1995 VCE CHEMISTRY CAT 1

"CHEMISTRY IN A PRACTICAL CONTEXT"

DETAILED SUGGESTED SOLUTIONS

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Section A

Specific instructions for Section A

Section A, Question 1, consists of 18 multiple-choice items. Section A is worth approximately 25 per cent of the marks available. You should spend approximately 23 minutes on this section. Choose the response that is correct or best answers the question, and mark your choice on the multiple-choice answer sheet according to the instructions on that sheet.
A correct answer scores 1, an incorrect answer scores zero. No credit will be given for an item if two or more letters are marked for that item. Marks will not be deducted for incorrect answers and you should attempt every item.

Data

Relative atomic masses

H = 1.00; C = 12.0; O = 16.0; Cl = 35.5; Ca = 40.0; Fe = 56.0

Question 1

Items 1, 2 and **3** below refer to the operation of a blast furnace

Item 1

The production of iron involves the injection of a gas at the base of the blast furnace. The gas is
A. carbon dioxide.
B. carbon monoxide
C. air.
D. steam.

ANS C
Air is injected at the base of the blast furnace.

Item 2

The name of the gaseous reductant that operates within the blast furnace is
A. carbon dioxide.
B. carbon monoxide.
C. nitrogen.
D. hydrogen.

ANS B
The gaseous reductant within the blast furnace is carbon monoxide produced from air and coke according to the equations: $C(s) + O_2(g) \rightarrow CO_2(g)$ and $CO_2(g) + C(s) \rightarrow 2CO(g)$.

Item 3

Limestone is the source of a reactant within the blast furnace that reacts with any silica present. The primary purpose of this reaction is to
A. provide heat for the main reaction in the blast furnace.
B. reduce the silicon content of the iron produced.
C. reduce the calcium content of the iron produced.
D. provide carbon for the production of steel.

ANS B
Limestone is the source of calcium carbonate which reacts with silica according to the equation: $CaCO_3(s) + SiO_2(s) \rightarrow CaSiO_3(l) + CO_2(g)$. The calcium silicate formed is called 'slag' and floats on top of the molten iron. It is removed and thus the silicon content of the iron produced is thereby reduced.

Section A

Question 1

Item 4

The chemical formulas of two commercial detergents are $C_{12}H_{25}SO_3.Na$ (detergent A) and $C_{10}0H_{21}N(CH_3)_3.Cl$ (detergent B). Which one of the following statements is correct?

A. Both detergent A and detergent B are non-ionic detergents.
B. Detergent A is an anionic detergent and detergent B is a cationic detergent.
C. Detergent A is a cationic detergent and detergent B is an anionic detergent.
D. Both detergent A and detergent B are anionic detergents.

ANS B

The formulas are (A) $C_{12}H_{25}SO_3^-$ and (B) $C_{10}0H_{21}N(CH_3)_3^+$. An anion is a negative ion and a cation is a positive ion. Hence, detergent A is an anionic detergent and detergent B is a cationic detergent.

Item 5

An iron catalyst is used to improve the efficiency of the Haber process for the production of ammonia according to the following equation

$$N_2(g) + 3H_2(g) \Leftrightarrow 2NH3(g); \Delta H = -91 \text{ kJ mol}^{-1}$$

The effect of the catalyst is to

A. decrease the activation energy of the reaction.
B. increase the value of the equilibrium constant for the reaction.
C. change the composition of the equilibrium mixture so as to increase the amount of ammonia.
D. reverse the sign of the ΔH of the reaction.

ANS A

A catalyst increases the **rate** of both the forward and the reverse reactions in an equilibrium mixture. As a result equilibrium is achieved more rapidly. It does this by lowering the activation energy (the energy barrier) of the reaction.

Item 6

When 50 mL of 0.2 M HCI and 50 mL of 0.2 M $Ba(OH)_2$ are mixed, the pH of the resulting solution will be closest to

A. 0.1
B. 0.4
C. 7.0
D. 13.0

ANS D

Initial number of mole of HCl = 0.05 x 0.2 = 0.01. Initial number of mole of Ba(OH)2 = 0.05 x 0.2 = 0.01. The balanced equation for the reaction is $2HCl(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$. Hence, 0.01 mol of HCl reacts exactly with 0.005 mol of $Ba(OH)_2$. Hence, 0.005 mol of $Ba(OH)_2$ is in excess. Hence, 0.005 x 2 = 0.01 mol of OH^- is in excess. Hence, $[H^+] = \frac{10^{-14}}{10^{-2}} = 10^{-12}$.

Hence, pH of the resulting solution = 12 (closest to 13).

This calculation is not really required since the resulting solution is alkaline and 13 is the only alkaline pH!!

Section A

Question 1

***Items 7** and **8** below refer to the following information*

The self-ionisation constant of water, derived from the reaction

$$2H_20(1) \Leftrightarrow H_30^+(aq) + OH^-(aq); \Delta H = 57 \text{ kJ mol}^{-1}$$

can be expressed as $K_w = [H_30^+][0H^-] = lO^{-14} M^2$ at 25 °C

Item 7
In alkaline solutions at 25 °C
A. 10^{-14} M > $[H_30^+]$ > $[OH^-]$
B. 10^{-14} M > $[OH^-]$ > $[H_30^+]$
C. $[OH^-] > 10^{-7}$ M > $[H_30^+]$
D. $[H_30^+] > 10^{-7}$ M > $[OH^-]$

ANS C
In alkaline solutions, the concentration of hydroxide ions is greater than the concentration of hydronium ions. Because the product of these two concentrations must equal 10^{-14},
$[OH^-] > 10^{-7}$ M > $[H_30^+]$

Item 8
At 60 °C the pH of pure water will be
A. 14 exactly
B. >7.0
C. 7 exactly
D. <7.0

ANS D
The forward reaction is endothermic. Hence, an increase in temperature will favour the forward reaction. Hence, the concentrations of both OH^- and H_3O^+ will increase and the value of K_w will increase.
Hence, the concentration of H_3O^+ in pure water will be greater than 10^{-7}M.
Hence, the pH of pure water will be **less than** 7.0

Section A

Question 1

Item 9

The number of mole of chloride ions in 3.85 g of $FeCl_3$ is closest to

A. 0.0079
B. 0.024
C. 0.036
D. 0.072

ANS D

Using the data given , $n(FeCl_3) = \frac{3.85}{56.0 + (3 \times 35.5)} = \frac{3.85}{162.5}$.

Hence, $n(Cl^-) = 3 \times \frac{3.85}{162.5} = 0.0711$ which is closest to 0.072

Item 10

A sample of Fe_2O_3 contains 0.60 mole of oxide ions. The total mass of the sample of Fe_2O_3 is closest to

A. 29g
B. 32g
C. 64g
D. 144g

ANS B

From the chemical formula , $n(Fe_2O_3) = \frac{1}{3} \times n(O^{2-}) = \frac{1}{3} \times 0.60 = 0.20$ mol. Hence, using the data given, the mass of $Fe_2O_3 = 0.20 \times ((2 \times 56.0) + (3 \times 16.0)) = 0.20 \times 160.0 = 32$ g

Item 11

Hot concentrated sulfuric acid reacts with sulfur to produce sulfur dioxide and water according to the equation

$$S(s) + 2H_2SO_4(1) \rightarrow 3S0_2(g) + 2H_2O(l)$$

In this reaction, sulfuric acid is acting primarily as

A. a strong acid.
B. a reducing agent.
C. an oxidising agent.
D. a dehydrating agent.

ANS C

In this reaction, the oxidation number of sulfur in elemental sulfur is zero, while in sulfuric acid, it is +6. The oxidation number of sulfur in sulfur dioxide is +4. Hence, sulfuric acid is acting as an oxidising agent. It has oxidised sulfur to sulfur dioxide and has itself been reduced to sulfur dioxide.

Section A

Question 1

Item 12
Hydrogen iodide decomposes according to the equation

$$2HI(g) \Leftrightarrow H_2(g) + I_2(g); K = 0.006 \text{ at } 320 \text{ K}$$

If 2 mole of each of HI, H_2 and I_2 were mixed in a I L vessel at 320 K then, at equilibrium,
A. the concentration of I_2 would have decreased.
B. the concentration of HI would be unchanged.
C. the value of K would have increased to 1.
D. the number of gas molecules present would have decreased.

ANS A
The concentration fraction = $\frac{[H_2].[I_2]}{[HI]^2}$.
Initially, the value of this concentration fraction = $\frac{2 \text{ x } 2}{2^2} = 1.0$
At equilibrium, at this temperature, the value of the concentration fraction = the equilibrium constant = 0.006. Hence, the concentration of both I_2 and H_2 would have decreased and the concentration of HI would have increased.

Item 13
Methanol may be prepared commercially from CO(g) and H_2(g) at 400 °C in the presence of a suitable catalyst according to the equation

$$CO(g) + 2H_2(g) \Leftrightarrow CH_3OH(g); \Delta H = -92 \text{ kJ mol}$$

The amount of CH_30H present at equilibrium could be increased by increasing the
A. pressure of the reaction mixture.
B. temperature of the reaction mixture.
C. volume of the reaction chamber.
D. amount of catalyst present in the reaction mixture.

ANS A
The forward reaction involves a decrease in the number of gas molecules. Hence, if the pressure of the reaction mixture is increased, the forward reaction will be favoured and the amount of CH_3OH at equilibrium will be increased.

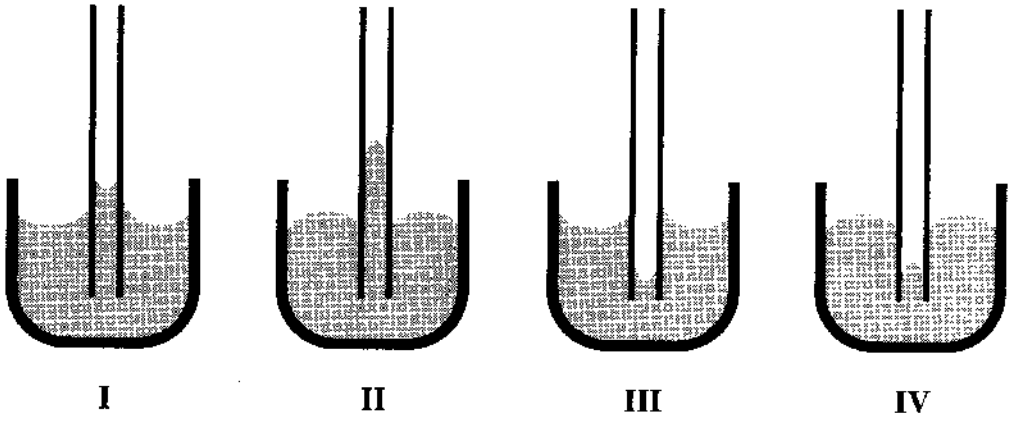
Section A

Question 1

Item 14
Which one of the following will **not** increase the rate of formation of hydrogen from the reaction of magnesium with hydrochloric acid?
A. Add sodium chloride solution to the magnesium/acid mixture.
B. Increase the temperature of the magnesium/acid mixture.
C. Increase the concentration of the hydrochloric acid in contact with the magnesium.
D. Use the metal in the form of finely powdered magnesium instead of as magnesium ribbon.

ANS A
The chemical reaction is $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
Increases in temperature, concentration and surface area will **usually** increase the rate of a chemical reaction. Assuming that sodium chloride does not function as a catalyst in this reaction, the addition of sodium chloride to the reaction mixture will not increase the rate of reaction.

Item 15
Fine clean glass capillaries are placed into samples of pure water and pure mercury.

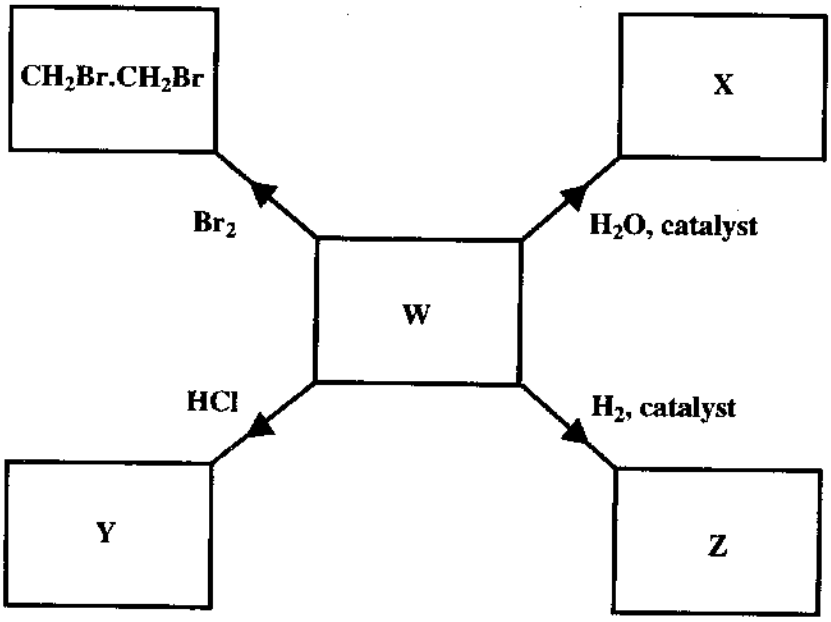


The expected appearance of the liquids in the capillaries would be
A. I = water; II = mercury
B. II = water; III = mercury
C. III = water; IV = mercury
D. I = water; IV = mercury

ANS D
The attraction between glass and water is greater than the attraction between water molecules. Hence, water forms a concave meniscus and is drawn up the capillary tube (I). The attraction between glass and mercury is less than the attraction between mercury atoms. Hence, mercury forms a convex meniscus and is pulled down the capillary tube (IV)

Section A

Items 16 and 17 below refer to the following diagram



Item 16

In the above diagram, the compounds W and X may be, respectively,

A. C_2H_4 and CH_3CH_2Br

B. CH_3CH_2Br and $HOCH_2CH_2OH$

C. C_2H_4 and CH_3CH_2OH

D. CH_3CH_2Br and CH_3CH_2OH

ANS C

$CH_2Br.CH_2Br$ can be formed by the addition reaction between Br_2 and C_2H_4 (ethene) according to the equation: $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$

The addition of H_2O to C_2H_4 in the presence of a catalyst produces ethanol, CH_3CH_2OH, according to the equation: $C_2H4 + H_2O \rightarrow C_2H_5OH$

Item 17

In the above diagram, the compounds Y and Z may be, respectively,

A. CH_3CH_2Br and CH_3CH_2Cl

B. CH_3CH_2Cl and C_2H_6

C. C_2H_4 and CH_3CH_2OH

D. CH_3CH_2Br and CH_3CH_2OH

ANS B

The addition of HCl to C_2H_4 produces chloroethane, CH_3CH_2Cl, according to the equation: $C_2H_4 + HCl \rightarrow C_2H_5Cl$.

The addition of H_2 to C_2H_4 in the presence of a catalyst produces ethane, C_2H_6, according to the equation: $C_2H_4 + H_2 \rightarrow C_2H_6$.

Section A

Item 18
In the species SO_2 and HNO_3, the underlined atoms have oxidation numbers respectively of
A. +6 and +3
B. +4 and +5
C. +4 and +3
D. -2 and +5

ANS B
S + (2 x -2) = 0. Hence, S = +4.

N +1 + (3 x -2) = 0. Hence, N = +5

SECTION B

Specific Instructions for Section B

Section B consists of six short-answer questions (questions 2 to 7 inclusive). You must answer all of these questions. The section is worth 53 marks or approximately 75 per cent of the total. You should spend approximately 67 minutes on this section.

The marks allotted to each question and suggested time allocations are shown at the end of each question.

Questions should be answered in the spaces provided in this booklet.

You should

- give simplified answers with an appropriate number of significant figures for all numerical questions; unsimplified answers will not receive full marks.
- show all working in your answers to numerical questions. No marks can be given for an incorrect answer unless it is accompanied by details of the working.
- make sure all chemical equations are balanced and that the formulas for individual substances include an indication of state, { for example, $H_2(g)$; NaCl(s) } .

Section B

Question 2

a. Water will wet clean glass. A drop of water is placed on a clean glass surface and begins to spread.

i. A side view of a flat sheet of clean glass is shown below. Sketch on this the expected appearance of the drop a short time after it has started spreading.

ii. On your sketch, clearly show and label the contact angle for the drop on the glass.

iii What would be the approximate size of the angle when the drop had finished spreading on a very large sheet of glass?

b. Water does not wet plastic 'polythene' . Sketch the expected shape of a drop of water sitting on a clean flat plate of 'polythene' on the side view of a flat sheet of 'polythene' shown below. Show the contact angle on your sketch and indicate whether it would be greater or less than 90 degrees.

c. A stable emulsion is made from a mixture of a hydrocarbon oil and a dilute sodium chloride solution in the presence of an anionic detergent. The electrical conductivity of the emulsion is measured and found to be extremely low.

i. Name the type of this emulsion and explain how the conductivity of the emulsion enables you to determine the type of emulsion.

ii. Give a labelled sketch of the emulsion showing the orientation of the detergent molecules in the emulsion particle surface.

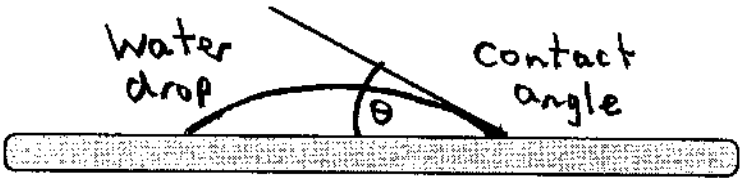
3+2+4 = 9 marks

(suggested time: 12 minutes)

Section B

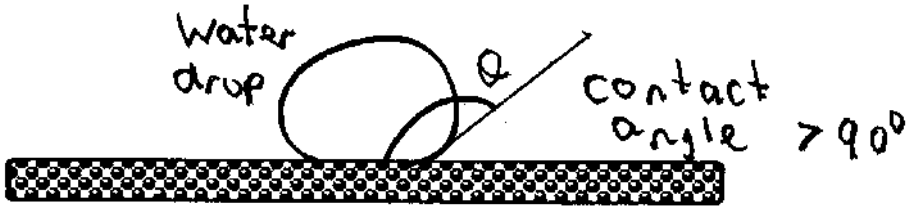
Question 2 (solution)

a. i. ii.



iii. When the drop had finished spreading on a very large sheet of glass, the contact angle would be approximately zero.

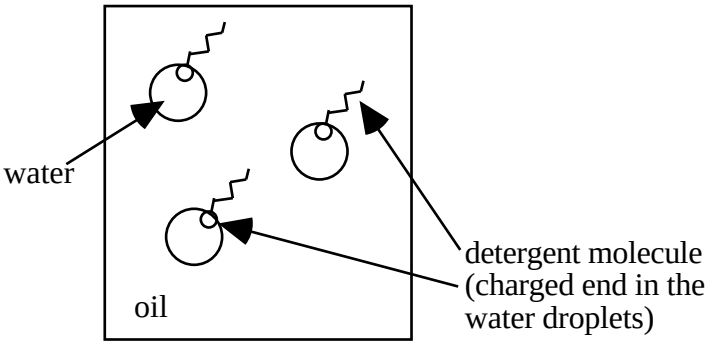
b.



c.

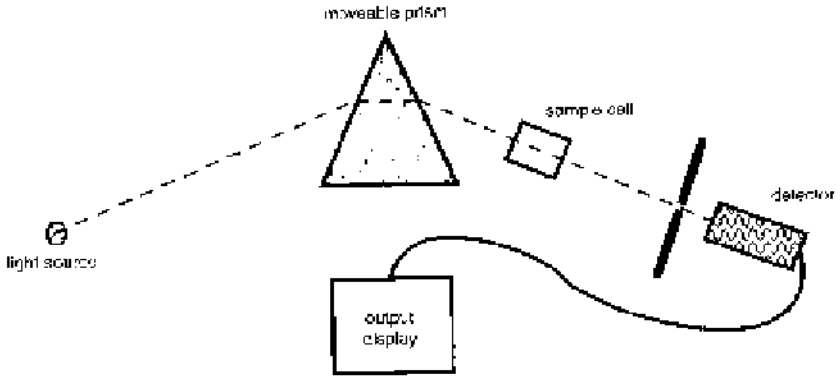
i. This is a water in oil emulsion with small water droplets dispersed throughout the oil. The extremely low electrical activity indicates that most of the material is oil which is generally a poorer conductor of electricity than water.

ii.



Section B

Question 3



a. Shown above is a labelled diagram of a simple ultraviolet-visible spectrometer. This instrument is used to measure the absorption of radiation by dissolved substances.

i. What is the purpose of the prism?

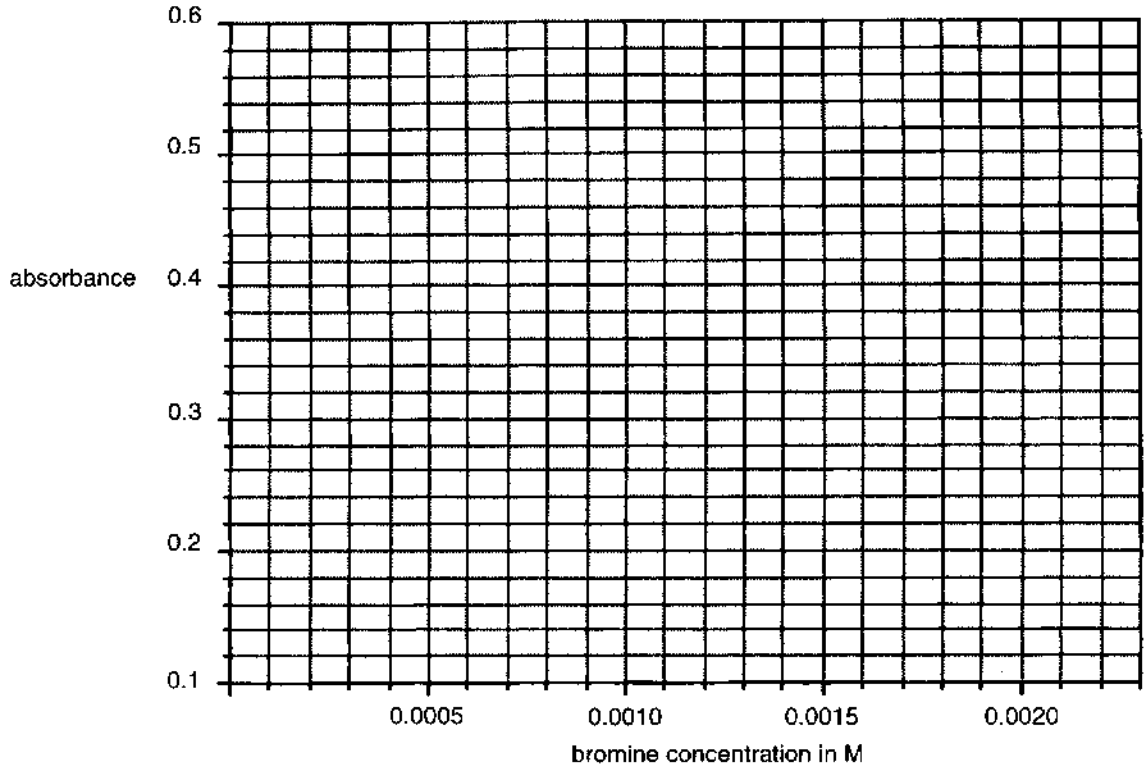
ii. What is the purpose of the detector?

b. Three different bromine solutions are prepared and the spectrum of each is measured in a spectrometer. The absorbances of a 1 cm thickness of each of the solutions are recorded at a wavelength of 400 nm and are shown in the table below. Use these data to sketch a graph of absorbance as a function of bromine concentration using the blank graph provided below.

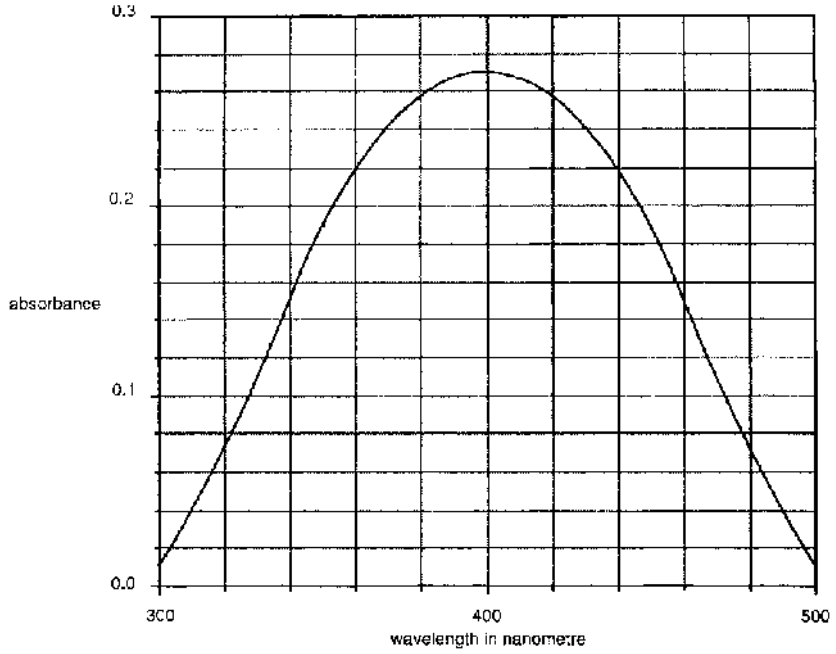
Br_2 concentration	0.00100 M	0.00150 M	0.00220 M
absorbance	0.230	0.340	0.500

Section B

Question 3 (continued)



A solution of bromine of unknown concentration is placed in a sample cell with a path length of I cm. A spectrum is measured and is shown in the graph below. Use the data in the graph to estimate the concentration of bromine in the unknown solution. Place your answer in the space provided under the graph below.



$[Br_2]$ = _____M

2+2+ 1=5 marks

(suggested time: 6 minutes)

Section B

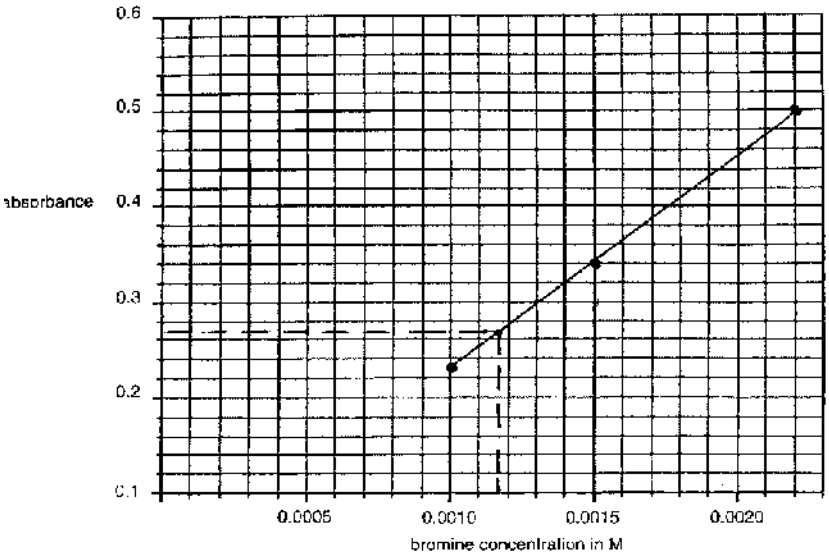
Question 3 (solution)

a.

i. The purpose of the prism is to refract the light from the light source so that only light of the desired frequencies (in this case ultraviolet) is directed through the sample cell.

ii. The purpose of the detector is to record how much light passes through the sample cell and thereby to determine how much light is absorbed by the sample cell at each particular frequency.

b.

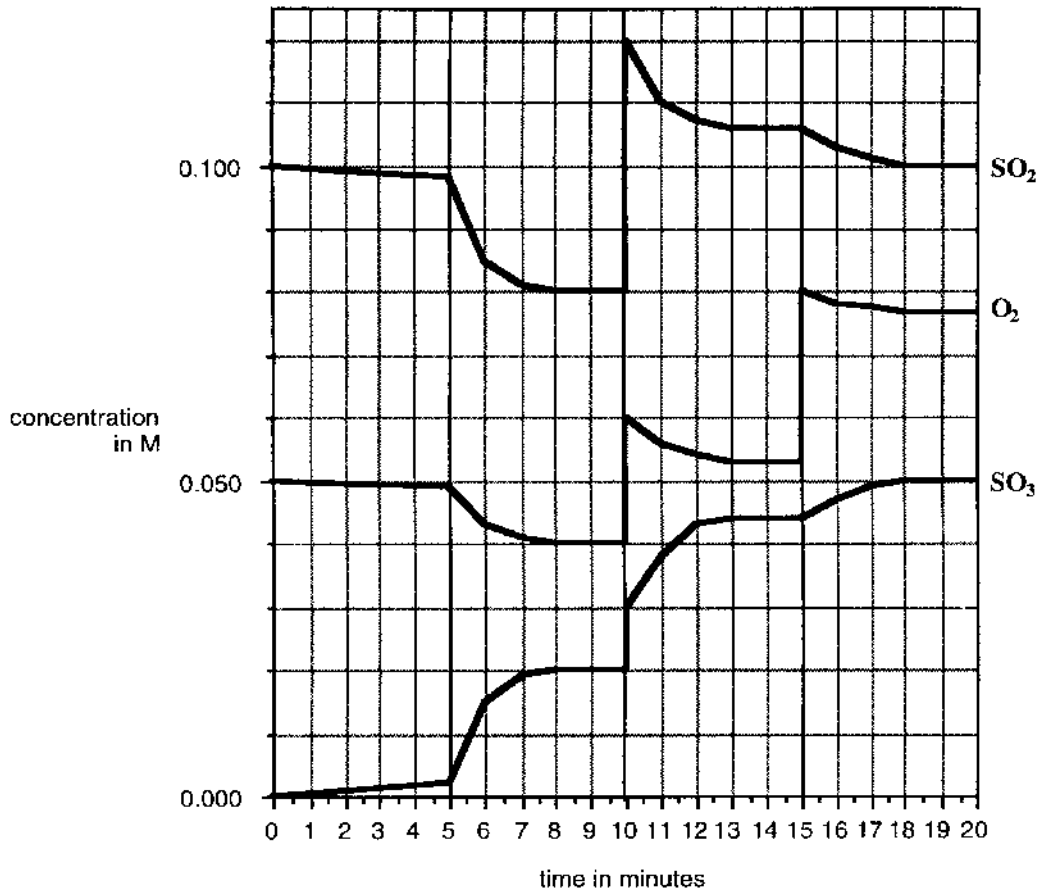


c. From the graph, the absorbance at 400 nm by the bromine solution of unknown concentration, is 0.27. Hence, as shown above, the concentration is approximately 0.00115 M

Section B

Question 4

The graph below is a plot showing changes in the concentrations of three gases, SO_2, O_2 and SO_3 with time over a 20 minute period in a fixed volume reaction vessel that is held at a constant temperature of 600 ^oC throughout. At one point during this time a catalyst is added to the gas mixture.



a. The reaction occurring is represented as

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g); \Delta H = -200 \text{ kJ mol}^{-1}$$

i. Use the graph to determine the equilibrium concentrations of each gas at the time the gas mixture first reaches equilibrium

$[O_2]$ = _____ $[SO_2]$ = _____ $[SO_3]$ = _____

ii. Write an expression for the equilibrium constant of the reaction in the space provided

K =

iii. Use the data from i. and ii. to calculate the value of the equilibrium constant, K, at 600 ^oC.

Section B

Question 4 (continued)

b. At what time was the catalyst added?

c. Explain why the concentration of SO_2 changes after the l 5 minute mark.

d. The reaction conditions described in this mixture of gases are not those that usually apply in the converter chamber of an industrial plant designed to produce large quantities of sulfuric acid.

Normal operating temperatures of about 450^{o}C and gas pressures of one atmosphere, using a vanadium pentoxide catalyst, lead to the conversion of about 98 per cent of the sulfur dioxide to sulfur trioxide.

i. Increasing the pressure of the reaction mixture increases the proportion of SO_2 converted to SO_3 at equilibrium. Yet the actual pressure used is about one atmosphere. Why are pressures of one atmosphere used rather than high pressures?

ii The rate of the catalysed formation of SO_3 from SO_2 and O_2 is high at 600^{o}C. Yet modern industrial practice is to use a temperature of about 450 ^{o}C where the rate of the catalysed reaction is lower. Explain why this lower temperature has been chosen for the industrial process.

5+1 + 2+ 4 = 12 marks

(suggested time: 15 minutes)

Section B

Question 4 (solution)

a. i. a The system is in equilibrium when the concentrations of the three gases remain constant over period of time. This occurs first at the 8 minute mark.

$[O_2] = 0.040$ M $\quad [SO_2] = 0.080$ M $\quad [SO_3] = 0.020$ M

ii. $K = \dfrac{[SO_3]^2}{[SO_2]^2\,[O_2]}$ iii. $K = \dfrac{(0.020)^2}{(0.080)^2 \times 0.040} = 1.5625 = 1.563$

b. From the graph, the reaction proceeds slowly until the 5 minute mark and then goes rapidly to equilibrium. Hence, the catalyst has been added at the five minute mark.

c. At the 15 minute mark, the concentration of oxygen increases instantaneously while the concentrations of sulfur dioxide and sulfur trioxide do not change. Extra oxygen has been added to the equilibrium mixture. As a result, the concentration of SO_3 increases and the concentration of SO_2 decreases until equilibrium is once again achieved.

d.

i. Since almost complete conversion takes place at one atmosphere pressure, the cost of providing equipment to produce higher pressures is not justified by the slight improvement in yield.

ii The higher the temperature, the lower the value of the equilibrium constant (since the forward reaction is exothermic). Hence, the lower the yield of SO_3. A compromise temperature of 450^oC is chosen to achieve an acceptable yield at a reasonable rate.

COMMENT ON QUESTION 4:
It is difficult to see how the data provided in the stem of this question can be correct. The instantaneous increase in the concentration of all three gases by a factor of 1.5 at the 10 minute mark indicates that the volume of the container has been decreased by a factor of $\frac{2}{3}$.
When equilibrium is reached at the 15 minute and 20 minute marks, a different equilibrium constant of approximately 3.3 can be calculated. This indicates that the temperature of the system has been decreased.

Section B

Question 5

Eggshells contain calcium carbonate. A student carried out an experiment to determine the percentage of calcium carbonate in some eggshells by reacting some crushed dried shells with 25.00 mL of 0.300 M hydrochloric acid. The equation for the reaction was

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

The mixture was allowed to stand until there were no more bubbles of carbon dioxide evolved. Then the hydrochloric acid that had not taken part in the reaction with the calcium carbonate in the eggshells was titrated against a standard solution of sodium hydroxide. The equation for this reaction was

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(I)$$

Relevant data for this experiment

Mass of eggshell used	0.620 g
Concentration of HCl solution	0.300 M
Volume of HCl solution added to the 0.620 g sample of eggshell	25.0 mL
Concentration of NaOH solution	0.200 M
Volume of NaOH used in the back titration	18.2 mL

a. Use the above information to complete a simple flow chart below showing the sequence of operations used to determine the amount of $CaCO_3$ in the eggshell sample.

b. Given bottles of standard 0.300 M HCl(aq) and 0.200 M NaOH(aq), list all the basic laboratory equipment that would be needed to carry out this determination.

c. List two important safety precautions you should take while carrying out the above procedures in the laboratory.

d. Calculate

i. the number of mole of HCl that was initially added to the 0.620 g of crushed eggshell.

ii. the number of mole of NaOH used in the back titration.

iii. the number of mole of HCI that reacted with the NaOH.

iv the number of mole of HCl that had reacted with the $CaCO_3$ in the eggshell

v. the number of mole of $CaCO_3$ in the 0.620 g sample of eggshell.

vi. the percentage by mass of $CaCO_3$ in the eggshell sample.

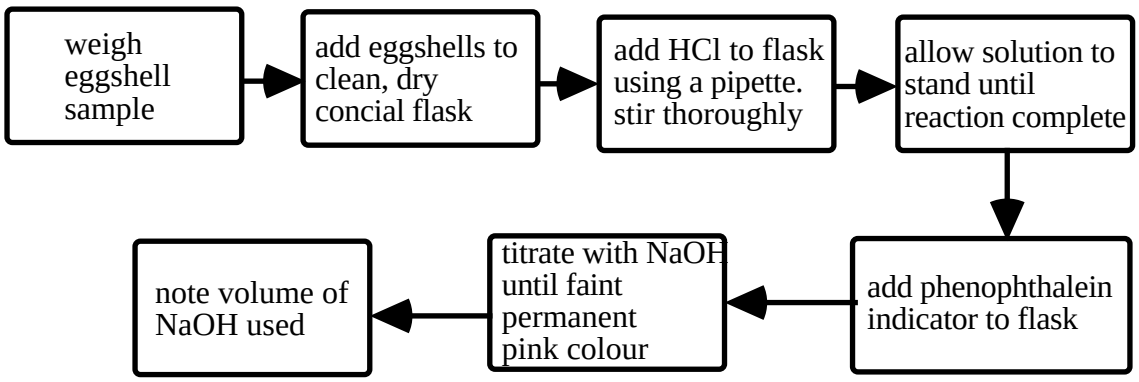
2+2+1 + 7= 12 marks

(suggested time: 15 minutes)

Section B

Question 5 (solution)

a. A simple flow chart for this determination would be:
(detailed treatment of the pipette and burette has not been included)



b. The basic laboratory equipment required would be:
balance, conical flask, pipette, stirring rod, indicator, burette.

c. Important safety precautions during this determination are:

(1) glasses to provide eye protection
(2) long hair tied back
(3) clothing and gloves to provide skin protection

d.

i. n(HCl) initially added to the eggshell = c x V = 0.300 x 0.025 = 0.0075 **ANS**

ii. n(NaOH) used in the back titration = c x V = 0.200 x 0.0182 = 0.00364 **ANS**

iii. From the equation, n(HCl) that reacted with NaOH = n(NaOH) = 0.00364 **ANS**

iv. n(HCl) that had reacted with the CaCO3 in the eggshell = 0.0075 - 0.00364 = 0.00386 **ANS**

v. From the equation, n($CaCO_3$) in the eggshell sample = $\frac{1}{2}$ x n(HCl) = $\frac{1}{2}$ x 0.00386 = 0.00193 **ANS**

vi. mass of $CaCO_3$ in the eggshell sample = 0.00193 x (40 + 12 + 48) = 0.00193 x 100 = 0.193

Hence, % by mass of $CaCO_3$ in the eggshell sample = $\frac{0.193}{0.620}$ x 100 = 31.1 % **ANS**

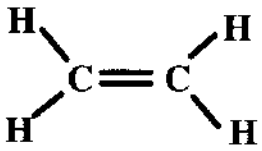
Section B

Question 6

Ethene is an important industrial chemical obtained by processing crude oil. The first step in the process is a fractional distillation of crude oil.

a. What is the purpose of the fractional distillation process?
b. Ethene and other unsaturated hydrocarbons are made by a process known as 'cracking'. Thus, propane may be cracked to form ethene and one other molecule.

i. What is meant by the term 'unsaturated'?
ii. Write a chemical equation for the cracking of propane.
iii. Sulfur compounds are often removed from crude oil before processing. What happens to any sulfur in oil when the oil is burned?
iv. Ethene is the first member of the alkene homologous series. The structural formula of ethene is shown below.



Draw similar structural formulas of all the possible isomers of the alkene with four carbon atoms.

1 +7= 8 marks
(suggested time: 10 minutes)

Question 6 (solution)

a. The purpose of the fractional distillation process is to separate the components of crude oil according to their boiling temperatures. Several fractions are produced each containing a number of hydrocarbons which have similar boiling temperatures.

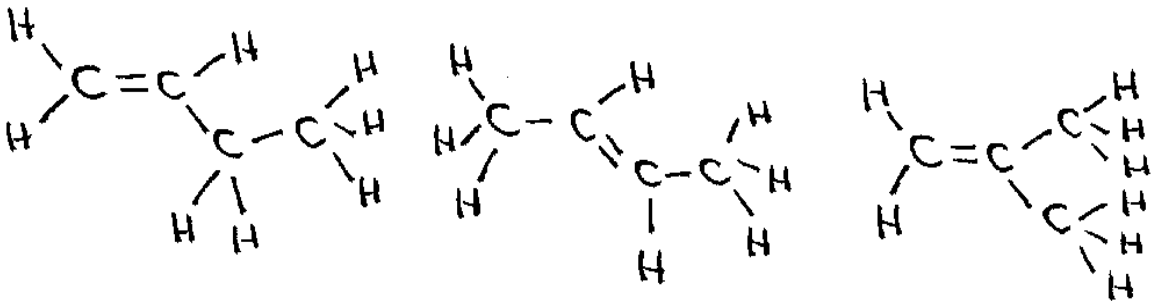
b. i. An 'unsaturated molecule' is one that contains at least one multiple (double or triple) covalent bond.

ii. The cracking of propane: $C_3H_8(g) \rightarrow C_2H_4 + CH_4$

iii. When oil is burned, the sulfur present is converted to sulfur dioxide according to the equation:

$$S(s) + O_2(g) \rightarrow SO_2(g)$$

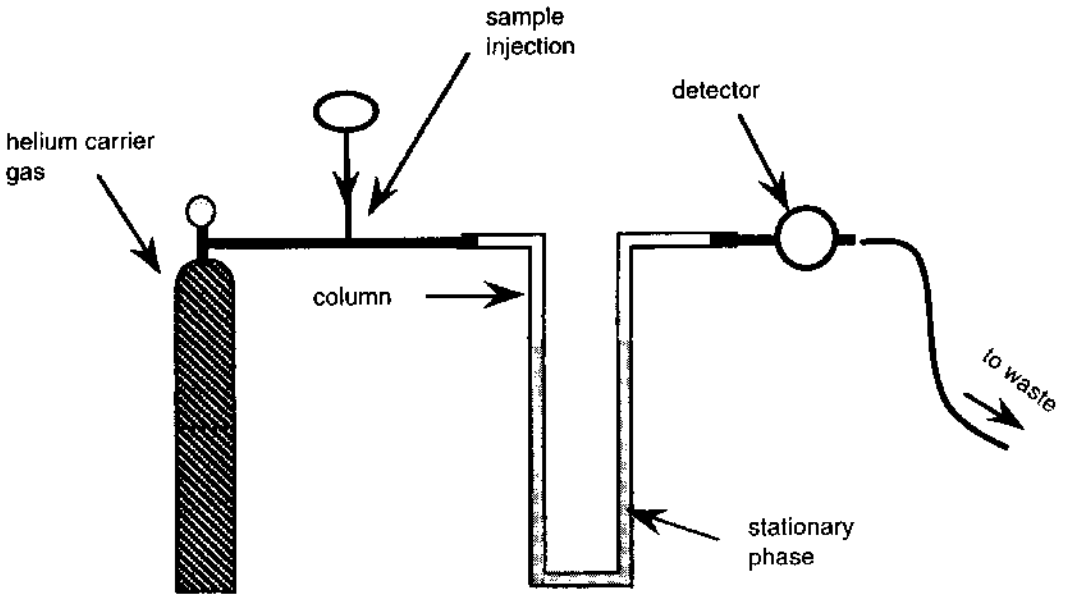
iv. There are three structural isomers as shown below:



1-butene 2-butene 2-methyl-1-propene

Section B

Question 7



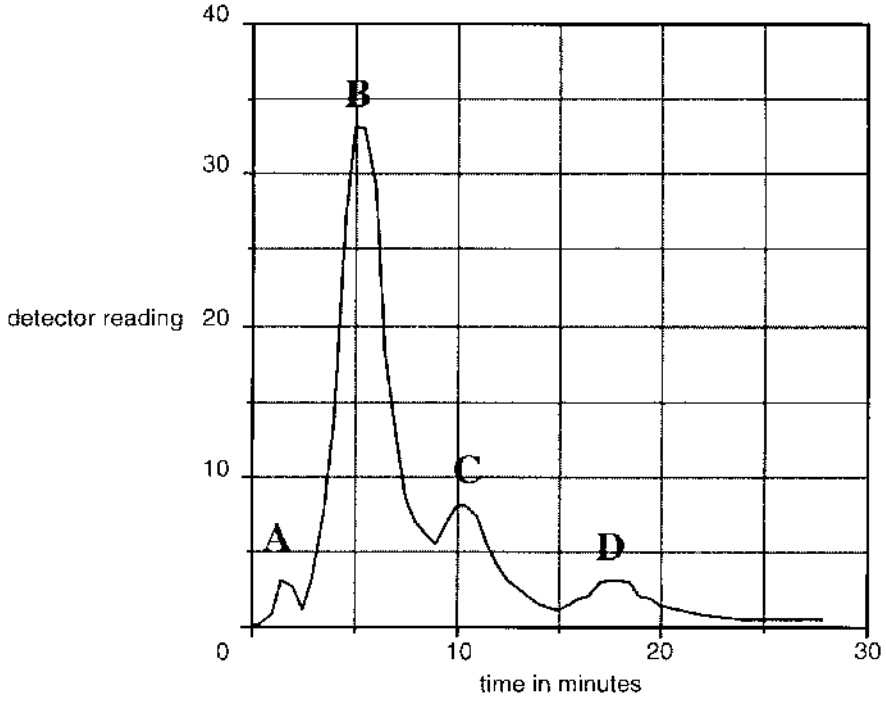
Shown above is a labelled diagram of a simple gas chromatograph designed to be used for the measurement of some of the volatile organic components of an industrial solvent.

i. What is the purpose of the helium gas?

ii. What is the purpose of the stationary phase?

Section B

Question 7 (continued)



b. Part of a gas chromatogram of a sample of the solvent is shown above. Four peaks, labelled A, B, C and D are shown. The names and formulas of the four molecules corresponding to these peaks are given below in alphabetical order. The strength of the interaction between an organic alcohol and the stationary phase used in this separation increases with increasing molar mass of the alcohol. Hence, place the letters A, B, C and D in the appropriate spaces beside these formulas so as to correctly identify the peaks.

Butanol (C_4H_9OH) _____

Ethanol (C_2H_5OH) _____

Methanol (CH_30H) _____

Propanol (C_3H_70H) _____

Briefly explain the reason for your answer.

c. Suggest a change you might make to the experimental arrangement in order to obtain a chromatogram in which the peaks were separated to a greater extent.

3+3+1 =7 marks
(suggested time: 9 minutes)

Section B

Question 7 (solution)

a. i. The purpose of the helium gas is to carry the volatile organic components through the stationary phase to the detector.

ii. The purpose of the stationary phase is to attract the components of the sample in a selective way so that the components are separated from each other and move to the detector at different rates.

b. The molar masses of these alcohols are:
Methanol (32), Ethanol (46), Propanol (60) and Butanol (74).
Hence, the strength of attraction to the stationary phase increases in this order.
Hence, the alcohols will reach the detector in this order.
A = Methanol, B = Ethanol, C = Propanol, D = Butanol

c. A chromatogram in which the peaks were separated to a greater extent could be obtained by increasing the length of the column containing the stationary phase. It would then take longer for the components most strongly attracted to the stationary phase to work through the system.

END OF SUGGESTED SOLUTIONS

1995 VCE CHEMISTRY CAT 1

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