VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
2006

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

									Letter
Figures									
Words									

CHEMISTRY

Written examination 1

Tuesday 6 June 2006

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*
A	20	20	20
B	8	8	61
			Total 81

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and 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 19 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 unauthorised electronic 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 flame test method of analysis can be used to distinguish between

A. methanol and ethanol.

B. sulfuric acid and nitric acid.

C. lithium nitrate and calcium nitrate.

D. sodium carbonate and sodium chloride.

Question 2

The molar volume of oxygen, in L, at 1.00 atmosphere and 100°C, is closest to

A. 30.6

B. 24.5

C. 22.4

D. 8.2

Question 3

Zinc metal reacts with 0.1 M hydrochloric acid to form hydrogen gas and zinc chloride solution.

The production of hydrogen gas is more vigorous if the zinc is powdered, rather than in large pieces, because the

A. activation energy of the reaction is lower.

B. activation energy of the reaction is higher.

C. frequency of collisions between zinc metal and hydrogen ions is higher.

D. fraction of reactant particles with sufficient energy to react is higher.

Question 4

Transport of oxygen in the body involves the complex molecules haemoglobin and oxyhaemoglobin.

$$\text{haemoglobin} + \text{oxygen} \rightleftharpoons \text{oxyhaemoglobin}$$

If carbon monoxide (CO) is present in the air, poisoning can occur because

A. the equilibrium constant, *K*, for the reaction is reduced.

B. CO reacts with oxygen to form CO_2, driving the equilibrium to the left.

C. the equilibrium shifts to the left because haemoglobin bonds strongly with CO.

D. CO catalyses the decomposition of oxyhaemoglobin into haemoglobin and oxygen.

Question 5

Sulfuric acid (H_2SO_4) and nitric acid (HNO_3) are both strong acids. Ethanoic acid (CH_3COOH) is a weak acid.

20.00 mL solutions of 0.10 M concentration of each of these three acids were separately titrated with a 0.10 M solution of sodium hydroxide (NaOH).

In order to react completely

A. all three acids would require the same amount of NaOH.

B. HNO_3 would require more NaOH than CH_3COOH but less than H_2SO_4.

C. H_2SO_4 and HNO_3 would require the same amount of NaOH but CH_3COOH would require less.

D. CH_3COOH and HNO_3 would require the same amount of NaOH but H_2SO_4 would require more.

Question 6

A student used paper chromatography to separate two components, I and II, in a solution. A spot of the solution was initially placed at the origin.

When the spot corresponding to component I (R_f = 0.50) had advanced 4.0 cm, the spot corresponding to component II was 1.0 cm behind.

The R_f value of component II is closest to

A. 0.68

B. 0.38

C. 0.25

D. 0.13

Question 7

Consider the molecule $CH_3CH_2CH_2CH_2CHClCH_2CH_3$.

The systematic name of this molecule is

A. 5-chloroheptane.

B. 3-chloroheptane.

C. 5-chlorooctane.

D. 3-chlorooctane.

Question 8

The raspberry-flavoured food additive, butyl methanoate, can be prepared from $CH_3CH_2CH_2CH_2OH$ using

A. an addition reaction with HCOOH.

B. an addition reaction with CH_3COOH.

C. a condensation reaction with HCOOH.

D. a condensation reaction with CH_3COOH.

Question 9

The number of structural isomers that are carboxylic acids with the formula $C_4H_8O_2$ is

A. 1

B. 2

C. 3

D. 4

Question 10

Two chemical reactions occur as follows.

$$CH_2{=}CHCH_2CH_2CH_3 + X \rightarrow \text{2-chloropentane}$$

$$\text{2-chloropentane} + \text{sodium hydroxide solution} \rightarrow Y$$

X and Y are given by

	X	Y
A.	Cl_2	$CH_3CH_2CH_2CHOHCH_3$
B.	HCl	$CH_3CH_2CH_2CHOHCH_3$
C.	Cl_2	$CH_3CH_2CH_2CH_2CH_2OH$
D.	HCl	$CH_3CH_2CH_2CH_2CH_2OH$

Question 11

Given the following information

$$Cl_2(g) \rightleftharpoons 2Cl(g); \quad K = 1.13 \times 10^{-6} \text{ M at } 1100°C$$

what would be the numerical value of the equilibrium constant for the reaction

$$2Cl(g) \rightleftharpoons Cl_2(g)$$

at the same temperature?

A. 8.85×10^{5}

B. 4.42×10^{5}

C. 2.26×10^{-6}

D. 1.13×10^{-6}

Question 12

The concentration of K^+ ions in 100 mL of 0.0500 M K_2CO_3 solution, in g L^{-1}, is

A. 0.196

B. 0.391

C. 1.96

D. 3.91

Question 13

Carbon monoxide can be oxidised to carbon dioxide.

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

3 mol of CO and 2 mol of O_2 are mixed.
When the reaction is complete there will be

A. 4 mol of CO_2 produced.

B. 2 mol of CO_2 produced.

C. 1 mol of CO unreacted.

D. 0.5 mol of O_2 unreacted.

Question 14

The equation for a reaction that occurs during the extraction of iron from iron ore is

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$$

During this reaction the oxidation number of iron changes from

A. +3 to 0, and CO is the reductant.

B. +6 to 0, and CO is the reductant.

C. +3 to 0, and CO is the oxidant.

D. +6 to 0, and CO is the oxidant.

Questions 15 and 16 refer to the following information.

Methanol can be produced in a reaction between carbon monoxide and hydrogen according to the following equation.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g); \quad \Delta H = -90 \text{ kJ mol}^{-1}$$

Question 15

Which one of the following changes would occur when a catalyst is added to an equilibrium mixture of carbon monoxide, hydrogen and methanol?

A. The value of ΔH would increase.

B. The amount of methanol would increase.

C. The temperature of the surroundings would increase.

D. The rates of both the forward and reverse reactions would increase.

Question 16

Which statement about the behaviour of a catalyst in this reaction is correct?

A. It decreases the activation energy of the forward reaction only.

B. It increases the activation energy of the forward reaction only.

C. It decreases the activation energies of both the forward and back reactions.

D. It increases the activation energies of both the forward and back reactions.

Question 17

Methanoic acid and ethanoic acid are both weak acids with the following acidity constants.

	K_a in M at 25°C
methanoic acid (HCOOH)	1.82×10^{-4}
ethanoic acid (CH_3COOH)	1.74×10^{-5}

Two separate solutions were prepared, one of 0.1 M methanoic acid and the other of 0.1 M ethanoic acid.

Which one of the following would be present in the highest concentration at 25°C?

A. CH_3COOH in the ethanoic acid solution

B. CH_3COO^- in the ethanoic acid solution

C. HCOOH in the methanoic acid solution

D. $HCOO^-$ in the methanoic acid solution

Question 18

Consider the following information for the reaction A + B $\rightarrow$ C.

heat of reaction	-120 kJ mol^{-1}
activation energy	$+200$ kJ mol^{-1}

The activation energy, in kJ mol^{-1}, for the reaction C $\rightarrow$ A + B, is

A. –320

B. –80

C. +80

D. +320

Question 19

A short section of a polymer molecule is shown below.

$$-CH_2CF_2CF_2CH_2CF_2CH_2CH_2CF_2CH_2-$$

This polymer could have been formed from

A. CF_2CH_2 only.

B. CF_2CF_2 and CH_2CH_2.

C. CF_2CF_2 and CH_2CHCF_3.

D. CH_3CHCF_2 and CF_3CHCF_2.

Question 20

The molecule $HOCH_2CH_2CH_2COOH$ (molar mass = 104 g mol^{-1}) forms a polymer in which the average polymer molecule contains 1000 monomer units.

The approximate molar mass of the polymer, in g mol^{-1}, is

A. 68 000

B. 86 000

C. 95 000

D. 104 000

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, $H_2(g)$; $NaCl(s)$

Question 1

A student was given four colourless liquids that were labelled **A**, **B**, **C** and **D**. They were known to be ethanol, ethanoic acid, pentane and hexene, but the exact identity of each liquid was unknown.

The student tested the properties of each liquid and obtained the following results.

	A	**B**	**C**	**D**
Solubility in water	insoluble	soluble	soluble	insoluble
Addition of red-coloured bromine (Br_2) solution	colour disappears	no immediate reaction	no immediate reaction	no immediate reaction
Addition of sodium carbonate (Na_2CO_3) powder	no reaction	gas evolved	no reaction	no reaction

Identify each of the liquids by completing the table below.

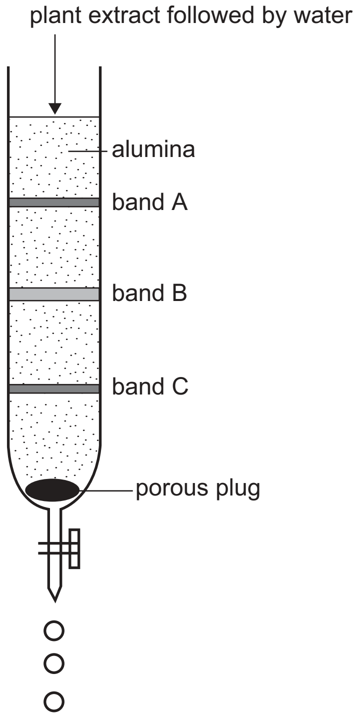
	Name of liquid
A	
B	
C	
D	

Total 4 marks

Question 2

A burette packed with finely divided alumina powder (Al_2O_3) was used to separate the components in a plant extract by chromatography. The alumina acts as the stationary phase and water was used as the mobile phase.

A solution of the plant extract was placed at the top of the alumina and, once it had been adsorbed, further water was added periodically. The components separated as three coloured bands, as shown in the diagram below.



a. **i.** In which one of the three bands, A, B or C, were the components most strongly adsorbed to the stationary phase?

____

ii. Band B starts to show signs of separating into two different bands just before it emerges from the bottom of the burette. Give one possible modification that could be made to this experiment to more effectively separate band B into its separate components.

____

____

1 + 1 = 2 marks

b. In another experiment, the components in the plant extract were separated in a similar way to paper chromatography, using a glass sheet coated with alumina and water as the mobile phase. Which one of the three bands, A, B or C, contains the component that would be most likely to have the smallest R_f value? Explain your answer.

____

____

1 mark

c. Which one of the three bands, A, B or C, contains the component that would have the smallest retention time if this separation was conducted using a high-performance liquid chromatograph with alumina as the stationary phase? Explain your answer.

1 mark

Total 4 marks

Question 3

A soluble fertiliser contains phosphorus in the form of phosphate ions (PO_4^{3-}). To determine the PO_4^{3-} content by gravimetric analysis, 5.97 g of the fertiliser powder was completely dissolved in water to make a volume of 250.0 mL. A 20.00 mL volume of this solution was pipetted into a conical flask and the PO_4^{3-} ions in the solution were precipitated as $MgNH_4PO_4$. The precipitate was filtered, washed with water and then converted by heating into $Mg_2P_2O_7$. The mass of $Mg_2P_2O_7$ was 0.0352 g.

a. Calculate the amount, in mole, of $Mg_2P_2O_7$.

1 mark

b. Calculate the amount, in mole, of phosphorus in the 20.00 mL volume of solution.

1 mark

c. Calculate the amount, in mole, of phosphorus in 5.97 g of fertiliser.

1 mark

d. Calculate the percentage of phosphate ions (PO_4^{3-}) by mass in the fertiliser. Ensure you express your answer to an appropriate number of significant figures.

3 marks

e. **i.** Several actions which could occur during this analytical procedure are listed below (**A**–**D**). For each action, indicate the likely effect on the calculated percentage of phosphate ions in the fertiliser by placing a tick in the appropriate box.

Action	**Calculated result would be too low**	**No effect on calculated result**	**Calculated result would be too high**
A. The $MgNH_4PO_4$ precipitate was not washed with water.			
B. The conical flask had been previously washed with water but not dried.			
C. A 25.00 mL pipette was unknowingly used instead of a 20.00 mL pipette.			
D. The mass of the fertiliser was recorded incorrectly. The recorded mass was 0.2 g higher than the actual mass.			

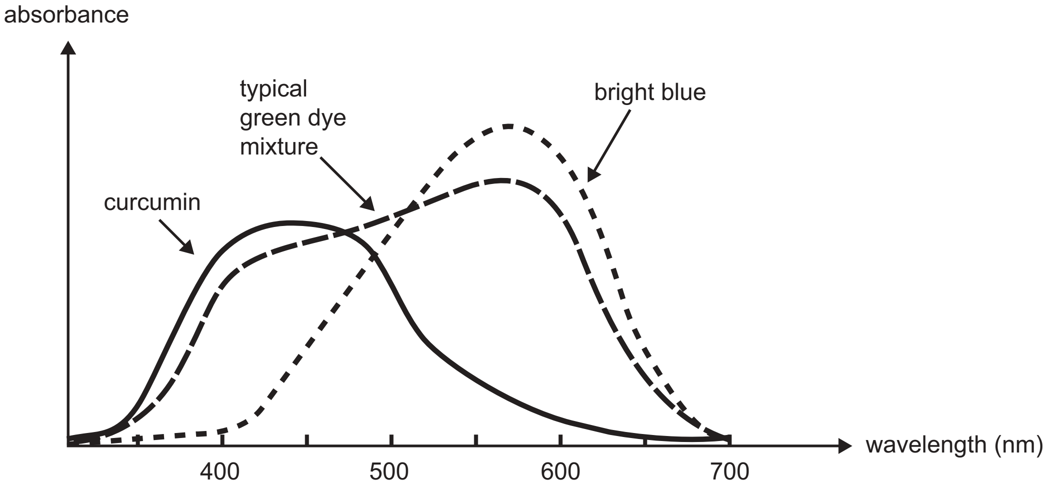
ii. In the case of action **B** above, explain your reasoning for the answer that you have given.

4 + 1 = 5 marks

Total 11 marks

Question 4

A green dye used to colour tinned peas is made by mixing the yellow chemical, curcumin, with another colouring agent called bright blue. The individual spectra of curcumin, bright blue and a typical green dye are represented below.



UV-visible spectroscopy is used to analyse the curcumin content of tinned peas.

a. Circle the wavelength below which would be best used for absorbance measurements to determine the curcumin content of the peas.

400 nm 450 nm 500 nm 550 nm 600 nm 650 nm

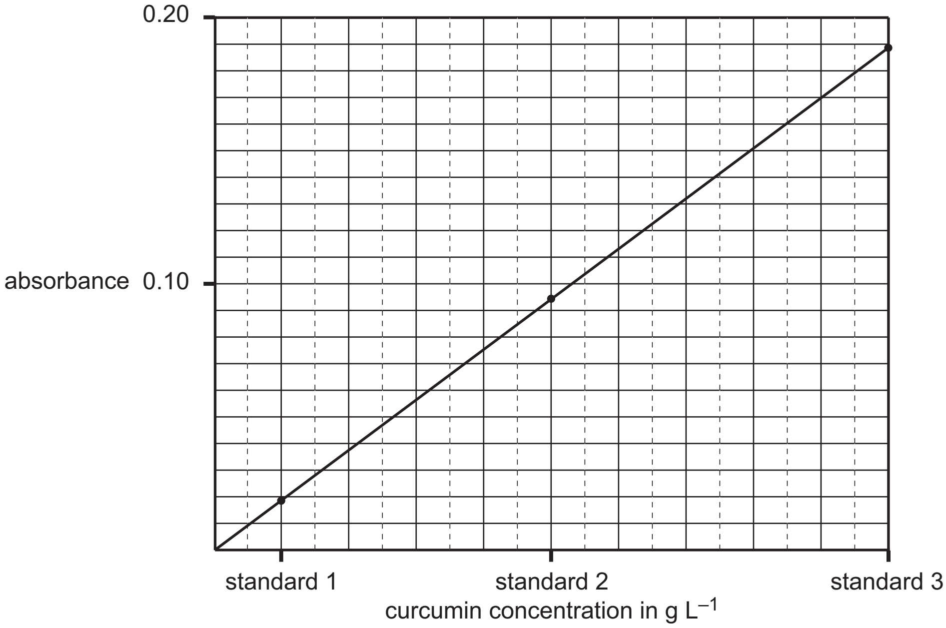
1 mark

b. In one analysis, a stock solution of curcumin was prepared by dissolving 0.100 g of curcumin ($C_{21}H_{20}O_6$; molar mass = 368.0 g mol^{-1}) in 250.0 mL of water.

The stock solution was then diluted to make the following three standard solutions.

standard solution	**curcumin concentration in g L^{-1}**
standard 1	1.00×10^{-3}
standard 2	5.00×10^{-3}
standard 3	1.00×10^{-2}

The absorbances of the standard solutions at the chosen wavelength were measured and the following calibration line was obtained.



i. Calculate the concentration of curcumin in the stock solution in mol L^{-1}.

ii. What volume of water must be added to 10.0 mL of the stock solution to make standard 3?

iii. The curcumin in a 9.780 g sample of peas was extracted into solution. The solution was filtered and made up to 100 mL in a volumetric flask. The absorbance of the solution at the wavelength used in the above calibration was found to be 0.170.

Calculate the curcumin content of the peas in milligram per gram of peas.

2 + 2 + 3 = 7 marks

Total 8 marks

Question 5

a. The hydrogen carbonate ion (HCO_3^-) can act both as an acid and as a base.

i. Write a chemical equation that shows HCO_3^- acting as an acid when it reacts with water.

___

ii. Write a chemical equation that shows HCO_3^- acting as a base when it reacts with water.

___

1 + 1 = 2 marks

b. Hypochlorous acid (HOCl) is a weak acid with an acidity constant, K_a, of 3.0×10^{-8} M at 25°C. Calculate the pH of a 0.50 M solution of hypochlorous acid at that temperature.

___

___

___

___

___

3 marks

c. The hydrogen ion concentration of a solution is described by the term pH. The hydroxide ion (OH^-) concentration is described in the same way by the term pOH.

A solution has a pOH of 3 at 25°C.

i. Calculate the **hydroxide ion** concentration of the solution, in mol L^{-1}.

___

___

___

ii. Calculate the **hydrogen ion** concentration of the solution, in mol L^{-1}.

___

___

___

1 + 1 = 2 marks

Total 7 marks

Question 6

In solution, pale yellow-coloured $Fe^{3+}(aq)$ and colourless $SCN^{-}(aq)$ form an equilibrium with $FeSCN^{2+}(aq)$. $FeSCN^{2+}(aq)$ is red in colour.

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightleftharpoons \underset{\text{red colour}}{FeSCN^{2+}(aq)}; \qquad \Delta H \text{ negative}$$

a. A student investigates this reaction using separate samples of an equilibrium mixture in which significant quantities of Fe^{3+}, SCN^{-} and $FeSCN^{2+}$ are present. In each case changes are made as indicated in the table below.

Complete the table by placing ticks in the appropriate boxes to indicate the effect of each change on

I. the intensity of the red colour of the solution; and

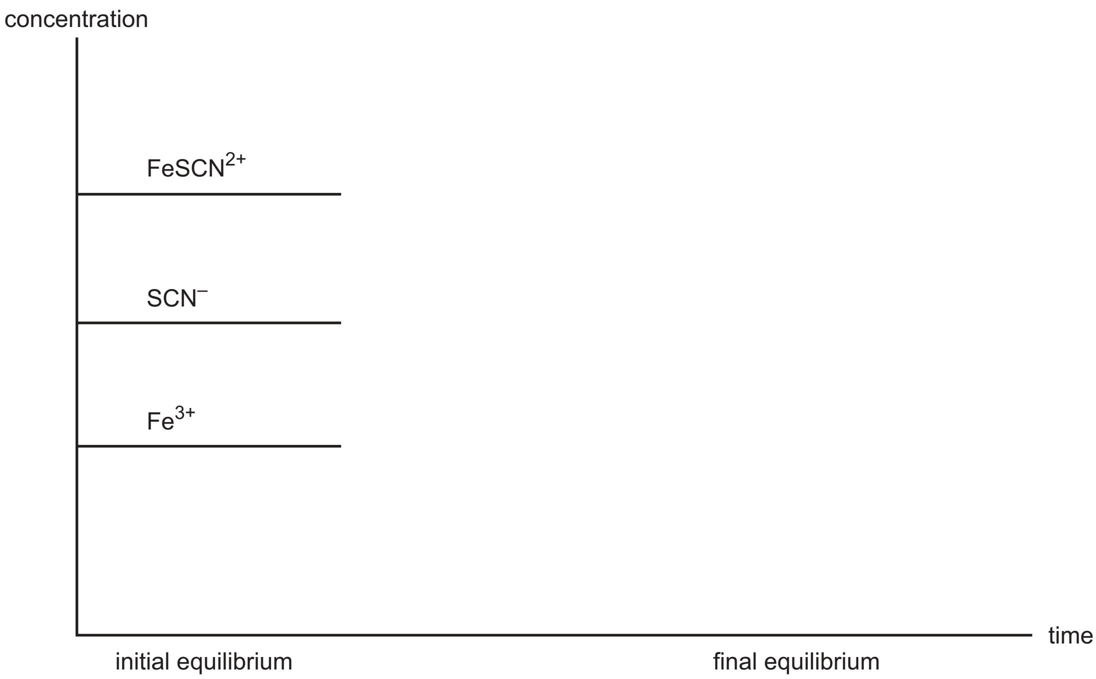
II. the concentration of $Fe^{3+}(aq)$

once the new equilibrium has been established.

Change to the equilibrium	**I.** Colour at new equilibrium compared with initial equilibrium		**II.** $[Fe^{3+}]$ at new equilibrium compared with initial equilibrium	
	less red	more red	decreased	increased
Sample 1: 1 drop of a concentrated solution of $Ag^{+}(aq)$ is added, which forms a AgSCN precipitate				
Sample 2: 1 drop of a concentrated solution of $Fe^{3+}(aq)$ is added				
Sample 3: 1 drop of a concentrated solution of $HPO_4^{2-}(aq)$ is added, which forms colourless $FeHPO_4^{+}(aq)$				
Sample 4: Addition of a large volume of water				

2 + 2 + 2 + 2 = 8 marks

b. The reaction is exothermic. The graph below represents the initial concentrations of the ions at equilibrium. Sketch the changes that would be expected to occur to these concentrations if the temperature of the equilibrium mixture was increased to a new, constant value.



1 mark

Total 9 marks

SECTION B – continued
TURN OVER

Question 7

Petroleum is a complex mixture of hydrocarbons. The hydrocarbons are mainly alkanes of various carbon chain lengths.

a. Write the name and molecular formula of an alkane which has nine carbon atoms.

Name ______________________________

Molecular formula ______________________________

1 mark

b. Alkanes with short carbon chains boil at lower temperatures than long chain alkanes. Explain, in terms of bonding, why this is so.

____

____

____

1 mark

c. Briefly describe the fractional distillation process that is used for refining petroleum. You may use a fully labelled sketch to answer this question.

____

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3 marks

d. Another process in petroleum refining involves cracking. Some of the products of the cracking process are unsaturated hydrocarbons.

i. When the gas propane (C_3H_8) is cracked, several different products can be obtained. Write the formulas for four likely products of this process.

____

____

ii. Ethene is an example of an unsaturated hydrocarbon. Write equations for two chemical reactions in which ethene acts as a reactant.

Reaction 1 ____

____

Reaction 2 ____

____

2 + 2 = 4 marks

Total 9 marks

Question 8

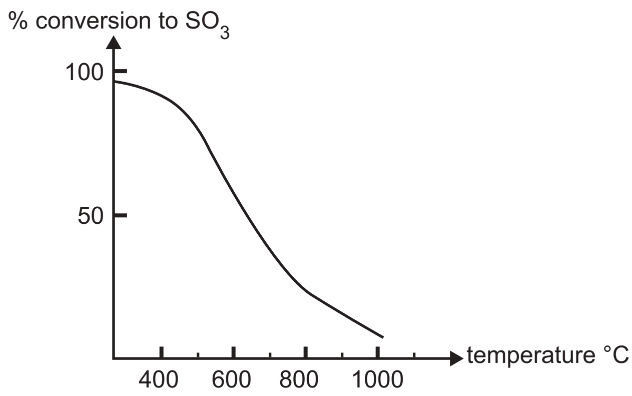
One of the steps involved in the industrial preparation of sulfuric acid is the oxidation of sulfur dioxide to sulfur trioxide according to the equation

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

a. Give the name or formula for the catalyst that is most widely used for this reaction.

1 mark

b. The graph below shows the percentage conversion of sulfur dioxide to sulfur trioxide at equilibrium at 1 atm pressure and various temperatures.



There is almost complete conversion of sulfur dioxide to sulfur trioxide at 300°C. However, this reaction is performed at a higher temperature of approximately 450°C in industry. Why?

1 mark

c. Explain why

i. high pressures would increase the equilibrium yield of sulfur trioxide in this reaction.

ii. atmospheric pressure is **usually** used in industry, even though high pressures increase the equilibrium yield of sulfur trioxide in this reaction.

1 + 1 = 2 marks

d. A chemical reaction that involves sulfuric acid occurs in each of the following situations. Write a balanced chemical equation for each reaction, showing the states of all reactants and products.

i. Dilute sulfuric acid is added to sodium carbonate solution.

ii. Sulfur trioxide gas is bubbled through concentrated sulfuric acid.

iii. A piece of zinc metal is added to 6 M sulfuric acid. Zinc ions are formed as well as an oxide of sulfur in which sulfur exhibits an oxidation state of +4.

2 + 1 + 2 = 5 marks

Total 9 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