VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2003

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

									Letter
Figures									
Words									

CHEMISTRY

Written examination 1

Tuesday 10 June 2003

Reading time: 11.45 am to 12.00 noon (15 minutes)
Writing time: 12.00 noon to 1.30 pm (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 (minutes)*
A	20	20	20	27
B	7	7	46	63
			Total 66	90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, an approved graphics calculator (memory cleared) and/or one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 17 pages, with a detachable data sheet in the centrefold.
- Answer sheet for multiple-choice questions.

Instructions
- Detach the data sheet from the centre of this book during reading time.
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other electronic communication devices into the examination room.

SECTION A – Multiple-choice questions

Instructions for Section A

Answer all questions in pencil on the answer sheet provided for multiple-choice questions.

A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No mark will be given if more than one answer is completed for any question.

Question 1

Ethanol can be manufactured by the reaction between ethene and water. This is represented by the equation

$$C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g) \quad \Delta H = -46 \text{ kJ mol}^{-1}$$

Which conditions would produce the highest percentage yield of ethanol at equilibrium?

A. low pressure and low temperature
B. high pressure and low temperature
C. low pressure and high temperature
D. high pressure and high temperature

Question 2

The rate of decomposition of hydrogen peroxide is increased by the presence of a catalyst.

The catalyst

A. increases the equilibrium constant for the reaction.
B. provides a reaction pathway with a lower activation energy.
C. provides a reaction pathway with a greater activation energy.
D. increases the average kinetic energy of the hydrogen peroxide molecules.

Question 3

At 25ºC, the pH of 0.0050 M $Ba(OH)_2$ is

A. 2.0
B. 2.3
C. 11.7
D. 12.0

Questions 4 and 5 refer to the following information.

0.12 g of a metal was reacted with excess hydrochloric acid. 125 mL of hydrogen gas was collected at 27ºC and 100 kPa.

Question 4

The amount of hydrogen gas, in mol, would be closest to

A. 5.0
B. 0.52
C. 0.052
D. 0.0050

Question 5

The metal involved could be

A. zinc.

B. sodium.

C. calcium.

D. magnesium.

Question 6

Consider the reaction

$$CH_3CH = CHCH_3 + Br_2 \rightarrow Z$$

Z would be represented by

A. $CH_3CHBrCHBrCH_3$

B. $CH_2BrCH_2CHBrCH_3$

C. $CH_3CHBrCH_2CH_2Br$

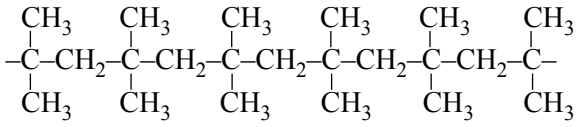
D. $CH_2BrCH_2CH_2CH_2Br$

Question 7

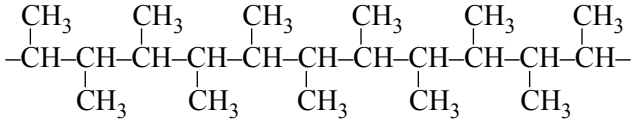
Consider the addition polymerisation of $CH_3CH = CHCH_3$.

The structure of the resulting polymer would be

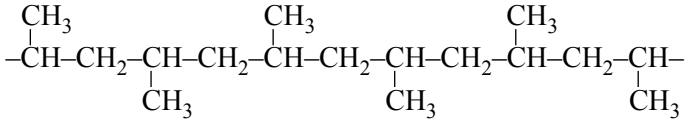
A.



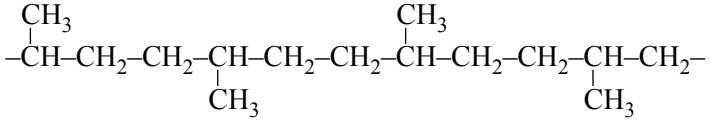
B.



C.



D.



Question 8

Consider the reaction

$$CH_3CH = CHCH_3 + H_2O \rightarrow X$$
$$X + CH_3COOH \rightarrow Y$$

The structure of Y would be

A. $CH_3CH_2\underset{\displaystyle CH_3}{\underset{|}{C}}HCOOCH_3$

B. $CH_3COOCH\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_3$

C. $CH_3CH_2CH_2COOCH_3$

D. $CH_3OOCH_2CH_2CH_2CH_3$

Questions 9 and 10 refer to the following information.

Consider the equilibrium

$$2ClF_3(g) \rightleftharpoons 3F_2(g) + Cl_2(g) \quad \Delta H = \text{negative}$$

Question 9

An expression for the equilibrium constant for this reaction is

A. $\dfrac{[ClF_3]^2}{[F_2]^3\,[Cl_2]}$

B. $\dfrac{3[F_2]\,[Cl_2]}{2[ClF_3]}$

C. $\dfrac{[F_2]^3\,[Cl_2]}{[ClF_3]^2}$

D. $\dfrac{2[ClF_3]}{3[F_2]\,[Cl_2]}$

Question 10

For a particular equilibrium mixture, the temperature is **lowered** and the amount of ClF_3 changes by 0.010 mol.

The changes occurring would be

	ClF_3	F_2	Cl_2
A.	increase by 0.010 mol	decrease by 0.015 mol	decrease by 0.0050 mol
B.	increase by 0.010 mol	decrease by 0.0067 mol	decrease by 0.020 mol
C.	decrease by 0.010 mol	increase by 0.015 mol	increase by 0.0050 mol
D.	decrease by 0.010 mol	increase by 0.067 mol	increase by 0.020 mol

Question 11

Catalytic cracking of alkanes is carried out by passing the hydrocarbon vapour over a heated catalyst in the absence of air.

Which of the following is **not** a possible product of the catalytic cracking of hexane?

A. propene

B. methane

C. hydrogen

D. carbon dioxide

Question 12

The compound that is a structural isomer of CH_3CH_2COOH is

A. $HCOOCH_2CH_3$

B. $CH_3CH_2CH_2OH$

C. $CH_3COOCH_2CH_3$

D. $CH_3CHOHCH_2OH$

Question 13

How many hydrogen atoms are there in a molecule of 3-nonanol?

A. 9
B. 19
C. 20
D. 21

Question 14

The number of structural isomers with the formula C_4H_9Cl is

A. 1
B. 2
C. 3
D. 4

Question 15

Oxides of nitrogen are formed in air at the high temperatures generated in lightning flashes according to the equation

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g) \qquad K_1 = 5 \times 10^{-3} \text{ at } 3000^oC$$

At 3000ºC, the equilibrium constant K_2 for the reaction

$$4NO(g) \rightleftharpoons 2N_2(g) + 2O_2(g)$$

would be

A. 4×10^4
B. 1×10^2
C. 1×10^{-2}
D. 5×10^{-3}

Question 16

A group of chemists complain about the smell that they noticed when reading new copies of a particular journal. The publishers of the journal decide to try to identify the substance, or substances, responsible for this smell.

Which of the following analytical methods would be the most likely choice for the first stage of an analysis?

A. flame tests
B. paper chromatography
C. gas-liquid chromatography
D. atomic absorption spectroscopy

Question 17

Equal masses of each of the following substances are dissolved in separate samples of water to give 500 mL of solution.

Which substance would produce the solution with the lowest pH?

A. NH_3
B. HCl
C. HNO_3
D. $HClO_4$

Question 18

The oxidation number of Cl in $HClO_4$ is

A. +7

B. +5

C. +3

D. –1

Question 19

A sample of hydrocarbon contains 81.8% carbon by mass.

The empirical formula of the compound would be

A. CH_2

B. CH_3

C. C_2H_5

D. C_3H_8

Question 20

Concentrated sulfuric acid reacts with glucose. One of the chemical reactions that can occur may be represented as

$$C_6H_{12}O_6(s) + 6H_2SO_4(l) \rightarrow 6C(s) + 6H_3O^+(aq) + 6HSO_4^-(aq)$$

This reaction is best described as being

A. dehydration only.

B. acid-base and redox only.

C. dehydration and acid-base only.

D. dehydration, acid-base and redox.

END OF SECTION A

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 given 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).

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Question 1

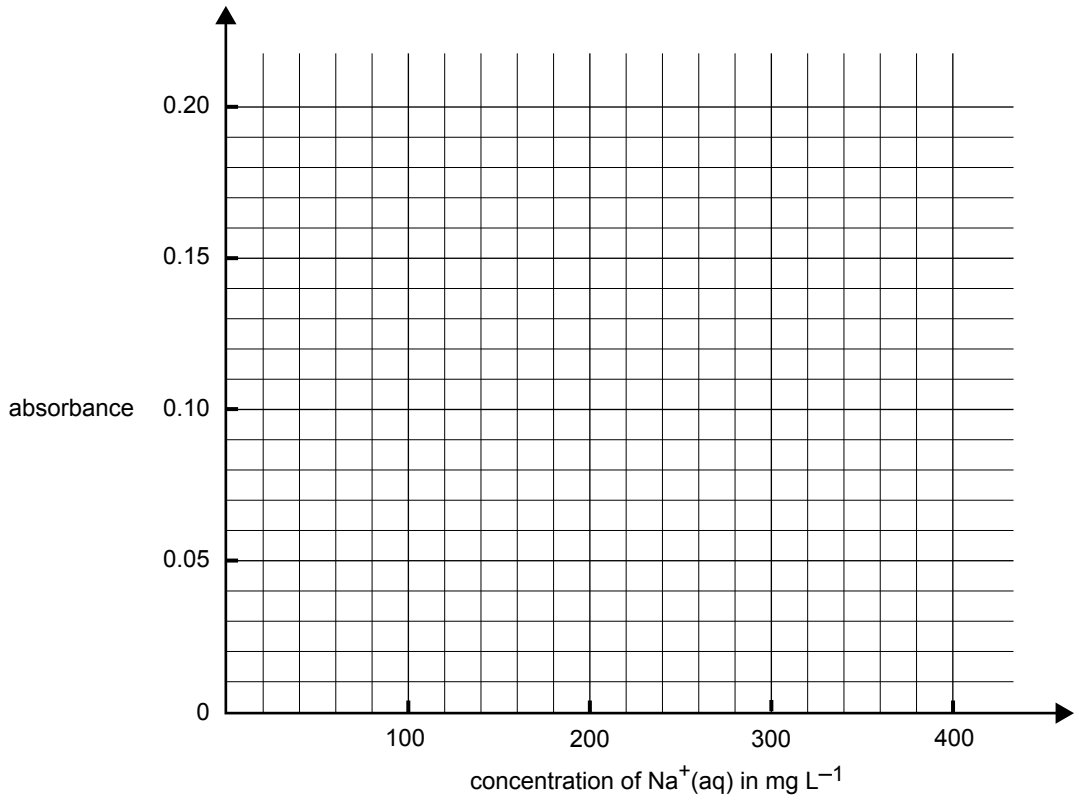
Sodium is an essential element in our diets. However, the amount of sodium present in some foods is often much higher than levels recommended by doctors. A sauce was analysed using atomic absorption spectroscopy to determine the sodium content.

A 25.00 mL sample of the sauce was diluted to 1.00 L with deionised water.

Four aqueous samples of known NaCl concentration were also prepared as standard solutions. The absorbances of the four standard solutions and the diluted sauce solution were measured. The results are given in the table below.

concentration of $Na^+(aq)$	**absorbance**
100 mg L^{-1}	0.051
200 mg L^{-1}	0.100
300 mg L^{-1}	0.149
400 mg L^{-1}	0.199
diluted sauce	0.185

a. Use the above data for the $Na^+(aq)$ standards to plot a calibration line on the graph below.



1 mark

b. Use your calibration graph to determine the sodium ion concentration in the diluted sample of the sauce and in the original sauce. Enter your answers in the table below.

concentration of $Na^+(aq)$ in diluted solution of sauce in mg L^{-1}	concentration of $Na^+(aq)$ in original (undiluted) sauce in mg L^{-1}

2 marks

c. **i.** What important assumption must you make in order to calculate the NaCl content of the sauce from the Na^+ concentration?

ii. Calculate the concentration of NaCl in the original (undiluted) sauce in g L^{-1}.

iii. The maximum recommended daily NaCl intake for a healthy adult is 2.5 g. What percentage of a maximum daily recommended intake would be consumed by a person who eats 10 mL of the original (undiluted) sauce?

1 + 3 + 2 = 6 marks

d. Why is it that atomic absorption spectroscopy will measure only the sodium ion concentration in your sample and not the concentration of some other substance or substances as well?

2 marks

Total 11 marks

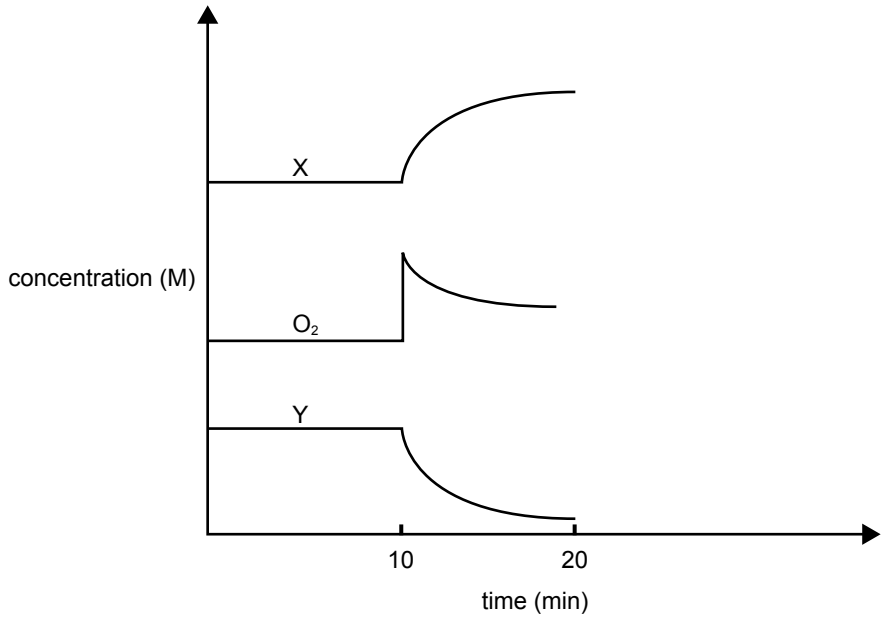
Question 2

Part of the Contact Process for the manufacture of sulfuric acid involves the conversion of sulfur dioxide to sulfur trioxide, as shown by the equation

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -192 \text{ kJ mol}^{-1}$$

As part of a laboratory study of this process, a container was filled with an equilibrium mixture of sulfur dioxide, sulfur trioxide and oxygen in the presence of a catalyst. The container was initially at 450°C. The container had a fixed volume and was **thermally well insulated**.

Concentrations during a following experiment are shown on the diagram below.



a. What change occurred at the 10 minute point?

_____

_____

1 mark

b. Which components of the equilibrium mixture are represented by X and Y?

X =

Y =

1 mark

c. Give explanations for the changes in concentration that occur in X, Y and O_2 between 10 and 20 minutes.

3 marks

d. Would the temperature of the mixture **increase, decrease** or **remain the same** between 10 and 20 minutes? Explain your reasoning.

2 marks

Total 7 marks

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Question 3

Esters are the basis of many naturally occurring odours and are therefore widely used in the creation of artificial flavours. Methyl butanoate is a component of the smell of pineapple. A manufacturer decides to test the use of some of this compound in an ice-cream mix.

Chromium trioxide is an oxidising agent that can convert a simple alcohol to the corresponding carboxylic acid.

a. Give a simple structure for the ester methyl butanoate.

1 mark

b. Using 1-butanol and methanol as starting materials give chemical equations showing the steps in the preparation of methyl butanoate. Give the name of any catalyst used.

3 marks

Total 4 marks

Question 4

Methanoic acid HCOOH is a weak acid present in the sting of some ants. It ionises in water according to

$$HCOOH(aq) \rightleftharpoons HCOO^-(aq) + H^+(aq) \quad K_a = 1.8 \times 10^{-4} \text{ at } 25^oC$$

a. Explain the meaning of the terms 'weak acid' and 'strong acid'.

2 marks

b. Write the expression for the K_a of methanoic acid.

1 mark

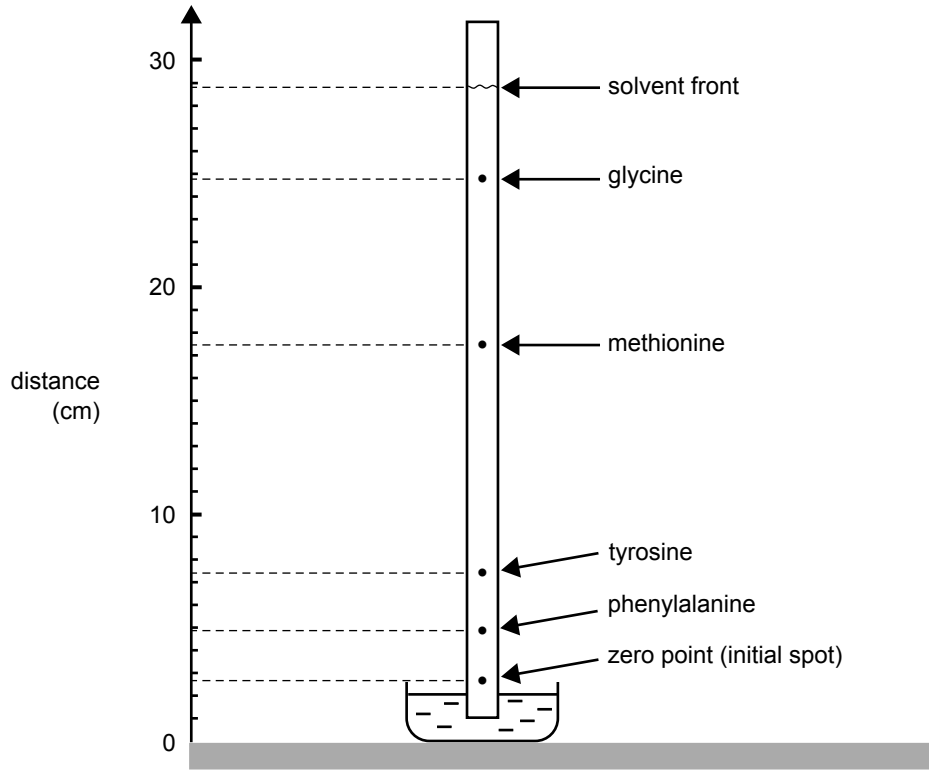
c. Assuming a small degree of dissociation, calculate the concentrations of $H^+(aq)$ and $HCOO^-(aq)$ in 0.10 M methanoic acid at 25°C.

2 marks

Total 5 marks

Question 5

Chromatography is often used for the analysis of the mixture of amino acids that is formed when proteins are broken down. The small protein methionine enkephalin has some pain killing activity. An aqueous solution of methionine enkephalin is broken down into its constituent amino acids and the resultant solution of amino acids is subjected to paper chromatography. A strip from such a chromatogram is shown below.



Amino acids are colourless, but the position of an amino acid spot on the strip can be seen by spraying the strip with a solution of ninhydrin, a substance that reacts with amino acids to produce an intense purple colour.

a. The identities of the four amino acids in this particular mixture have been determined by measuring their R_f values.

i. Explain how an R_f value is calculated.

ii. Calculate the R_f of the methionine spot.

1 + 2 = 3 marks

b. Describe how the sample containing the mixture of the four amino acids was added to the paper in order to begin the procedure.

1 mark

c. What factors determine the different R_f values of the different amino acids?

2 marks

Total 6 marks

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Question 6

a. The Earth's oceans contain significant amounts of dissolved carbon dioxide. The dissolving process can be described by the following chemical equilibria.

$$CO_2(g) \rightleftharpoons CO_2(aq)$$

$$CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

Use this information to explain the likely effect of the increasing concentration of atmospheric CO_2 on the pH of seawater at the ocean surface.

3 marks

b. Several different acid-base systems contribute to the hydrogen ion concentration in blood. One of these systems is represented by the equilibrium

$$CO_2(aq) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq) \quad K_a = 7.9 \times 10^{-7}$$

The concentration of $CO_2(aq)$ in freshly oxygenated blood is approximately 1.3×10^{-5} M and the pH of blood is 7.4.

i. Calculate the concentration of the hydrogen ion, H^+, in fresh blood.

ii. Calculate the concentration of the hydrogen carbonate ion, HCO_3^-, in fresh blood.

1 + 2 = 3 marks

Total 6 marks

Question 7

Pyrolusite, an ore of manganese, contains manganese in the form of MnO_2. A sample of pyrolusite from a newly discovered deposit is analysed to determine the degree of purity of the deposit.

To determine the amount of Mn in the pyrolusite sample, 1.25 g of dried pyrolusite was heated with 100 mL of 0.150 M oxalic acid ($H_2C_2O_4$). The oxalic acid was in excess, so that all of the MnO_2 reacted according to

$$MnO_2(s) + H_2C_2O_4(aq) + 2H^+(aq) \rightarrow Mn^{2+}(aq) + 2CO_2(g) + 2H_2O(l)$$

20.00 mL of the resulting solution is then titrated with an 0.0510 M solution of the triiodide ion

$$I_3^-(aq) + H_2C_2O_4(aq) \rightarrow 2CO_2(g) + 2H^+(aq) + 3I^-(aq)$$

22.00 mL of the 0.0510 M triiodide solution was needed to react with the remaining oxalic acid.

a. Calculate the amount in mole of oxalic acid remaining in the original 100 mL solution after the pyrolusite had been reacted with the oxalic acid.

3 marks

b. Calculate the amount in mole of oxalic acid used to reduce the MnO_2 in the 1.25 g of pyrolusite.

2 marks

c. Calculate the amount in mole of MnO_2 present in the original 1.25 g of pyrolusite and hence the percentage of MnO_2 by mass present in the pyrolusite.

2 marks

Total 7 marks

END OF QUESTION AND ANSWER BOOK