INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME

CLASS | INDEX NUMBER

CHEMISTRY 8872/02

Paper 2 Structured and Free Response Questions **19 Sept 2014**

2 hours

Section A: Structured
Candidates answer Section A on the Question Paper

Section B: Free Response
Additional Materials: Writing Paper
Data Booklet

READ THESE INSTRUCTIONS FIRST

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

Section A: Structured Questions (40m)
Answer **all** questions in the space provided.

Section B: Free Response Questions (40m)
Answer **two** questions on separate writing papers.

You are advised to show all working in calculations.
You are reminded of the need for good English and clear presentation in your answers.
You are reminded of the need for good handwriting.
Your final answers should be in 3 significant figures.

You may use a calculator.

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 Use	
Section A	
1	/8
2	/10
3	/14
4	/8
Section B	
	/20
	/20
Significant figures	
Handwriting	
Total	/80

This document consists of **16** printed pages.

Section A

Answer **all** the questions in this section in the spaces provided.

1 (a) The enthalpy change of neutralisation for ethanoic acid can be calculated from the temperature rise that occurs when aqueous ethanoic acid is neutralised by aqueous sodium hydroxide. In an experiment, 50.0 cm^3 of 1.30 mol dm^{-3} NaOH was placed in a polystyrene cup and 50.0 cm^3 of 1.20 mol dm^{-3} ethanoic acid was placed in a measuring cylinder. Initial temperatures of NaOH and CH_3COOH were recorded.

The acid was added to the alkali and the mixture was then stirred gently with the thermometer. The highest temperature reached was recorded.

Results:

initial temperature of NaOH / ^oC	29.0
initial temperature of CH_3COOH / ^oC	29.2
highest temperature reached / ^oC	37.0

You should assume 4.2 J is required to raise the temperature of 1 cm^3 of solution by 1 ^oC.

(i) From the experimental data, calculate the heat evolved in the reaction.

(ii) Using your answer to **(i)**, calculate the enthalpy change of neutralisation of CH_3COOH with NaOH.

(iii) When the experiment is repeated with HC*l* instead of CH_3COOH, the enthalpy change of neutralisation obtained is more exothermic. Suggest a reason for this observation.

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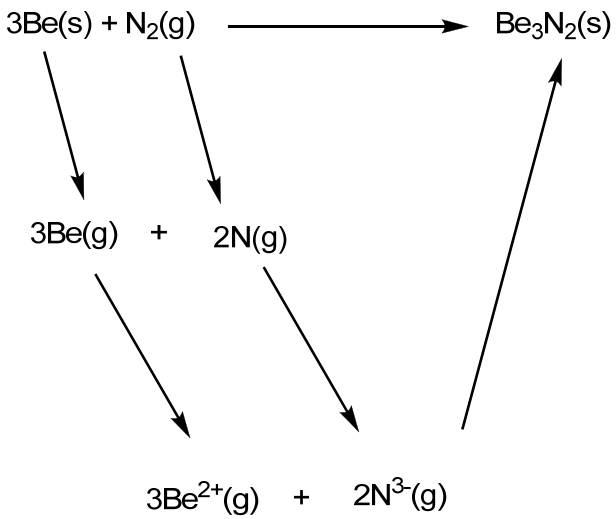
[4]

(b) Beryllium burns in nitrogen to form a refractory material, beryllium nitride, Be_3N_2.

(i) Using relevant information from the *Data Booklet* and the following information, calculate the lattice energy of beryllium nitride.

$3Be(s) + N_2(g) \longrightarrow Be_3N_2(s)$	$\Delta H_1 = -588$ kJ mol^{-1}
$3Be(s) \longrightarrow 3Be(g)$	$\Delta H_2 = +324$ kJ mol^{-1}
$2N(g) + 6e \longrightarrow 2N^{3-}(g)$	$\Delta H_3 = +1404$ kJ mol^{-1}



(ii) Explain if the lattice energy of lithium oxide, Li_2O is more or less exothermic than beryllium nitride.

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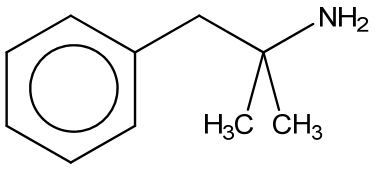
[4]

[Total: 8]

2 Halogenoalkanes are useful starting materials and intermediates in organic synthesis. It can undergo various substitution reactions with nucleophiles.

Phentermine is a prescribed diet drug which acts as an appetite suppressant by affecting the central nervous system. This drug can be synthesised from 2–chloro–2–methylpropyl benzene and ammonia.



phentermine

The rate equation for this reaction is given as

Rate= k[(2–chloro–2–methylpropyl)benzene],

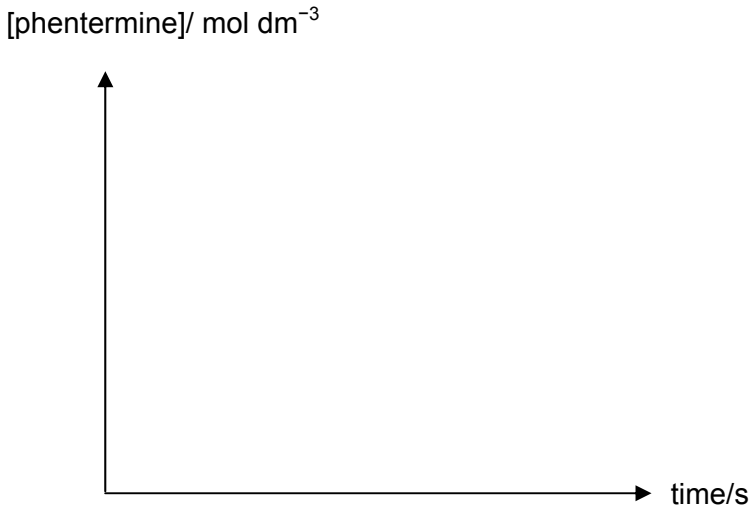
where (2–chloro–2–methylpropyl)benzene is a reactant present in the mechanism.

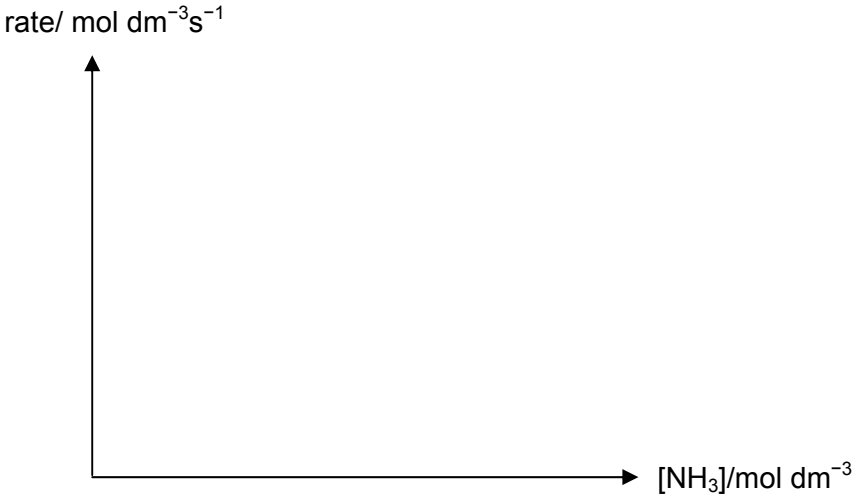
(a) (i) A series of experiments with different concentrations of the two reactants were conducted. The initial rates of the formation of phentermine were determined and shown in the table below.

Experiment	initial concentration/ mol dm^{-3}		initial rate/ mol $dm^{-3}s^{-1}$
	[(2–chloro–2 methyl propyl) benzene]	[NH_3]	
1	5.0×10^{-3}	10.0×10^{-3}	2.8×10^{-7}
2	15.0×10^{-3}	5.0×10^{-3}	***x***
3	***y***	15.0×10^{-3}	1.12×10^{-6}

Calculate the value of ***x*** and ***y***.

(ii) On the axes below, sketch the graphs for the reaction.

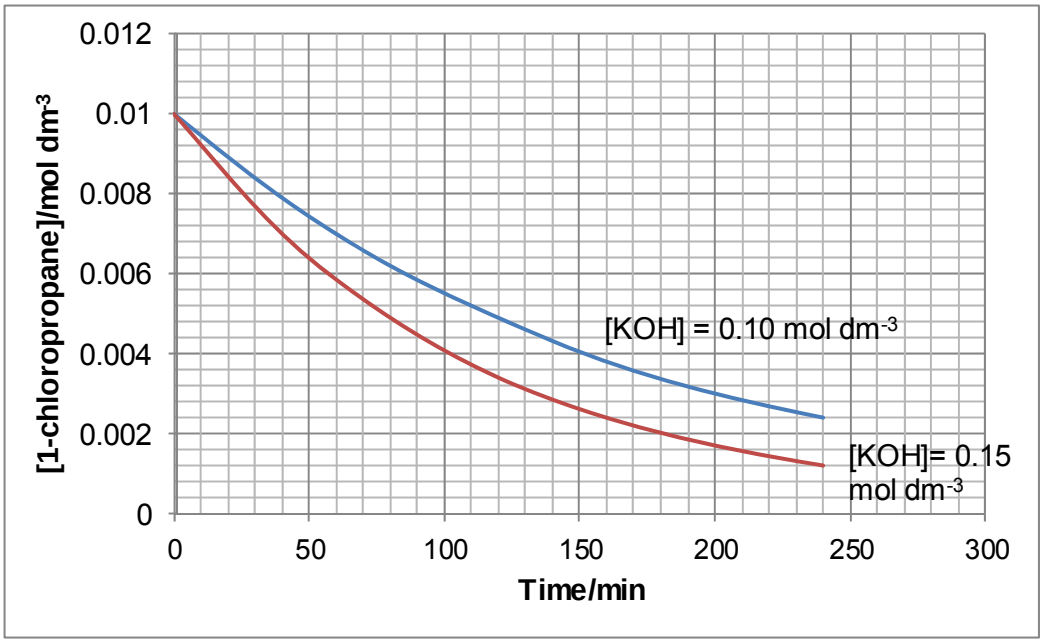




[4]

(b) Another halogenoalkane, 1–chloropropane undergoes substitution with potassium hydroxide to form propanol.

The kinetics of this hydrolysis reaction was investigated by plotting graphs of concentration of 1–chloropropane against time. Two experiments were conducted where the concentration of potassium hydroxide was kept constant at two different values.



(i) From the graphs given above, deduce the order of reaction with respect to 1—chloropropane. Explain your answer.

(ii) Deduce the order of reaction with respect to potassium hydroxide. Explain your answer.

(iii) Construct the rate equation for this reaction.

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[6]

[Total: 10]

3 **(a)** Some physical properties of the oxides of elements **D**, **E** and **F** are given below.

formula of oxide	**melting point/ ^{o}C**	**appearance at room temperature and pressure**	**conductivity in molten state**
DO_2	1700	white solid	none
EO	2850	white solid	good
FO_2	−73	colourless gas	none

Describe the types of structures and **all** the bonds in the above three oxides.

	DO_2	**E**O	**F**O_2
structure			
type(s) of bonding and forces of attraction			

[7]

(b) **(i)** Draw the dot−and−cross diagrams of SO_2 and SO_3 molecules.

(ii) With the use of chemical equations, show the reactions between SO_2 and SO_3 with NaOH.

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[4]

(c) Sulfur and chlorine can react together to form disulfur dichloride, S_2Cl_2. When 1.00 g of S_2Cl_2 was reacted with water, 0.36 g of sulfur, S was formed, together with a solution containing a mixture of sulfurous acid, H_2SO_3, and hydrochloric acid, HCl.

(i) Calculate the mole ratio between S_2Cl_2 and S in the above reaction.

(ii) Hence, deduce the equation for the reaction between S_2Cl_2 and water.

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[3]

[Total: 14]

4 **(a)** The reactivity of a halogenoalkane is affected by the nature of the halogen atom. To study this phenomenon, the following experiment was carried out separately on 1–chloropropane and 1–bromopropane.

0.2 mol of the halogenoalkane was heated under reflux with 0.05 mol of sodium hydroxide in aqueous solution for 10 minutes. Dilute nitric acid was then added to neutralise any remaining sodium hydroxide. Silver nitrate solution was added until no further precipitate was formed. The precipitate was filtered off, dried and weighed.

The mass of the precipitate obtained in each case is shown below:

halogenoalkane	mass of precipitate/ g
1–chloropropane	1.00
1–bromopropane	3.76

(i) State the identity and the colour of the precipitate for 1–chloropropane and 1–bromopropane.

1–chloropropane: ……

1–bromopropane: ……

(ii) Which halogenoalkane shows the highest reactivity? Use the data above to justify your answer.

.....

(iii) Using values from the *Data Booklet*, account for the different reactivity for the two halogenoalkanes.

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.....

[6]

(b) Give the structural formula of the product when 1–chloropropane, $CH_3CH_2CH_2Cl$ is reacted with potassium cyanide and state the type of reaction.

Product:

Type of reaction: .....

[2]

[Total: 8]

Section B

Answer **two** questions from this section on separate answer paper.

5 Maleic acid is one of two stereoisomers of butenedioic acid, HOOCCH=CHCOOH. Maleic acid is the *cis*−isomer whereas fumaric acid is the *trans*−isomer. This question examines the chemistry of maleic acid and its derivatives.

(a) **(i)** Draw the full structural formula of maleic acid.

(ii) The two stereoisomers have different melting points as intramolecular hydrogen bonding is possible only in one isomer. Identify this isomer and hence, explain whether it has a higher or lower melting point, compared to the other isomer.

[5]

(b) The standard enthalpy change of formation of solid maleic acid can be calculated using an energy cycle.

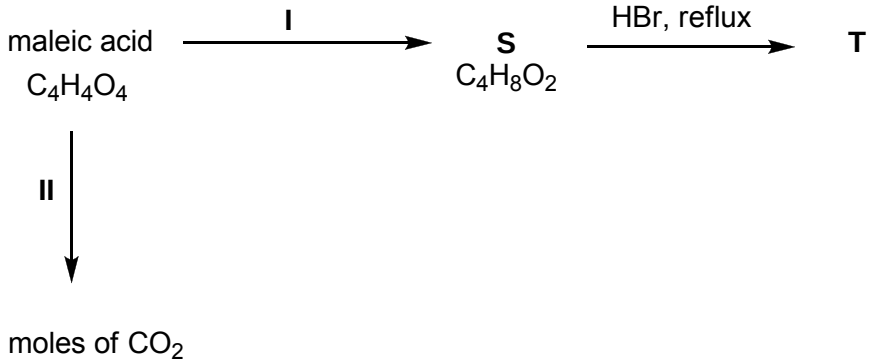
(i) With the aid of an equation with state symbols, define the term *standard enthalpy change of formation of maleic acid*.

(ii) Using the data given below, calculate the standard enthalpy change of formation of maleic acid. Show your working clearly.

compound	standard enthalpy changes /kJ mol^{-1}
maleic acid ($C_4H_4O_4$)	ΔH_c^{θ} = −1355
$H_2O(l)$	ΔH_f^{θ} = –285.8
$CO_2(g)$	ΔH_f^{θ} = –393.5

[5]

(c) Maleic acid can undergo the following reactions.

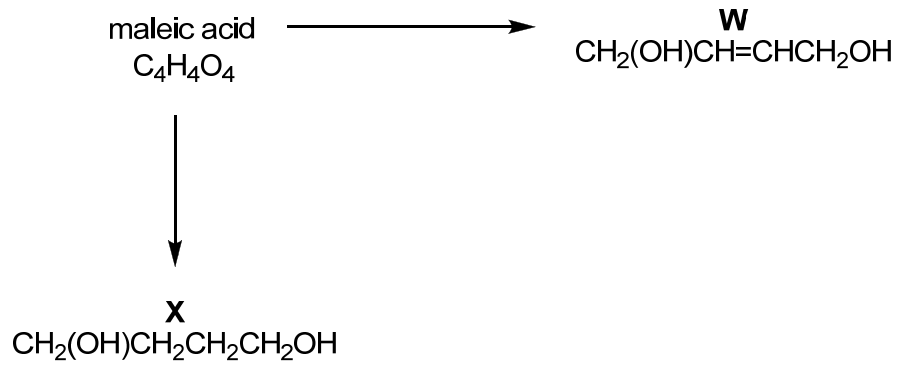


(i) State the reagents and conditions required for steps **I** and **II**.

(ii) Draw the structural formulae of **S** and **T**.

[4]

(d) In the laboratory, maleic acid can be converted to **W** and **X** via the reaction scheme below.



Suggest a chemical test to distinguish the following. You should state clearly the observations for each compound.

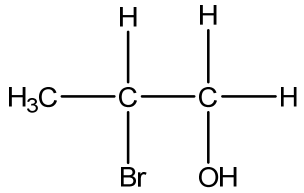
(i) maleic acid from **W**

(ii) **W** from **X**

[6]

[Total: 20]

6 **(a)** Compound **P**, C_3H_7Cl forms compound **Q**, C_3H_8O when it is heated in aqueous sodium hydroxide. Compound **Q** reacts with warm aqueous alkaline iodine to give a yellow precipitate. Compound **Q** will react to form **R**, C_3H_6, when it is refluxed with excess concentrated sulfuric acid. **R** also reacts with aqueous bromine to give a number of products, one of which is shown below.



Deduce the structure of the compounds **P**, **Q** and **R**, explaining the chemistry of the reactions described.

[6]

(b) Compounds **A** and **B** are among many compounds secreted by insects to attract members of the same species.

$CH_3(CH_2)_3COOH$	$CH_3COO(CH_2)_4CH_3$
A	**B**

Such compounds are used in traps to control the population of insect populations. These compounds need to be made synthetically.

(i) State the reagents and conditions used in the manufacture of compound **A** from pentan−1−ol, $CH_3(CH_2)_3CH_2OH$. State the type of reaction.

(ii) Compare the acidity of compound **A** with pentan−1−ol, $CH_3(CH_2)_3CH_2OH$ and explain the reasons.

(iii) Concentrated sulfuric acid is used in the manufacture of compound **B** from pentan−1−ol. State the other reagent and condition used.

(iv) State the roles of concentrated sulfuric acid in the manufacture of compound **B** from pentan−1−ol.

[9]

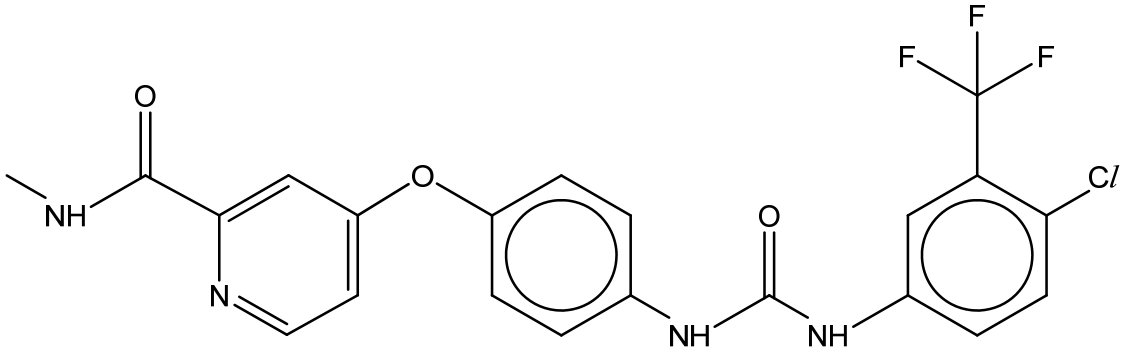
(c) **(i)** Describe and explain the general trend in ionisation energy across period 3.

(ii) Explain the anomaly in the trend of first ionisation energy between phosphorous and sulfur.

[5]

[Total: 20]

7 **(a)** Liver is one of the major organs which are crucial to life. Many processes such as manufacture of essential proteins, processing and storing of nutrients and destruction of toxins are done by the liver. When cells in the liver undergo changes, it can lead to liver cancer. Liver cancer is the fourth common cancer worldwide. One of the treatments proven to extend the survival rate of liver cancer patients is the combination of sorafenib and doxorubicin. The chemical structure of sorafenib is shown below.



sorafenib

(i) Determine the molecular formula of sorafenib.

(ii) Calculate the total mass of carbon present in 1 mg of sorafenib.

[3]

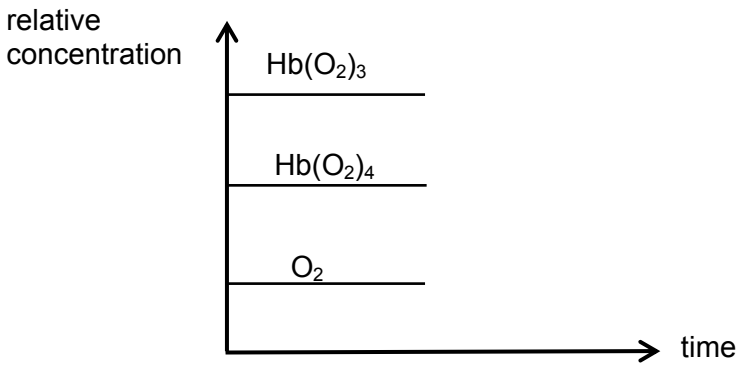
(b) Humans need oxygen to function. Oxygen is carried through the body by a protein called haemoglobin, Hb which binds oxygen in the lungs and carries it to the tissues. Each oxygen molecule binds to haemoglobin in a stepwise manner represented by the equations below.

step	equation
1	$Hb + O_2 \rightleftharpoons HbO_2$
2	$HbO_2 + O_2 \rightleftharpoons Hb(O_2)_2$
3	$Hb(O_2)_2 + O_2 \rightleftharpoons Hb(O_2)_3$
4	$Hb(O_2)_3 + O_2 \rightleftharpoons Hb(O_2)_4$

(i) Define the *Le Chatelier's Principle*.

(ii) Using the Le Chatelier's Principle, explain why haemoglobin binds oxygen in the lungs and releases oxygen in the tissue.

(iii) Copy and sketch a **fully labelled** graph that shows the changes in concentration of $Hb(O_2)_3$, O_2 and $Hb(O_2)_4$ in the lungs when a patient is using the oxygen mask during his hospital stay.



(iv) Another convenient way for reaction involving gases is to express the equilibrium constant using partial pressure, K_p. Partial pressure is only applicable for gases.

Consider an equilibrium system:

$$a\ \mathbf{A}(l) + b\ \mathbf{B}(g) \rightleftharpoons c\ \mathbf{C}(g) + d\ \mathbf{D}(g)$$

It is found experimentally that

$$K_p = \frac{P_C{}^c P_D{}^d}{P_B{}^b}$$

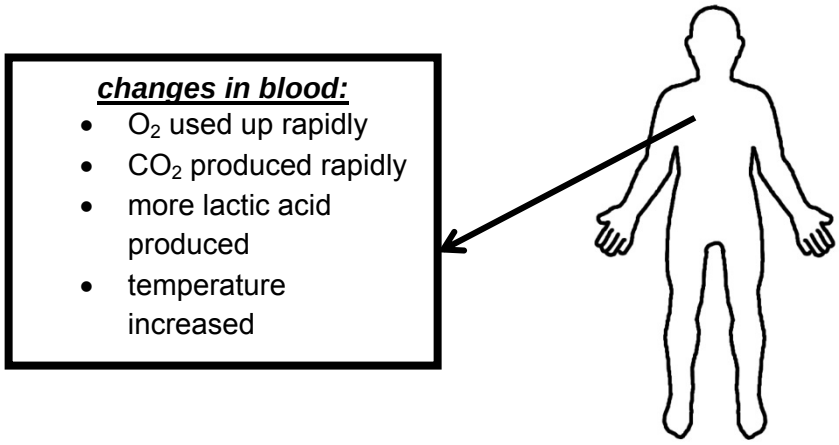
where P_B = partial pressure of **B** and the units for pressure is in atmosphere(atm)

Write an expression for K_p, including units, for the following equilibrium occurring in our body.

$$Hb(s) + 4O_2(g) \rightleftharpoons Hb(O_2)_4(s)$$

[9]

(c) One way to keep healthy is through regular exercise. However when a person does too much exercise or inappropriate exercise, it becomes harmful to the body. When we exercise, our heart rate, blood pressure and amount of blood pumped per heart beat increases. The body metabolism increases producing CO_2 and acid in the muscles. The following diagram shows the effects of excessive exercise.



(i) The ideal pH of the body should be maintained at 7.4. Explain what effect excessive exercise has on one's body.

(ii) Fortunately, humans have buffers in the blood to protect them against large changes in pH. Explain the term *buffer solution*.

(iii) The most important buffer for maintaining the pH in our body is the carbonic acid−bicarbonate (H_2CO_3/HCO_3^-) buffer. Explain with the aid of equation(s) how the blood buffer protects the body from the changes in the body caused by excessive exercise.

(iv) Titration is a quantitative method used in the laboratory to determine the unknown concentration of an acid present in a solution. A strong base such as sodium hydroxide is used to titrate against the acid.

The results obtained in a titration involving ***x*** cm^3 of 1 mol dm^{-3} hydrochloric acid and 10.0 cm^3 of 1 mol dm^{-3} of sodium hydroxide can be analysed using a pH titration curve. Sketch the pH titration curve labelling the equivalence point and pH at equivalence point.

[8]

[Total: 20]