  - (i) Calculate the pH of ethylamine
  - (ii) Calculate the volume of ethylamine needed for complete neutralisation of the [1] acid.
  - (iii) Comment on the significance of the solution in terms of its buffering ability when an additional 24.0 cm<sup>3</sup> of ethylamine was added to the solution in 4a)ii).

[2]

[1]

- (b) In a sewerage treatment plant steps are taken to remove any heavy metals like lead and cadmium to a safe level before the treated water is discharged into the sea. Waste water can be tested for presence of lead ions by reacting it with potassium iodide to form a yellow lead iodide solid. Given the numerical value for the Ksp of lead iodide is  $9.8 \times 10^{-9}$ .
  - (i) Calculate the concentration of the iodide ions present in a saturated solution [2] of lead iodide and hence the solubility of lead iodide in mol dm<sup>-3</sup>
  - (ii) Calculate the minimum concentration needed for lead ions to be detected if it [2] was mixed with equal volume of 0.500 mol dm<sup>-3</sup> potassium iodide.
- (c) Compound A, is used in various sun-tan creams to absorb excessive ultra-violet radiation and stop the skin from burning.



[The  $CH_3O$  group can be considered as inert and can be disregarded in this question].

Name the three functional groups (besides the  $CH_3O$  ether group and phenyl [3] group) present in **A**.

- (d) Draw the structures of the products when **A** is treated with
  - (i) Hot acidified potassium permanganate (VII)
  - (ii) ethanoyl chloride

[3]

(e) The laboratory preparation of **A** involves the following steps:



(i)	State the type of reaction taking place, and give the reagents and conditions for step III.	[3]
(ii)	Outline the mechanism of step I.	[3]

5 The following are the boiling points of chloride compounds

Compound	Mr	Boiling Point / °C
Nitrogen trichloride	120.5	71
Boron trichloride	117.3	12.6

- (a) The M<sub>r</sub> of nitrogen trichloride and boron trichloride are very similar yet their boiling points differ significantly. Draw the dot cross diagrams for nitrogen trichloride and boron trichloride and state with reason the shape of the compounds. Hence explain the differences in their boiling points.
- (b) A green solution of nickel(II) sulphate is converted to a blue solution containing  $[Ni(NH_3)_6]^{2+}$  ions by the addition of an excess of aqueous ammonia.
  - (i) Explain why nickel(II) sulphate solution is coloured [3]
  - (ii) Suggest why a different colour is observed for the solution containing  $[Ni(NH_3)_6]^{2+}$  ions. [2]
  - (iii) Ethylene diammine (en) is said to be a *bidentate ligand*.Explain the meaning of the terms in *italics*. [1]
- (c) Compound M has a molecular formula  $C_{13}H_{16}O$ . M decolourises aqueous bromine and produces white fumes with PCI<sub>5</sub>. It reacts with hot acidified potassium manganate (VII) to produce N ( $C_8H_8O$ ), P ( $C_3H_2O_5$ ) and Q  $(C_2H_4O_2)$ . **N** does not react with Fehling's solution but reacts with aqueous alkaline iodine to give a yellow precipitate and a salt R ( $C_7H_5O_2Na$ ). P gives effervescence with solid sodium carbonate and gives an orange precipitate with 2,4-dinitrophenylhydrazine. **Q** gives effervescence with solid sodium not carbonate but does give orange precipitate with 2.4dinitrophenylhydrazine.

[10]

Identify **M**, **N**, **P**, **Q**, **R** and explain the reactions