THE SCHOOL FOR EXCELLENCE 2006

UNIT 3 CHEMISTRY

WRITTEN EXAMINATION 1

Reading Time: 15 minutes
Writing Time: 1 hour 30 minutes

QUESTION AND ANSWER BOOK

Structure of Book

Section		Number of Questions	Number of Questions to be Answered	Number of Marks	Suggested Times (min)
A	Multiple choice questions	20	20	20	20
B	Short answer questions	8	8	70	70
				Total 90	Total 90

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SECTION A – MULTIPLE CHOICE QUESTIONS

Instructions For Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

QUESTION 1
The number of ions in $5.00\ g$ of H_3PO_4 is closest to

A $\quad 1.23 \times 10^{23}$
B $\quad 2.46 \times 10^{23}$
C $\quad 1.20 \times 10^{25}$
D $\quad 2.41 \times 10^{25}$

QUESTION 2
$100\ ml$ of a $1.00\ M$ solution of potassium nitrate is mixed with $100\ ml$ of a $1.00\ M$ solution of calcium nitrate. The concentration of nitrate ions in the final solution is closest to

A $\quad 0.100\ M$
B $\quad 1.00\ M$
C $\quad 1.50\ M$
D $\quad 2.00\ M$

QUESTION 3
The compound in which oxygen has the highest oxidation number is

A $\quad Cr_2O_7^{2-}$
B $\quad HOF$
C $\quad H_2SO_4$
D $\quad H_2O_2$

QUESTION 4
Which of the following analytical techniques could be used to measure the concentration of **very small** quantities of alcohol in blood?

A $\quad$ High Pressure Liquid Chromatography
B $\quad$ Paper Chromatography
C $\quad$ Atomic Absorption Spectroscopy
D $\quad$ Gas Liquid Chromatography

QUESTION 5
Which of the following reactions is **not** a redox process?

A $\quad 2K_{(s)} + Br_{2(l)} \rightarrow 2KBr_{(s)}$

B $\quad Ca(OH)_{2(s)} + CO_{2(g)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$

C $\quad NH_4NO_{3(s)} \rightarrow N_2O_{(g)} + 2H_2O_{(g)}$

D $\quad CH_{4(g)} + Cl_{2(g)} \rightarrow CH_3Cl_{(g)} + HCl_{(g)}$

QUESTION 6
A student wishes to determine the percentage by mass of lead in a sample. Which solution could **not** be used to produce a precipitate containing lead?
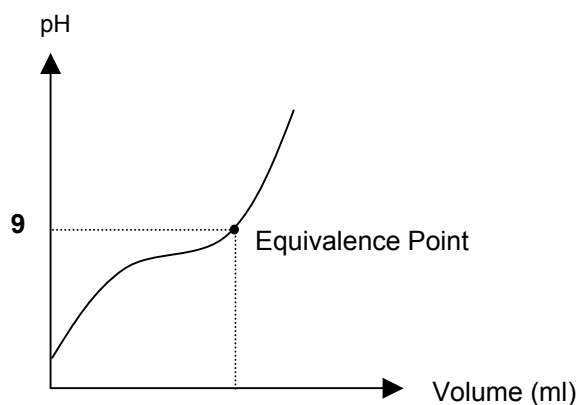
A $\quad Na_2SO_4$

B $\quad NaCl$

C $\quad NaNO_3$

D $\quad NaOH$

QUESTION 7
The pH changes that occur during the titration of an acid and base are shown below.

The acid and base could be

A $\quad 0.10\ M\ CH_3COOH$ and $0.10\ M\ NaOH$

B $\quad 0.10\ M\ HCl$ and $0.10\ M\ NaOH$

C $\quad 0.10\ M\ CH_3COOH$ and $0.10\ M\ NH_3$

D $\quad 0.10\ M\ HCl$ and $0.10\ M\ NH_3$

QUESTION 8
Carbon monoxide reacts with oxygen as follows: $2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$

If $100\ cm^3$ of CO and $100\ cm^3$ of O_2 are mixed at STP, the final volume of gas in the mixture will be

A $\quad 50\ cm^3$

B $\quad 100\ cm^3$

C $\quad 150\ cm^3$

D $\quad 200\ cm^3$

The following information refers to Questions 9 and 10.

The diagram below represents an energy profile for the formation of carbon monoxide from carbon dioxide and carbon: $C_{(s)} + CO_{2(g)} \rightarrow 2CO_{(g)}$.
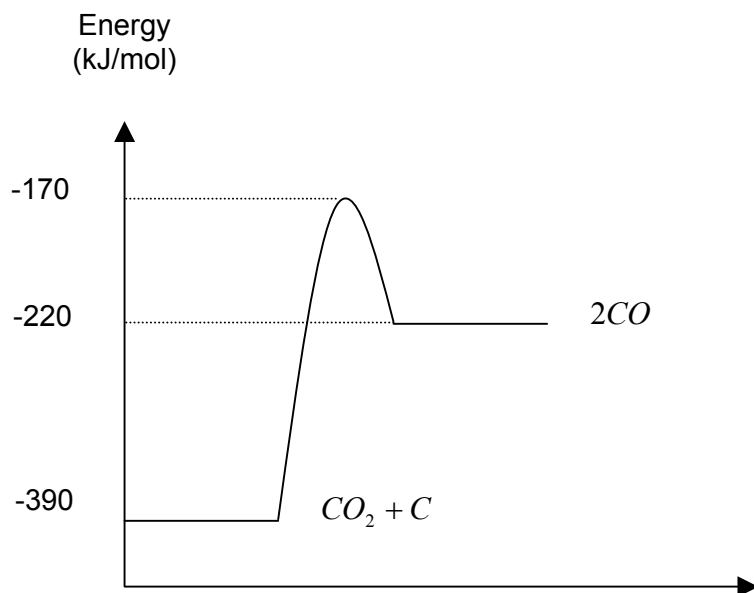
QUESTION 9
The ΔH for the forward reaction in $kJ\ mol^{-1}$ is

A -170
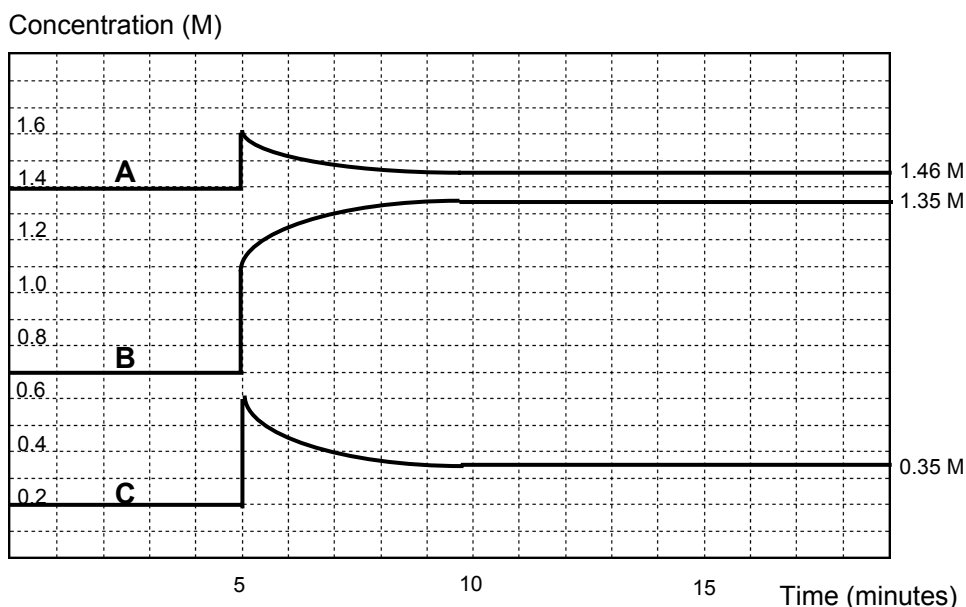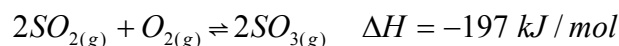B -220
C 170
D 220

QUESTION 10
The activation energy in $kJ\ mol^{-1}$ for the reverse reaction is

A -220
B -50
C 50
D 220

The following information refers to Questions 11 and 12.

The graph below represents the changes in concentration of the gases involved in the reaction:

$$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)} \quad \Delta H = -197 \; kJ/mol$$

Concentration (M)

QUESTION 11
Compounds A, B and C respectively are

A SO_2, O_2, SO_3

B SO_2, SO_3, O_2

C SO_3, O_2, SO_2

D O_2, SO_3, SO_2

QUESTION 12
Which **one** of the following statements is true?

A   The volume of the container was decreased at 5 minutes keeping temperature constant.
B   The volume of the container was decreased at 5 minutes, however, temperature was not held constant.
C   The volume of the container was increased at 5 minutes keeping temperature constant.
D   The volume of the container was increased at 5 minutes, however, temperature was not held constant.

QUESTION 13

The dissociation constants for ethanol and ethanoic acid are 1×10^{-17} $mol\ dm^{-3}$ and 1.7×10^{-5} $mol\ dm^{-3}$ respectively. Which **one** of the following statements regarding these molecules is true?

	pH	Acid Strength
A	pH of ethanol is lower	Ethanol is the stronger acid
B	pH of ethanol is lower	Ethanoic acid is the stronger acid
C	pH of ethanol is higher	Ethanol is the stronger acid
D	pH of ethanol is higher	Ethanoic acid is the stronger acid

QUESTION 14

Molecular bromine (Br_2), which is brown in colour, reacts according to the following equations:

$$Br_{2(aq)} + H_2O_{(l)} \rightleftharpoons HBrO_{(aq)} + Br^-_{(aq)} + H^+_{(aq)}$$
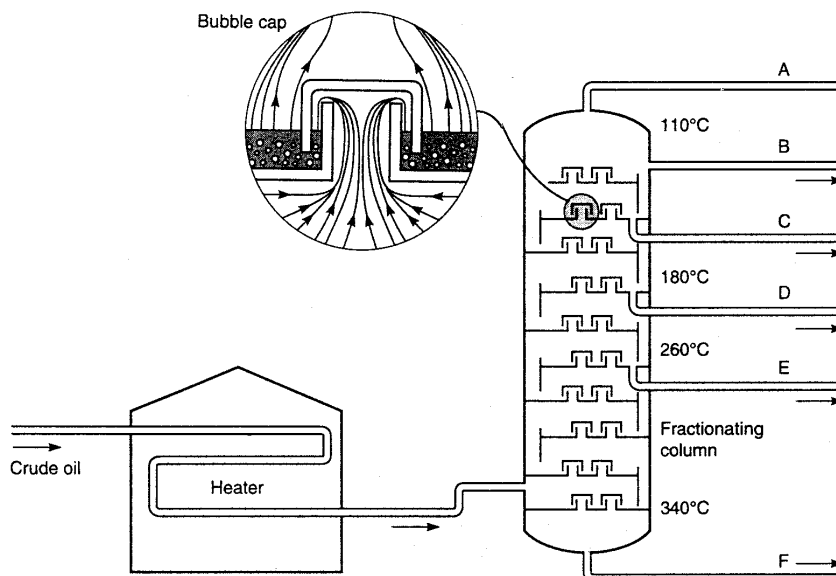$$HBrO_{(aq)} \rightleftharpoons H^+_{(aq)} + BrO^-_{(aq)}$$
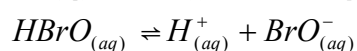
The brown colour of the solution will fade when

A $NaOH$ is added.
B HCl is added.
C $HBrO$ is added.
D $NaBr$ is added.

QUESTION 15
A diagram representing a fractionating tower is illustrated below.


The order in which the molecules below are distilled is best represented by

	A	C	E	F
A	$C_{30}H_{32}$	C_2H_6	C_5H_{12}	$C_{10}H_{22}$
B	$C_{30}H_{32}$	$C_{10}H_{22}$	C_5H_{12}	C_2H_6
C	C_2H_6	C_5H_{12}	$C_{10}H_{22}$	$C_{30}H_{32}$
D	C_2H_6	$C_{30}H_{32}$	$C_{10}H_{22}$	C_5H_{12}

QUESTION 16
Saran is a copolymer made by polymerising a mixture of two monomers. A section of Saran has the following structure:

$$-CH_2-CCl_2-CH_2-CHCl-CH_2-CCl_2-CH_2-CHCl-CH_2-CCl_2-CH_2-CHCl-$$
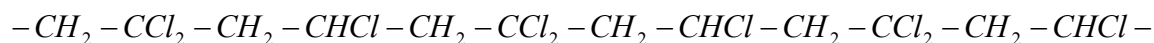
The monomers used to form this polymer include

A CH_2CCl_2 and CH_2CHCl
B CH_2CH_2 and CCl_2CCl_2
C CH_3CHCl_2 and CH_3CH_2Cl
D CH_2CH_2 and Cl_2

QUESTION 17
Which of the following structures is **not** an isomer of the other three?

A   2,2-dimethyl-1-hexene
B   2,4-dimethyl-1-pentene
C   2-hexene
D   2-methyl-2-pentene

QUESTION 18
H_2SO_4 is an incredibly diverse molecule in that it exhibits a range of chemical properties that make it the ideal agent in many chemical processes. Which of the following properties is **not** characteristic of H_2SO_4?

A   Acidic properties
B   Dehydrating properties
C   Oxidising properties
D   Reducing properties

QUESTION 19
Which one of the following statements relating to the production of sulfuric acid via the Contact Process is incorrect?

A   Each reaction involved in the Contact Process is redox in nature.
B   Each reaction involved in the Contact Process is exothermic.
C   The temperature in the Converter is held at approximately $450^o C$.
D   The pressure in the Converter is held at approximately 1 atmosphere.

QUESTION 20
Which of the following species is **not** a product of the various reactions involved in the Contact Process?

A $O_{2(g)}$

B $SO_{2(g)}$

C $SO_{3(g)}$

D $H_2S_2O_{7(l)}$

SECTION B – SHORT ANSWER QUESTIONS

Instructions For Section B

Answer all questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be give full marks.

- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.

- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_{2(g)}$; $NaCl_{(s)}$.

QUESTION 1

A student decides to investigate the equilibrium properties and rates of the reaction involving vitamin C ($C_6H_8O_6$) and iodine (I_2) solution, as described in the reaction below.

$$C_6H_8O_{6(aq)} + I_{2(aq)} \rightleftharpoons C_6H_6O_{6(aq)} + 2HI_{(aq)}$$
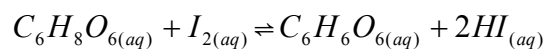
Equimolar amounts of vitamin C and iodine were originally added to a vessel at 25^oC. The concentration of iodine was then monitored using colorimetry at a wavelength of 400 nm.

The absorption of a series of standard solutions containing iodine, which is brown in colour, is given below.
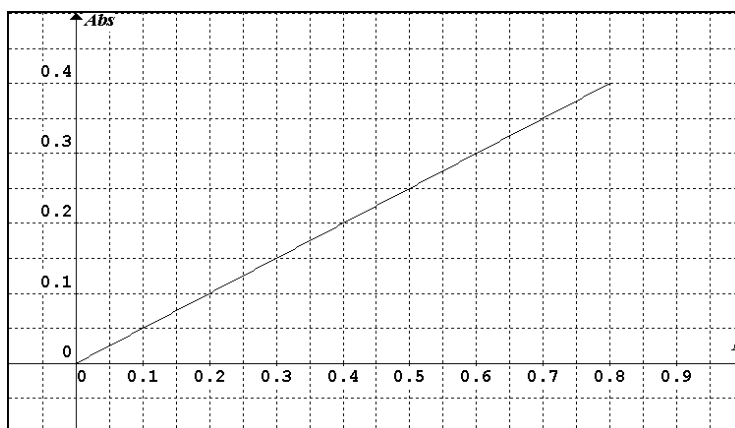
A sample of the reaction mixture was removed at 30 second intervals. The reaction was stopped and the absorbance of each sample was determined using colorimetry. The absorbances were then plotted against time, as illustrated in the graph below.

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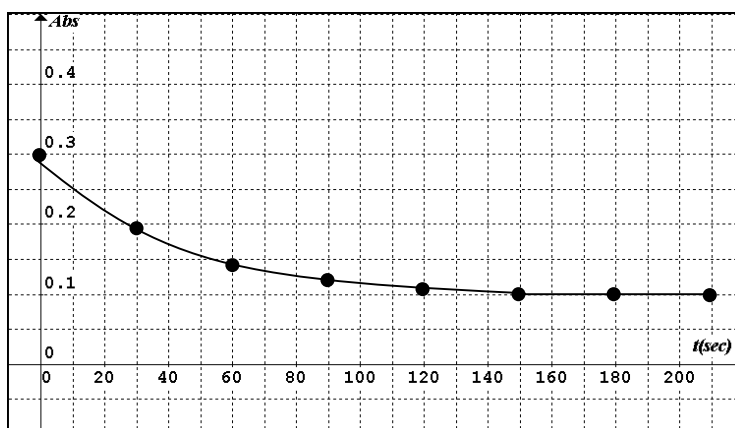
a. (i) At what time did the system described by the reaction
$C_6H_8O_{6(aq)} + I_{2(aq)} \rightleftharpoons C_6H_6O_{6(aq)} + 2HI_{(aq)}$ reach equilibrium?

_____

<div align="right">1 mark</div>

(ii) What is the concentration of iodine when the system reaches equilibrium?

_____

<div align="right">1 mark</div>

b. (i) Write an expression for the equilibrium constant for this reaction.

_____

_____

_____

<div align="right">1 mark</div>

(ii) If the equilibrium constant for the formation of $C_6H_6O_{6(aq)}$ is $3.125\ M$ at the given temperature, determine the concentration of $C_6H_6O_{6(aq)}$ when the system reaches equilibrium.

_____

_____

_____

_____

_____

_____

_____

_____

<div align="right">3 marks</div>

c. (i) On the axes below, sketch one possible curve that reflects the changes in absorbance you could expect to observe if the temperature was increased.
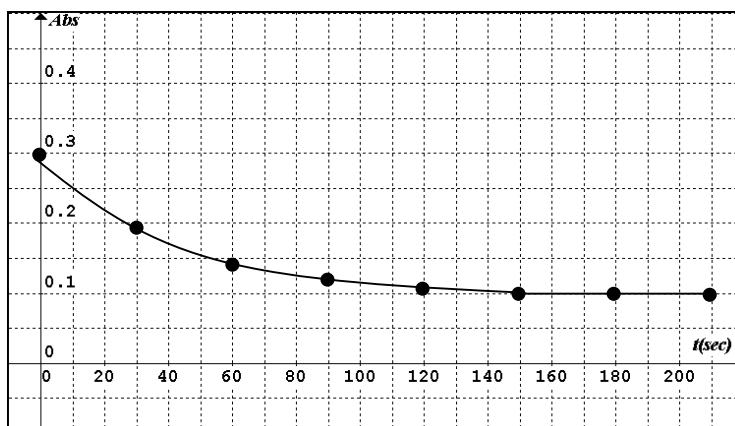
2 marks

(ii) On the axes below, sketch one possible curve that reflects the changes in absorbance you could expect to observe if $C_6H_6O_{6(aq)}$ were regularly removed from the reaction mixture, keeping volume and temperature constant.

2 marks

Total 10 marks

QUESTION 2
Below is a simplified diagram of a gas chromatograph.

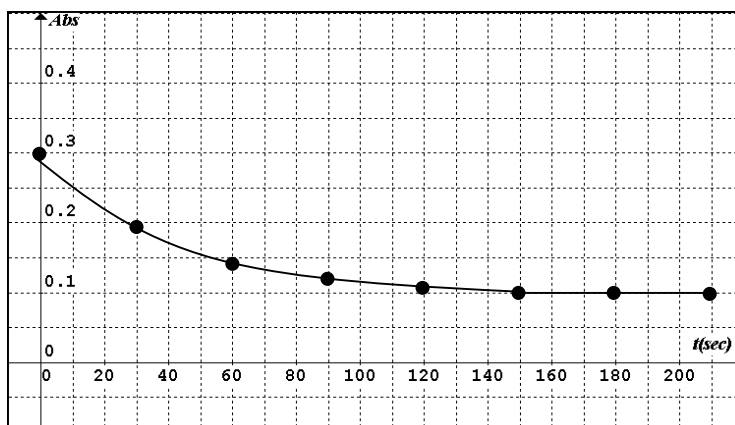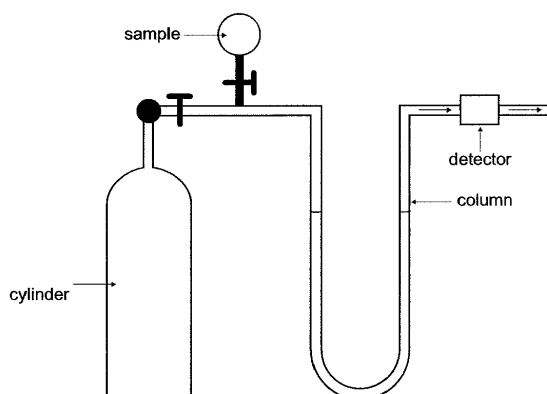**a.** (i) Which **one** of the following gases is **least** likely to be chosen as the mobile phase in Gas Liquid Chromatography (GLC)? Circle the correct response and provide **one** reason for your answer.

Helium   Oxygen   Nitrogen   Argon

_____

_____

_____

_____

<div align="right">1 + 1 marks</div>

(ii) The column containing the stationary phase is contained in an oven at controlled temperatures. State why it is important to maintain the column at a constant temperature.

_____

_____

_____

_____

<div align="right">1 mark</div>

Part of a gas chromatogram of a sample of organic molecules is given below.

Retention Time (min)
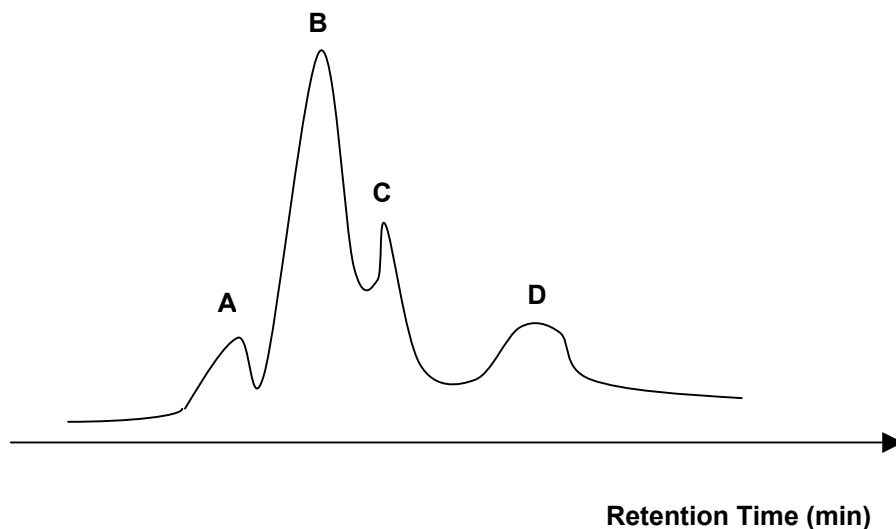
Four peaks, labelled A, B, C and D are shown. The formulae of the molecules corresponding to these peaks are given below.

b. Identify the order in which the molecules leave the column by placing the letters A, B, C or D in the appropriate spaces next to the given formulae. Briefly explain the reason for your answer by referring to structure and bonding.

C_4H_{10} Peak _____

$C_4H_8O_2$ Peak _____

$C_4H_{10}O$ Peak _____

C_4H_8 Peak _____

Explanation:

_____

_____

_____

2 + 1 marks

In order to determine the concentration of butanol in an unknown sample, a number of standard solutions containing known quantities of butanol were injected into a GLC. The unknown butanol sample was then tested under identical conditions.

Abundance (Units)

20 μg/ml Butanol	40 μg/ml Butanol	60 μg/ml Butanol	Time (minutes)
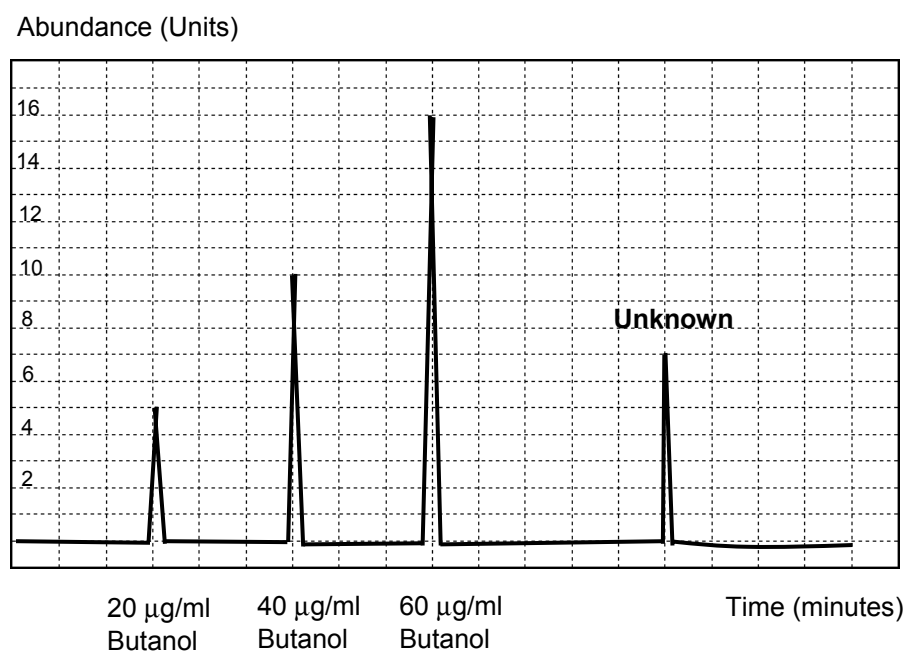
c. (i) Plot a calibration curve of the concentration of butanol as a function of peak height on the axes below.
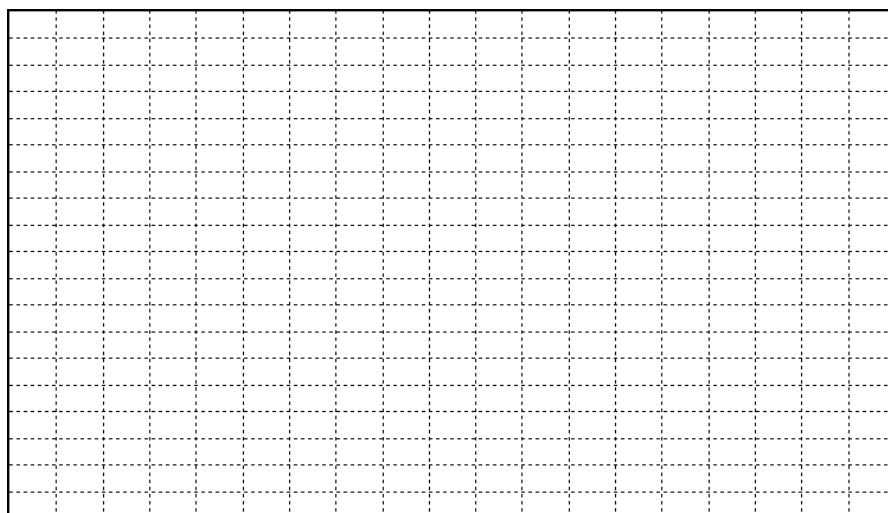
1 mark

(ii) Use this curve to determine the concentration of butanol in the unknown sample in $\mu g / ml$.

_____

<div align="right">1 mark</div>

(iii) Express the concentration of butanol in the unknown sample in ppm.

_____

_____

_____

_____

<div align="right">2 marks</div>

<div align="right">**Total 10 marks**</div>

QUESTION 3

Milk of magnesia is a viscous, mildly basic mixture that is used to treat acid reflux (heartburn) and occasionally to prevent constipation.

The active ingredient of milk of magnesia is $Mg(OH)_2$.

An accurate analysis of milk of magnesia is difficult because $Mg(OH)_2$ exists as a white opaque solution that does not transmit light, and due to that fact that some of the solution may cling to the sides of a flask, preventing complete titration. The opaque solution also makes it difficult to detect the colour change of the endpoint in acid-base titrations.

For this reason, a back titration is usually employed to determine the percentage by weight of $Mg(OH)_2$ in milk of magnesia.

In an experiment to determine the percentage by weight of $Mg(OH)_2$ in a popular brand of milk of magnesia, five samples of milk of magnesia, each at 0.750 g, were first reacted with $50.00 \, ml$ of a $0.200 \, M$ hydrochloric acid solution in separate flasks.

a.   Write an equation to represent the reaction that occurs when $Mg(OH)_2$ reacts with the hydrochloric acid solution.

_____

<div align="right">1 mark</div>

The excess hydrochloric acid in the resulting solutions were titrated with $0.350 \, M \, NaOH$, using phenolphthalein as the indicator. The reaction that occurred is described by the equation:

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$
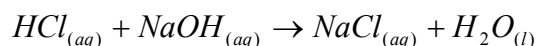
The end point was reached when the following volumes of $NaOH$ had been delivered from the burette.

Flask 1: $25.25 \, ml$
Flask 2: $24.50 \, ml$
Flask 3: $22.60 \, ml$
Flask 4: $22.70 \, ml$
Flask 5: $22.80 \, ml$

b.   (i)   Determine the average titre that should be used for the calculations relating to this titration.

_____

<div align="right">1 mark</div>

(ii) Calculate the amount of $NaOH$ that was delivered from the burette.

_____

_____

<div align="right">1 mark</div>

(iii) Calculate the amount of HCl that reacted with the $NaOH$.

_____

_____

<div align="right">1 mark</div>

(iv) Calculate the amount of HCl that reacted with the $Mg(OH)_2$.

_____

_____

_____

<div align="right">2 marks</div>

(v) Calculate the percentage by mass of $Mg(OH)_2$ in the sample of milk of magnesia.

_____

_____

_____

_____

<div align="right">2 marks</div>

c. (i) Would the percentage of $Mg(OH)_2$ be higher or lower than the true value if some milk of magnesia got stuck on the sides of the flask and was not titrated?

_____

<div align="right">1 mark</div>

(ii) Would the percentage of $Mg(OH)_2$ be higher or lower than the true value if the burette used to deliver the standard $NaOH$ was rinsed with water and not dried prior to use?

_____

<div align="right">1 mark</div>

<div align="right">**Total 10 marks**</div>

QUESTION 4

The production of ethanol from ethene is given by the reaction:

$$C_2H_{4(g)} + H_2O_{(g)} \overset{H_3PO_4}{\rightleftharpoons} C_2H_5OH_{(g)}$$
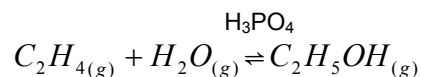
a. Identify the type of reaction that is occurring in the above equation. Circle the correct response(s):

Addition   Substitution   Hydration   Condensation   Esterification

1 mark

The graph below shows the variation in the equilibrium constant for this reaction at different temperatures.
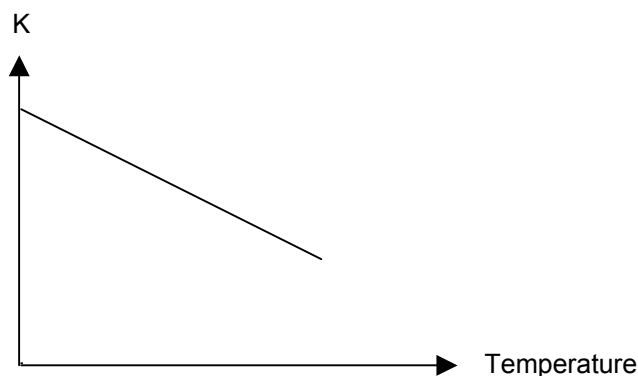
b. (i) Use this graph to determine whether the production of ethanol is exothermic or endothermic.

_____

_____

1 mark

(ii) State whether the formation of ethanol is favoured by high or low pressures and temperatures.

_____

_____

2 marks

Most of our ethene supplies are derived from cracking of select fractions from crude oil.

c. (i) Write two equations to represent the cracking of propane.

Equation 1:

_____

_____

Equation 2:

_____

_____

<div align="right">1+1 = 2 marks</div>

(ii) Explain why alkenes are produced during the cracking process.

_____

_____

<div align="right">1 mark</div>

Alkenes are typically more reactive than their corresponding alkanes due to the presence of unsaturated C-C bonds.

d. Outline a procedure to compare the reactivity of an alkene such as ethene with its corresponding alkane. Describe the results that would be obtained, including the relevant chemical equations.

_____

_____

_____

_____

_____

_____

_____

_____

_____

<div align="right">4 marks</div>

<div align="right">**Total 11 marks**</div>

QUESTION 5

Esters are formed by condensation reactions between two important classes of organic molecules. A common ester used in industry has the semi-structural formula:

$$CH_3COOCH_2CH_2CH_2CH_3$$

a. (i) Circle the functional group in the above ester.

(ii) State the systematic name of the ester $CH_3COOCH_2CH_2CH_2CH_3$.

_____

1 mark

b. (i) Write an equation to represent the formation of $CH_3COOCH_2CH_2CH_2CH_3$. In your answer, include the names of the reactants involved, as well as any catalysts used in the process.

_____

_____

2 marks

(ii) How does the catalyst increase the equilibrium yield of ester?

_____

_____

_____

_____

2 marks

(iii) Why is the production of esters not usually performed using dilute aqueous solutions of reactants?

_____

_____

1 mark

Total 6 marks

QUESTION 6

The concentration of $H_3O^+_{(aq)}$ in pure water at different temperatures is illustrated in the graph below.

[H₃O⁺] (M)

Temperature (°C)
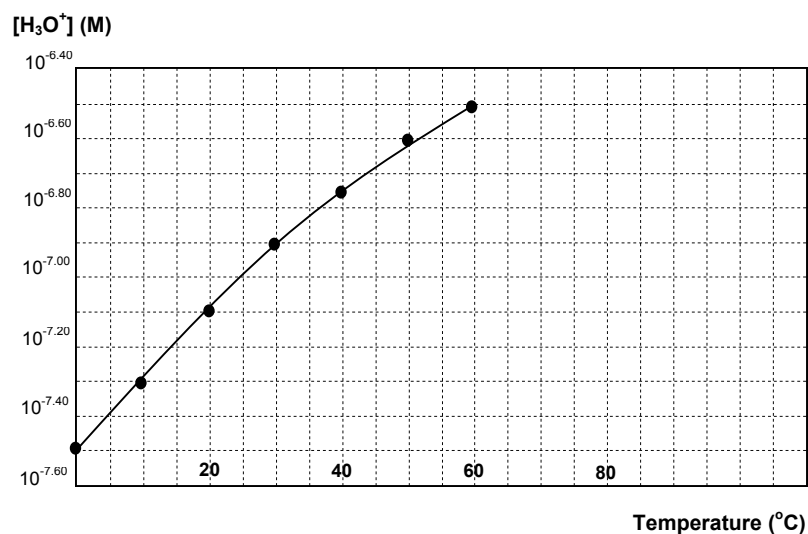
(a) What is the concentration of $[OH^-_{(aq)}]$ in neutral water at $50^o C$?

_____

_____

1 mark

(b) Calculate K_w at $50^o C$.

_____

_____

1 mark

(c) Hence calculate the pH of $0.00400\ M\ NaOH$ at $50^o C$.

_____

_____

_____

_____

2 marks

Total 4 marks

QUESTION 7

The hydrolysis of acetic acid is described by the equation

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)} \quad \Delta H = -ve$$
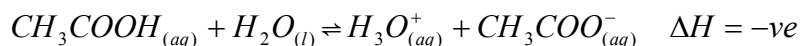
a. (i) When CH_3COO^- is removed from the above equilibrium system, the rate of the forward reaction as the system returns to equilibrium will

Increase   Decrease   Remain the Same

Circle the appropriate answer.

(ii) The mixture is diluted at constant temperature. The concentration of CH_3COO^- when equilibrium has been re-established will be

Higher   Lower   The same   as in the previous equilibrium mixture.

Circle the appropriate answer.

(iii) Solid sodium hydroxide is added to the equilibrium mixture. When equilibrium has been re-established, the temperature of the system will be

Higher   Lower   The same   as in the previous equilibrium mixture.

Circle the appropriate answer.

1 + 1 + 1 = 3 marks

---

b. The percentage hydrolysis of CH_3COOH at 25^oC is 1.30%. Calculate the K_a of a $0.10\ M\ CH_3COOH$ solution at the given temperature.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

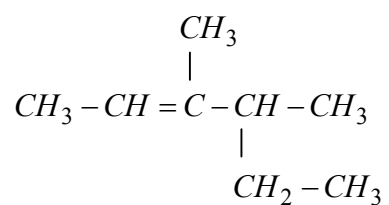<div align="right">3 marks</div>

<div align="right">**Total 6 marks**</div>

QUESTION 8

a. (i) Draw the structural formula of 2-chloro-5,5-dimethyl hexane.

1 mark

(ii) State the systematic name for the molecule below.

$$CH_3 - CH = \overset{\overset{\displaystyle CH_3}{\displaystyle |}}{C} - \underset{\underset{\displaystyle CH_2 - CH_3}{\displaystyle |}}{CH} - CH_3$$

_____

1 mark

b. Write a balanced equation for the oxidation of ethanol by dichromate ions ($Cr_2O_7^{2-}$) given that under these conditions, acetic acid and Cr^{3+} are produced.

_____

_____

_____

_____

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3 marks

c. A $0.900\ g$ sample of a compound containing only carbon, oxygen and hydrogen was burned in excess oxygen producing $1.32\ g$ of carbon dioxide and $0.540\ g$ of water.

(i) Determine the percentage by mass of carbon in carbon dioxide.

_____

_____

1 mark

(ii) Hence calculate the mass of carbon in the $0.900\ g$ sample.

_____

_____

1 mark

(iii) A similar series of calculations were performed to determine the mass of hydrogen in the $0.900\ g$ sample. If the mass of hydrogen was determined as $0.0560\ g$, calculate the mass of oxygen in the unknown sample.

_____

_____

1 mark

(iv) Determine the empirical formula of this organic compound.

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2 marks

(v) $2.90\,g$ of the unknown sample was vaporised. If the gaseous vapour occupies a volume of $484\,cm^3$ at $1.25 \times 10^5\,Pa$ at 179^oC, find the molecular formula of the unknown compound.

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3 marks

Total 13 marks

THE SCHOOL FOR EXCELLENCE 2006

UNIT 3 CHEMISTRY - WRITTEN EXAMINATION 1

MULTIPLE CHOICE QUESTIONS - ANSWER SHEET

Please note that the format and requirements of this answer sheet are different to the answer sheet that will be issued in the VCAA examination. Copies of the actual examination answer sheet may be obtained at: **www.vcaa.vic.edu.au**

Choose the correct response or the one which best answers the question by shading the square corresponding to your response in the table below.

Question 1	A	B	C	D
Question 2	A	B	C	D
Question 3	A	B	C	D
Question 4	A	B	C	D
Question 5	A	B	C	D
Question 6	A	B	C	D
Question 7	A	B	C	D
Question 8	A	B	C	D
Question 9	A	B	C	D
Question 10	A	B	C	D
Question 11	A	B	C	D
Question 12	A	B	C	D
Question 13	A	B	C	D
Question 14	A	B	C	D
Question 15	A	B	C	D
Question 16	A	B	C	D
Question 17	A	B	C	D
Question 18	A	B	C	D
Question 19	A	B	C	D
Question 20	A	B	C	D