VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
2007

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures									Letter
Words									

CHEMISTRY

Written examination 1

Wednesday 13 June 2007

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	7	7	53
			Total 73

- 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 21 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

Analysis of the components of a mixture using gas-liquid chromatography normally involves measuring the

A. R_f values of components, using a gas as the mobile phase.
B. R_f values of components, using a liquid as the mobile phase.
C. retention time of components, using a gas as the mobile phase.
D. retention time of components, using a liquid as the mobile phase.

Question 2

Which one of the following analyses is best performed using atomic absorption spectroscopy?

A. measuring the amount of potassium in salt
B. determining the amount of caffeine in coffee
C. measuring the carbonate content of mineral water
D. detecting the presence of ethanoic acid in a sample of wine

Question 3

Different quantities of nitrogen oxide (NO) are listed below.

Which one contains the **least** number of molecules?

A. 6×10^2 L at 273 K and 1 atm
B. 6×10^{23} molecules
C. 6×10^2 g
D. 6 mol

Question 4

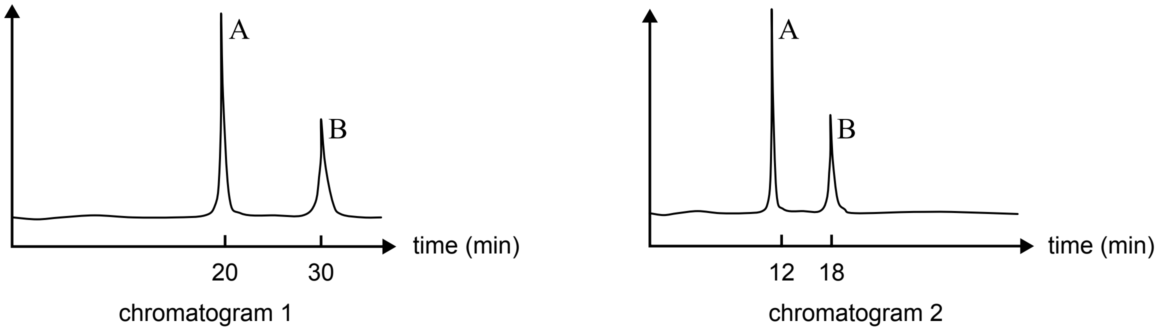
When 2.54 g of solid iodine reacts with excess chlorine and the unreacted chlorine is evaporated, 4.67 g of a yellow product remains.

The empirical formula of the product is

A. ICl_2
B. ICl_3
C. ICl_4
D. ICl_5

Question 5

Chromatogram 1 was obtained by analysis of a sample of a mixture of two sugars, A and B, using high-performance liquid chromatography (HPLC). Chromatogram 2 was obtained by analysing another sample of the same mixture by HPLC under different conditions.



Consider the following changes which could be made to the operating conditions for HPLC.

I decreasing the pressure of the mobile phase

II decreasing the temperature

III using a less tightly packed column

Which of the changes would be most likely to produce chromatogram 2?

A. I only

B. II only

C. III only

D. I and II only

Questions 6 and 7 refer to the following information.

Propanone (C_3H_6O) can be made from 2-propanol using a copper-zinc catalyst.

$$C_3H_8O(g) \rightleftharpoons C_3H_6O(g) + H_2(g); \quad \Delta H = -54 \text{ kJ mol}^{-1}$$

Question 6

At equilibrium at a particular temperature, 10% of the 2-propanol is converted to propanone.

In order to increase the percentage yield of propanone at equilibrium, you should

A. lower the temperature and lower the pressure.

B. lower the temperature and raise the pressure.

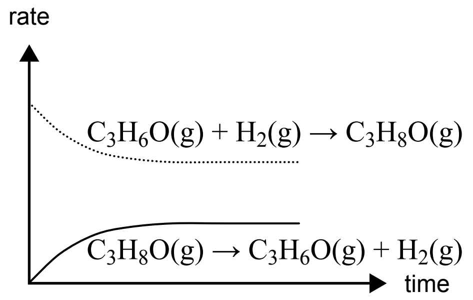
C. raise the temperature and lower the pressure.

D. raise the temperature and raise the pressure.

Question 7

When 2-propanol reacts to form an equilibrium mixture with propanone and hydrogen, which one of the following best represents how the **rates** of the forward and back reactions change over time?

A.



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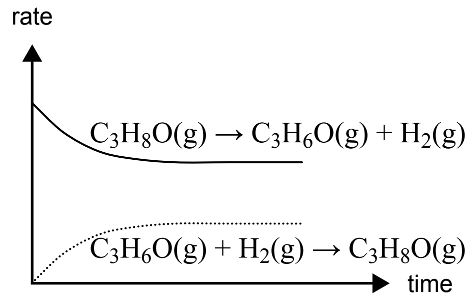
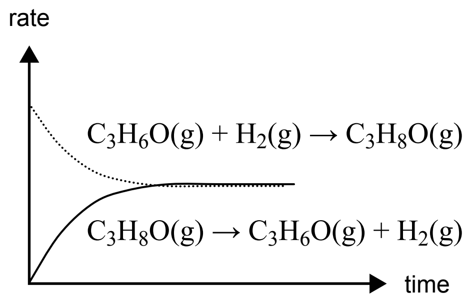
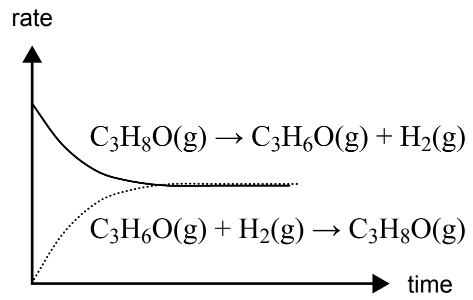


C.



D.



Question 8

A chemical reaction has a ΔH of -150 kJ mol^{-1} and the activation energy for its **reverse** reaction is 350 kJ mol^{-1}.

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

A. +500

B. +200

C. +150

D. –200

Question 9

Which one of the following is **least** likely to be a product of a redox reaction between sulfuric acid and zinc metal?

A. H_2

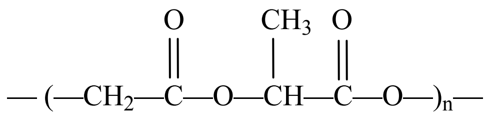
B. H_2S

C. SO_2

D. SO_3

Question 10

Cuts and wounds are often stitched using a biodegradable polymer with the formula



It is made from a condensation polymerisation reaction between lactic acid ($HOCH(CH_3)COOH$) and glycolic acid.

The formula of glycolic acid is

A. $HOCH_2COOH$

B. $HOCH_2CH_2OH$

C. $HOOCCH_2COOH$

D. $HOOCCH_2CH_2OH$

Question 11

Which of the following statements would apply to compounds that belong to the same homologous series?

I they have similar physical properties

II they have similar chemical properties

III they contain the same functional group

IV they have the same molecular formula but different structures

A. III only

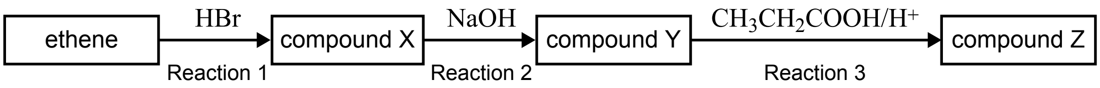
B. IV only

C. II and III only

D. I, II, III and IV

Questions 12 and 13 refer to the following information.

Ethene can be converted into other carbon-containing compounds using the reagents shown in the following flow chart.



Question 12

Compounds X, Y and Z are, respectively

A. bromoethane, ethanol, propyl ethanoate.

B. bromoethane, ethanol, ethyl propanoate.

C. bromoethene, ethanoic acid, ethyl propanoate.

D. bromoethene, ethene hydroxide, propyl ethanoate.

Question 13

Reactions 1, 2 and 3 can be described as, respectively

A. addition, addition, neutralisation.

B. addition, substitution, condensation.

C. substitution, neutralisation, oxidation.

D. substitution, substitution, condensation.

Question 14

Hydrogen iodide is produced by the reaction between hydrogen and iodine.

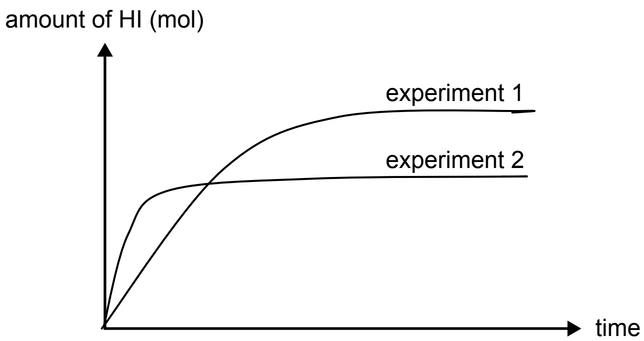
$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Two experiments were conducted.

Experiment 1: quantities of $H_2(g)$ and $I_2(g)$ were placed in a sealed vessel and the reaction allowed to proceed at constant temperature.

Experiment 2: experiment 1 was repeated, but at a different temperature.

The graph below shows the amount of hydrogen iodide produced over the course of experiments 1 and 2.



These results show that experiment 2 was conducted at a

A. lower temperature than experiment 1 and the reaction is endothermic.

B. lower temperature than experiment 1 and the reaction is exothermic.

C. higher temperature than experiment 1 and the reaction is endothermic.

D. higher temperature than experiment 1 and the reaction is exothermic.

Questions 15 and 16 refer to the following information.

One litre of an aqueous solution of potassium hydroxide (KOH) has a pH of 12.0 at 25°C.

Question 15

The amount of solid KOH, in mol, that must be added to the solution to **raise** the pH to 13.0 would be

A. 10^{-13}

B. 10^{-12}

C. 0.09

D. 0.10

Question 16

The amount of pure HCl gas, in mol, that must be added to the solution to **lower** the pH from pH 12.0 to 2.0 would be

A. 10

B. 2.0

C. 0.02

D. 0.01

Question 17

Two bottles, I and II, have the same volume and are at the same temperature.

Bottle I contains 10 g of argon gas only.

Bottle II contains 10 g of neon gas only.

Compared to bottle I, the number of atoms and pressure in bottle II would be

	number of atoms	pressure
A.	equal	the same
B.	equal	higher
C.	approximately double	the same
D.	approximately double	higher

Question 18

A sodium lamp emits yellow-coloured light. If the light from the lamp was passed through a container of sodium vapour, it is likely that the light emerging from the container would appear

A. brighter, due to electrons in atoms in the sodium vapour moving from higher to lower energy levels.

B. brighter, due to electrons in atoms in the sodium vapour moving from lower to higher energy levels.

C. duller, due to electrons in atoms in the sodium vapour moving from higher to lower energy levels.

D. duller, due to electrons in atoms in the sodium vapour moving from lower to higher energy levels.

Question 19

The reaction

$$A + B \rightarrow C; \quad \Delta H \text{ negative}$$

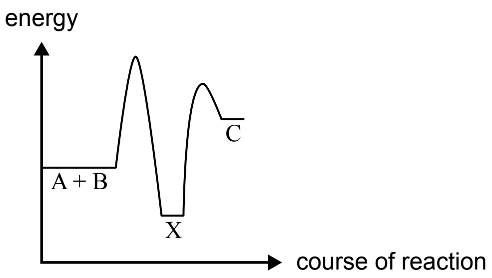
involves a two-step process

$$A + B \rightarrow X; \quad \Delta H \text{ positive}$$

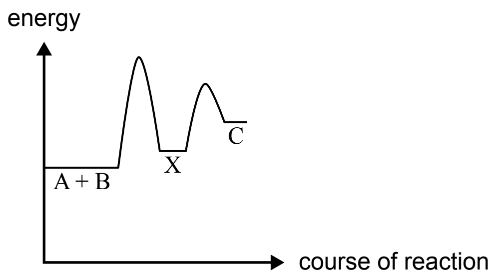
$$X \rightarrow C; \quad \Delta H \text{ negative}$$

Which one of the following diagrams best represents the energy changes during the course of the reaction?

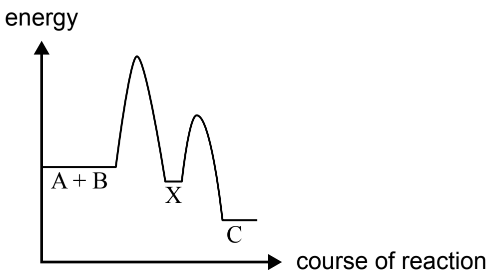
A.



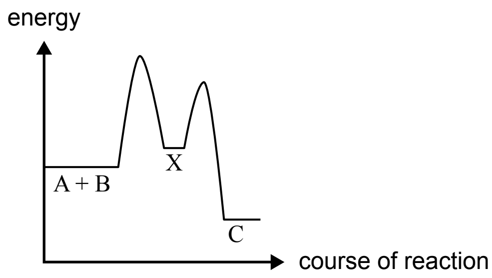
B.



C.

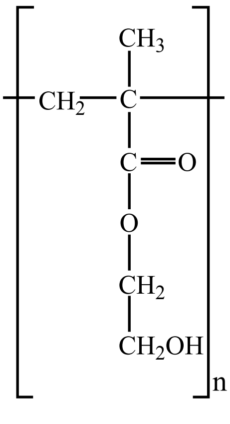


D.



Question 20

The following structure represents the repeating unit of a polymer used in the manufacture of contact lenses.



Which one of the following is a correct statement about the monomers that react to form this polymer?

A. Each monomer contains a double bond between carbon atoms which allows addition polymerisation to take place.

B. Two different monomers react to form the polymer, one with carboxyl groups and the other with hydroxy groups.

C. The total mass of the monomers is greater than the mass of the polymer formed because water is eliminated in the polymerisation reaction.

D. Each monomer contains both a carboxyl and a hydroxy group which allows condensation polymerisation to take place, forming a polyester.

END OF SECTION A

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TURN OVER

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

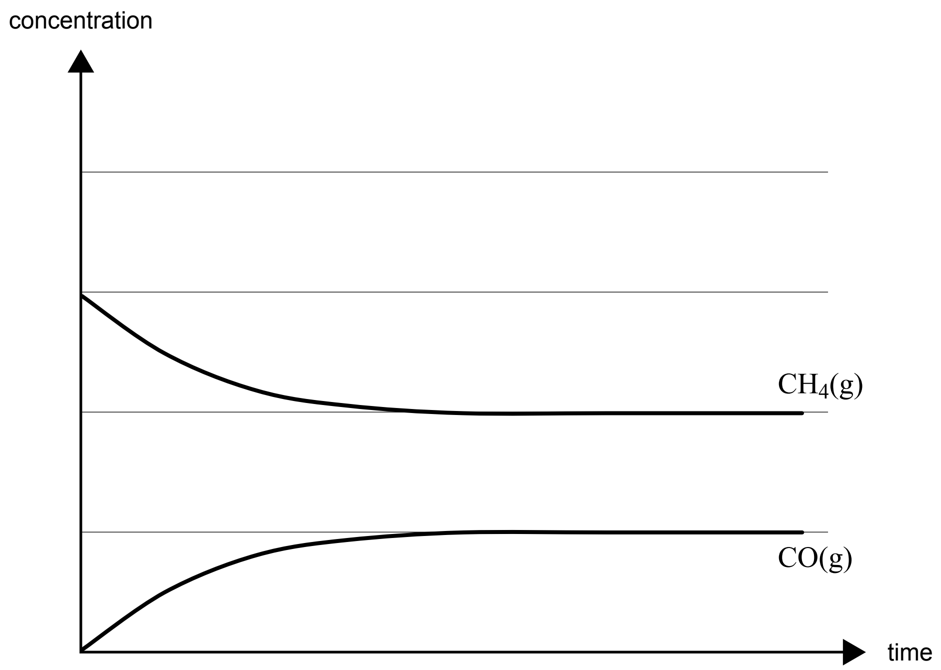
- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of 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

Carbon monoxide and hydrogen can be produced from the reaction of methane with steam according to the equation

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g); \quad \Delta H = +206 \text{ kJ mol}^{-1}$$

Some methane and steam are placed in a closed container and allowed to react at a fixed temperature. The following graph shows the change in concentration of methane and carbon monoxide as the reaction progresses.



a. **i.** On the graph above, draw a line to show the change in concentration of hydrogen gas as the reaction progresses. **Label this line**.

ii. On the graph above, draw a line to show how the formation of carbon monoxide would differ over time in the presence of a catalyst. **Label this line**.

1 + 1 = 2 marks

b. Great care must be taken when handling carbon monoxide as it is a highly poisonous gas. Even at low concentrations it competes very successfully with oxygen for haemoglobin, the oxygen carrier in the blood.

The reactions can be written as

haemoglobin + oxygen $\rightleftharpoons$ oxyhaemoglobin; K_1
haemoglobin + carbon monoxide $\rightleftharpoons$ carbon monoxide–haemoglobin; K_2

What does the above information indicate about the magnitude of the equilibrium constant K_1 compared with the magnitude of the equilibrium constant K_2?

1 mark

c. The rates of chemical reactions may be explained using the collision theory model. Indicate whether the following statements about rates and the collision theory model are true or false by placing ticks in the appropriate boxes.

Statement	True	False
i. Endothermic reactions are always slower than exothermic reactions.		
ii. All particles have the same kinetic energy at a fixed temperature.		
iii. Reactant particles need to collide with sufficient energy to react.		
iv. The rate of a reaction at a constant temperature increases as the reaction proceeds.		
v. Increasing the temperature increases the fraction of collisions with energy above the activation energy.		

3 marks

Total 6 marks

Question 2

Bromophenol blue is a weak acid (represented as BH) that acts as an acid-base indicator. In solution the following equilibrium is established.

$$\underset{\text{yellow}}{BH(aq)} \rightleftharpoons \underset{\text{blue}}{B^-(aq)} + H^+(aq); \quad K_a = 6.3 \times 10^{-5}\ M$$

At low pH bromophenol blue exists mainly as the acid, BH, which is yellow in colour, while at high pH it exists mainly as its conjugate base, B^-, which is blue. An intermediate colour is observed when the concentration of the acid and the concentration of the conjugate base are similar.

a. Write an expression for K_a in terms of the concentrations of BH, B^- and H^+.

1 mark

b. **i.** When $[BH] = [B^-]$, the mixture appears green. Calculate the pH at which $[BH] = [B^-]$.

ii. Calculate the ratio $[B^-]/[BH]$ when the pH of a solution of bromophenol blue is 7.

iii. What colour will the indicator solution appear at pH 7? Justify your answer.

2 + 1 + 1 = 4 marks

Total 5 marks

Question 3

Some rocks were thought to consist of insoluble silica (SiO_2) and calcium carbonate ($CaCO_3$; molar mass 100.1 g mol^{-1}). The fraction of $CaCO_3$ in an 8.64 g sample of the crushed rock was determined by mixing the sample with excess hydrochloric acid. The acid reacts with $CaCO_3$ according to the following equation.

$$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The resulting solution was filtered and the SiO_2 that was collected was washed and dried. The mass of SiO_2 was found to be 1.55 g.

a. Calculate the expected percentage of $CaCO_3$ in the original rock sample.

2 marks

b. In order to check the result from **part a.**, excess ammonium oxalate solution was added to the filtered solution. The calcium ions present precipitate as $CaC_2O_4.H_2O$.

The $CaC_2O_4.H_2O$ was collected by filtration, washed and dried. It was then heated to convert it to CaO (molar mass 56.1 g mol^{-1}) and a mass of 3.87 g was obtained.

Using this mass of CaO, calculate the percentage of $CaCO_3$ in the rock sample. Ensure that you express your answer to an appropriate number of significant figures.

3 marks

c. Suppose that the percentage of $CaCO_3$ determined by the chemical analysis with ammonium oxalate was **less** than the result found in **part a.** above. Provide one possible explanation for the difference.

1 mark

Total 6 marks

Question 4

Sulfur dioxide (SO_2) is a chemical of major industrial significance.

a. SO_2 gas can be produced in a reaction between concentrated sulfuric acid and nickel metal. A solution containing Ni^{2+} ions is also formed.

Write balanced equations for the

i. oxidation reaction

ii. reduction reaction

iii. overall reaction, showing the states of all reactants and products.

1 + 1 + 2 = 4 marks

b. SO_2 can also be produced in a chemical reaction between zinc sulfite ($ZnSO_3$) and hydrochloric acid according to the equation

$$ZnSO_3(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + SO_2(g) + H_2O(l)$$

Is this reaction also a redox reaction? Explain your answer.

1 mark

c. The SO_2 produced as a by-product of the extraction of lead from its ore can cause serious pollution. In order to avoid releasing the SO_2 into the atmosphere it is often collected and used to produce chemicals of industrial importance. Give the formula of such a chemical.

1 mark

d. The following pairs of statements refer to the reaction of $SO_2(g)$ with $O_2(g)$ in the presence of vanadium (V) oxide. Each statement contains one or more missing words.

Circle the most appropriate words beside each statement.

i.

Statements	**Circle the most appropriate words**		
1. The product of this reaction is ______________.	oleum	sulfuric acid	sulfur trioxide
2. At constant temperature, the chemical energy of the product is ____________ the chemical energy of the reactants.	equal to	more than	less than

ii.

1. The equilibrium yield of product is ______________ as temperature decreases at constant pressure.	unchanged	increased	decreased
2. The equilibrium yield of product is ______________ as pressure increases at constant temperature.	unchanged	increased	decreased

iii.

1. The reaction rate is ______________ as the temperature increases at constant pressure.	unchanged	increased	decreased
2. The activation energy of the reaction is ______________ by the presence of vanadium (V) oxide.	unchanged	increased	decreased

1 + 1 + 1 = 3 marks

Total 9 marks

Question 5

Paraffin oil contains a mixture of high molecular mass alkanes. A gaseous mixture of ethene and other low molecular mass alkanes and alkenes can be produced in the laboratory by heating paraffin oil in the presence of alumina.

a. **i.** What is the general name given to this process?

ii. Suggest the likely function of the alumina.

1 + 1 = 2 marks

b. If one of the components of paraffin oil is $C_{17}H_{36}$, write a balanced equation in which this component forms ethene and only one other product.

1 mark

c. A chemist collects three samples of ethene and performs the following reactions. Write balanced equations for each one.

i. addition of bromine (Br_2)

ii. complete combustion

iii. heated with steam and a catalyst at 300°C

1 + 1 + 1 = 3 marks

d. A low molecular mass alkane was extracted from a gas sample obtained by this method. The following sequence of chemical reactions was then performed using this alkane.

- The alkane was allowed to react with chlorine in the presence of ultraviolet light. Two compounds, A and B, were formed, each of molar mass 78.5 g mol^{-1}.
- One of these two compounds was isolated and allowed to react with potassium hydroxide solution. The product of this reaction was heated with acidified potassium dichromate solution to form C, an acidic compound.

i. Draw the structural formulas of compounds A and B in the boxes below, showing **all bonds** present in the molecules. Give the systematic name of each compound.

Name ______________________	Name ______________________

ii. Draw the structural formula of compound C in the box below, showing **all bonds** present in the molecule. Give the systematic name of the compound.

Name ______________________

4 + 2 = 6 marks

Total 12 marks

Question 6

When the substance CH_3CHO (substance X) is dissolved in water it reacts to form an equilibrium mixture with $CH_3CH(OH)_2$ (substance Y) according to the equation

$$X(aq) + H_2O(l) \rightleftharpoons Y(aq)$$

The concentration of X can be determined using UV-visible spectroscopy. X absorbs strongly at 290 nm. Y shows no absorption at this wavelength.

In a particular experimental arrangement at 25°C, the relationship between absorbance at 290 nm and concentration of X is given by

$$\text{Absorbance} = 4.15 \times [X]$$

In the experiment, 0.110 mol of X is dissolved rapidly in 1.00 L of water at 25°C. The absorbance of the solution changes as some of the X is converted to Y. The table below shows the change in absorbance over time (measured in seconds).

Absorbance	0.430	0.303	0.270	0.255	0.250	0.250
Time (s)	6.00	60.0	90.0	120	240	480

a. Calculate the concentration of X, in M, when the reaction reached equilibrium.

1 mark

b. Calculate the absorbance at the instant that X was dissolved in the water, before any reaction occurred.

1 mark

c. Calculate the percentage of the original 0.110 mol of X that has been converted into Y at equilibrium.

2 marks

d. The average rate of a reaction can be determined by calculating the change in concentration of a reactant per second. Calculate the average rate, in $M\ s^{-1}$, at which the concentration of X changed during the first 6.00 s of the reaction.

2 marks

Total 6 marks

Question 7

Sulfur dioxide gas is commonly used as a preservative in wine. An important source of SO_2 is solid sodium metabisulfite ($Na_2S_2O_5$; molar mass 190 g mol^{-1}). $Na_2S_2O_5$ reacts readily with acid as follows.

$$Na_2S_2O_5(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + 2SO_2(g)$$

a. Calculate the volume, in litres, of SO_2 produced at 1.00 atm pressure and 15.0°C when 250 g of $Na_2S_2O_5$ reacts with excess acid.

3 marks

b. The concentration of an aqueous solution of SO_2 (solution A) is to be determined using its reaction with an aqueous solution of triiodide ions (I_3^-). The relevant half reactions are

$$SO_2(aq) + 2H_2O(l) \rightarrow 4H^+(aq) + SO_4^{2-}(aq) + 2e^-$$

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

50.0 mL of a 0.0125 M solution of I_3^- is added to 50.0 mL of solution A, providing excess of I_3^-. The final 100.0 mL solution is called solution B.

i. Write an overall balanced chemical equation for the reaction that occurs, identifying the substance that is the reductant.

Equation ______________________________

Reductant ______________

ii. Calculate the amount, in mol, of I_3^- added to solution A.

iii. The excess I_3^- remaining in the solution is determined by titration with a standard solution of sodium thiosulfate ($Na_2S_2O_3$). The equation for the reaction is

$$S_2O_3^{2-}(aq) + I_3^-(aq) + H_2O(l) \rightarrow 3I^-(aq) + S_2O_4^{2-}(aq) + 2H^+(aq)$$

14.70 mL of a 0.00850 M solution of $Na_2S_2O_3$ reacts exactly with all the I_3^- remaining in solution B. Calculate the original concentration of SO_2 in solution A.

2 + 1 + 3 = 6 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

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

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

1 atm = 101 325 Pa = 760 mmHg

0°C = 273 K

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

Avogadro constant = $6.02 \times 10^{23}\ \text{mol}^{-1}$

$K_w = 1.00 \times 10^{-14}\ \text{M}^2$ at 25ºC

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** 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** (266)	107 **Bh** (264)	108 **Hs** (277)	109 **Mt** (268)	110 **Ds** (271)	111 **Rg** (272)	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** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

END OF DATA SHEET