VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2004

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures									Letter
Words									

CHEMISTRY

Written examination 1

Tuesday 8 June 2004

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	26
B	6	6	48	64
			Total 68	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 22 pages, with a detachable data sheet in the centrefold.

Instructions
- Remove the data sheet from the centre of this book during reading time.
- Use ONLY pencil to mark your responses in Section A. Use ONLY blue or black pen to write your responses in Section B.
- Write your **student number** in the space provided above on this page.
- All written responses must be in English.

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. 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.

Use pencil **only** to mark your answers to all multiple-choice questions in this section. For each question, shade the box beside the response that you have chosen as your answer.

All answers must be completed like this example:

The capital city of Victoria is

A **A.** Sydney
B **B.** Perth
■ **C.** Melbourne
D **D.** Hobart

If you make a mistake, or wish to change your answer, **ERASE** the incorrect answer – **DO NOT** cross it out.

Question 1

Suspicions are raised that a sample of soft drink has become accidentally contaminated with a small amount of lead in the form of $Pb^{2+}(aq)$.

The most suitable analytical method of testing for the presence of Pb^{2+} in the sample is

A **A.** gas chromatography.
B **B.** paper chromatography.
C **C.** UV-visible spectroscopy.
D **D.** atomic absorption spectroscopy.

Question 2

Ethanol is now added to some brands of petrol in order to replace some of the hydrocarbons with a renewable resource.

The most suitable analytical method of testing for the presence of ethanol in a sample of petrol is

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

Question 3

An aqueous mixture of two substances (Y and Z) is subjected to analysis by both paper chromatography and high performance liquid chromatography (HPLC). In both forms of chromatography, component Z of the mixture was bonded more strongly to the stationary phase than component Y.

In terms of R_f and R_t, where R_t is the retention time in HPLC, component Z has the

A **A.**	higher R_f	higher R_t
B **B.**	higher R_f	lower R_t
C **C.**	lower R_f	higher R_t
D **D.**	lower R_f	lower R_t

Question 4

In the 19th century, relative atomic masses (RAMs) were determined by gravimetric analysis. In a particular experiment, to determine the RAM of a metal (X), 3.27 g of X was completely reacted with oxygen to produce 4.07 g of the oxide of formula XO.

The RAM of X is

A **A.** 12.8
B **B.** 32.7
C **C.** 65.4
D **D.** 130.8

Question 5

10^{-2} mole of HCl is added to exactly 1.00 L of pure water at 25ºC.

The **change** in pH of the water is closest to

A **A.** 10^{-2}
B **B.** 2
C **C.** 5
D **D.** 7

Question 6

Consider the reaction

$$MnO_2(s) + 4HCl(aq) \rightarrow Cl_2(g) + 2H_2O(l) + MnCl_2(aq)$$

The atoms whose oxidation numbers change during this reaction are

A **A.** Mn
B **B.** Mn and Cl
C **C.** Mn, Cl and O
D **D.** Mn, Cl, O and H

Question 7

A 2 L sample of a gaseous hydrocarbon is burnt in excess oxygen. The only products of the reaction are 8 L of $CO_2(g)$ and 10 L of $H_2O(g)$, all at 100ºC and 1 atm pressure.

The formula of the hydrocarbon is

A **A.** CH
B **B.** C_2H_4
C **C.** C_4H_{10}
D **D.** C_8H_{10}

Question 8

A sample of fertiliser was analysed and found to contain 80% by mass of ammonium nitrate (NH_4NO_3) and 20% by mass of potassium chloride (KCl).

The mass of nitrogen in a 1.00 kg packet of the fertiliser is

A **A.** 140 g
B **B.** 175 g
C **C.** 280 g
D **D.** 350 g

Question 9

A standard solution of potassium permanganate ($KMnO_4$) has a concentration of 0.0240 M. It is titrated against a solution of iron (II) sulfate ($FeSO_4$).

The equation for the reaction is

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$$

15.60 mL of the $KMnO_4$ solution reacts exactly with 20.00 mL of the $FeSO_4$ solution.

The concentration of the $FeSO_4$ solution, in M, is

A **A.** 0.0187
B **B.** 0.0307
C **C.** 0.0936
D **D.** 0.1540

Question 10

25.00 mL of a 0.100 M solution of HCl is added to 25.00 mL of a 0.180 M solution of NaOH.

The concentration of $OH^-(aq)$ remaining in the solution, in M, is

A **A.** 0.0400
B **B.** 0.0500
C **C.** 0.0800
D **D.** 0.1000

Question 11

Which of the following could **not** be a product of the reduction of sulfuric acid when it acts as an oxidant?

A **A.** S
B **B.** H_2S
C **C.** SO_2
D **D.** $H_2S_2O_7$

Question 12

A traffic warden working at a busy city intersection becomes sleepy after a few hours work. The atmosphere at the intersection is found to contain several parts per million of carbon monoxide (CO). Carbon monoxide in the traffic warden's blood reacts according to the equation

$$HbO_2 + CO(g) \rightleftharpoons HbCO + O_2(g)$$

Hb represents haemoglobin.

On the basis of this information, the equilibrium constant for the forward reaction of this equation is

A **A.** less than one.
B **B.** greater than one.
C **C.** one.
D **D.** unable to be estimated from the information.

Question 13

For the reaction

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq), \quad K_w = 10^{-14} \quad \text{at } 25^oC$$

55.9 kJ mol^{-1} of heat is evolved when one mole of $H^+(aq)$ reacts with one mole of $OH^-(aq)$.

At 80ºC, the K_w and pH for pure water is

	K_w	pH
A.	greater than 10^{-14}	less than 7
B.	greater than 10^{-14}	greater than 7
C.	less than 10^{-14}	less than 7
D.	less than 10^{-14}	greater than 7

Questions 14, 15 and 16 refer to the following information

NaOCl is completely dissociated in water to form $Na^+(aq)$ and $OCl^-(aq)$. In solution, OCl^- hydrolyses according to the equation

$$OCl^-(aq) + H_2O(l) \rightleftharpoons HOCl(aq) + OH^-(aq) \qquad (1)$$

Question 14

100 mL of pure water at constant temperature is added to a 100 mL solution of 0.10 M NaOCl.

When the solution reaches equilibrium again, the

A **A.** $[H^+]$ has decreased.
B **B.** pH of the solution has decreased.
C **C.** concentration of HOCl has increased.
D **D.** value of the equilibrium constant has halved.

Question 15

If K_1 is the equilibrium constant for the reaction (1) above, then the value of K_2, the equilibrium constant for the reaction

$$2OCl^-(aq) + 2H_2O(l) \rightleftharpoons 2HOCl(aq) + 2OH^-(aq) \qquad (2)$$

at the same temperature, is equal to

A **A.** K_1
B **B.** $2 \times K_1$
C **C.** $4 \times K_1$
D **D.** K_1^2

Question 16

The HOCl produced in a solution of NaOCl can react further to produce small amounts of chlorine, $Cl_2(aq)$, in water according to the equation

$$HOCl(aq) + H^+(aq) + Cl^-(aq) \rightleftharpoons Cl_2(aq) + H_2O(l)$$

Which of the following, when added to a solution of NaOCl, would **not** raise the concentration of Cl_2 in the solution?

A **A.** NaCl
B **B.** NaOH
C **C.** H_2SO_4
D **D.** HOCl

Question 17

The K_a of hydrofluoric acid, HF, is 6.8×10^{-4}.

The pH of a 0.10 M solution of HF in water is closest to

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

Question 18

100 mL of 1.00 M HCl is added to a 2 g piece of limestone, $CaCO_3$.

Which of the following will **not** increase the initial rate of this reaction?

A **A.** adding 150 mL of 1 M HCl in place of 100 mL of 1 M HCl
B **B.** adding 100 mL of 2 M HCl in place of 100 mL of 1 M HCl
C **C.** heating the 100 mL of 1 M HCl before adding it to the limestone
D **D.** adding 100 mL of 1 M HCl to powdered $CaCO_3$ in place of the single piece of limestone

Question 19

In a chemical reaction at constant temperature the addition of a catalyst

A **A.** affects the equilibrium constant.
B **B.** provides an alternative reaction pathway.
C **C.** increases the percentage yield at equilibrium.
D **D.** increases the fraction of molecules with more than a given kinetic energy.

Question 20

Nitrogen (II) oxide and chlorine react according to the equation

$$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g); \quad \Delta H = -38 \text{ kJ mol}^{-1}$$

The activation energy for the forward reaction is 62 kJ mol^{-1}.

The activation energy of the reverse reaction, in kJ mol^{-1}, is

A **A.** –62
B **B.** 24
C **C.** 38
D **D.** 100

END OF SECTION A
TURN OVER

SECTION B – Short-answer questions

Instructions for Section B

Answer **all** questions. Use only blue or black pen to write your responses.

Write your responses in the space provided. Do **NOT** respond to a question anywhere other than in the space immediately following the question. Where lines are provided under a question, the number of lines is intended to be more than sufficient for your response.

If you need more space, there is also unlined space provided for each question part.

Do **NOT** write in the shaded regions that border each page – no writing in that region will be marked.

To obtain full marks for your response you should

- give simplified answers, with an appropriate number of significant figures, to all numerical questions.
- show all working in your answers to numerical questions. Partial credit may be given if an incorrect answer 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

The main source of the element magnesium in Australia is the ore magnesite, in which magnesium is present as magnesium carbonate ($MgCO_3$).

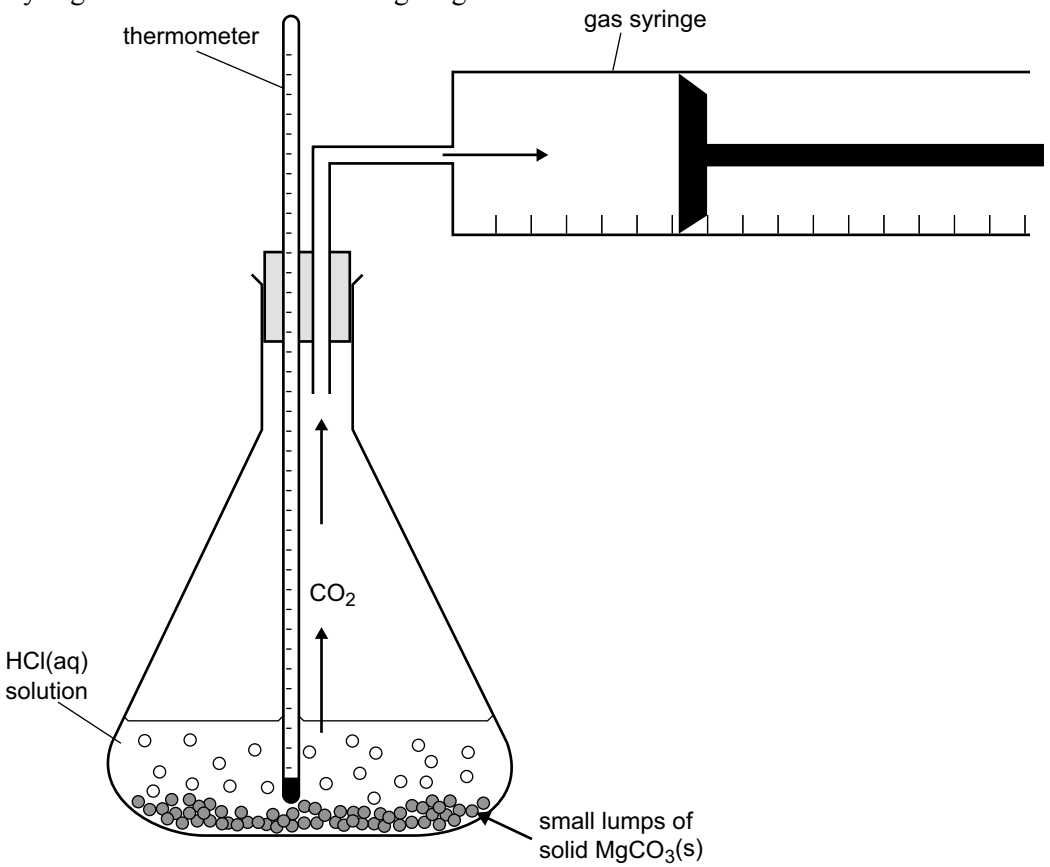
a. Calculate the percentage by mass of magnesium in magnesium carbonate.

1 mark

b. Magnesium carbonate reacts with aqueous hydrochloric acid according to the reaction

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$$

A series of laboratory experiments was set up to study the rate of this reaction under some different conditions. The initial reaction rate was determined by measuring the rate of evolution of CO_2 in a gas syringe as shown in the following diagram.



Four experiments were carried out as follows. **In each case, the amount of HCl present was in excess.**

Experiment	[HCl] (M)	Mass of $MgCO_3$(g)	Initial temp in °C	Final temp in °C	Initial rate of CO_2 evolution in mL min^{-1}
1	0.10	1.0	20	25	5
2	0.10	1.0	30	35	50
3	0.10	2.0	20	30	10
4	0.20	1.0	20	25	20

i. Is the reaction exothermic or endothermic? Explain how you can tell from these results.

1 mark

ii. Considering experiments 1 and 2, explain why the increase in the initial temperature has raised the reaction rate.

1 mark

SECTION B – Question 1 – continued

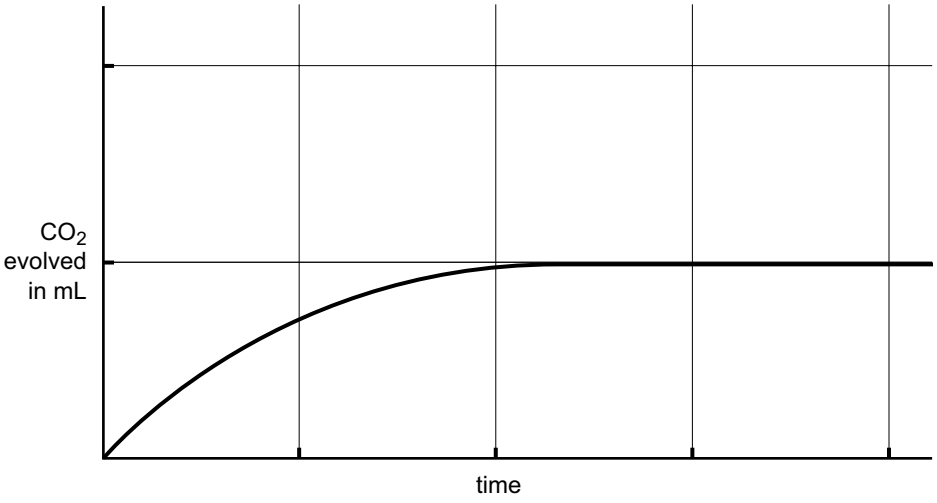
iii. Considering experiments 1 and 3, explain why the greater mass of magnesium carbonate would have increased the reaction rate.

1 mark

iv. Considering experiments 1 and 4, explain why the higher concentration of HCl would have increased the reaction rate.

1 mark

v. Results from experiment 1 are plotted on the sketch graph below. On the same axes, sketch the results from experiment 3.



2 marks

Total 7 marks

SECTION B – continued
TURN OVER

Question 2

a. Give the systematic names of the following organic compounds.

i. $CH_3CHOHCH_3$ _____

1 mark

ii. HCOOH _____

1 mark

iii. $CH_3CH_2CHClCH_3$ _____

1 mark

iv. $CH_3CH_2COOCH_2CH_3$ _____

1 mark

b. Complete the following chemical equation by giving relevant structural formulas in the boxes provided.

$C_2H_6 + Cl_2 \rightarrow$ [ ] + [ ]

1 + 1 = 2 marks

SECTION B – Question 2 – continued

c. A representation of a section of a polymer chain is

$$–O–CH_2–CH_2–O–CO–CH_2–CO–O–CH_2–CH_2–O–CO–CH_2–CO–O–$$

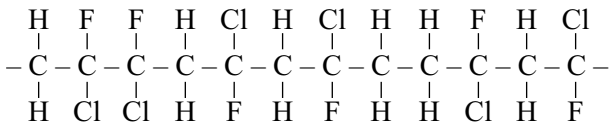
i. In the two boxes provided, give the structures of the two different monomers needed to make this polymer.

2 marks

ii. In the following box, give the formula of the other molecule formed when the monomers combine to form the polymer.

1 mark

d. A representation of a section of a polymer chain is



In the following box, give the structure of the monomer from which the polymer is made.

1 mark

Total 10 marks

SECTION B – continued
TURN OVER

Question 3

Experiments were carried out on several different cracking reactions of butane (semi-structural formula of butane is $CH_3CH_2CH_2CH_3$). The following series of different possible reactions of butane were observed under a variety of different conditions.

$$CH_3CH_2CH_2CH_3 \rightarrow V + W$$
$$CH_3CH_2CH_2CH_3 \rightarrow X + W$$
$$CH_3CH_2CH_2CH_3 \rightarrow Y + Z$$

Molecules V, W, X, Y and Z were further investigated and the following three items of information were obtained.

$$V + Cl_2 \rightarrow CH_3CHClCHClCH_3$$

X has the same molecular formula as V but has a different structure

$$Y + H_2O \rightarrow CH_3CH_2CH_2OH$$

On the basis of all the information provided, give the semi-structural formulas of each of the following molecules.

i. V _____

1 mark

ii. W _____

1 mark

iii. X _____

1 mark

iv. Y _____

1 mark

v. Z _____

1 mark

Total 5 marks

SECTION B – continued

Question 4

a. In order to help prevent tooth decay, fluoride ions at a level of 0.9 mg L^{-1} of F^- are added to Melbourne's public water supplies. The fluoride ions are obtained by adding sodium fluoride (NaF) to the water.

i. Calculate the mass of sodium fluoride in mg that must be present in one litre of water to produce a concentration of fluoride ions of 0.90 mg L^{-1}.

2 marks

ii. What mass of sodium fluoride, in kilogram, must be added to a 750 ML reservoir (1 ML = 10^6 L) to produce a concentration of fluoride ions of 0.90 mg L^{-1}?

1 mark

iii. Calculate the number of fluoride ions swallowed by a person who drank one litre of water from the reservoir.

2 marks

b. One method of determining the concentration of fluoride ions in water uses a red-coloured indicator, I_n, that reacts with fluoride ions in solution to give a colourless product. The reaction can be represented as

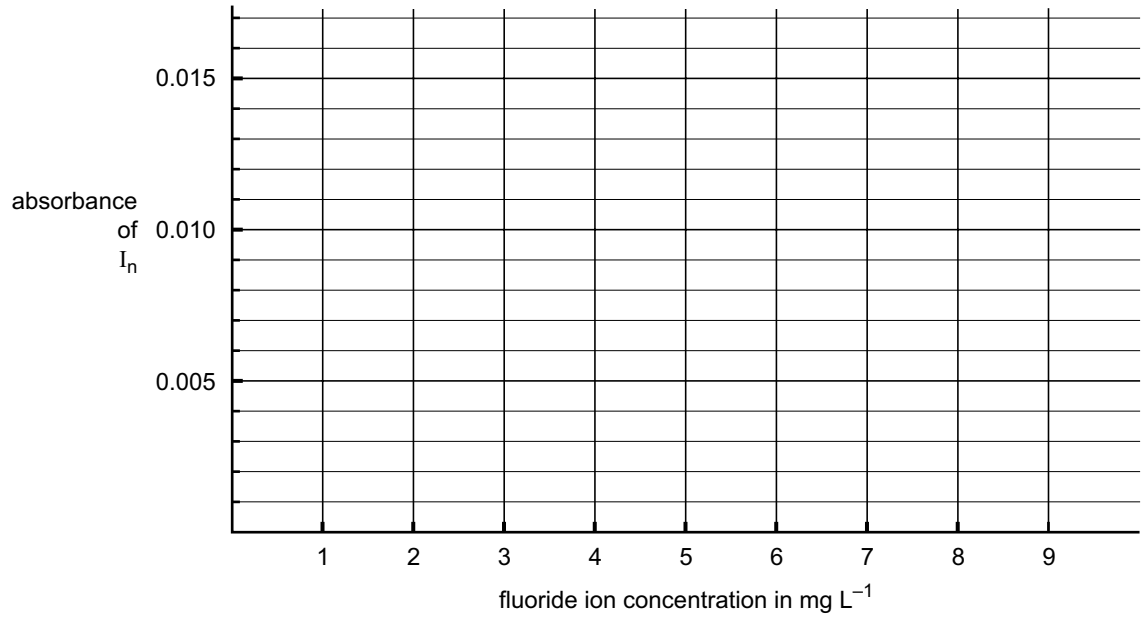
$$\underset{\text{red-coloured indicator}}{I_n(aq)} + \underset{\text{colourless}}{F^-(aq)} \rightarrow \underset{\text{colourless}}{FI_n^-(aq)}$$

A calibration curve was prepared using five different aqueous solutions of sodium fluoride, each of known ion concentration. *Q* mole of I_n is then added to 25.00 mL of each of five NaF solutions and an NaF solution of unknown concentration. The intensity of the red I_n colour of each of the mixtures is then determined using a UV-visible spectrophotometer.

The measured absorbances are given in the following table.

Fluoride ion concentration in mg L^{-1}	Absorbance of I_n
1.00	0.0130
2.00	0.0110
3.00	0.0090
4.00	0.0070
5.00	0.0050
unknown NaF sample	0.0120

i. Draw a calibration curve on the graph provided.



1 mark

SECTION B – Question 4 – continued

ii. Why does the absorbance fall with increasing fluoride ion concentration?

1 mark

iii. Use your calibration curve to determine the fluoride ion concentration of the unknown NaF sample in mg L^{-1}.

1 mark

iv. What was the value of Q?

2 marks

Total 10 marks

SECTION B – continued
TURN OVER

Question 5

The industrial production of sulfuric acid can be described as a four-stage process beginning with the burning of raw sulfur with oxygen.

a. Stage 1 The burning of sulfur

Give the equation for the burning of sulfur in oxygen.

_____

1 mark

b. Stage 2 The oxidation of sulfur from the +4 to the +6 oxidation state

i. Give the equation for this reaction.

_____

1 mark

ii. What goes wrong in the industrial process if the temperature for this stage of the process is too high, and why?

_____

_____

_____

_____

2 marks

iii. What goes wrong in the industrial process if the temperature for this stage of the process is too low, and why?

1 mark

c. Stage 3 The conversion of S in the +6 oxidation state from a gaseous to a liquid form by reacting the +6 form of the gas with a suitable solvent

i. Give the chemical reaction for this process.

1 mark

ii. Explain why water is not used as the solvent for this process.

1 mark

d. Stage 4 The production of liquid sulfuric acid

Give the chemical reaction for this process.

1 mark

Total 8 marks

SECTION B – continued

TURN OVER

Question 6

CO_2 is added to 1.00 L of pure water at 25°C in a pressurised bottle. The pressure of CO_2 above the water was raised to 3.00 atm and the gaseous CO_2 came to equilibrium with the CO_2 dissolved in the water. At equilibrium, the mass of CO_2 dissolved in the water was 5.00 g.

a. The equilibrium constant for this reaction, in atm M^{-1}, can be written as

$$K_n = \frac{p(CO_2, g)}{[CO_2(aq)]}$$

where $p(CO_2)$ represents the pressure of CO_2.

Calculate the value of this equilibrium constant at 25°C.

2 marks

b. 500 mL of the aqueous solution of CO_2 is heated to 30°C and then opened to the atmosphere so that effectively all the CO_2 in the aqueous solution escapes into the gas phase. Calculate, in litre, the volume of CO_2 that would be evolved at 1.00 atm pressure and 30°C.

4 marks

c. Dissolved CO_2 acts as a weak acid in water according to the equation

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

and the acidity constant of CO_2 in water at 25°C is given by

$$K_a = \frac{[H^+][HCO_3^-]}{[CO_2]} = 4.5 \times 10^{-7} M^2$$

Some CO_2 is added to a solution of $NaHCO_3$ at 25°C. In the solution, the concentration of the hydrogen carbonate ions (HCO_3^-) is 0.050 M and the CO_2 concentration is 0.0020 M. Calculate the pH of the solution.

2 marks

Total 8 marks

END OF QUESTION AND ANSWER BOOK