TEMASEK JUNIOR COLLEGE

PRELIMINARY EXAMINATIONS

HIGHER 2

CANDIDATE NAME									
CIVICS GROUP			/						
CENTER NUMBER	S					INDEX NUMBER			

CHEMISTRY
9729/02

Paper 2 Structured Questions **23 August 2018**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Civics Group, centre number, index number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.
A Data Booklet is provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

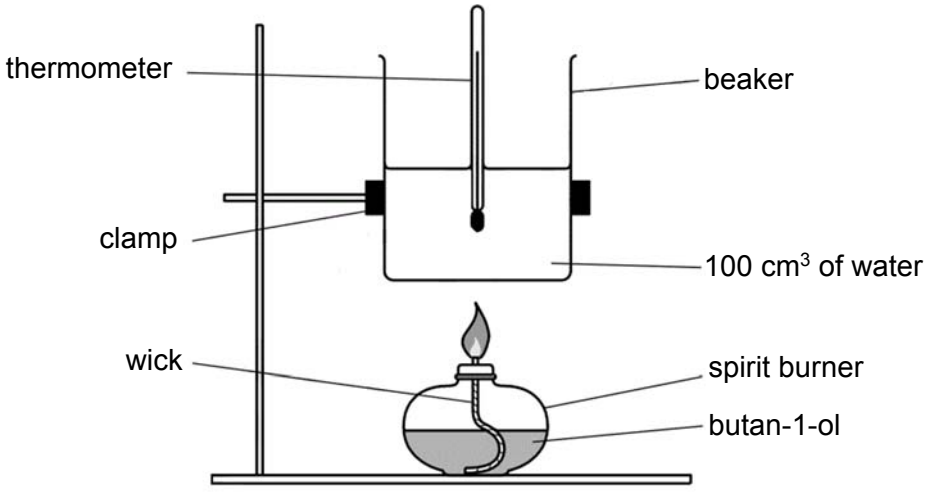
For Examiner's Use	
1	/ 21
2	/ 13
3	/ 9
4	/ 8
5	/ 14
6	/ 10
Total	/ 75

This document consists of **18** printed pages

SECTION A
Answer all questions in the spaces provided.

1 (a) For many compounds, the enthalpy change of formation cannot be calculated directly. An indirect method based on enthalpy change of combustion can be used.

The enthalpy change of combustion of butan-1-ol can be found by a calorimetry experiment in which the heat given off during combustion is used to heat a known mass of water and the temperature change recorded.



temperature of water before heating = 25.0 °C

temperature of water after heating = 66.1 °C

mass of spirit burner and butan-1-ol before heating = 80.44 g

mass of spirit burner and butan-1-ol after heating = 79.70 g

(i) Explain the meaning of the term *standard enthalpy change of combustion*.

- **The *standard enthalpy change of combustion* of a substance, $\Delta H_c°$, is the heat energy evolved when one mole of the substance is completely burnt in oxygen at 298 K and 1 bar.**

[1]

(ii) The heat transfer from the spirit burner to water is known to be only 70% efficient. From the data provided above, determine the enthalpy change of combustion of butan-1-ol.

mass of butan-1-ol reacted = 80.44 – 79.70 = 0.74 g

No. of moles of butan-1-ol reacted = 0.74 / 74 = 0.0100 mol

amount of heat taken in by water = mcΔT

= 100 x 4.18 x (66.1 – 25.0)

- **= 17.2 kJ**

Heat provided by butan-1-ol = 100 x 17.2 / 70 = 24.6 kJ

enthalpy change of combustion of butan-1-ol = - 24.6/ 0.0100

- **= - 2460 kJ mol^{-1}**

[2]

(iii) The entropy change of combustion of butan-1-ol is -252 J K^{-1} mol^{-1}. Using your answer in **(a)(ii)**, calculate the Gibb's free energy for combustion of butan-1-ol at 298 K.

$\Delta G = \Delta H - T\Delta S$

$= -2460 - (298)(-252 \times 10^{-3})$

- **= - 2380 kJ mol^{-1} (allow ecf from (a)(ii))**

[1]

(b) The table below gives some data on four fuel sources: methanol, ethanol, hydrogen and octane. Octane can serve as a rough approximation of petrol.

name	formula	molar mass/ g mol^{-1}	density/ g cm^{-3}	$\Delta H_c^{\ominus}$ (298K)/ kJ mol^{-1}	$\Delta H_f^{\ominus}$ (298K)/ kJ mol^{-1}
methanol	CH_3OH	32	0.793[a]	-726.0	-239.1
ethanol	CH_3CH_2OH	46	0.789[a]	-1367.3	
liquid hydrogen	H_2	2	0.0711[b]	-285.8[#]	
octane	$CH_3(CH_2)_6CH_3$	114	0.703[a]	-5470.2	-250.0

[a] At 298K and 1 bar pressure

[b] At 20K and 1 bar pressure

[#] standard enthalpy change of combustion of hydrogen **gas**

(i) State the value of the standard enthalpy change of formation of hydrogen **gas**, H_2.

- **0 kJ mol^{-1} (by definition, elements in standard state are reference zero)**

[1]

(ii) Calculate the density of gaseous hydrogen at 298 K and 1 bar pressure. Give your answers in g cm^{-3}.

$PV = nRT$

$PV = (m/Mr)\,RT$

$\rho = \frac{P \times Mr}{RT} = \frac{10^5 \times 2}{8.31 \times 298} = 80.8$ g m^{-3}

- **$= 8.08 \times 10^{-5}$ g cm^{-3}**

[1]

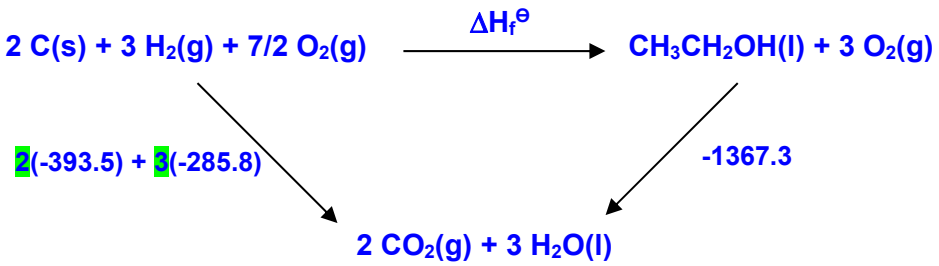
(iii) Write the chemical equation that represents the standard enthalpy change of combustion of ethanol, including the state symbols.

- **CH_3CH_2OH (l) + $3O_2$(g) → $2CO_2$(g) + $3H_2O$(l)**

[1]

(iv) The standard enthalpy change of combustion of carbon is -393.5 kJ mol^{-1}. Using this value and the standard enthalpy change of combustion data in the table, calculate the standard enthalpy change of formation of ethanol.

Show your working clearly in the form of an energy cycle diagram.



- **Energy cycle, balanced equations, state symbols**
  By Hess' law,
- **$\Delta H_f^\ominus$ -1367.3 = 2(-393.5) + 3(-285.8)**
- **$\Delta H_f^\ominus$ = -277.1 kJ mol^{-1}**

[3]

(v) An important property of a fuel, especially when the fuel has to be lifted such as in aviation, is the energy released on combustion per gram of fuel.

Calculate the enthalpy change of combustion per gram of fuel at 1 bar pressure and 298K for methanol.

Enthalpy change of combustion per gram of fuel = -726/32 = -22.7 kJ g^{-1}

[1]

(vi) Another important characteristic of a fuel, especially when there is a fuel tank of limited size, is the energy released on combustion per cm^3 of fuel.

Calculate the enthalpy change of combustion per cm^3 of fuel for octane.

Enthalpy change of combustion per cm^3 of fuel

= -5470.2/ (114/0.703) = -33.7 kJ cm^{-3} [1]

(vii) Explain why, given the data in the question, it is not strictly possible to make a fair comparison of the energy released per cm^3 of liquid hydrogen with other fuels.

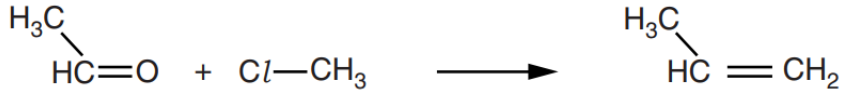
Enthalpy change of combustion value for hydrogen is for standard conditions, and so relates to gaseous hydrogen, not to liquid hydrogen.

Latent heat of vaporisation of hydrogen is not accounted for.

Allow comment about how the value of density of liquid hydrogen is unsuitable for the calculation of energy per unit volume for gaseous hydrogen. [1]

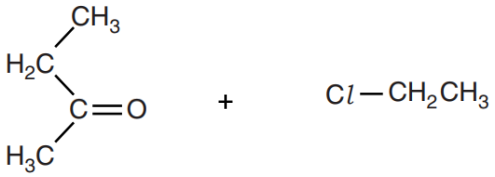
(c) Apart from alkanes and alcohols, alkenes are commonly used as fuel. Alkenes can be synthesised through the Wittig reaction, using halogenoalkane and carbonyl compound as the reactants in the presence of triphenyl phosphine.

The equation below shows the synthesis of propene using the Wittig reaction.

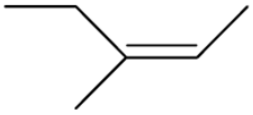
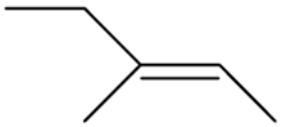


triphenyl phosphine propene

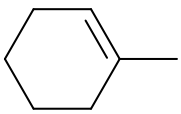
(i) Draw the structures of the two cis-trans isomers formed from the reaction of the following compounds.



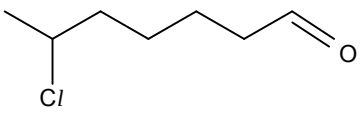
[2]

- 
- 

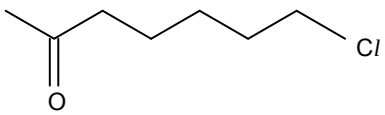
(ii) Draw the structural formula of the organic reactant used to generate 1-methylcyclohexene through the Wittig reaction.



1-methylcyclohexene

- 

OR



[1]

Alkenes react readily with interhalogen compound IC*l* to give halogenalkane. IC*l* reacts faster with alkenes than pure halogens and can be used to detemine the number of carbon-carbon double bonds present in organic compounds.

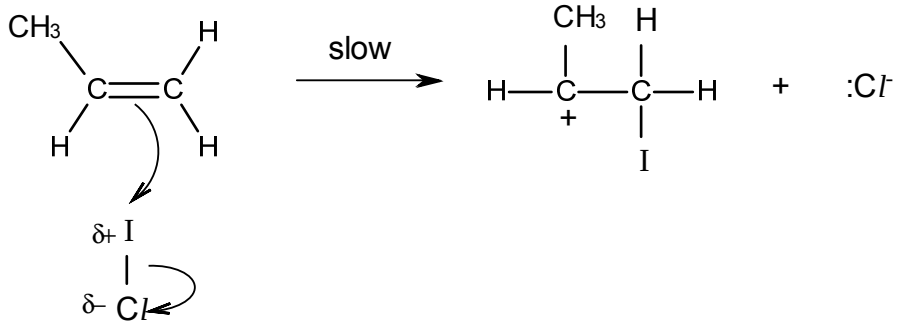
(iii) Suggest why IC*l* reacts with alkenes faster than the pure halogens, Cl_2, Br_2 and I_2.

- **The I – C*l* bond has a permanent dipole. Since the iodine side (has a delta positive charge and) is more attracted to the electron-rich carbon-carbon double bond.**
  OR
  I – C*l* is a stronger electrophile because it has a permanent dipole and is more attracted to the C=C bond

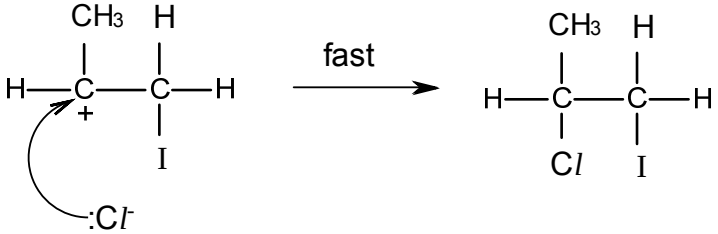
[1]

(iv) Name and describe the mechanism of reaction between propene and IC*l* to give the major product. In your answer you should show all charges and lone pairs and show the movement of electrons by curly arrows.

- **Electrophilic addition**
- **Step 1:**



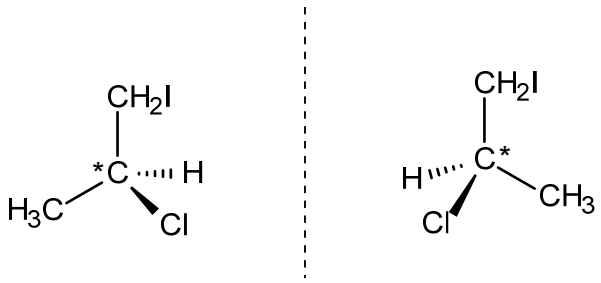
- **Step 2:**



deduct one mark if the minor product is formed through the reaction

[3]

(v) Draw the pair of enantiomers of the major product from the reaction between propene and IC*l*.



(award full credit if enantiomers of minor product shown)

[1]

[Total: 21]

2 **(a)** What do you understand by the *Brønsted–Lowry* theory of acids and bases?

Bronsted-Lowry acids are proton donors and bases are proton acceptors. [1]

(b) **I** $C_2H_5N + H_2O \rightleftharpoons C_2H_5NH^+ + OH^-$ $K_c = 1.7 \times 10^{-9}$ mol dm^{-3}

II $C_6H_5O^- + CH_3CO_2H \rightleftharpoons C_6H_5OH + CH_3CO_2^-$ $K_c = 1.3 \times 10^{6}$ mol dm^{-3}

For each of the above equilibrium **I** and **II**,

(i) identify the two acids and the two bases present;

Equilibrium **I**. Two acids are **H_2O and $C_2H_5NH^+$**

Two bases are **C_2H_5N and OH^-**

Equilibrium **II.** Two acids are **CH_3CO_2H and C_6H_5OH**

Two bases are **$C_6H_5O^-$ and $CH_3CO_2^-$** [2]

(ii) using the given information, suggest, with reasons, which ion or molecule is the stronger acid, and which is the stronger base.

Equilibrium **I**: stronger acid: **$C_2H_5NH^+$** stronger base : **OH^-**

Explanation for Equilibrium **I**: **Since $K_c < 1$, reaction proceeds to the greater extent in a direction in which a stronger acid ($C_2H_5NH^+$) and stronger base (OH^-) form a weaker acid and weaker base.**

Equilibrium II: stronger acid: **CH_3CO_2H** stronger base: **$C_6H_5O^-$**

Explanation for Equilibrium **II**: **Since $K_c > 1$, reaction proceeds to the greater extent in a direction in which a stronger acid (CH_3CO_2H) and stronger base ($C_6H_5O^-$) form a weaker acid and weaker base.**

Note: A stronger acid has a weaker conjugate base (the acid gives up its proton more readily because its conjugate base holds it less strongly) [3]

(c) A student adds an excess of aqueous ethanoic acid to solid calcium carbonate.

(i) Write a full equation for the reaction between ethanoic acid and solid calcium carbonate.

$2CH_3CO_2H + CaCO_3 \rightarrow (CH_3CO_2)_2Ca + CO_2 + H_2O$ [1]

(ii) Explain why a buffer solution has been formed.

Solution contains CH_3COOH and CH_3COO^- or solution contains a weak acid and its conjugate base. [1]

(iii) With the aid of an equation, explain how this buffer solution controls pH when an alkali is added.

On addition of an alkali, CH_3COOH will react with the added alkali resulting in no significant change in pH.

$CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$ [1]

(d) A biochemist plans to make up a buffer solution that has a pH of 5.00.

The biochemist adds solid calcium ethanoate to 400 cm^3 of 0.200 mol dm^{-3} ethanoic acid. He assumes that the volume of the solution remains constant at 400 cm^3 on dissolving the calcium ethanoate.

K_a for ethanoic acid = 1.75×10^{-5} mol dm^{-3}
M_r of calcium ethanoate = 158.1

(i) Calculate the mass of calcium ethanoate that the biochemist needs to dissolve in the ethanoic acid to prepare this buffer solution.

$pK_a = -\log(1.75 \times 10^{-5}) = 4.57$

$pH = pKa + \log [CH_3COO^-]/[CH_3COOH]$

$\log [CH_3COO^-]/[CH_3COOH] = pH - pK_a = 5 - 4.57 = 0.243$

$[CH_3COO^-]/[CH_3COOH] = 10^{0.243} = 1.75$

- **$[CH_3COO^-] = 1.75 \times 0.200 = 0.350$**

Or from $K_a = [CH_3COO^-][H^+]/[CH_3COOH]$

- **no of moles of CH_3COO^- in 400 cm^3 = $0.350 \times (400/1000) = 0.140$ mol**

- **mass of $(CH_3COO)_2Ca = (0.140 \div 2) \times 158.1 = 11.07$ or 11.1 g** [3]

(ii) When the biochemist prepares the buffer solution, the volume of solution increases slightly. Suggest whether the pH of the buffer solution would be the same, greater than, or less than your calculated value in **(d)(i)**. Explain your reasoning.

pH is the same / constant because the ratio / proportion of $[CH_3COO^-]/[CH_3COOH]$ is the same. [1]

[Total: 13]

3 (a) **J**, **K**, **L** and **M** are consecutive elements in the same period of the Periodic Table. The oxide of **J** is basic, oxide of **K** is amphoteric, and the oxides of **L** and **M** are acidic. The halides of **M** can be used to convert alcohols to halogenoalkanes in the absence of water.

(i) Identify the elements **J**, **K**, **L** and **M**.

J: **Mg** **K**: **Al** **L**: **Si** **M**: **P**

[1]

(ii) State and explain the variation of atomic radius from **J** to **M**.

- **Atomic radius decreases from L to M.**
  Nuclear charge increases as number of protons increases. Screening effect remains approximately constant as electrons are added to the same electronic shell. Hence the electrons are attracted more strongly by the nucleus.

[1]

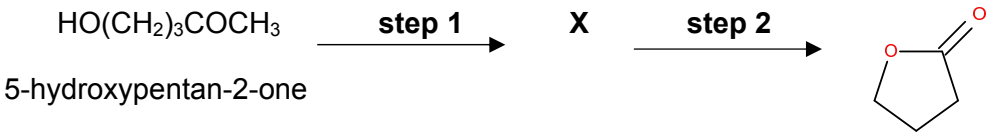
(iii) Compare the melting points of **L** and **M** and explain your answer.

- **L (Si) has a higher melting point than M (P) as Si as a giant molecular structure while P has a simple molecular structure.**
  - **Melting L requires a lot of energy to break numerous strong covalent bonds compared to the weaker intermolecular instantaneous dipole - induced dipole forces of attraction between phosphorous molecules.**

[2]

(b) Lactones are cyclic esters and are constituents in many natural products used in the flavours and fragrances industry. They also exhibit antioxidant, antimicrobial and anticancer activity.

Butano-4-lactone can be synthesised from 5-hydroxypentan-2-one via a 2-step route as shown.



5-hydroxypentan-2-one

butano-4-lactone

(i) State the reagents and conditions for **steps 1** and **2** and identify the intermediate **X** involved.

- **step 1: alkaline aqueous iodine, heat, followed by acidification with dilute sulfuric acid**
- **step 2: concentrated sulfuric acid, heat**
- **X: $HO(CH_2)_3CO_2H$**

(Accept if student gives X: $HO(CH_2)_3CO_2^-$, then step 2 will be PCl_5, followed by heating)

[3]

(ii) Compound **Y** is a non-cyclic constitutional isomer of butano-4-lactone which exhibits enantiomerism. **Y** gives a reddish brown ppt in an alkaline solution of complexed $Cu^{2+}(aq)$ and can also liberate carbon dioxide gas upon reaction with acidified $KMnO_4$.

Based on the above reactions, identify the functional groups in **Y** and suggest the structural formula of **Y**.

- **Aldehyde and terminal alkene**
- **CH_2=CHCH(OH)CHO**

[2]

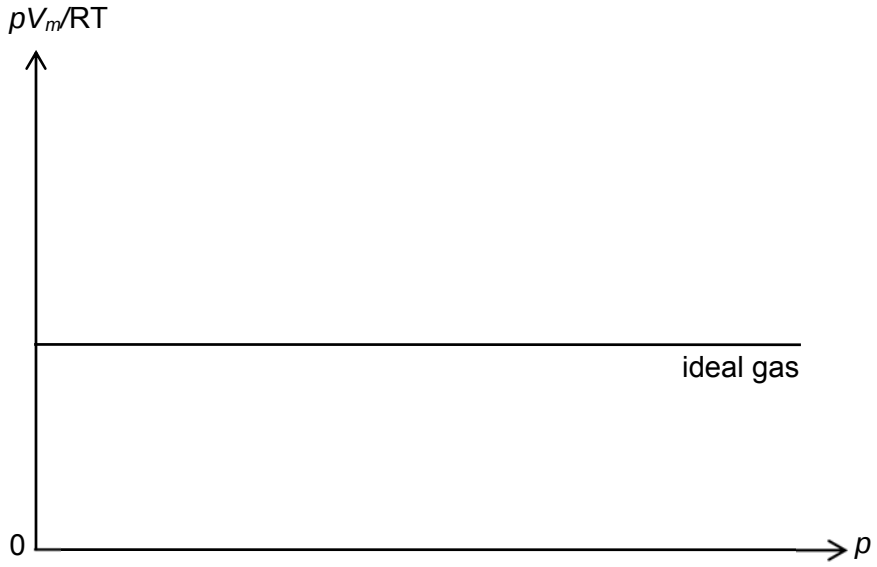
[Total: 9]

4 **(a)** Air comprises mainly nitrogen and oxygen, with trace quantities of other gases such as argon, carbon dioxide, and even ammonia.

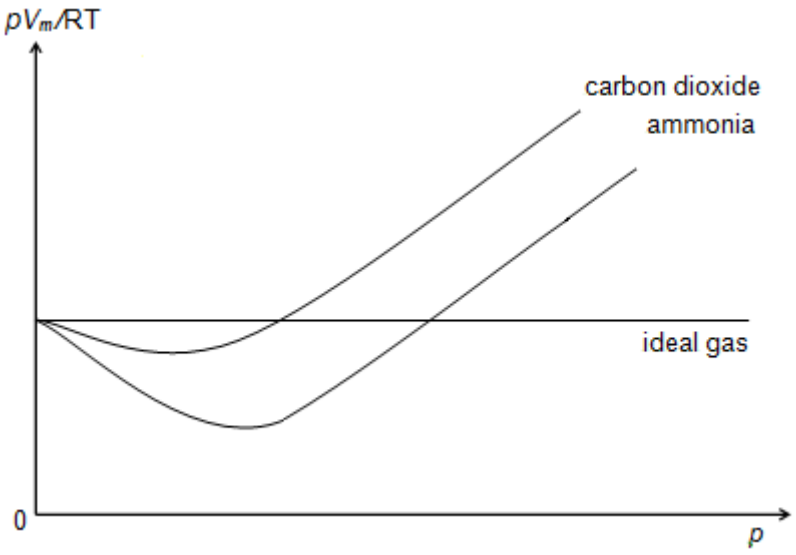
(i) State two assumptions of the kinetic theory of gases.

- **The gas consists of particles of negligible volume compared to the volume of the container it occupies.**
- **The gas particles exert no attractive forces on each other.** [2]

(ii) A sketch of $\boldsymbol{pV_m/RT}$ against $\boldsymbol{p}$ for 1 mole of an ideal gas at 293 K is given below.



On the same axes, show how 1 mole each of carbon dioxide and ammonia will behave at 293 K. Label your graphs clearly.



[Note: graphs don't cut/intercept each other]

[1]

(iii) Briefly explain your answer to **(a)(ii)**.

• $NH_3(g)$ experiences stronger hydrogen bonding between molecules compared to the weaker instantaneous dipole–induced dipole interactions between CO_2 molecules, hence it shows a greater negative deviation than CO_2 at low pressure.

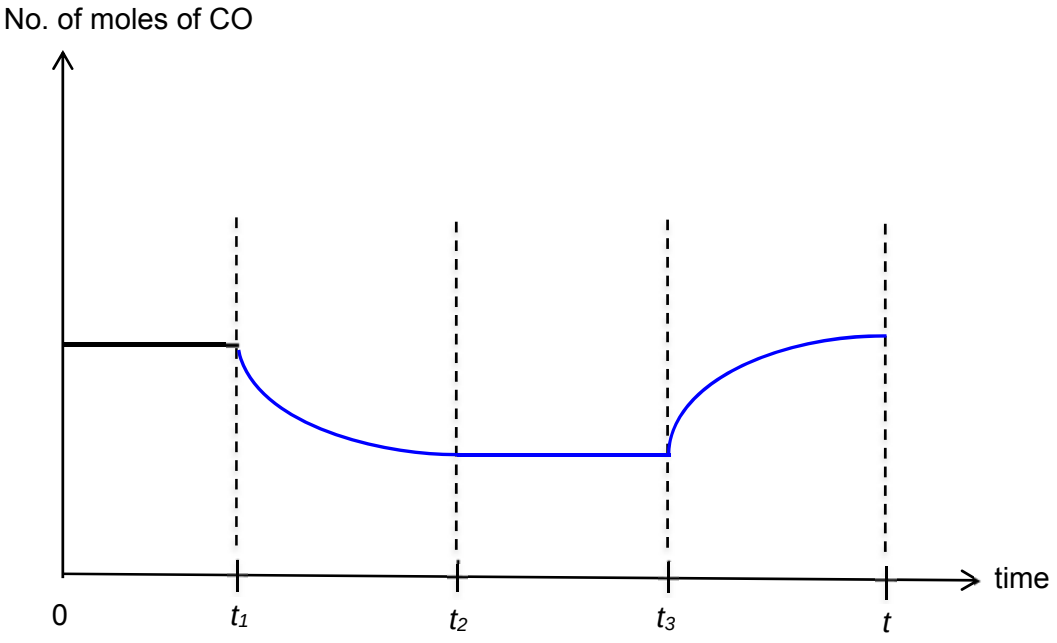
• As CO_2 has a larger molecular size than NH_3, the volume taken up by CO_2 gas molecules is greater. Hence it shows a greater positive deviation than NH_3. [2]

(b) Water gas is a synthesis gas that comprises carbon monoxide and hydrogen. The gas is made by passing steam over coke:

$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g) \qquad \Delta H > 0$$

The system was initially at equilibrium. At time t_1, the volume of the reaction vessel was suddenly reduced and the system allowed to reach equilibrium. Pressure was then increased by adding argon at constant volume at t_2, followed by an increase in temperature at t_3.

Sketch on the axes the graph that should be observed from time = t_1 to time = t when equilibrium is re-established once again.



[3]

[Total:8]

5 Chromium is a steely-grey lustrous metal. The name of this element is derived from the Greek word "chrōma" meaning colour, because many of its compounds are intensely coloured.

(a) State and explain **one** difference in physical property between chromium and calcium. [1]

Cr has a higher melting/boiling point than Ca.

Cr has stronger metallic bonds as both the 3d and 4s electrons can be used in metallic bonding, hence more energy is required to overcome the stronger metallic bonds. Ca uses only 4s electron for metallic bonding.

Cr has a greater density than Ca.

Cr has a greater atomic mass but its atomic radius is smaller. Hence atomic volume is smaller. Since density = mass/volume, density of Cr is greater than Ca.

(b) Chromium reacts with oxygen to form a series of oxides.

One of these oxides, chromium (IV) oxide, CrO_2, is often used to coat data tapes, due to its high conductivity and ferromagnetic properties, which provide a good high audio-frequency response.

When the oxide from a length of tape was dissolved in dilute sulfuric acid, it disproportionates to give $Cr^{3+}(aq)$ and $Cr_2O_7^{2-}(aq)$. The resulting solution needed 20.0 cm^3 of 0.015 mol dm^{-3} Fe^{2+} solution to reduce the $Cr_2O_7^{2-}$ completely to Cr^{3+}.

$$6Fe^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2O$$

(i) Write an equation for the disproportionation of CrO_2 in acid solution showing how you arrived at the overall equation.

$$\mathbf{CrO_2 + 4H^+ + e^- \rightarrow Cr^{3+} + 2H_2O} \quad \mathbf{x4}$$

$$\mathbf{2CrO_2 + 3H_2O \rightarrow Cr_2O_7^{2-} + 6H^+ + 4e^-} \quad \mathbf{x1}$$

$$\mathbf{6CrO_2 + 10H^+ \rightarrow 4Cr^{3+} + Cr_2O_7^{2-} + 5H_2O}$$

[2]

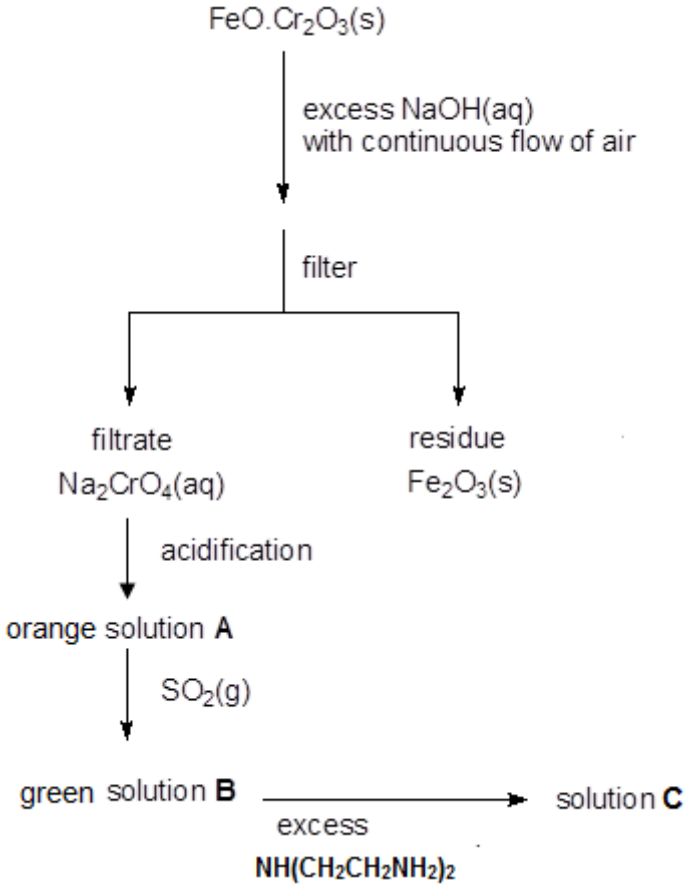
(ii) Use the data to calculate the mass of CrO_2 in the length of data tape.

$6CrO_2 \equiv Cr_2O_7^{2-} \equiv 6Fe^{2+}$

Amount of Fe^{2+} used = $0.015 \times 0.0200 = 3.00 \times 10^{-4}$ mol

- **Hence amount of CrO_2 = 3.00×10^{-4} mol**
- **Mass of CrO_2 = $3.00 \times 10^{-4} \times 84.0 = 0.0252$ g** [2]

(c) Chromite, $FeO.Cr_2O_3$, is the chief source of chromium. The reaction scheme below shows the conversion of chromite.

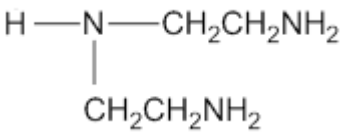


(i) Identify the chromium containing species present in solution **A** and in solution **B**.

Solution **A**: **$Cr_2O_7^{2-}$**

Solution **B**: **$[Cr(H_2O)_6]^{3+}$** [2]

B reacts with excess tri-dentate ligand,diethylenetriamine, $NH(CH_2CH_2NH_2)_2$, to form **C**.



diethylenetriamine

(ii) What type of reaction occurs when **B** is converted to **C**?

- **Ligand substitution** [1]

(iii) Letting the tri-dentate ligand be **L**, deduce the formula of the complex ion in **C**.

- **$[CrL_2]^{3+}$** [1]

(iv) Explain why **B** is coloured.

- **The Cr^{3+} ion has partially filled d orbitals.**
- **The water ligands cause a splitting of the energy of d orbitals into 2 groups with an energy gap, ΔE, between them. The energy gap, ΔE, between the non-degenerate orbitals corresponds to the wavelength of light in the visible region of the electromagnetic spectrum.**
- **When a d-electron from lower energy group is promoted to the higher energy group, radiation in the visible region of the electromagnetic spectrum corresponding to ΔE is absorbed. Light energy (green) that is not absorbed will be seen as the colour of the complex.** [3]

(d) Ag_2CrO_4 is a brown-red crystalline solid and is a chemical precursor to modern photography.

The solubility product of Ag_2CrO_4 is 1.1×10^{-12}.

(i) Write an expression for the solubility product, K_{sp} of Ag_2CrO_4.

- **$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$** [1]

(ii) Calculate the solubility of Ag_2CrO_4, in mol dm^{-3}.

Let the solubility of Ag_2CrO_4 be x mol dm^{-3}

$Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq)$

$2x \qquad x$

$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$

$1.1 \times 10^{-12} = 4x^3$

$x = (1.1 \times 10^{-12}/4)^{1/3}$

$= 6.50 \times 10^{-5}$

- **The solubility of Ag_2CrO_4 is 6.50×10^{-5} mol dm^{-3}.** [1]

[Total: 14]

6 This question is about the chemistry of Group 17 elements and their compounds.

(a) Although halogens and their compounds can be toxic, some are essential for the human body's functioning and are used in everyday products such as disinfectants and bleaching agents.

(i) State and explain how the oxidising power of the halogens vary down the group.

- **oxidising power of the halogens decreases.**
- **Down the group, $E^{\ominus}_{X_2/X^-}$ becomes less positive, there is lower tendency for X_2 to be reduced to X^- (Or electron affinity of the halogen decreases), thus oxidising power of halogens decreases from Cl_2 to I_2.**

[2]

(ii) The halogens can react with each other to form interhalogen compounds such as IBr.

IBr eacts with water in which water is acting as the nucleophile. The equation for the reaction is as follows.

$$IBr + H_2O \rightarrow H\mathbf{X} + HO\mathbf{Y}$$

State the type of reaction taking place and identify **X** and **Y**.

- **hydrolysis**
- **X is bromine while Y is iodine.**

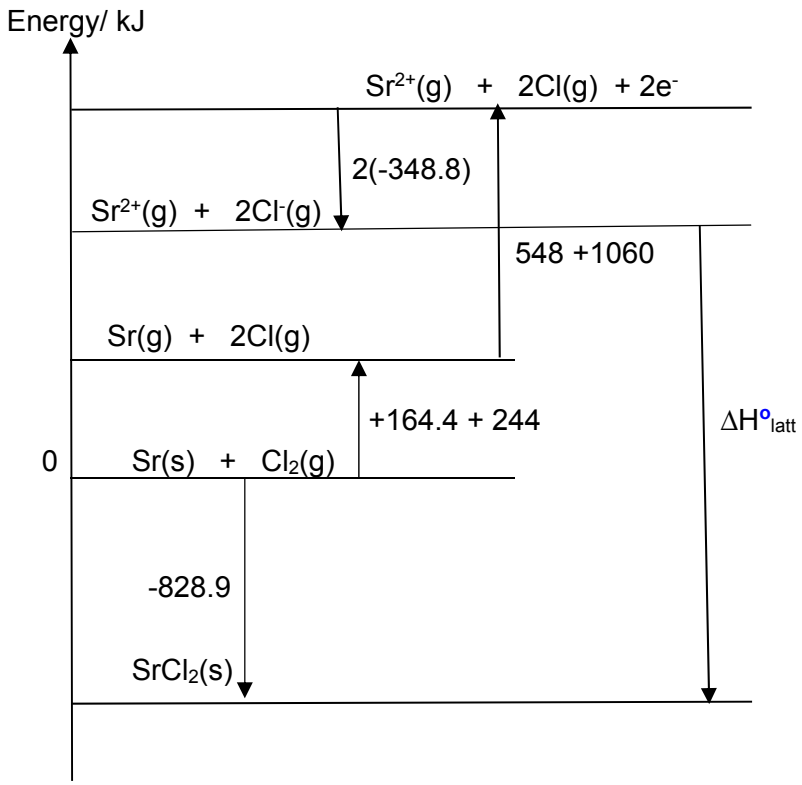
[2]

(b) **(i)** Strontium chloride, $SrCl_2$ is a typical salt which forms neutral aqueous solutions. It emits a bright red colour in a flame which allows it to be used as a source of redness in fireworks.

On the incomplete outline below, construct the energy level diagram to calculate the lattice energy of $SrCl_2(s)$. Label all enthalpy changes involved and the chemical species at each stage.

Your diagram should include relevant data from the *Data Booklet* together with the following data.

Standard enthalpy change of formation of $SrCl_2(s)$	–828.9 kJ mol^{-1}
Standard enthalpy change of atomisation of Sr(s)	+164.4 kJ mol^{-1}
1st electron affinity of Cl(g)	–348.8 kJ mol^{-1}



Using Hess' Law,

$-828.9 = 164.4 + 244 + 548 + 1060 + 2(-348.8) + \Delta H^o_{latt}$

- **ΔH^o_{latt} = -2148 kJ mol^{-1}**

[Energy level diagram:
1m for enthalpy change values and zero for elements
1m for correct relative energy levels and state symbols (not >2 missing]

[3]

(ii) Using your answer in **(b)(i)**, calculate the ΔH^o_{soln} of $SrCl_2(s)$, given the following data:

Standard enthalpy change of hydration of $Sr^{2+}(g)$	–1446 kJ mol^{-1}
Standard enthalpy change of hydration of $Cl^-(g)$	–378 kJ mol^{-1}

- **$\Delta H^o_{soln} = 2148 + (-1446) + 2(-378) = -54$ kJ mol^{-1}**

[1]

(iii) The standard enthalpy change of solution of $CaCl_2(s)$ is -87.7 kJmol^{-1}.

Explain the difference in the standard enthalpy change of solution of $SrCl_2(s)$ which you calculated in **(b)(ii)** and that of $CaCl_2(s)$.

ΔH_{sol} = -(-Lattice Energies) + (-ΔH_{hyd}) = |L.E.| - | ΔH_{hyd} |

|L.E.| $\propto \frac{|q^+q^-|}{r^+ + r^-}$

| ΔH_{hyd} | $\propto \frac{|q|}{r}$

- **Cationic radius of Sr^{2+} ion is larger than Ca^{2+}, therefore the decrease in | ΔH_{hyd} | of Sr^{2+} is larger than the decrease in |L.E.|.**
- **ΔH_{sol} is expected to be more endothermic for $SrCl_2(s)$.**

[2]

[Total: 10]