Neap:

Trial Examination 2007

VCE Chemistry Unit 3

Written Examination

Question and Answer Booklet

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

Student's Name: ______________________________

Teacher's Name: ______________________________

Structure of Booklet

Section	Number of questions	Number of questions to be answered	Marks	Suggested time (minutes)
A Multiple-choice	20	20	20	30
B Short-answer	6	6	45	60
			Total 65	Total 90

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, 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 booklet of 14 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 booklet during reading time.
Please ensure that you write **your name** and your **teacher's name** in the space provided on this booklet and in the space provided on the answer sheet for multiple-choice questions.
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 booklet and hand them in.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2007 VCE Chemistry Unit 3 Written Examination.

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.

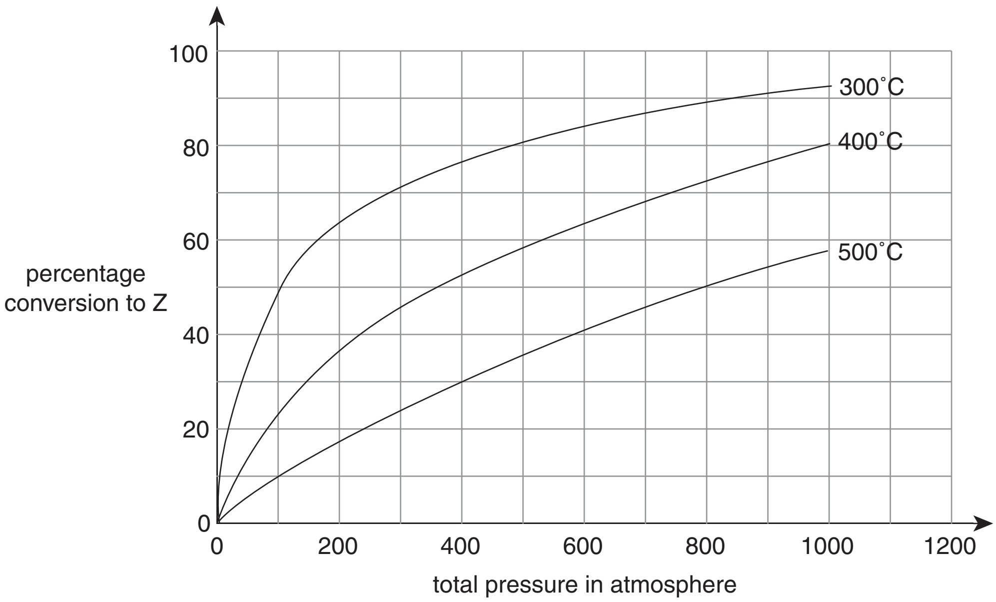
A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No mark will be given if more than one answer is completed for any question.

Question 1

The industrial production of chemical Z proceeds in the presence of a catalyst according to the equation

$$X(g) + 3Y(g) \rightarrow 2Z(g)$$

The graph below shows the variation in the equilibrium yield of Z with pressure at a range of temperatures.



The production of Z according to the equation shown is

A. exothermic because the yield of Z increases as pressure increases.

B. exothermic because the yield of Z decreases as temperature increases

C. endothermic because the yield of Z increases as pressure increases.

D. endothermic because the yield of Z decreases as temperature increases.

Question 2

At 40°C, the hydronium ion concentration in pure water is 1.71×10^{-7} M.

Pure water at 40°C will therefore

A. be acidic with a pH of 6.8.

B. contain hydroxide ions at a concentration of 5.85×10^{-8} M.

C. contain less ions than water at 25°C.

D. have a K_w value of 2.92×10^{-14} M^2.

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Question 3

Which of the following gases would be unsuitable for use as the mobile phase in a gas–liquid chromatography experiment?

A. N_2

B. Ne

C. O_2

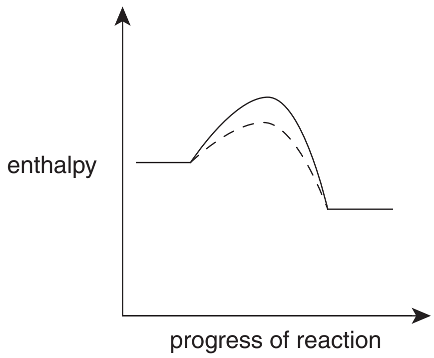
D. Ar

Question 4

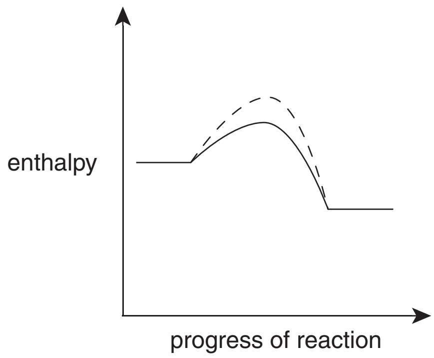
Shown below are energy profiles for four reactions, each shown for the reaction with (– – – –) and without (———) a catalyst.

Which profile represents an exothermic reaction, with and without a catalyst?

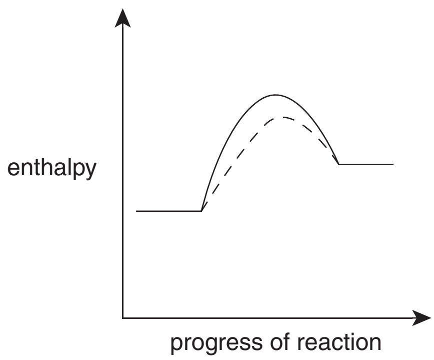
A.



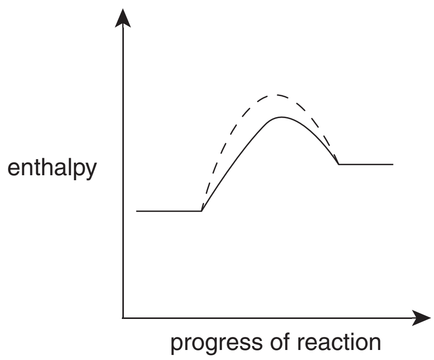
B.



C.



D.



Question 5

Two 0.050 g of samples of magnesium ribbon were placed in separate flasks. 50.0 mL of 1.0 M HCl was added to flask X. 50.0 mL of 0.50 M HCl was added to flask Y. The magnesium completely reacted in both flasks.

Which of the following would be the same for flasks X and Y?

A. the time for complete reaction

B. the mass loss from the flask

C. the initial rate of reaction

D. the magnesium ion concentration in the flask during the reaction

Question 6

Four mixtures consisting of gases X, Y and Z were prepared and later analysed. The results of these analyses are shown below.

Mixture	[X] (M)	[Y] (M)	[Z] (M)
I	2	2	4
II	1	2	4
III	2	2	1
IV	2	2	2

The reaction occurring may be represented by the equation below.

$$2X(g) + Y(g) \rightleftharpoons 3Z(g) \qquad K = 0.125$$

Which mixture (I to IV) had reached equilibrium?

A. I
B. II
C. III
D. IV

Question 7

HCN is a weak acid with an acidity constant, K_a, of 6.0×10^{-10} M at 25°C.

The pH of an 0.10 M solution of HCN would be

A. 1.0
B. 4.1
C. 4.6
D. 5.1

Question 8

One mole of a hydrocarbon reacts exactly with six moles of oxygen to produce four moles of carbon dioxide.

The hydrocarbon could be

A. butane.
B. 2-methylpropene.
C. 2-pentene.
D. methylpropane.

Question 9

The volume of 2.38 g of a gas was found to be 2.4 L at 1.2 atm and 200°C.

The gas could be

A. C_2H_6
B. C_2H_2
C. O_2
D. N_2

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Question 10

A saturated solution of limewater, $Ca(OH)_2$, at 25°C contains $Ca(OH)_2$ at a concentration of 1.62×10^{-2} M. The pH of the solution is

A. 1.49
B. 1.79
C. 12.2
D. 12.5

Question 11

Equal masses of each of the following substances were dissolved in separate beakers of water. Each beaker was then made up to a total volume of solution of 250 mL.

Which substance would produce the solution with the highest pH?

A. NaOH
B. KOH
C. CH_3OH
D. CH_3COOH

Questions 12 to 14 refer to the following information.

The first two steps in the industrial production of nitric acid are shown below.
Step 1: Catalytic oxidation of ammonia

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -907 \text{ kJ mol}^{-1} \qquad K_1$$

Step 2: Oxidation of nitrogen monoxide

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \qquad \Delta H = -114 \text{ kJ mol}^{-1} \qquad K_2$$

Question 12

If some of the nitrogen monoxide in step 1 was removed then

A. the amount of nitrogen dioxide produced in step 2 would be increased.
B. more ammonia and oxygen would be consumed in step 1.
C. the value of K_1 would be decreased.
D. the rate of the reaction in step 2 would be increased.

Question 13

In order to maximise the yield of nitrogen dioxide in step 2, the step 2 reaction should be conducted at

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

Question 14

Consider the reaction $4NH_3(g) + 7O_2(g) \rightarrow 4NO_2(g) + 6H_2O(g)$.

The equilibrium constant for this reaction is equivalent to

A. $K_1 \times K_2$
B. $K_1 \times 2K_2$
C. $K_1^2 \times K_2$
D. $K_1 \times K_2^2$

Questions 15 to 17 refer to the following information.

During a forensic examination of a man who allegedly died of a heart attack, ethylene glycol ($HOCH_2CH_2OH$) was detected in the man's liver. On further investigation it was determined that he must recently have ingested about 30 mL of ethylene glycol. This would have caused death to occur within 48 hours. Ethylene glycol is a liquid with a luminescent green colour and is used as a component of antifreeze.

Question 15

In order to draw these conclusions regarding the ethylene glycol, the analyses performed were

A. initially qualitative followed by quantitative.

B. both qualitative.

C. both quantitative.

D. initially quantitative followed by qualitative.

Question 16

Which of the following instrumental methods would be suitable for analysis of ethylene glycol?

A. atomic absorption spectroscopy (AAS) and gas–liquid chromatography (GLC)

B. high performance liquid chromatography (HPLC) and atomic emission spectroscopy (AES)

C. GLC and UV-visible spectroscopy

D. AAS and UV-visible spectroscopy

Question 17

Which of the following compounds is a structural isomer of ethylene glycol?

A. 1,1-dihydroxyethane

B. 1,1-dihydroxyethene

C. 1,2-dihydroxyethane

D. 1,2-dihydroxyethene

Question 18

Which of the following is a redox reaction?

A. $H_2SO_4(aq) + Na_2O(s) \rightarrow H_2O(1) + Na_2SO_4(aq)$

B. $AgNO_3(aq) + NaCl(aq) \rightarrow NaNO_3(aq) + AgCl(s)$

C. $2HCl(g) + Mg(OH)_2(aq) \rightarrow 2H_2O(l) + MgCl_2(aq)$

D. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

Question 19

Which of the following is a **not** structural isomer of propyl ethanoate?

A. hexanoic acid

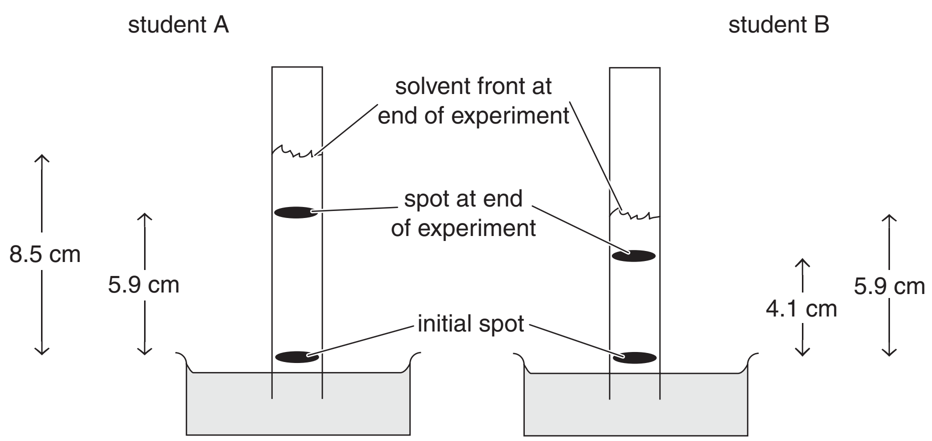
B. butyl methanoate

C. ethyl propanoate

D. methyl butanoate

Question 20

In a practical class, two students were each given a sample of an orange solid dissolved in a small volume of ethanol. Both students conducted a paper chromatography exercise using the same type of solvent and filter paper. Their results are shown below.



Which of the following statements concerning the two orange samples can be made based on the chromatograms shown?

A. The two orange solids are different because the chromatograms are different.

B. The sample used by student A had a larger mass, leading to a larger R_f value.

C. The two orange solids may be the same because the R_f value for each on the two chromatograms is the same.

D. The two orange solids are different because the R_f values for each on the two chromatograms are different.

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).

Question 1

Spectroscopic analysis of samples involves the study of the interaction of light with the sample. In the various forms of quantitative spectroscopic analysis, light of a particular wavelength interacts with the sample being analysed. The absorbance of this wavelength by the sample is determined, and this absorbance value can be used to deduce the concentration of the sample.

a. Explain how the particular wavelength to be used for analysis is chosen in UV-visible spectrometry.

2 marks

b. Explain how a measure of absorbance of light can be used to deduce the sample concentration using UV-visible spectrometry.

2 marks

Total 4 marks

Neap:

Trial Examination 2007

VCE Chemistry Unit 3

Written Examination

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}
Molar volume at SLC = 24.5 L mol^{-1}
Avogadro constant = 6.02 × 10^{23} mol^{-1}
Ionisation constant for water at 25°C, K_w = 1.0 × 10^{-14} M^2

IDEAL GAS EQUATION

$pV = nRT$

THE ELECTROCHEMICAL SERIES

THE ELECTROCHEMICAL SERIES	*E*° IN VOLT
$F_2(g) + 2e^- \rightleftharpoons 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightleftharpoons 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightleftharpoons Au(s)$	+1.68
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+1.51
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	+1.23
$Br_2(aq) + 2e^- \rightleftharpoons 2Br^-(aq)$	+1.09
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$I_2(aq) + 2e^- \rightleftharpoons 2I^-(aq)$	+0.62
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightleftharpoons SO_2(g) + 2H_2O(l)$	+0.20
$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$	+0.15
$S(s) + 2H^+(aq) + 2e^- \rightleftharpoons H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$ (defined)	0.00
$Pb^{2+}(aq) + 2e^- \rightleftharpoons Pb(s)$	–0.13
$Sn^{2+}(aq) + 2e^- \rightleftharpoons Sn(s)$	–0.14
$Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$	–0.23
$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$	–0.28
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	–0.44
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	–0.76
$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$	–0.83
$Mn^{2+}(aq) + 2e^- \rightleftharpoons Mn(s)$	–1.03
$Al^{3+}(aq) + 3e^- \rightleftharpoons Al(s)$	–1.67
$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	–2.34
$Na^+(aq) + e^- \rightleftharpoons Na(s)$	–2.71
$Ca^{2+}(aq) + 2e^- \rightleftharpoons Ca(s)$	–2.87
$K^+(aq) + e^- \rightleftharpoons K(s)$	–2.93
$Li^+(aq) + e^- \rightleftharpoons Li(s)$	–3.02

THE 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** 20.2
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** 45.0	22 **Ti** 47.9	23 **V** 50.9	24 **Cr** 52.0	25 **Mn** 54.9	26 **Fe** 55.8	27 **Co** 58.9	28 **Ni** 58.7	29 **Cu** 63.5	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** 195.1	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 **Ds** (271)	111 **Rg** (272)							

Lanthanides

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

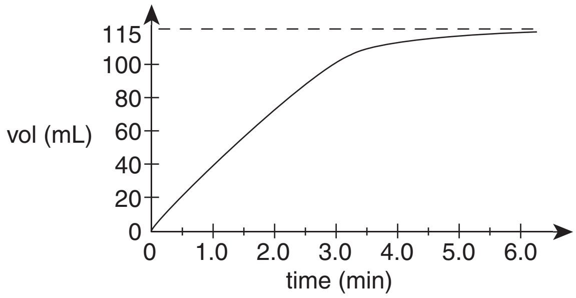
Actinides

90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** 237.1	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (251	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)

END OF DATA SHEET

Question 2

0.469 g of metal carbonate (MCO_3) granules were weighed and placed in a flask containing excess dilute hydrochloric acid. The gas evolved was collected at SLC and its volume recorded every 30 seconds. The results obtained are shown in the graph below.



a. Write a balanced equation for the reaction of MCO_3 with hydrochloric acid, given that the salt produced is soluble.

1 mark

b. Calculate

i. the amount (in mol) of carbon dioxide produced during the reaction.

ii. the amount (in mol) of metal carbonate reacting during the reaction.

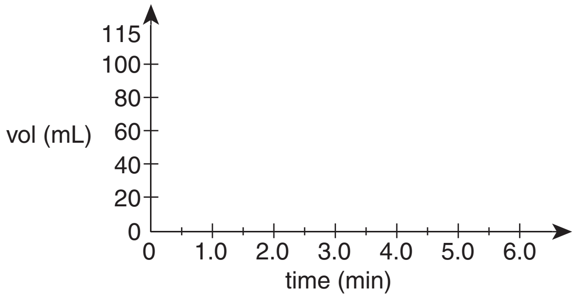
iii. the molar mass of the metal carbonate.

1 + 1 + 1 = 3 marks

c. Deduce the identity of the metal in the metal carbonate.

1 mark

d. On the axes shown below, sketch the expected shape of the graph if the experiment was repeated using 0.235 g of powdered MCO_3.



2 marks

Total 7 marks

Question 3

Oxalic acid ($C_2H_2O_4$), a dioic acid, is a poisonous substance found in the leaves of the rhubarb plant. It is a diprotic acid, with acidity constants $K_{a1} = 5.6 \times 10^{-2}$ and $K_{a2} = 5.2 \times 10^{-5}$.

a. Draw the structure of oxalic acid.

1 mark

b. Write an expression for the second acidity constant K_{a2} for oxalic acid.

1 mark

c. The following species would be present in a 1.0 M solution of oxalic acid.

$$C_2H_2O_4,\ C_2HO_4^-,\ H_3O^+$$

i. Rank these species in order from most concentrated to least concentrated in the solution (place the relevant formulas in the boxes provided).

⟶ decreasing concentration

ii. Explain your choices in part **i.**

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____

____

1 + 2 = 3 marks

d. Hydrated oxalic acid $H_2C_2O_4.2H_2O$ may be used as a primary standard for acid–base volumetric analysis. State **two** properties a substance must have in order to be used as a primary standard.

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2 marks

Total 7 marks

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Question 4

Propene (C_3H_6) is derived from crude oil by the processes of fractional distillation and cracking.

a. Briefly describe the process of fractional distillation of crude oil.

2 marks

b. Write an equation to show the cracking of octane to produce propene and one other product.

1 mark

c. Propene reacts with chlorine gas according to the equation

$$C_3H_6(g) + Cl_2(g) \rightarrow C_3H_6Cl_2(g)$$

i. Draw the structure of the product, $C_3H_6Cl_2$.

ii. Name the structure drawn in **i.**

iii. Draw the structure of one other isomer of $C_3H_6Cl_2$.

iv. Name the isomer drawn in **iii.**

v. Explain why the isomer drawn in **iii.** cannot be produced by the reaction of propene with chlorine gas.

1 + 1 + 1 + 1 + 1 = 5 marks

Total 8 marks

Question 5

An important step in the manufacture of sulfuric acid by the Contact process is the oxidation of sulfur dioxide according to the equation

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

a. In an experiment to investigate this reaction at 1000°C, 1.00 mol of SO_2 was mixed with 1.00 mol of O_2 in a 1.00 L vessel. When the mixture reached equilibrium the vessel contained 0.172 mol of SO_2.

Calculate the value of the equilibrium constant, *K*, for the reaction at 1000°C.

3 marks

b. To improve the yield of SO_3 in this reaction, should the temperature be raised or lowered? Explain your choice.

2 marks

c. A number of reactions involving sulfuric acid are shown in the equations below. Select from these reactions (1 to 5) when answering the questions which follow. (A reaction may be selected more than once.)

1. $H_2SO_4(aq) + MgO(s) \rightarrow MgSO_4(aq) + H_2O(l)$

2. $S(l) + 2H_2SO_4(l) \rightarrow 3SO_2(g) + 2H_2O(l)$

3. $C_{12}H_{22}O_{11}(s) \xrightarrow{H_2SO_4(l)} 12C(s) + 11H_2O(g)$

4. $Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$

5. $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$

Select

i. one reaction showing sulfuric acid acting as an oxidant.

ii. one reaction showing sulfuric acid acting as an acid.

iii. one reaction in which the oxidation number of sulfur is unchanged.

1 + 1 + 1 = 3 marks

Total 8 marks

Question 6

In order to confirm the ethanol content of a white wine, a titration experiment was performed. A 10.0 mL sample of wine was pipetted into a standard flask, and the volume made up to 200.0 mL with distilled water. A 25.00 mL aliquot of the diluted wine was pipetted into a conical flask, and titrated with a 0.0915 M acidified potassium permanganate solution. The average titre was 22.34 mL. The reaction proceeded according to the equation

$$4MnO_4^-(aq) + 5CH_3CH_2OH(aq) + 12H^+(aq) \rightarrow 4Mn^{2+}(aq) + 5CH_3COOH(aq) + 11H_2O(l)$$

a. Write the half-equation for the oxidation reaction occurring during the titration.

1 mark

b. **i.** Determine the amount (in mol) of potassium permanganate used in the titration.

ii. Determine the amount (in mol) of ethanol in the 10.0 mL sample.

iii. Determine the percentage by volume (% v/v) of ethanol in the wine, given that the density of ethanol is 0.785 g mL^{-1}.

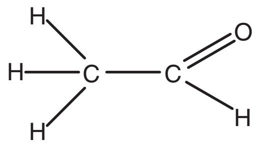
1 + 2 + 3 = 6 marks

c. During the titration, an error was made and one piece of glassware was incorrectly given a final rinse with distilled water. This error resulted in the determined % v/v ethanol being higher than the expected value.

Which piece of glassware, pipette, burette or standard flask, was incorrectly rinsed? Explain your choice.

2 marks

d. If the ethanol in the wine is reacted with acidified potassium dichromate, an intermediate product called ethanal may be produced. Ethanal, the structure of which is shown below, belongs to the homologous series of compounds known as alkanals.



i. Explain what is meant by the term homologous series.

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ii. Explain the expected trend in boiling points for the series of compounds methanal, ethanal, propanal and butanal.

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1 + 1 = 2 marks
Total 11 marks

END OF QUESTION AND ANSWER BOOKLET