VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
2005

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Letter

Figures									
Words									

CHEMISTRY

Written examination 1

Tuesday 7 June 2005

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	23
B	8	8	57	67
			Total 77	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.
- 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.
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 following are analytical instruments.

gas-liquid chromatograph
UV-visible spectrophotometer
atomic absorption spectrophotometer

Two features that are common to all three of these instruments are

A. detector and recorder.
B. light source and detector.
C. monochromator and recorder.
D. light source and liquid sample.

Question 2

A mixture extracted from honey contains two different sugars.
The most appropriate way of separating these sugars would be with the use of

A. high-performance liquid chromatography.
B. atomic absorption spectroscopy.
C. UV-visible spectrophotometry.
D. flame tests.

Question 3

Sulfur dioxide and oxygen are mixed to form sulfur trioxide according to

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Which one of the following best describes the effect of adding the catalyst V_2O_5 to the mixture?

	Equilibrium yield	Reaction rate
A.	increases	increases
B.	no change	increases
C.	no change	no change
D.	increases	no change

Question 4

Deuterium (symbol D) is an isotope of hydrogen. Water made from deuterium has the symbol D_2O and has similar properties to normal water. D_2O ionises according to the equilibrium

$$D_2O \rightleftharpoons D^+ + OD^-$$

$K_d = [D^+]\,[OD^-] = 1.82 \times 10^{-16}$ M^2 at 25°C.

In a neutral solution of pure D_2O at 25°C the concentration of D^+, in mole per litre, is

A. 1.00×10^{-7}

B. 1.35×10^{-8}

C. 0.91×10^{-16}

D. 1.82×10^{-16}

Question 5

0.10 mole of C_4H_9OH reacts completely with molecular oxygen, O_2.

The number of mole of oxygen molecules used is

A. 0.50

B. 0.55

C. 0.60

D. 0.65

Question 6

50.00 mL of a 0.020 M solution of $Ba(OH)_2$ is added to 50.00 mL of a 0.060 M solution of HNO_3.

The hydrogen ion concentration in the resultant solution, in mole per litre, is

A. 0.010

B. 0.020

C. 0.030

D. 0.040

Question 7

Sodium hydride (NaH) reacts with water as follows.

$$NaH(s) + H_2O(l) \rightarrow Na^+(aq) + OH^-(aq) + H_2(g)$$

This reaction should be classified as

A. acid-base but not redox.

B. redox but not acid-base.

C. both acid-base and redox.

D. neither redox nor acid-base.

Questions 8 and 9 refer to the following information.

The amount of calcium carbonate ($CaCO_3$; molar mass = 100.1 g mol^{-1}) in the ore dolomite can be determined by gravimetric analysis. The dolomite sample is dissolved in acid and the calcium ions (Ca^{2+}) present are precipitated as calcium oxalate (CaC_2O_4; molar mass = 128.1 g mol^{-1}). The calcium oxalate is filtered, dried and strongly heated to form calcium oxide (CaO; molar mass = 56.1 g mol^{-1}).

Question 8

In one analysis the mass of dolomite used was 3.72 g. The mass of calcium oxide formed was found to be 1.24 g.

The percentage of calcium carbonate in the dolomite sample is closest to

A. 26.9

B. 33.3

C. 56.0

D. 59.5

Question 9

Two possible sources of error in this analysis are

I – the precipitate of calcium oxalate is not rinsed with water after being filtered.

II – the calcium oxide is not heated to constant mass.

Which of these two errors, if any, would lead to a result that is too high?

A. I only

B. II only

C. both I and II

D. neither I nor II

Question 10

Hydrogen and chlorine react according to the equation

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

3 mole of H_2 and 2 mole of Cl_2 are placed in a vessel and sealed.

When reaction is complete the vessel will contain

A. 5 mole of HCl

B. 6 mole of HCl and 1 mole of Cl_2

C. 4 mole of HCl and 1 mole of Cl_2

D. 4 mole of HCl and 1 mole of H_2

Question 11

An organic compound is known to contain only carbon, hydrogen and oxygen. The compound contains, by mass, 39.1% of carbon and 8.7% of hydrogen.

The number of carbon atoms in the empirical formula is

A. 1

B. 2

C. 3

D. 4

Question 12

A solution of sodium hydroxide (NaOH) has a pH of 10.

10 mL of this solution is mixed with 990 mL of water.

The pH of the diluted solution is closest to

A. 8

B. 9

C. 11

D. 12

Question 13

20.0 mL of 0.10 M hydrochloric acid (HCl) reacts with 20.0 mL of 0.30 M potassium hydroxide (KOH) solution.

The concentration of potassium ions in the resultant solution, in mole per litre, is

A. 0.10

B. 0.15

C. 0.20

D. 0.30

Question 14

A 100 mL sample of helium exerts a pressure of 1 atm at 10°C. The volume of the container is reduced to 50 mL and then the temperature is increased to 20°C.

The pressure now exerted by the helium, in atmosphere, is closest to

A. 0.5

B. 1

C. 2

D. 4

Question 15

Equal masses of the two gases oxygen (O_2) and sulfur dioxide (SO_2) are placed in separate vessels. Both vessels have the same volume and are at the same temperature. The pressure exerted by the oxygen is 100 kPa.

The pressure, in kPa, exerted by the SO_2 is closest to

A. 25

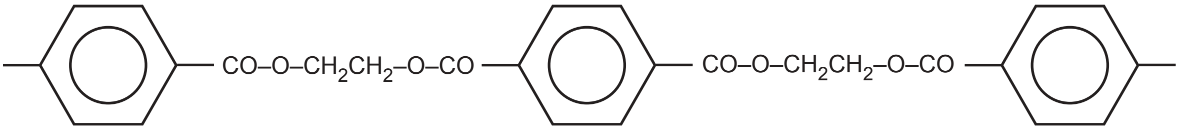
B. 50

C. 100

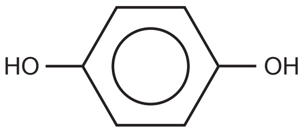
D. 200

Question 16

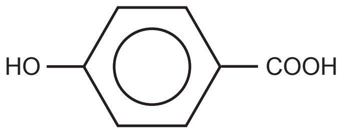
A representation of a section of a polymer chain that has been produced from two different monomers is given below.



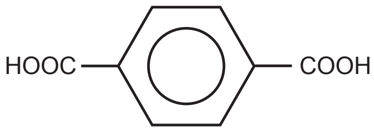
The two monomers are

A. 

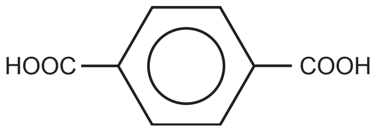
and $HOOCCH_2CH_2\,COOH$

B. 

and $HO\,CH_2CH_2\,COOH$

C. 

and $HO\,CH_2CH_2\,OH$

D. 

and $HO\,CH_2\,OH$

Question 17

One litre of air at atmospheric pressure and 25°C is held in a flask. The pressure of oxygen in the flask is 0.201 atm (20.4 kPa).

The concentration of oxygen in the flask, in mole per litre, is

A. 8.2

B. 0.12

C. 0.098

D. 0.0082

Question 18

In the following four substances, $H_2S_2O_7$, N_2O_5, HIO_3, Cl_2O_7, the atom with the highest oxidation number is

A. I

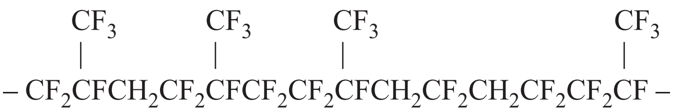
B. S

C. N

D. Cl

Question 19

A representation of a section of a polymer chain, that has been produced from two different monomers, is given below.



The two monomers are

A. $CH_2{=}CF_2$ and $CF_2{=}CFCF_3$

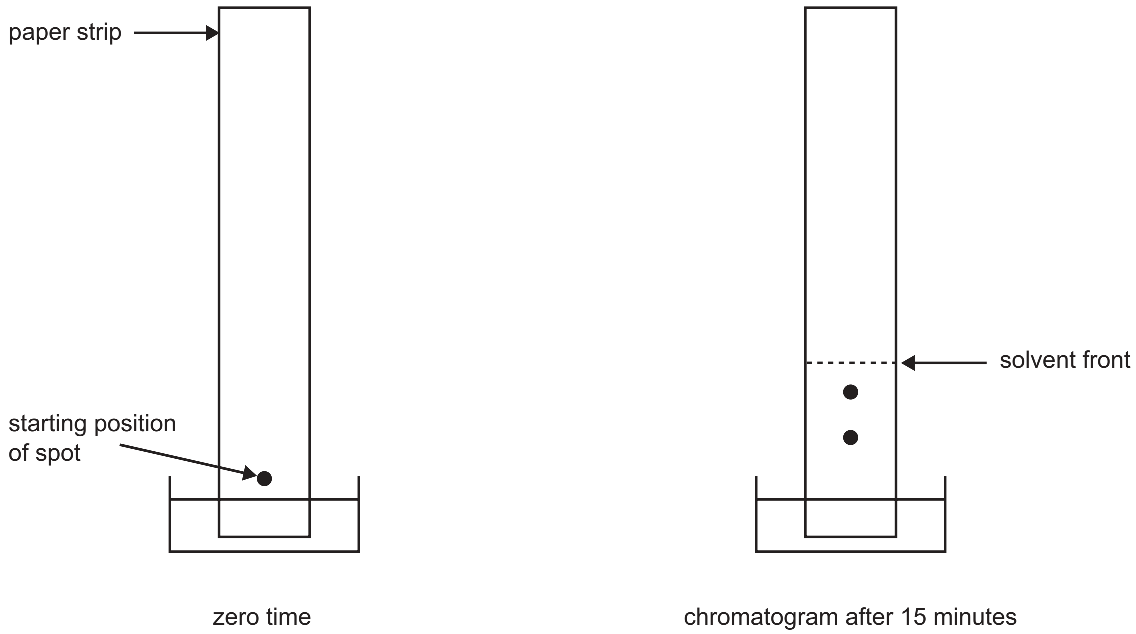
B. $CF_2{=}CF_2$ and $CF_2{=}CFCF_3$

C. $CH_2{=}CF_2$ and $CH_2{=}CFCF_3$

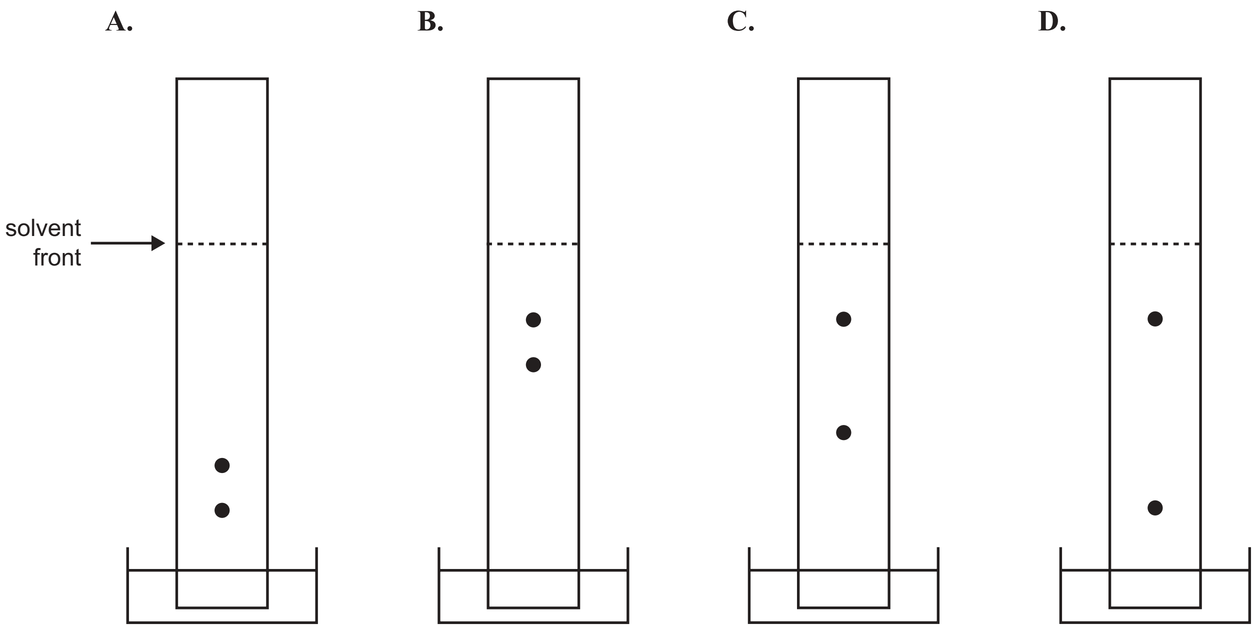
D. $CF_2{=}CF_2$ and $CH_2{=}CFCF_3$

Question 20

Some students used paper chromatography to separate the pigments in purple ink. They set up a chromatogram and after 15 minutes the colours had separated as shown in the diagram.



Which one of the following diagrams is most likely to indicate the appearance of the chromatogram after a further 30 minutes?



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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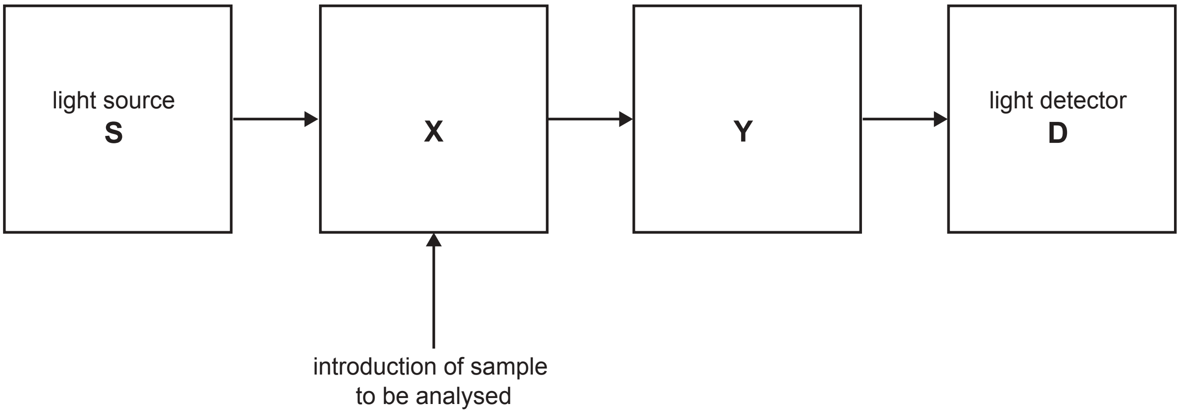
Question 1

An analyst determines the concentration of calcium ions in a city's water supply using Atomic Absorption Spectroscopy (AAS) as the analytical tool. A simplified diagram of an AA spectrophotometer is shown below.



a. What particular characteristic is needed by the lamp providing the light source S?

1 mark

b. A sample of water from the water supply is introduced into X for analysis. What happens to the Ca^{2+} ions introduced into X? Explain your answer.

2 marks

c. What happens to the light in Y?

1 mark

d. The intensity of the light arriving in D is recorded. What additional experiments does the analyst carry out so that he can convert the light intensity recording into an actual concentration of Ca^{2+} ?

1 mark

e. In a particular measurement the concentration of $Ca^{2+}(aq)$ was 0.025 ppm (part per million). A concentration of 1 ppm is the same as a concentration of 1×10^{-6} mg L^{-1}. Calculate the concentration of $Ca^{2+}(aq)$ in the water supply in mol L^{-1}.

2 marks

Total 7 marks

Question 2

For quality control, a chemist analyses the vitamin C (molecular formula $C_6H_8O_6$) content of a new brand of fruit juice. The reaction used is an oxidation-reduction reaction in which I_3^- is the oxidant and vitamin C is the reductant.

The reaction is

$$C_6H_8O_6(aq) + I_3^-(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 3I^-(aq)$$

The half reaction for the oxidation of $I^-(aq)$ to $I_3^-(aq)$ is

$$I_3^-(aq) + 2e^- \rightarrow 3I^-(aq)$$

a. Give the half reaction for the oxidation of vitamin C.

1 mark

b. A 20.00 mL sample of the fruit juice was made up to 250.0 mL with pure water in a volumetric flask.

25.00 mL aliquots of the diluted fruit juice were then placed in a conical flask and titrated with a solution in which $[I_3^-] = 2.00 \times 10^{-4}$ M. An average titre of 15.65 mL was obtained.

i. Calculate the amount of I_3^- present in the average titre, in mole.

ii. Calculate the amount of vitamin C present in each 25.00 mL aliquot, in mole.

iii. Calculate the concentration of vitamin C in the original (undiluted) sample of fruit juice in mole per litre.

1 + 1 + 2 = 4 marks

c. During the analysis the chemist rinsed, but did not dry, each item of glassware. She had available for use: pure water, the original fruit juice, the diluted fruit juice and the standard I_3^- solution. For each item listed below, name the liquid that should be used to rinse it by placing a tick in the appropriate box.

	pure water	original fruit juice	diluted juice	standard I_3^- solution
i. 20.00 mL pipette				
ii. 250.0 mL volumetric flask				
iii. 25.00 mL pipette				
iv. conical flask				

1 + 1 + 1 + 1 = 4 marks

Total 9 marks

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Question 3

a. Draw **full** structural formulas for all possible structural isomers of C_4H_9Cl.

4 marks

b. 1-chlorobutane can be hydrolysed to 1-butanol. 1-butanol can then be oxidised to a carboxylic acid of empirical formula $C_4H_8O_2$.

i. Give the name or formula of a suitable laboratory oxidising agent for the reaction of 1-butanol to a carboxylic acid.

___

___

ii. Give the systematic name for the carboxylic acid.

___

___

1 + 1 = 2 marks

c. Draw full structural formulas of all carboxylic acids with the empirical formula $C_4H_8O_2$.

2 marks

d. Using systematic nomenclature, name the compounds represented by the following formulas.

i. $CH_3CH_2COOCH_3$

___

ii. $CH_2OHCH_2CH_2CH_2CH_2CH_2CH_2CH_3$

___

iii. $CH_3CH_2CH_2CHClCH_3$

___

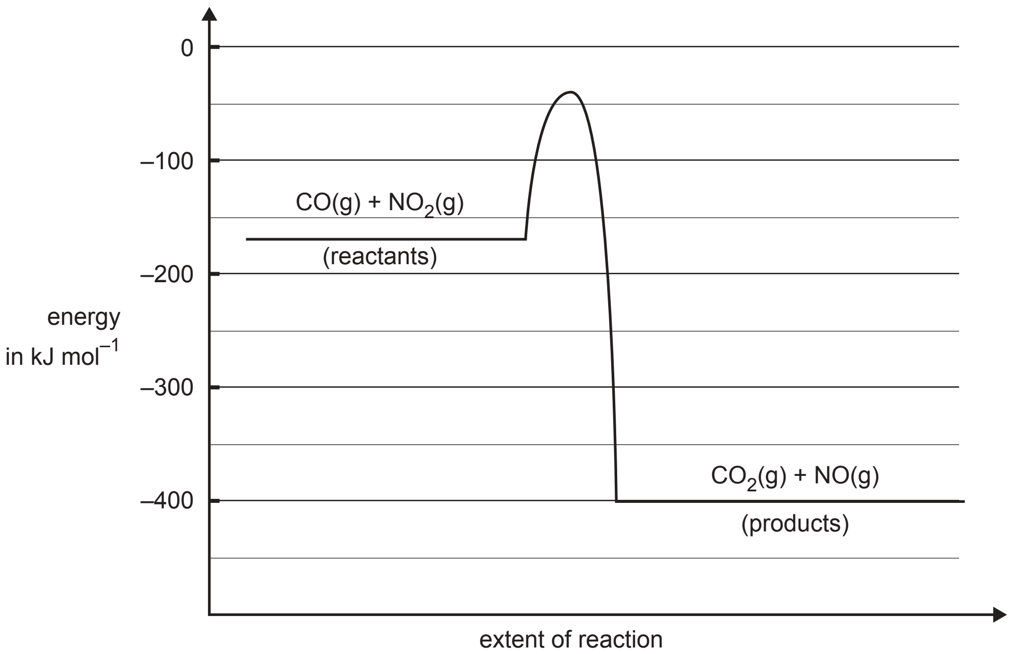
1 + 1 + 1 = 3 marks

Total 11 marks

Question 4

The graph below represents the energy changes over the course of a chemical reaction

$$CO(g) + NO_2(g) \rightarrow CO_2(g) + NO(g)$$



a. Give the magnitude and sign of the ΔH for the forward reaction in kJ mol^{-1}.

1 mark

b. Give the activation energy for the reverse reaction in kJ mol^{-1}.

1 mark

c. Give two reasons explaining why the rate of this reaction increases with increasing temperature.

2 marks

d. A suitable catalyst is discovered for the reaction. What would be the likely effect of the catalyst on

i. the activation energy? Explain your answer.

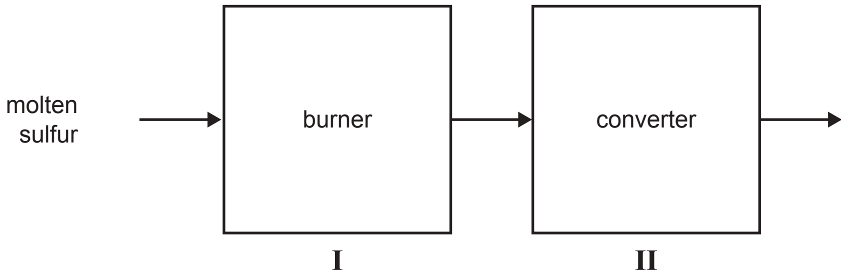
ii. the ΔH? Explain your answer.

1 + 1 = 2 marks

Total 6 marks

Question 5

Sulfuric acid can be produced from mined sulfur via the Contact Process. The first two stages in the industrial production of sulfuric acid by this process are represented below.



a. Give a reason why, in stage I, the molten sulfur is sprayed into the burner rather than being allowed to flow through it.

1 mark

b. A conflict is involved in choosing the best temperature to be used in stage II, where the reaction is

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

i. Describe the nature of the conflict and explain how the conflict is resolved.

ii. Would increasing the pressure of the reacting mixture in the converter affect the amount of SO_3 produced in stage II? Explain your answer.

2 + 2 = 4 marks

c. Sulfuric acid is a diprotic acid. The first ionisation reaction of sulfuric acid is complete while its second ionisation is that of a weak acid. Give chemical equations for both the first and second ionisation reactions of sulfuric acid.

2 marks

d. Give one major industrial use of sulfuric acid.

1 mark

Total 8 marks

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Question 6

Dinitrogen tetroxide (N_2O_4) is a colourless gas. It exists in equilibrium with nitrogen dioxide (NO_2), a brown gas. The concentration of NO_2 in a gas mixture can be determined using a spectrophotometer. The equation for the reaction is

$$N_2O_4(g) \rightleftharpoons 2NO_2(g);\ K = 5.5 \times 10^{-3}\ \text{M at } 25°\text{C} \ldots\ldots (1)$$

a. Write the expression for the equilibrium constant for this reaction.

1 mark

b. Some pure NO_2 is placed in a gas syringe at 25°C and allowed to reach equilibrium.

i. Keeping the volume constant the temperature is then raised to 35°C. The brown colour then becomes more intense. Is the above reaction (1) exothermic or endothermic? Explain your answer.

ii. Keeping the temperature at 35°C the plunger of the syringe is then pushed in so as to halve the volume. Equilibrium is then re-established. Is the brown colour of the mixture more intense or less intense than before the volume was halved?

2 + 1 = 3 marks

c. Give the numerical value at 25°C of the equilibrium constant of the reaction

$$NO_2(g) \rightleftharpoons \frac{1}{2} N_2O_4(g)$$

2 marks

Total 6 marks

Question 7

Ethanoic acid (CH_3COOH) is a weak acid in water.

a. Write an equation showing the ionisation of ethanoic acid in water.

1 mark

b. A 0.100 M solution of ethanoic acid in water at 25°C has a pH of 2.88.

i. Calculate the hydrogen ion concentration in a 0.100 M solution of ethanoic acid.

ii. Calculate the acidity constant of ethanoic acid at 25°C.

1 + 2 = 3 marks

c. At 25°C, methanoic acid (HCOOH) has an acidity constant that is approximately ten times greater than the acidity constant of ethanoic acid.

i. Comparing two 0.10 M solutions of methanoic and ethanoic acids, which solution would have the higher pH? Give a simple qualitative explanation for your answer.

ii. Equal volumes of both solutions were titrated against a 0.10 M solution of NaOH. Which of the solutions, if either, would require the greater volume of the NaOH solution for complete neutralisation? Explain your conclusion.

1 + 2 = 3 marks

Total 7 marks

Question 8

To live, the human body needs a regular supply of oxygen, which is distributed throughout the body by the red pigment, haemoglobin (Hb). Hb is carried around the body by the red blood cells in the blood.

a. Write a simple equation showing oxygen reacting with haemoglobin.

1 mark

b. Using this equation explain, in terms of equilibrium principles, how a low oxygen concentration can lead to the cells in a human body being deprived of oxygen.

1 mark

c. At high altitudes, the pressure of atmospheric oxygen is significantly less than it is at sea level. People who live most of their lives on very high mountains normally have a number of special adaptations to living at high altitudes. One such adaptation is the possession of a significantly higher red blood count (that is, a larger number of red blood cells in the blood) compared with people living at sea level. Explain how a high blood count is a useful adaptation to high altitude living.

1 mark

Total 3 marks

END OF QUESTION AND ANSWER BOOK

CHEMISTRY

Written examination 1

DATA SHEET

Directions to students

This data sheet is provided for your reference.
Make sure that you remove this data sheet from the centrefold during reading time.
Any writing, jottings, notes or drawings you make on this data sheet will **not** be considered in the marking.
At the end of the examination, make sure that you do **not** leave the data sheet in the centrefold of the question and answer book.
You may keep this data sheet.

Physical constants

$F = 96\ 500$ C mol^{-1}

$R = 8.31$ J K^{-1} mol^{-1}

1 atm = 101 325 Pa = 760 mmHg

0°C = 273 K

Molar volume at STP = 22.4 L mol^{-1}

Avogadro constant = 6.02×10^{23} mol^{-1}

Ideal gas equation

$pV = nRT$

The electrochemical series

	$E°$ in volt
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightarrow Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(1)$	+1.23
$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$	+1.09
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	+0.54
$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$S(s) + 2H^+(aq) + 2e^- \rightarrow H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	–0.13
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	–0.14
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.23
$Co^{2+}(aq) + 2e^- \rightarrow Co(s)$	–0.28
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	–0.83
$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$	–1.03
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	–1.67
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.34
$Na^+(aq) + e^- \rightarrow Na(s)$	–2.71
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	–2.87
$K^+(aq) + e^- \rightarrow K(s)$	–2.93
$Li^+(aq) + e^- \rightarrow Li(s)$	–3.02

Periodic table of the elements

1 **H** 1.0																	2 **He** 4.0
3 **Li** 6.9	4 **Be** 9.0											5 **B** 10.8	6 **C** 12.0	7 **N** 14.0	8 **O** 16.0	9 **F** 19.0	10 **Ne** 20.1
11 **Na** 23.0	12 **Mg** 24.3											13 **Al** 27.0	14 **Si** 28.1	15 **P** 31.0	16 **S** 32.1	17 **Cl** 35.5	18 **Ar** 39.9
19 **K** 39.1	20 **Ca** 40.1	21 **Sc** 44.9	22 **Ti** 47.9	23 **V** 50.9	24 **Cr** 52.0	25 **Mn** 54.9	26 **Fe** 55.9	27 **Co** 58.9	28 **Ni** 58.7	29 **Cu** 63.6	30 **Zn** 65.4	31 **Ga** 69.7	32 **Ge** 72.6	33 **As** 74.9	34 **Se** 79.0	35 **Br** 79.9	36 **Kr** 83.8
37 **Rb** 85.5	38 **Sr** 87.6	39 **Y** 88.9	40 **Zr** 91.2	41 **Nb** 92.9	42 **Mo** 95.9	43 **Tc** 98.1	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 197.0	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (264)	108 **Hs** (265)	109 **Mt** (268)	110 **Uun**	111 **Uuu**	112 **Uub**		114 **Uuq**		116 **Uuh**		118 **Uuo**

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.3	63 **Eu** 152.0	64 **Gd** 157.2	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.1	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (254)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

END OF DATA SHEET