H

PIONEER JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
HIGHER 1

CANDIDATE NAME									
CT GROUP	**1**	**6**				INDEX NUMBER			

CHEMISTRY **8872/01**

Paper 1 Multiple Choice **22 September 2017**
50 minutes

Additional Materials: Multiple Choice Answer Sheet
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, CT group and index number in the spaces provided.

Do not use staples, paper clips, highlighters, glue or correction fluid.

There are **thirty** questions in this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

This document consists of **13** printed pages.

Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

1 20 cm^3 of a gaseous hydrocarbon was mixed with 100 cm^3 of oxygen and the mixture sparked so that the hydrocarbon was completely burnt. The volume of gas remaining at the end of the combustion was 70 cm^3. After passing over soda lime, this volume was reduced by 60 cm^3. All gases were measured at 25°C and at the same pressure.

Determine the molecular formula of the hydrocarbon.

A C_2H_4

B C_2H_6

C C_3H_6

D C_3H_8

2 Carbon monoxide, CO, is a colourless, odourless and toxic gas. It is formed as a result of partial oxidation of carbon-containing compounds. The maximum safe toleration level of CO in air is 50 ppm. (1 ppm = 1 mg kg^{-1})

How many molecules of CO gas are present in 1 kg of air at this toleration level?

A $\dfrac{50 \times 10^{-3} \times 6.02 \times 10^{23}}{28}$

B $50 \times 10^{-3} \times 28 \times 6.02 \times 10^{23}$

C $\dfrac{50 \times 6.02 \times 10^{-3}}{28}$

D $50 \times 28 \times 6.02 \times 10^{23}$

3 Equimolar amounts of ClO_2 and OH^- ions react to produce three products: water, chlorate(III) ions ClO_2^- and another chloro-oxy anion, ClO_x^-

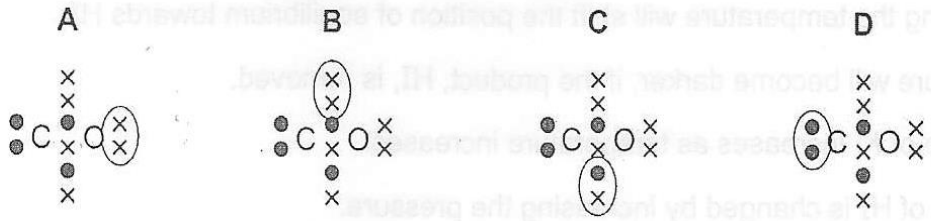
What is the oxidation state of chlorine in the chloro-oxy anion, ClO_x^- ?

A +1 **B** +2 **C** +5 **D** +7

4 Which of the following particles would, on losing an electron, have a half-filled set of p orbitals?

A O^+ **B** O^- **C** N **D** N^-

5 Which circled pair of electrons represents a co-ordinate bond?



6 Which molecules contain within their structure three atoms arranged in a straight line?

A ICl_3

B SO_4^{2-}

C CCl_4

D H_2S

7 Consider the following four isoelectronic compounds.

1 **$(CH_3)_3CH$**
2 **$CH_3CH_2CH_2CH_3$**
3 **$CH_3CH_2CH_2OH$**
4 **CH_3CH_2Cl**

What is the order of decreasing boiling point of these compounds?

A 1 → 2 → 4 → 3

B 3 → 4 → 1 → 2

C 3 → 4 → 2 → 1

D 4 → 3 → 2 → 1

8 Given the following thermochemical data, what is the standard enthalpy change of the reaction, $\Delta H_r^{\ominus}$.

$$CH_2{=}CHCH{=}CH_2\ (g) \xrightarrow{\Delta H_r^{\ominus}} CH_3C{\equiv}CCH_3\ (g)$$

Standard enthalpy change of combustion of $CH_3C{\equiv}CCH_3$ (g)	= –2577 kJ mol^{-1}
Standard enthalpy change of formation of carbon dioxide	= –394 kJ mol^{-1}
Standard enthalpy change of formation of water	= –286 kJ mol^{-1}
Standard enthalpy change of formation of $CH_2{=}CHCH{=}CH_2$(g)	= +110 kJ mol^{-1}

A – 253 kJ mol^{-1} **B** – 33 kJ mol^{-1}
C + 33 kJ mol^{-1} **D** + 253 kJ mol^{-1}

9 Which one of the following equations correctly represents the standard enthalpy change of formation of water?

A $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

B $H_2(g) + ½\ O_2(g) \rightarrow H_2O(l)$

C $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

D $2H(g) + O(g) \rightarrow H_2O(l)$

10 Chlorine dioxide, ClO_2, is a yellow gas which can be synthesised in the laboratory by the following reaction:

$$2AgClO_3(s) + Cl_2(g) \rightleftharpoons 2AgCl\ (s) + 2ClO_2(g) + O_2(g) \qquad \Delta H = 0$$

Which of the following statements about the above reaction is correct?

A Adding more $AgClO_3$ (s) increases the equilibrium yield of ClO_2.

B The equilibrium constant changes when temperature changes.

C Decreasing the pressure decreases the equilibrium yield of ClO_2.

D The addition of a catalyst increases the rates of both the forward and the reverse reactions.

11 The values for the ionic product of water, K_w, at two different temperatures are given below.

Temperature / ^oC	K_w / mol^2dm^{-6}
25	1.00×10^{-14}
30	$1 .44 \times 10^{-14}$

Which of the following is correct for pure water at 30^oC?

A $[H^+] = 1.44 \times 10^{-7}$ $moldm^{-3}$

B $[H^+] > [OH^-]$

C pH = 7

D pH < 7

12 A solution was made by mixing 0.002 mol of $H_2SO_4(aq)$ and 0.005 mol of KOH(aq). Water was added until the volume of the solution was 1 dm^3.

What is the pH of the solution at 25^oC?

A 12.0

B 11.7

C 11.5

D 11.0

13 The decomposition $2N_2O_5 \rightarrow 4NO_2 + O_2$ is first order with respect to N_2O_5.

In an experiment, 0.10 mol of pure N_2O_5 was put into an evacuated flask. It was found that there was 0.025 mol of N_2O_5 left 34 minutes later.

Which statement is true?

A It took 17 minutes for the amount of NO_2 to rise from 0 mol to 0.10 mol.

B There was 0.0625 mol of N_2O_5 left after 17 minutes.

C There was 0.0125 mol of N_2O_5 left after 68 minutes.

D The amount of NO_2 in the flask went up by four times in the first 34 minutes.

14 A piece of magnesium ribbon was added to $25cm^3$ of 0.100 $moldm^{-3}$ of dilute hydrochloric acid. The magnesium was completely dissolved and the total volume of hydrogen gas evolved was measured.

In a second experiment, an identical piece of magnesium ribbon was added to solution **X**. Solution **X** is prepared by adding $25cm^3$ of 0.100 $moldm^{-3}$ of dilute hydrochloric acid to $25cm^3$ of 0.0200 $moldm^{-3}$ of hydrochloric acid. The total volume of hydrogen evolved was measured.

How will the initial rate of reaction and total volume of hydrogen evolved in the second experiment compare to the first experiment?

	Initial rate of reaction	Total volume of hydrogen evolved
A	Decrease	Increase
B	Decrease	no change
C	Increase	Increase
D	Increase	no change

15 Water was poured into a mixture containing solid oxides of elements **A**, **B** and **C**. The mixture was filtered to obtain a colourless solution with a pH of 2 and a residue.

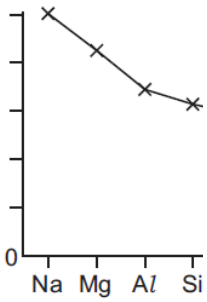
The residue was then treated with excess hot concentrated sodium hydroxide and all the residue dissolved.

What are the identities of elements **A**, **B** and **C**?

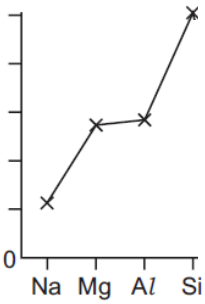
	Element **A**	Element **B**	Element **C**
A	aluminium	silicon	phosphorus
B	aluminium	silicon	sodium
C	magnesium	aluminium	sulfur
D	magnesium	silicon	phosphorus

16 The graphs below show the variation in two properties of the elements Na to Si.

Graph 1



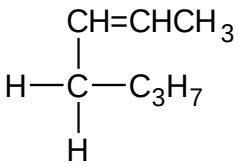
Graph 2



Which properties are illustrated in Graphs 1 and 2?

	Graph 1	**Graph 2**
A	electronegativity	melting point
B	electronegativity	electrical conductivity
C	atomic radius	melting point
D	atomic radius	electrical conductivity

17 The compound shown below has the following structure:



How many isomers does this compound have?

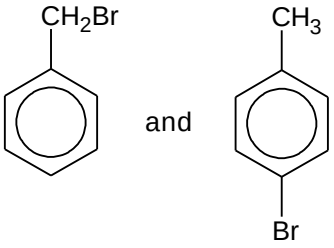
A 2 **B** 4 **C** 8 **D** 16

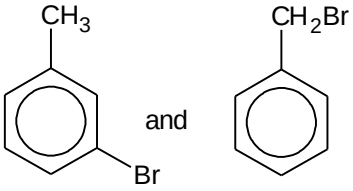
18 How many different alkenes, including geometric isomers, could be produced by the removal of HBr from $(CH_3)_2CBrCH_2CH_3$?

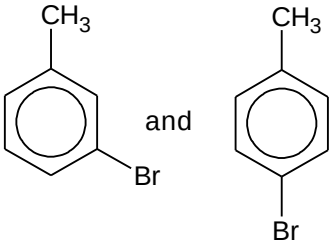
A 2 **B** 3 **C** 4 **D** 5

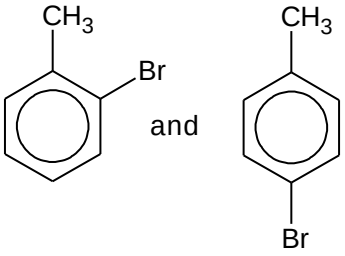
19 A student placed a stoppered conical flask containing iron powder, bromine and methylbenzene in cupboard. The flask was removed when no further change was observed.

Which of the following are likely to be the main products formed?

A 

B 

C 

D 

20 Chlorodifluoromethane, R-22, is a type of hydrochlorofluorocarbon. It is commonly used as a refrigerant and propellant. Its use is being phased out as it contributes to ozone depletion.

Which of the following statements about R-22 is **incorrect**?

A Ultraviolet rays can break down R-22 into chlorine radicals which will react with ozone

B R-22 is a gas at room temperature because of weak intermolecular forces

C Fluorine radicals are not formed because the C-F bond is very strong

D R-22 is very reactive and flammable

21 Which of the following reagents and conditions will **not** give a positive observation for ethanal?

A $LiAlH_4$ in dry ether

B $K_2Cr_2O_7(aq)$, $H_2SO_4(aq)$, heat

C $KMnO_4(aq)$, $H_2SO_4(aq)$, heat

D $I_2(aq)$, NaOH(aq), warm

22 In an attempt to make propanoic acid, propan-2-ol was added to a solution of potassium dichromate(VI) dissolved in dilute sulfuric acid and the mixture was heated.

No propanoic acid was produced.

Which of the following statements explain this?

A The sulfuric acid dehydrates the propan-2-ol to form propene.

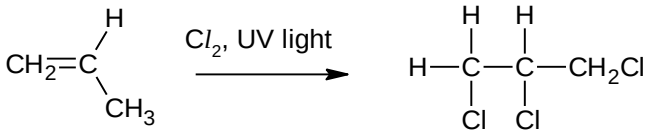
B The propan-2-ol forms propanal when oxidised.

C The propan-2-ol forms propanone when oxidised

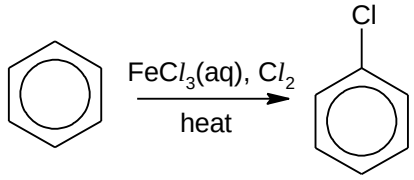
D Potassium dichromate(VI) will not oxidise propan-2-ol.

23 What of the following reactions will **not** result in the formation of the product?

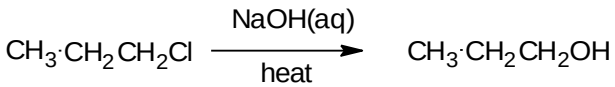
A



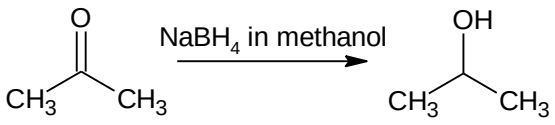
B



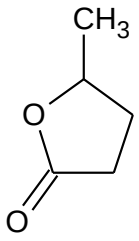
C



D



24 The molecule shown below is a naturally occurring organic compound found in fruits and could be a possible bio-fuel alternative to ethanol.



Which statement about this compound is **not** correct?

A It can be prepared by warming 4-hydroxypentanoic acid, $CH_3CH(OH)CH_2CH_2CO_2H$, in the presence of an acid catalyst

B It can decolourise hot acidified potassium manganate(VII)

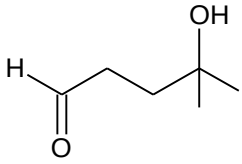
C It reacts readily with warm, aqueous alkali.

D It reacts with 2,4-dinitrophenylhydrazine solution to give an orange solution

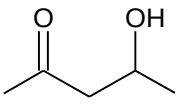
25 When treated with alkaline I_2(aq), 1 mol of compound **Y** forms 1 mol of CHI_3. Compound **Y** is formed when compound **X** is reacted with HCN(aq) with a trace amount of NaOH. 1 mol of compound **X** forms 12 dm^3 of gas when reacted with sodium metal but 1 mol of compound **Y** forms 24 dm^3 of gas.

Which of the following could be compound **X**?

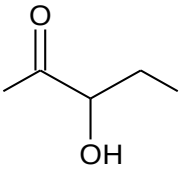
A



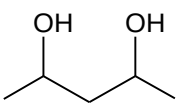
B



C



D



Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

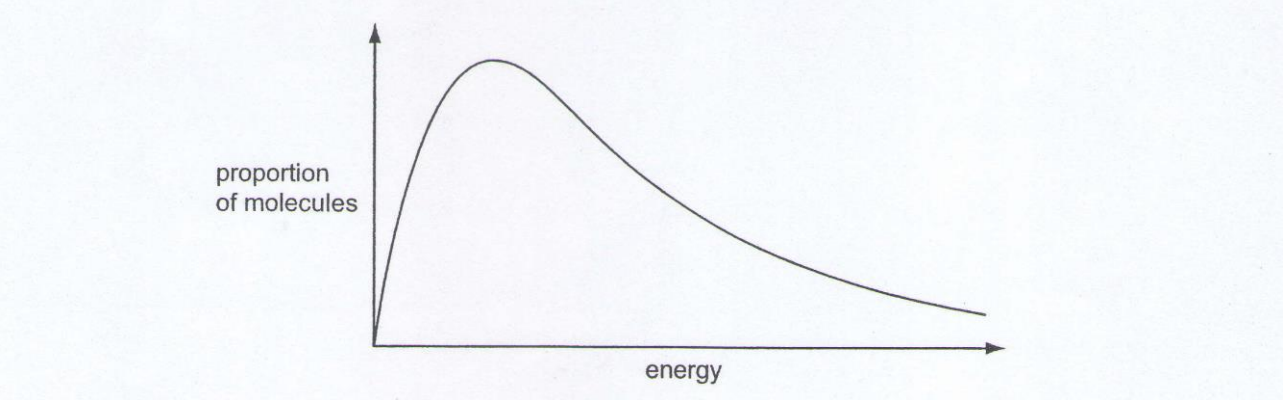
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and **3** are correct	**1** and **2** only are correct	**2** and **3** only are correct	**1** only is correct

No other combination of statements is used as a correct response.

26 The diagram represents the Boltzmann Distribution of molecular energies at a given temperature.



Which of the following statements are correct at a higher temperature?

1 The maximum of the curve is displaced to the right

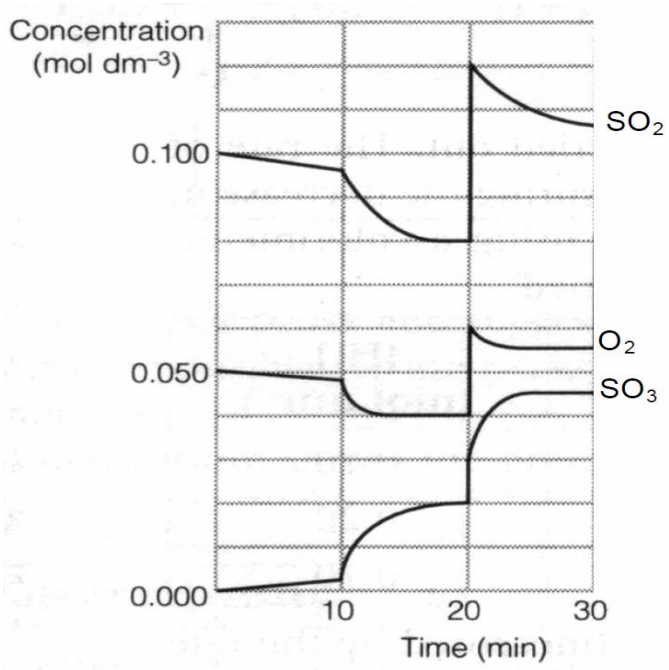
2 The proportion of molecules with energies **above** any given value increases.

3 The proportion of molecules **with** any given value increases

27 During the Contact process, sulfur dioxide is converted to sulfur trioxide as shown by the equation below.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

The following graph shows how the concentration of the three gases changed when a series of changes was made.



Which of the statements are correct?

1 At 20 minute, the numerical value of the equilibrium constant, K_c, is 1.56.

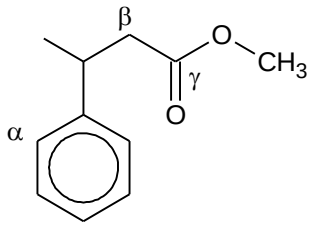
2 At 20 minute, the pressure of the system was increased by reducing the volume.

3 At 10 minute, heat was removed from the system.

28 Which of the reagents can be used to differentiate the pair of compounds given?

	Compound 1	Compound 2	Reagents
1	$AlCl_3$	$SiCl_4$	H_2O
2	$SiCl_4$	PCl_5	damp blue litmus paper
3	$NaCl$	MgO	dilute H_2SO_4

29 Which of the following statements on the given compound are true?



1 There are 14 hydrogen atoms

2 There are 7 sp^2 and 4 sp^3 hybridised carbons

3 The bond angles around carbons α, β, and γ are all 120°

30 Which of the following pairs of reactions require the same reagents and conditions?

1

2

3

End of paper

2017 PJC H1 Chemistry Preliminary Exam Answer

1 C	6 A	11 D	16 C	21 A	26 B
2 A	7 C	12 D	17 B	22 C	27 A
3 C	8 C	13 A	18 A	23 B	28 D
4 D	9 B	14 B	19 D	24 D	29 B
5 B	10 D	15 A	20 D	25 B	30 C

H

PIONEER JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
HIGHER 1

CANDIDATE NAME									
CT GROUP	1	6				INDEX NUMBER			

CHEMISTRY 8872/02

12 September 2017
2 hours

Additional Materials: Data Booklet
Writing Paper
Graph Paper

READ THESE INSTRUCTIONS FIRST

Write your name, CT group and index number in the spaces provided.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
The use of an approved scientific calculator is expected where appropriate.

Section A
Answer **all** the questions in the spaces provided.

Section B
Answer **two** questions on separate writing papers. If there is no answer to the question, a *blank sheet* of paper must still be submitted.
You are advised to show all working in calculations.
You may use a calculator.
The number of marks is given in brackets [ ] at the end of each question or part question.

At the end of the examination, fasten all your work securely together.

FOR EXAMINER'S USE			
Paper 1		**Paper 2 Section B**	
Total	/ 30	Total	/ 40
Paper 2 Section A			
1	/ 10	4	/ 6
2	/ 10	5	/ 7
3	/ 7	Total	/ 40
Penalty	s.f. / units	**GRADE**	

This document consists of **19** printed pages

Section A (40 marks)

Answer **all** questions. Write your answers in the spaces provided.

1 (a) Burning sodium in air produces a mixture of sodium oxide, Na_2O, and sodium peroxide, Na_2O_2. The amount of sodium oxide in the mixture can be determined by the following method.

- The mixture is dissolved in water

$$Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2 \qquad \textbf{reaction 1}$$

- The solution is acidified and an excess of potassium iodide solution is added, iodine is liberated by the following reaction.

$$2KI + H_2O_2 + 2H^+ \rightarrow 2H_2O + 2K^+ + I_2 \qquad \textbf{reaction 2}$$

- The iodine is titrated with standard sodium thiosulfate solution

$$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI \qquad \textbf{reaction 3}$$

(i) When a sample of the mixed oxides, of mass 1.00 g was treated in this way, it was found that 33.40 cm^3 of 0.200 $moldm^{-3}$ $Na_2S_2O_3$ was required to react with all the iodine released.

Calculate the amount of Na_2O in the oxide mixture. [4]

(ii) In terms of oxidation state, deduce all the changes in oxidation number that occurs for **reaction 3**, stating which element is involved in each change.

……..

……..

……..[2]

(b) Sodium oxide and aluminium oxide are white solids.

A student is tasked to add sodium oxide to water followed by a few drops of universal indicator to the resultant solution.

(i) Describe what will be observed when a few drops of universal indicator is added to the resultant solution prepared by adding sodium oxide to water. Write a balanced equation for this reaction.

……..……..

……..…… [1]

Equation: ……..…..[1]

Another student is tasked to add aluminium oxide to hydrochloric acid and aqueous sodium hydroxide separately.

(ii) Write balanced equations to show the reaction between aluminium oxide with hydrochloric acid and aqueous sodium hydroxide

Equation for the reaction between aluminium oxide and hydrochloric acid.

……...[1]

Equation for the reaction between aluminium oxide and aqueous sodium hydroxide

……...[1]

[total:10]

2 (a) Chromium, potassium and sodium are common elements that are found in many compounds commonly used in the school laboratory.

(i) Give the full electronic configuration of chromium atom.

……...
[1]

(ii) The first ionisation energy of potassium is lower than that of sodium. Explain why.

……..

……..

……..
[2]

(b) An aqueous sodium chromate (VI) contains yellow CrO_4^{2-} ions. An aqueous potassium dichromate (VI) contains orange $Cr_2O_7^{2-}$ ions. These chromate (VI) ions exist in equilibrium with dichromate (VI) ions as shown by the expression below:

$$\underset{\text{yellow}}{2\,CrO_4^{2-}\,(aq)} + 2H^+ \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}\,(aq)} + H_2O\,(l)$$

(i) Write an expression for the equilibrium constant K_c, for this reaction.

[1]

(ii) A 2.0 dm^3 solution is prepared in which the initial amount of CrO_4^{2-} ions , H^+ ions and $Cr_2O_7^{2-}$ ions are 2.40 mol , 3.00 mol and 0.112 mol respectively. When equilibrium is reached, the pH of the mixture is 0 at 298 K.

Show relevant workings to calculate the amount of H^+ ions at equilibrium.

Amount of H^+ ions at equilibrium = …….
[1]

(iii) Using your answer in **(b)(ii)**, fill in the blanks with the correct values

	$2CrO_4^{2-}$ (aq)	$+2H^+$ (aq)	$\rightleftharpoons$	$Cr_2O_7^{2-}$(aq)	+ H_2O (*l*)
Initial/ mol					
Change/ mol					
Equilibrium/ mol					

[1]

(iv) Using your K_c expression in **b(i)**, calculate the numerical value of K_c for this equilibrium, stating its units.

[2]

(v) Describe and explain the colour changes when solid P_4O_6 was added into the equilibrium mixture containing the CrO_4^{2-}(aq) and $Cr_2O_7^{2-}$ (aq) ions.

……..

……..

……..

……..

……..

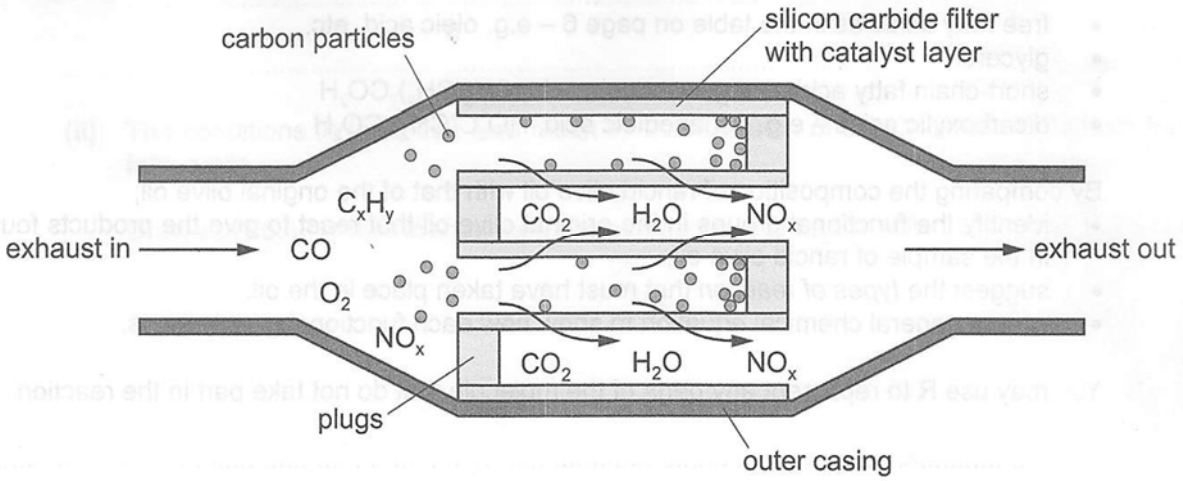
……..

[2]

[Total: 10]

3 Nearly all petrol and diesel vehicles have some kind of catalytic converter fitted to the exhaust to reduce the amount of polluting substances emitted into the atmosphere.

For diesel engines the catalytic converter may also include a particle filter to remove solid particles of carbon. The diagram shows one design of diesel particle filter.



(a) The walls of the particle filter are made from silicon carbide, SiC. This is a hard solid that will not melt at the high temperatures of the exhaust.

Suggest how the structure and bonding in silicon carbide makes it resistant to melting, even at high temperatures.

……..

……..

……..

……..

……..[2]

(b) CO pollutants react with oxygen and are removed from the exhaust. The reaction is as shown below:

$$CO\ (g) + \tfrac{1}{2}\ O_2\ (g) \rightarrow CO_2\ (g)$$

(i) Name the enthalpy change of reaction that is represented by the above reaction.

…… [1]

(ii) The enthalpy change of reaction for this reaction, ΔH is **-283 kJ mol^{-1}**

$$CO\ (g) + ½\ O_2\ (g) \rightarrow CO_2\ (g)$$

The catalyst from the catalytic converter helps to remove the CO pollutants from the exhaust more quickly.

Draw a reaction pathway diagram to represent the reaction. Draw labelled arrows to show ΔH, activation energy, E_a, of the reaction and activation energy of the catalysed reaction, E_a(catalysed) on your diagram.

[2]

(iii) Using bond energy data from the *D*ata *B*ooklet, calculate the enthalpy change of the reaction: $CO\ (g) + ½\ O_2\ (g) \rightarrow CO_2\ (g)$

[Use a value of 1070 kJ mol^{-1} for the bond energy of CO bond in carbon monoxide and a value of 805 kJmol^{-1} for the bond energy of each C=O bond in CO_2 respectively.]

[1]

(iv) The theoretical value given in **b(ii)** is -283 kJmol^{-1}. Comment on the difference between your calculated value in **(b)(iii)** and the theoretical value in **(b)(ii).**

……..

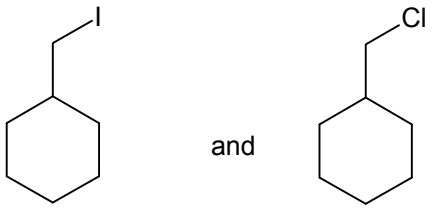
……..……

[1]

[total:7]

4 Suggest simple chemical tests to distinguish the following pairs of compounds. You are required to state the observations of each compound.

(a)



Compound **A** Compound **B**

Chemical test: ……..……..

……..

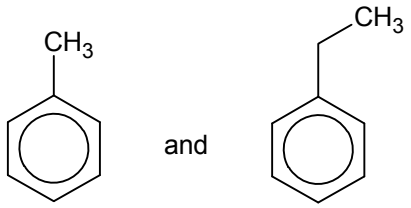
Observation for compound **A** ……..……

……..

Observation for compound **B** ……..……..

……..... [3]

(b)



Compound **C** Compound **D**

Chemical test: ……..……..

……..

Observation for compound **C** ……..……..

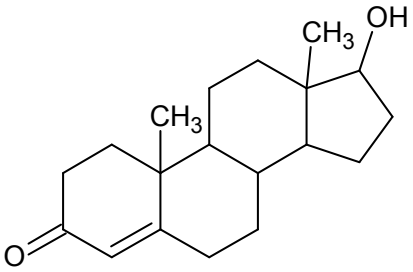
……..

Observation for compound **D** ……..……..

……..... [3]

[Total: 6]

5 (a) Androstanes are a group of compounds with a tetracyclic hydrocarbon ring structures. An example of an androstane is testosterone.



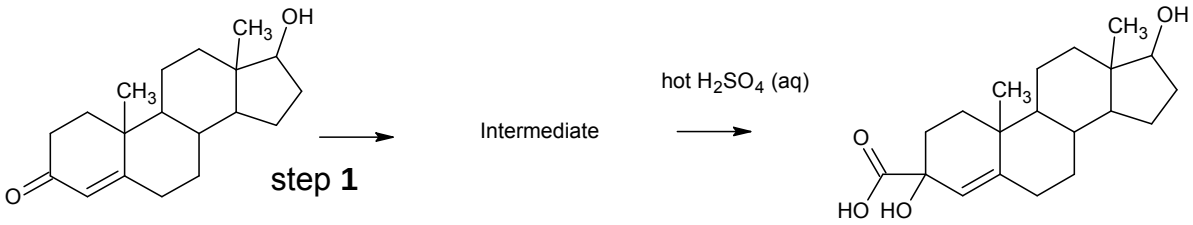
testosterone

(i) Name the functional groups present in testosterone.

……..

……..
[2]

Testosterone can be converted into the compound **A** as shown.



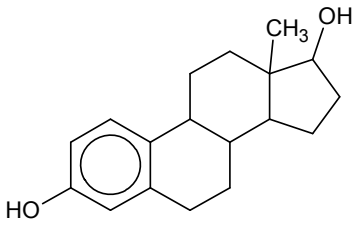
(ii) Give the reagents and conditions for step **1**. [1]

……

(iii) Draw the structure of the intermediate formed. [1]

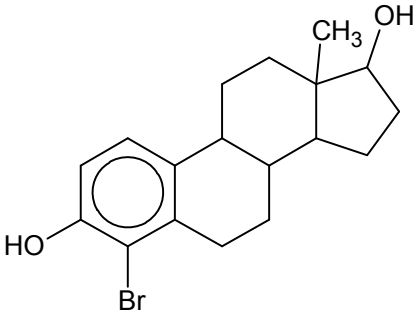
(iv) Draw the structure when testosterone undergoes addition reaction with aqueous bromine. [1]

(b) In the body, the enzyme aromatase can convert testosterone into estrogen.



Estrogen

The following product is obtained when estrogen undergoes substitution with bromine under suitable conditions.



Unlike Testosterone which undergoes addition reaction with aqueous bromine, explain why estrogen undergoes substitution with aqueous bromine instead of addition?

……..……..

……..

……..

……..

……..

[2]

[Total:7]

Section B (40 marks)

Answer **two** of the three questions in this section on separate paper.

1 (a) Sodium and silicon are elements in Period 3 of the Periodic Table.

Describe what will you see when both elements are burned separately in chlorine. Give an equation for each reaction. [4]

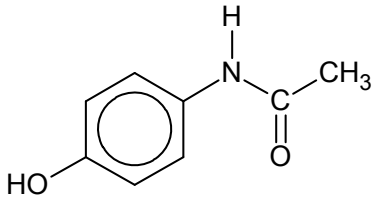
(b) Ethanol can be burned in an excess of oxygen as a fuel but in the body ethanol is partially oxidised. Complete combustion of ethanol to give carbon dioxide releases 1367 kJ mol^{-1} whilst the metabolism of ethanol in the human body leads to partial oxidation to give ethanoic acid, CH_3CO_2H, which releases 770 kJ mol^{-1}. Complete oxidation of ethanoic acid,CH_3CO_2H, to give carbon dioxide releases 873 kJ mol^{-1}

(i) Write an equation to represent the enthalpy change of combustion of ethanol. [1]

(ii) Calculate the energy released if one mole of ethanol in the body were to be oxidised to ethanoic acid and water only. [1]

(iii) Assuming in the body, ethanol is oxidised to a mixture of ethanoic acid and carbon dioxide, use the data to calculate the proportion of ethanol metabolised to form CH_3COOH. [2]

Paracetamol is a suitable analgesic for patients who regularly drink moderate to large amounts of alcohol. It is also used widely to treat fever and pain. Paracetamol is also commonly known as panadol.



paracetamol

Some information on paracetamol is provided in the table below.

Molecular Formula	$C_8H_9NO_2$
Density	1.263 g/cm^3
Melting Point	169 ^oC
Boiling Point	420 ^oC
Bioavailability	75% (oral) 100% (intravenous)
Biological half-life	2 hours

**Bioavailability refers to the percentage of a drug which enters the blood circulation system when introduced into the body and hence able to have an active and effective effect.*

**Biological half-life of a drug is the time taken for the drug to reduce to half its original amount in the body.*

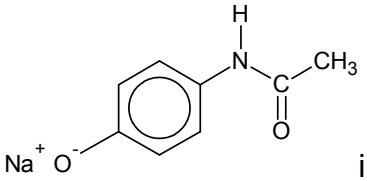
(c) Paracetamol can be produced from the reaction between 4-aminophenol and ethanoic anhydride as shown below.

C_6H_7NO	+	$C_4H_6O_3$	→	$C_8H_9NO_2$	+	$C_2H_4O_2$
4-aminophenol		ethanoic anhydride		paracetamol		
M_r = 109				M_r = 151		

Excess ethanoic anhydride is used in this reaction and it is known that the yield of this reaction is 60%.

(i) Calculate the minimum mass of the 4-aminophenol that are required to produce 10 g of paracetamol. [1]

(ii) Paracetamol is usually sold as its sodium salt:



in authorised pharmacies.

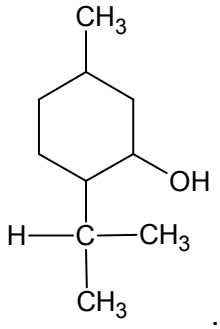
When the sodium salt has dissolved inside the patient's body, the anions and cations are each surrounded by a number of water molecules. This process is known as ion dipole interaction which will improve the solubility of drug inside the bloodstream.

Draw simple diagrams to show how a water molecule can be attached to a sodium cation, and to the anion. Label each diagram to show the type of interaction involved. [2]

(iii) A doctor wishes to prescribe oral medication for one of his patients suffering from acute dental pain.

The patient is advised to take four 250 mg paracetamol tablets in each dosage. Calculate the total mass of paracetamol which remains in the blood circulation system when it is introduced into the body after 4 hours. [2]

(d) Menthol is another molecule that is used medicinally in ointments, cough drops, and nasal inhaler. Menthol has the following structure show below:



.

Pulegone, **A** and isopulegone, **B** are isomers with the molecular formula $C_{10}H_{16}O$.

Both isomers decolourise bromine water, and give an orange precipitate with 2,4-dinitrophenylhydrazine reagent but none reduces Fehling's solution.

On treatment with H_2, and a platinum catalyst, both isomers are reduced to menthol.

When treated with hot concentrated $KMnO_4$, **A** gives two compounds: C_3H_6O, and **C**,$C_7H_{10}O_2$; **B** gives only a single compound **D**, $C_{10}H_{16}O_4$;

Compound **D** gives a yellow precipitate with alkaline aqueous iodine.

Suggest structures for **A, B, C** and **D**, and explain the observations described above.

[7]

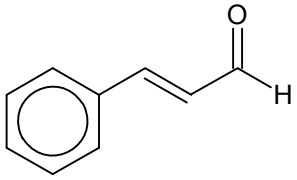
[Total: 20]

2 (a) A white solid is formed when magnesium is burn in air. The solid dissolves partially when water is added, forming a solution which turns red litmus paper blue. When solid phosphorus pentachloride is added, the white solid dissolves.

Explain the observation as fully as you can. [3]

(b) The benzene ring is an important functional group for many natural aromatic compounds. The earliest use of the term '*aromatic*" was by August Wilhelm Hofmann in 1855. The term was used to describe a group of compounds, many of which have aromas.

(i) The compound that gives cinnamon its characteristic smell is cinnamaldehyde.



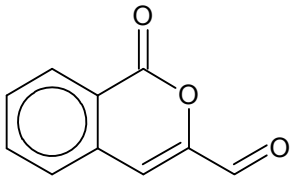
cinnamaldehyde

Draw the organic products when cinnamaldehyde is treated with

(I) $LiAlH_4$ in dry ether

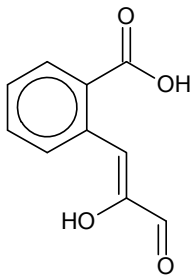
(II) $K_2Cr_2O_7(aq)$, $H_2SO_4(aq)$, heat [2]

The functional group responsible for the smell of butter and cheese is the lactone functional group. An example of a lactone is artemidinal.



artemidinal

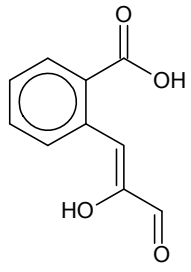
(ii) State the molecular formula of artemidinal. [1]

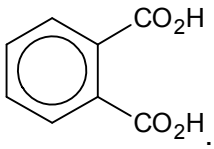


Artemidinal undergoes a reaction to form

(iii) Name the type of reaction that occurs to effect this conversion. [1]

(iv) State the reagents and conditions to effect this conversion. [1]



can be oxidised to benzene-1,2-dicarboxylic acid 

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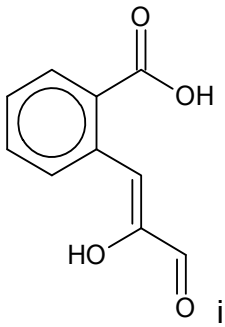


(v) Write a balanced equation for the conversion of into benzene-1,2-dicarboxylic acid.

[1]

(c) The kinetics of the reaction between sodium thiosulfate(V) and hydrochloric acid was investigated.

$$Na_2S_2O_3 + 2HCl \longrightarrow S + SO_2 + H_2O + 2NaCl$$

An experiment was performed in which 0.200 mol dm^{-3} of sodium thiosulfate, $Na_2S_2O_3$, was reacted with 2.00 $moldm^{-3}$ of hydrochloric acid, HCl. A graph of concentration of $Na_2S_2O_3$ against time was plotted.

The following table shows $[Na_2S_2O_3]$ at various times

Time / s	$[Na_2S_2O_3]$ / $moldm^{-3}$
0	0.200
80	0.167
183	0.135
315	0.103
490	0.071
760	0.039

(i) Plot these data on suitable axes and, showing all your working and drawing clearly any construction lines on your graph, deduce the order of reaction with respect to $Na_2S_2O_3$. [3]

In order to determine the order of reaction with respect to hydrochloric acid, two more experiments are carried out as shown in the table.

Experiment	Volume of $Na_2S_2O_3$ / cm^3	Volume of HC*l* added / cm^3	Volume of deionised water / cm^3	Relative rate
1	20	30	10	1
2	20	20	20	1

In both **experiment 1** and **2**, deionised water was added to thiosulfate solution first and hydrochloric acid was added last before timing was started. The time taken for a fixed amount of sulfur to be produced is measured and the relative rate of the reaction is recorded.

(ii) Explain why different volume of deionised water is used in both experiments? [1]

(iii) With relevant workings, determine the order of reaction with respect to hydrochloric acid. [1]

(iv) In **experiment 3**, 20 cm^3 of thiosulfate solution was added to 30 cm^3 of hydrochloric acid first and 10cm^3 of deionised water was added last before timing was started.

He realised that the time taken to produce the same amount of sulfur is shorter than **experiment 1.**

Give a reason when the time taken for **experiment 3** is shorter than **experiment 1**? [1]

(v) Draw the dot and cross diagram for the **ionic compound** $Na_2S_2O_3$ given that in the $S_2O_3^{2-}$ anion,

- it is tetrahedral around the central S atom
- there is no dative bond in the $S_2O_3^{2-}$ anion.
- the negative charge resides on the more electronegative atom.

[2]

(d) The oxides of sulfur namely sulfur (IV) oxide, SO_2 and sulfur (VI) trioxide, SO_3 have different boiling points.

Oxides of sulfur	Boiling point (^oC)
SO_2	-10
SO_3	45

In terms of structure and bonding, account for the difference in the boiling points between the two compounds. [3]

[total: 20]

3 Magnesium ions, chloride ions and other ions that are found inside a lake from the weathering of soils and rocks in the watershed, the atmosphere, and dissolved gases such as carbon dioxide is the source of "mineral water". The table below shows the composition of ions found inside a typical lake that is a source of mineral water.

Ion	Concentration / mol dm^{-3}
Ca^{2+}	2.00×10^{-4} mol dm^{-3}
Mg^{2+}	2.00×10^{-4} mol dm^{-3}
Cl^-	2.00×10^{-4} mol dm^{-3}
HCO_3^-	6.00×10^{-4} mol dm^{-3}

(a) From the data in the table shown above, suggest the relative amounts of the following four ionic compounds, $CaCl_2$:$MgCl_2$: $Ca(HCO_3)_2$: $Mg(HCO_3)_2$, in the mineral water respectively. [1]

(b) Various reactions take place in this ecosystem:

Reaction 1 involves the decomposition of aqueous hydrogen carbonate into the lake as shown:

$2HCO_3^-(aq) \rightleftharpoons CO_2(g) + H_2O(l) + CO_3^{2-}(aq)$ **Reaction 1**

Reaction 2 involves the dissolution of calcium carbonate from the rock into its aqueous ions that were released into the lake as shown:

$CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$ **Reaction 2**

Reaction 3 involves the dissolution of calcium hydrogen carbonate from the rock into its aqueous ions that were released in the lake as shown:

$Ca(HCO_3)_2(s) \longrightarrow Ca^{2+}(aq) + 2HCO_3^-(aq)$ **Reaction 3**

By using the appropriate reactions above, answer **(b)(i), (ii)** and **(iii).**

(i) When a sample of the mineral water was partially evaporated, a white solid was formed and the amount of gaseous carbon dioxide increased. Suggest whether the white solid is calcium hydrogen carbonate or calcium carbonate. [1]

(ii) Hence explain how this process leads to the formation of the white solid. [3]

(iii) When rainwater containing dissolved carbon dioxide gas had percolated through the rocks, the concentration of calcium ions in mineral water increased. Explain why. [2]

(c) A sample of rainwater collected from the lake contains carbonic acid, $H_2CO_3(aq)$.

A conical flask containing 25.0 cm^3 of H_2CO_3 obtained from the lake is titrated against NaOH(aq) with three drops of phenolphthalein indicator. The end point is reached when 20.00 cm^3 of NaOH is added.

He proceeded with two more titrations as described below in **(c)(i)** and **(c)(ii)**.

(i) In the second titration, the student rinsed a new conical flask with deionised water but forget to dry it with towel paper.

Predict how will the end point compared to that of the first titration? Explain your answer. [2]

(ii) In the third titration, a student added twenty drops of phenolphthalein in the hope to see a more distinct end point colour change.

Predict how will the end point compared to that of the first titration? Explain your answer. [2]

(d) Carbon dioxide exists in equilibrium with the water in our bloodstream and an equilibrium consisting of H_2CO_3 and HCO_3^- is set up.

This pair of compounds forms a natural buffer solution in our bodies.

(i) Define what is meant by buffer solution. [1]

(ii) When we exercise, lactic acid is produced in our muscles.

Write one equation to represent how the buffer system in our body works when we exercise. [1]

(e) Halogenoalkanes are an important part in the history of humans. They are present in many forms such as antibiotics, refrigerants and polymers.

When one mole of 1-bromo-4-chlorobutane is heated with one mole of aqueous sodium hydroxide, 4-chlorobutan-1-ol is produced but not 4-bromobutan-1-ol.

Explain your answer. [2]

(f) Substitution of alkanes with halogens can be performed to obtain halogenoalkanes in the laboratory.

(i) Alkanes are used in increasing quantities as refrigerant instead of chlorofluorocarbons as they do not contribute to ozone depletion.

Suggest one potential hazard of using alkanes instead of chlorofluorocarbons. [1]

(ii) Alkanes have carbon atoms which undergo sp^3 hybridisation. Draw a sp^3 hybridised carbon atom. [1]

(iii) In terms of electron donating ability, a sp^3 hybridised carbon atom is more electron donating than a sp^2 hybridised carbon atom which is more electron donating than a sp hybridised carbon atom.

By using the above information, explain why $CH_2=CHCO_2H$ is a stronger acid than $CH_3CH_2CO_2H$ [3]

[total:20]

End of paper

H

PIONEER JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
HIGHER 1

CANDIDATE NAME

CT GROUP | 1 | 6 | | | |

INDEX NUMBER | | | | |

CHEMISTRY

8872/02

12 September 2017

2 hours

Additional Materials: Data Booklet
Writing Paper
Graph Paper

READ THESE INSTRUCTIONS FIRST

Write your name, CT group and index number in the spaces provided.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
The use of an approved scientific calculator is expected where appropriate.

Section A
Answer **all** the questions in the spaces provided.

Section B
Answer **two** questions on separate writing papers. If there is no answer to the question, a *blank sheet* of paper must still be submitted.
You are advised to show all working in calculations.
You may use a calculator.
The number of marks is given in brackets [ ] at the end of each question or part question.

At the end of the examination, fasten all your work securely together.

FOR EXAMINER'S USE			
Paper 1		**Paper 2 Section B**	
Total	/ 30	Total	/ 40
Paper 2 Section A			
1	/ 10	4	/ 6
2	/ 10	5	/ 7
3	/ 7	Total	/ 40
Penalty	s.f. / units	**GRADE**	

This document consists of **19** printed pages

Section A (40 marks)

Answer **all** questions. Write your answers in the spaces provided.

1 (a) Burning sodium in air produces a mixture of sodium oxide, Na_2O, and sodium peroxide, Na_2O_2. The amount of sodium oxide in the mixture can be determined by the following method.

- The mixture is dissolved in water

$$Na_2O_2 + 2H_2O \rightarrow 2NaOH + H_2O_2 \qquad \textbf{reaction 1}$$

- The solution is acidified and an excess of potassium iodide solution is added, iodine is liberated by the following reaction.

$$2KI + H_2O_2 + 2H^+ \rightarrow 2H_2O + 2K^+ + I_2 \qquad \textbf{reaction 2}$$

- The iodine is titrated with standard sodium thiosulfate solution

$$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI \qquad \textbf{reaction 3}$$

(i) When a sample of the mixed oxides, of mass 1.00 g was treated in this way, it was found that 33.40 cm^3 of 0.200 $moldm^{-3}$ $Na_2S_2O_3$ was required to react with all the iodine released.

Calculate the amount of Na_2O in the oxide mixture. [4]

Amt of $S_2O_3^{2-}$ = (33.40/1000)(0.200) = 6.68 x 10^{-3} mol

Amt of I_2 liberated from reaction 2= ½ (6.68 x 10^{-3}) = 3.34 x 10^{-3} mol [1]
= amt of H_2O_2 formed from reaction 1 = Amt of Na_2O_2 reacted in reaction 1 [1]

Mass of Na_2O_2 = 3.34 x 10^{-3} x (2(23.0 + 2(16.0) = 0.2605 g
Mass of Na_2O = 1.00 – 0.2605 = 0.7395 g [1]

n(Na_2O) = 0.7395 / [2(23.0) + 16.0] = 0.01192 mol [1]

(ii) In terms of oxidation state, deduce all the changes in oxidation number that occurs for **reaction 3**, stating which element is involved in each change. [2]

The oxidation state of S changes from +2 in $S_2O_3^{2-}$ to +2.5 in $S_4O_6^{2-}$ [1]

The oxidation state of I changes from 0 in I_2^- to -1 in NaI [1]

(b) Sodium oxide and aluminium oxide are white solids.

A student is tasked to add sodium oxide to water followed by a few drops of universal indicator.

(i) Describe what will be observed when a few drops of universal indicator is added to the resultant solution prepared by adding sodium oxide to water. Write a balanced equation for this reaction.

Sodium hydroxide solution will give a blue/ violet / indigo colour with the universal indicator. [1]

Equation: $Na_2O + H_2O \rightarrow 2NaOH$ [1]

[2]

Another student is tasked to add aluminium oxide to hydrochloric acid and aqueous sodium hydroxide separately.

(ii) Write balanced equations to show the reaction between aluminium oxide with hydrochloric acid and aqueous sodium hydroxide

Equation for the reaction between aluminium oxide and hydrochloric acid.

$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$ [1]

[1]

Equation for the reaction between aluminium oxide and aqueous sodium hydroxide. [1]

$Al_2O_3 + 2NaOH + 3H_2O \longrightarrow 2Na[Al(OH)_4]$ [1]

[total:10]

[Turn Over

2 (a) Chromium, potassium and sodium are common elements that are found in many compounds commonly used in the school laboratory.

(i) Give the full electronic configuration of chromium atom:

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ [1]

[1]

(ii) The first ionisation energy of potassium is lower than that of sodium. Explain why.

Atomic radius increases down the group due to increasing number of quantum shells [1], attraction decreases down the group. [1] [2]

(b) An aqueous sodium chromate (VI) contains yellow CrO_4^{2-} ions. An aqueous potassium dichromate (VI) contains orange $Cr_2O_7^{2-}$ ions. These chromate (VI) ions exist in equilibrium with dichromate (VI) ions as shown by the expression below:

$$2\ CrO_4^{2-}\ (aq) + 2H^+ \rightleftharpoons Cr_2O_7^{2-}\ (aq) + H_2O\ (l)$$
yellow — orange

(i) Write an expression for the equilibrium constant K_c, for this reaction.

$K_c = [\ Cr_2O_7^{2-}\ ] / [\ CrO_4^{2-}\ ]^2\ [\ H^+\ ]^2$ [1] [1]

(ii) A 2.0 dm^3 solution is prepared in which the initial amount of CrO_4^{2-} ions , H^+ ions and $Cr_2O_7^{2-}$ ions are 2.40 mol , 3.00 mol and 0.112 mol respectively. When equilibrium is reached, the pH of the mixture is 0 at 298 K.

Show relevant workings to calculate the amount of H^+ ions at equilibrium.

$[H^+] = 10^{-pH} = 10^{-0} = 1.00\ moldm^{-3}$. $n(H^+)$ 1.00 x 2 = 2.00 mol

Amount of H^+ ions at equilibrium = 2.00 mol ……

[1]

(iii) Using your answer in **(b)(ii)**, fill in the blanks with the correct values

	$2CrO_4^{2-}$ (aq)	$+2H^+$ (aq)	$\rightleftharpoons$	$Cr_2O_7^{2-}$(aq)	+ H_2O (*l*)
Initial/ mol	2.40	3.00		0.112	--
Change/ mol	-1.00	-1.00		+0.50	--
Equilibrium/ mol	1.40	2.00		0.612	--

[1]

(iv) Using your K_c expression in **b(i)**, calculate the numerical value of K_c for this equilibrium, stating its units.

$K_c = [Cr_2O_7^{2-}] / [CrO_4^{2-}]^2 [H^+]^2$
$= (0.612/2) / (1.40/2)^2 (2.00/2)^2$
$= 0.6244 \approx 0.624$ [1]

Units: $mol^{-3}\ dm^9$ [1]

[2]

(v) Describe and explain the colour changes when solid P_4O_6 was added into the equilibrium mixture containing the CrO_4^{2-}(aq) and $Cr_2O_7^{2-}$ (aq) ions.

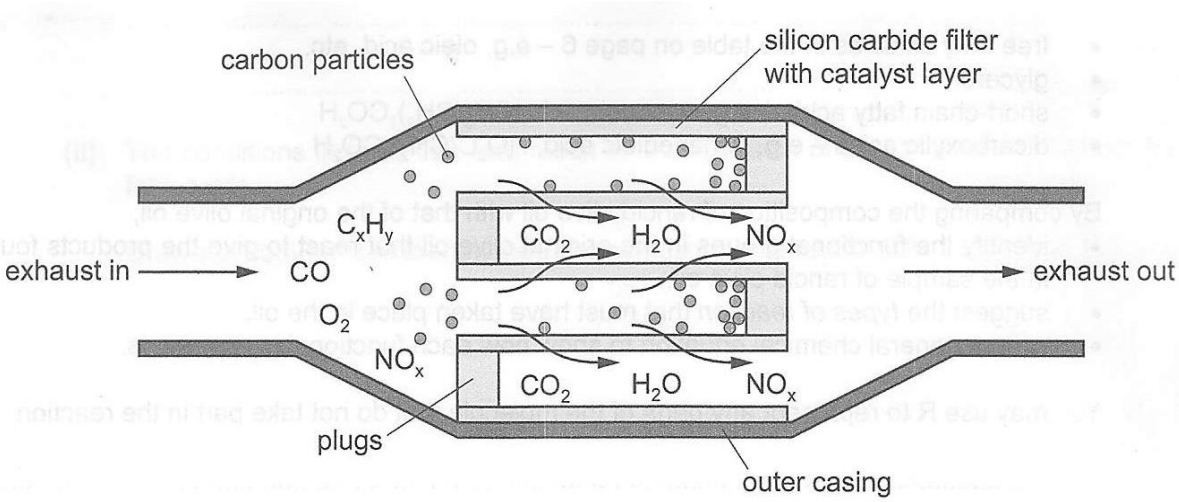
When phosphorus oxide is added, $[H^+]$ increases, position of equilibrium shift to the right to decrease H^+, [1]
hence higher percentage of orange $Cr_2O_7^{2-}$ and lower percentage of yellow CrO_4^{2-} is formed, giving rise to a solution that is more orange and less yellow at the next equilibrium. [1]

[2]

[Total: 10]

3 Nearly all petrol and diesel vehicles have some kind of catalytic converter fitted to the exhaust to reduce the amount of polluting substances emitted into the atmosphere.

For diesel engines the catalytic converter may also include a particle filter to remove solid particles of carbon. The diagram shows one design of diesel particle filter.



(a) The walls of the particle filter are made from silicon carbide, SiC. This is a hard solid that will not melt at the high temperatures of the exhaust.

Suggest how the structure and bonding in silicon carbide makes it resistant to melting, even at high temperatures.

SiC has a giant molecular structure [1] with extensive network of strong covalent bonds [1] to be overcome during melting. Hence even at high temperatures, the energy provided is not sufficient to overcome the bonds .

[2]

(b) CO pollutants react with oxygen and are removed from the exhaust. The reaction is as shown below:

$$CO\ (g) + \tfrac{1}{2}\ O_2\ (g) \rightarrow CO_2\ (g)$$

(i) Name the enthalpy change of reaction that is represented by the above reaction.

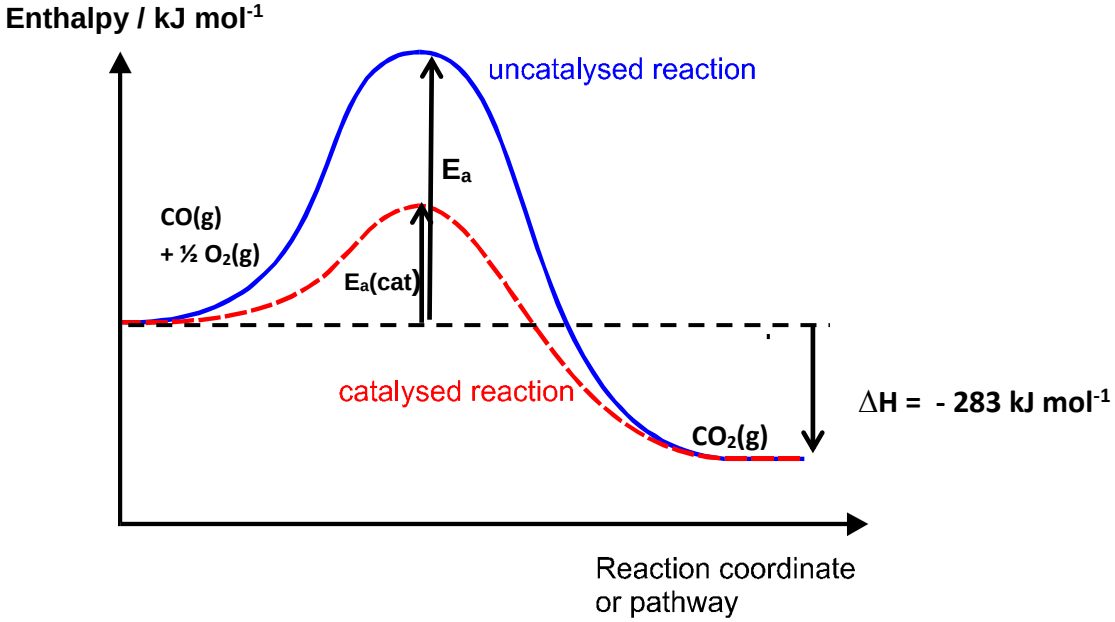
Enthalpy change of combustion of CO. [1] [1]

(ii) The enthalpy change of reaction for this reaction, ΔH is **-283 kJ mol^{-1}**

$$CO\ (g) + ½\ O_2\ (g) \rightarrow CO_2\ (g)$$

The catalyst from the catalytic converter helps to remove the CO pollutants from the exhaust more quickly.

Draw a reaction pathway diagram to represent the reaction. Draw labelled arrows to show ΔH, activation energy, E_a., of the reaction and activation energy of the catalysed reaction, E_a(catalysed) on your diagram.



(any 1 to 2 mistake minus 1 mark, 3 mistakes and more zero mark)

[2]

(iii) Using bond energy data from the *D*ata *B*ooklet, calculate the enthalpy change of the reaction: $CO\ (g) + ½\ O_2\ (g) \rightarrow CO_2\ (g)$

[Use a value of 1070 kJ mol^{-1} for the bond energy of CO bond in carbon monoxide and a value of 805 kJmol^{-1} for the bond energy of each C=O bond in CO_2 respectively.]

ΔH = BE(bonds broken) – BE(bonds formed)

= 1070 + ½ (496) – 2(805)

= -292 kJ mol^{-1} [1] [1]

(iv) The theoretical value given in **b(ii)** is -283 kJmol^{-1}. Comment on the difference between your calculated value in **(b)(iii)** and the theoretical value in **(b)(ii).**

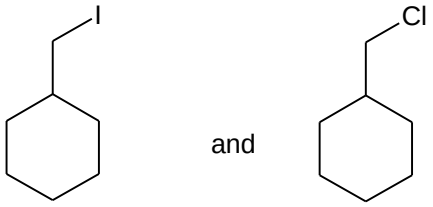
Bond energy used in (b)(iii) are average values and they differ in different chemical and electronic environment the bonds are in. [1] [1]

[total:7]

[Turn Over

4 Suggest simple chemical tests to distinguish the following pairs of compounds. You are required to state the observations of each compound.

(a)



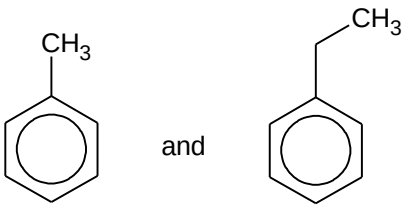
Compound **A** Compound **B**

[3]

Step 1: NaOH(aq), heat
Step 2: cool
Step 3: acidify with HNO_3(aq)
Step 4: $AgNO_3$(aq) [1]

Compound **A**: yellow precipitate of AgI is formed [1]
Compound **B**: white precipitate of AgC*l* observed [1]

(b)



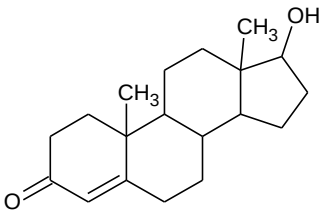
Compound **C** Compound **D**

$KMnO_4$(aq), H_2SO_4(aq), heat [1]

Compound **C**: purple $KMnO_4$ decolourises [1]
Compound **D**: purple $KMnO_4$ decolourises, effervescence observed. Gas forms white precipitate when pass through $Ca(OH)_2$(aq). Gas is CO_2. [1]

[3]
[Total: 6]

5 (a) Androstanes are a group of compounds with a tetracyclic hydrocarbon ring structures. An example of an androstane is testosterone.



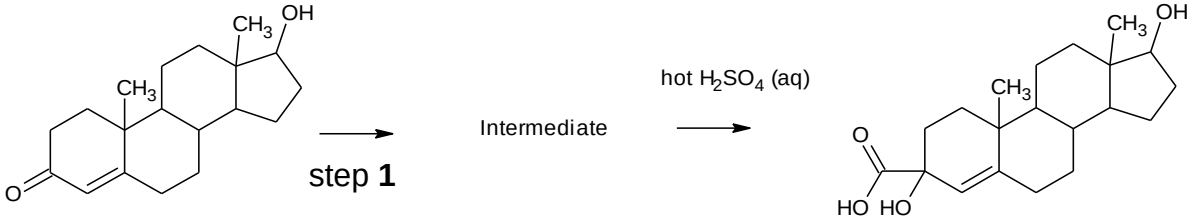
testosterone

(i) Name the functional groups present in testosterone.

Ketone, alkene, 2° alcohol [2 marks for all 3, 1 mark for 2]

[2]

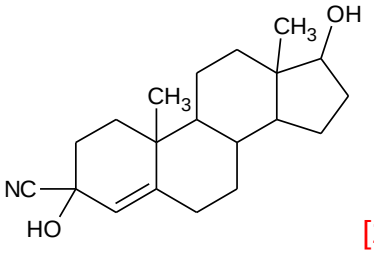
Testosterone can be converted into the compound **A** as shown.



(ii) Give the reagents and conditions for step **1**. [1]

Step **I**: HCN(aq), trace amount of NaCN/NaOH, 10-20 °C [1]

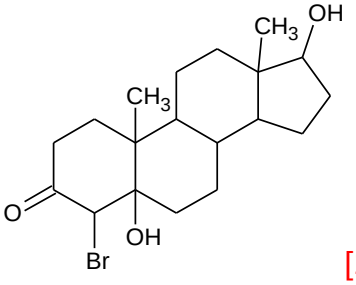
(iii) Draw the structure of the intermediate formed. [1]



[1]

(if there is missing C atoms in the cyclic ring , BOD)

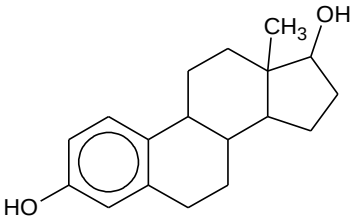
(iv) Draw the structure when testosterone undergoes addition reaction with aqueous bromine. [1]



[1]

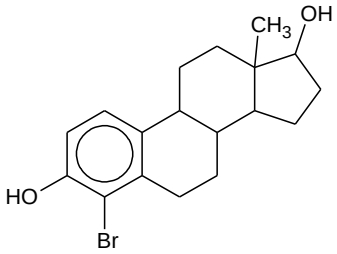
[Turn Over

(b) In the body, the enzyme aromatase can convert testosterone into estrogen.



Estrogen

The following product is obtained when estrogen undergoes substitution with bromine under suitable conditions.



Unlike Testosterone which undergoes addition reaction with aqueous bromine, explain why estrogen undergoes substitution with aqueous bromine instead of addition ?

Addition reaction will cause the destruction of the delocalised pi electron system, thus destroying the aromatic character of benzene. [1]

Hence when benzene reacts, the C-H bonds are broken and not the pi bonds so as to retain its aromaticity which stabilises benzene. [1]

[2]
[Total:7]

[total: 40]

Section B (40 marks)

Answer **two** of the three questions in this section on separate paper.

1 (a) Sodium and silicon are elements in Period 3 of the Periodic Table.

Describe what will you see when both elements are burned separately in chlorine? Give an equation for each reaction. [4]

$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$ [1]

Reacts vigorously in chlorine with an **orange flame** to give a **white solid**, sodium chloride. [1 for both observations]

$Si(s) + 2Cl_2(g) \rightarrow SiCl_4(l)$ [1]

Reacts slowly to form a colourless liquid [1]

(b) Ethanol can be burned in an excess of oxygen as a fuel but in the body ethanol is partially oxidised. Complete combustion of ethanol to give carbon dioxide releases 1367 kJ mol^{-1} whilst the metabolism of ethanol in the human body leads to partial oxidation to give ethanoic acid, CH_3CO_2H, which releases 770 kJ mol^{-1}. Complete oxidation of ethanoic acid,CH_3CO_2H, to give carbon dioxide releases 873 $kJmol^{-1}$

(i) Write an equation to represent the enthalpy change of combustion of ethanol. [1]

$C_2H_5OH\ (l) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 3H_2O\ (l)$ [1]

(ii) Calculate the energy released if one mole of ethanol in the body were to be oxidised to ethanoic acid and water only. [1]

1367 – 873 = 494 kJ mol^{-1} [1]

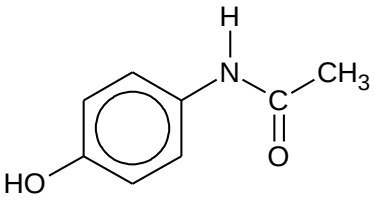
(iii) Assuming in the body, ethanol is oxidised to a mixture of ethanoic acid and carbon dioxide, use the data to calculate the proportion of ethanol metabolised to form CH_3COOH. [2]

Let 1 mol of C_2H_5OH be partially oxidised, such that x mol is oxidised to CH_3COOH, and 1 – x mol is oxidised to CO_2.

Amt of heat released = $494x + 1367(1-x) \approx 770$ [1]

$873x = 597 \quad x = 0.683$ [1]

Paracetamol is a suitable analgesic for patients who regularly drink moderate to large amounts of alcohol. It is also used widely to treat fever and pain. Paracetamol is also commonly known as panadol.



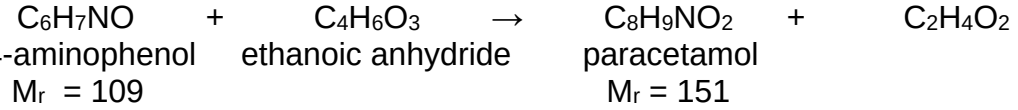
paracetamol

Some information on paracetamol is provided in the table below.

Molecular Formula	$C_8H_9NO_2$
Density	1.263 g/cm^3
Melting Point	169 ^oC
Boiling Point	420 ^oC
Bioavailability	75% (oral) 100% (intravenous)
Biological half-life	2 hours

**Bioavailability refers to the percentage of a drug which enters the blood circulation system when introduced into the body and hence able to have an active and effective effect.*
**Biological half-life of a drug is the time taken for the drug to reduce to half its original amount in the body.*

(c) Paracetamol can be produced from the reaction between 4-aminophenol and ethanoic anhydride as shown below.

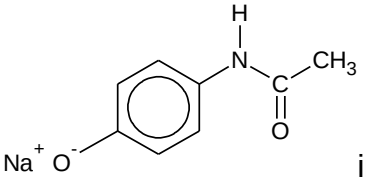


Excess ethanoic anhydride is used in this reaction and it is known that the yield of this reaction is 60%.

(i) Calculate the minimum mass of the 4-aminophenol that are required to produce 10 g of paracetamol. [1]

Mass of 4-aminophenol required = $\frac{10}{151}\times\frac{100}{60}\times 109$ = 12.0 g [1]

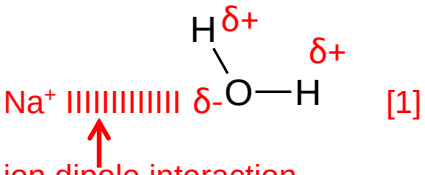
(ii) Paracetamol is usually sold as its sodium salt:



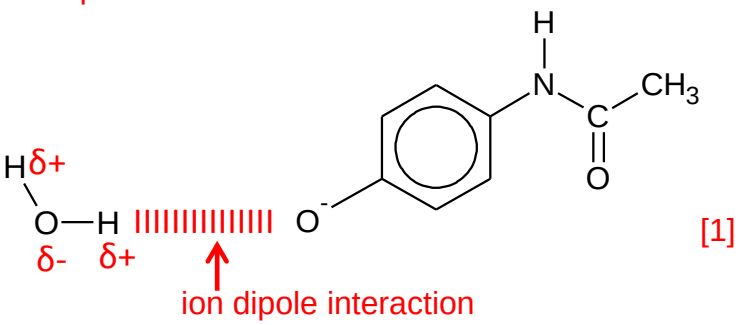
in authorised pharmacies.

When the sodium salt has dissolved inside the patient's body, the anions and cations are each surrounded by a number of water molecules. This process is known as ion dipole interaction which will improve the solubility of drug inside the bloodstream.

Draw simple diagrams to show how a water molecule can be attached to a sodium cation, and to the anion. Label each diagram to show the type of interaction involved. [2]



[1]



[1]

show the correct interaction for cation and anion with water molecules [1] each

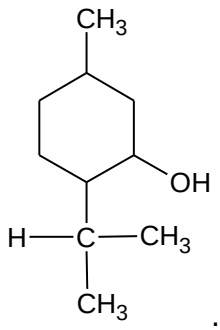
(iii) A doctor wishes to prescribe oral medication for one of his patients suffering from acute dental pain.

The patient is advised to take four 250 mg paracetamol tablets in each dosage. Calculate the total mass of paracetamol which remains in the blood circulation system when it is introduced into the body after 4hours. [2]

Mass of paracetamol in 4 x 250 mg tablets = 1000 mg
Mass of paracetamol that will be useful and effective
= 75% x 1000 = 750 mg [1]

Since biological half-life of paracetamol is 2 hours,
2 hours 2 hours
750 mg ➔ 375 mg ➔ 187.5 mg [1]

(d) Menthol is another molecule that is used medicinally in ointments, cough drops, and nasal inhaler. Menthol has the following structure show below:



Pulegone, **A** and isopulegone, **B** are isomers with the molecular formula $C_{10}H_{16}O$.

Both isomers decolourise bromine water, and give an orange precipitate with 2,4-dinitrophenylhydrazine reagent but none reduces Fehling's solution.

On treatment with H_2, and a platinum catalyst, both isomers are reduced to menthol.

When treated with hot concentrated $KMnO_4$, **A** gives two compounds: C_3H_6O, and **C**,$C_7H_{10}O_2$; **B** gives only a single compound **D**, $C_{10}H_{16}O_4$;

Compound **D** gives a yellow precipitate with alkaline aqueous iodine.

Suggest structures for **A, B, C** and **D**, and explain the observations described above. [7]

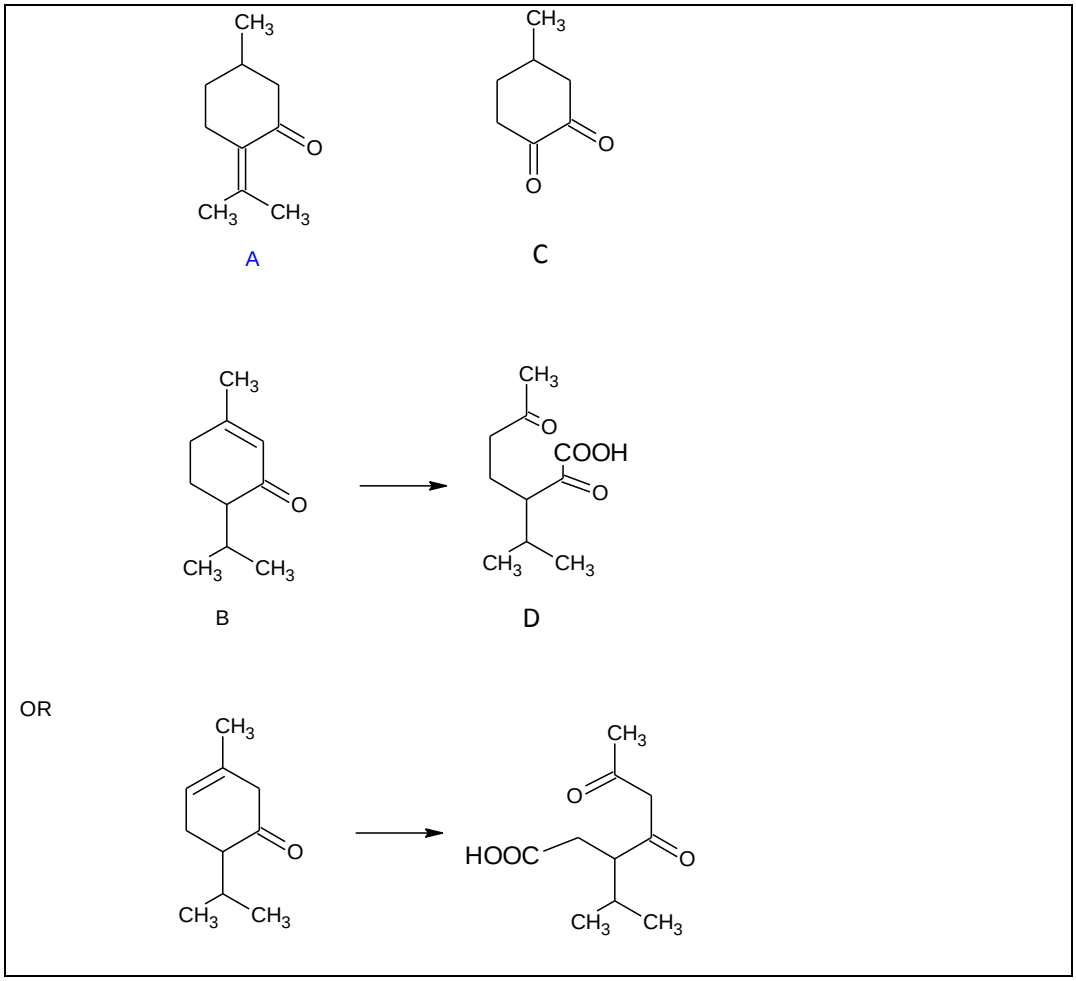
[Total: 20]

- A, B undergoes addition and have alkene functional group.
- A, B undergoes condensation with 2,4-DNPH, and does not undergo oxidation with Felhings solution, therefore ketones are present.
- A, B undergoes oxidation with $KMnO_4$.
- D has CH_3CO- in its structure, it undergoes oxidation with I_2, NaOH(aq). (Yellow ppt is CHI_3)

6-7 pt – 3 marks

4-5 pt – 2 marks

2-3 pt – 1 mark



[Total: 20]

2 (a) A white solid is formed when magnesium is burn in air. The solid dissolves partially when water is added, forming a solution which turns red litmus paper blue. When solid phosphorus pentachloride is added, the white solid dissolves.

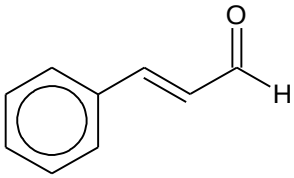
Explain the observation as fully as you can. [3]

Burning Mg in air produces MgO, a white solid. [1]

MgO is dissolves partially in water to form $Mg(OH)_2$, turning the solution basic. [1]
When PCl_5 dissolves in water it forms HCl which neutralises the $Mg(OH)_2$ to form soluble $MgCl_2$ (aq) / causing the solid to dissolve. [1]
Equations also accepted.

(b) The benzene ring is an important functional group for many natural aromatic compounds. The earliest use of the term '*aromatic*" was by August Wilhelm Hofmann in 1855. The term was used to describe a group of compounds, many of which have aromas.

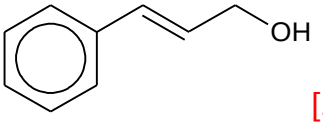
(i) The compound that gives cinnamon its characteristic smell is cinnamaldehyde.



cinnamaldehyde

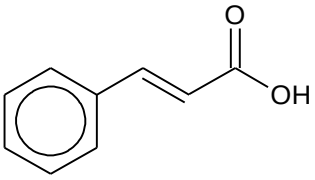
Draw the organic products when cinnamaldehyde is treated with

(I) $LiAlH_4$ in dry ether



[1]

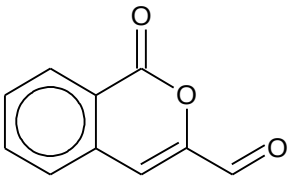
(II) $K_2Cr_2O_7(aq)$, $H_2SO_4(aq)$, heat [2]



[1]

`

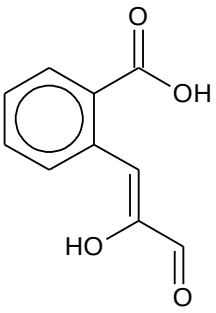
The functional group responsible for the smell of butter and cheese is the lactone functional group. An example of a lactone is artemidinal.



artemidinal

(ii) State the molecular formula of artemidinal. [1]

$C_{10}H_6O_3$ [1]



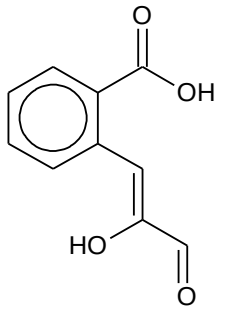
Artemidinal undergoes a reaction to form

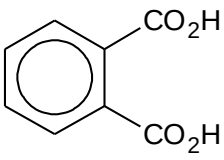
(iii) Name the type of reaction that occurs to effect this conversion. [1]

acid hydrolysis [1]

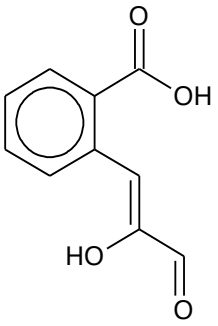
(iv) State the reagents and conditions to effect this conversion. [1]

H_2SO_4 (aq), heat [1]



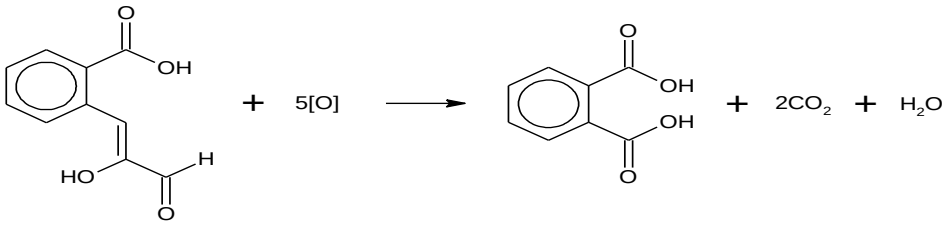


can be oxidised to benzene-1,2-dicarboxylic acid



(v) Write a balanced equation for the conversion of benzene-1,2-dicarboxylic acid.

[1]



[1]

(c) The kinetics of the reaction between sodium thiosulfate(V) and hydrochloric acid was investigated.

$$Na_2S_2O_3 + 2HCl \longrightarrow S + SO_2 + H_2O + NaCl$$

An experiment was performed in which 0.200 mol dm^{-3} of sodium thiosulfate, $Na_2S_2O_3$, was reacted with 2.00 $moldm^{-3}$ of hydrochloric acid, HC*l*. A graph of concentration of $Na_2S_2O_3$ against time was plotted.

The following table shows [$Na_2S_2O_3$] at various times

Time / s	[$Na_2S_2O_3$] / $moldm^{-3}$
0	0.200
80	0.167
183	0.135
315	0.103
490	0.071
760	0.039

(i) Plot these data on suitable axes and, showing all your working and drawing clearly any construction lines on your graph, deduce the order of reaction with respect to $Na_2S_2O_3$. [3]

Correct plotting to ½ small square & Correct axes ([$Na_2S_2O_3$] / $moldm^{-3}$ on vertical axis and time/s on the horizontal axis --- (1)

Construction lines to show two constant half lives ≈ 325 s on graph paper (1)

Correct determination of first order for $Na_2S_2O_3$ – (1)

In order to determine the order of reaction with respect to hydrochloric acid, two more experiments are carried out as shown in the table.

Experiment	**Volume of $Na_2S_2O_3$ / cm^3**	**Volume of HC*l* added / cm^3**	**Volume of deionised water / cm^3**	**Relative rate**
1	20	30	10	1
2	20	20	20	1

In both **experiment 1** and **2**, deionised water was added to thiosulfate solution first and hydrochloric acid was added last before timing was started. The time taken for a fixed amount of sulfur to be produced is measured and the relative rate of the reaction is recorded.

(ii) Explain why different volume of deionised water is used in both experiments? [1]

To maintain a constant total volume so that the volume of reagent added is proportional to the concentration in the reaction mixture. [1]

(iii) With relevant workings, determine the order of reaction with respect to hydrochloric acid. [1]

When the volume (hence $[S_2O_3^{2-}]$) is kept constant, and the volume increases by 30/20 = 1.5 times from experiment 2 to 1, the relative rate remains unchanged, hence it is zero order with respect to HCl [1]

OR

Rate = $k[S_2O_3^{2-}]^a[HCl]^b$ α $\underline{k(V_{S2O32-})^a (V_{HCl})^b}$

$$\frac{(\text{Relative rate})_{\text{experiment 1}}}{(\text{Relative rate})_{\text{experiment 2}}} = \frac{k(V_{S2O32-})^a (V_{HCl})^b}{k(V_{S2O32-})^a (V_{HCl})^b}$$

$$\frac{1}{1} = \frac{k(20)^a (30)^b}{k(20)^a (20)^b}$$

Hence b = 0 hence it is zero order wrt HCl [1]

(iv) In **experiment 3**, 20 cm^3 of thiosulfate solution was added to 30 cm^3 of hydrochloric acid first and 10cm^3 of deionised water was added last before timing was started.

He realised that the time taken to produce the same amount of sulfur is shorter than **experiment 1.**

Give a reason when the time taken for **experiment 3** is shorter than **experiment 1**? [1]

Before (timing) deionised water is added, the reaction has already started hence the time recorded for the fixed amount of sulfur to be produced will be shorter.

OR

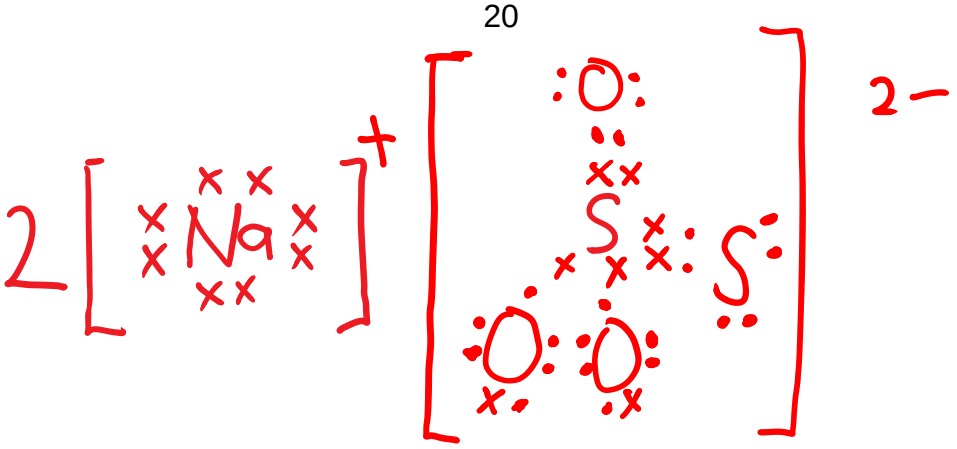
The total volume is 50 cm^3 instead of 60cm^3 hence the reaction started with higher concentration of $S_2O_3^{2-}$ resulting in shorter time required to produce fix amount of sulfur.

(v) Draw the dot and cross diagram for the **ionic compound** $Na_2S_2O_3$ given that in the $S_2O_3^{2-}$ anion,

- it is tetrahedral around the central S atom
- there is no dative bond in the $S_2O_3^{2-}$ anion.
- the negative charge resides on the more electronegative atom.

[2]

[1] for "2" Na^+ with eight valence electrons [1] for correct $S_2O_3^{2-}$



(d) The oxides of sulfur namely sulfur (IV) oxide, SO_2 and sulfur (VI) trioxide, SO_3 have different boiling points.

Oxides of sulfur	Boiling point (°C)
SO_2	-10
SO_3	45

In terms of structure and bonding, account for the difference in the boiling points between the two compounds. [3]

Both have simple molecular structure. [1]

There are more electrons to be polarised in SO_3 than in SO_2. [1]

Hence, the instantaneous dipole - induced dipole attraction between SO_3 molecules is *stronger* than the permanent dipole – dipole forces between SO_2 molecules, [1] accounting for the higher boiling point of SO_3.

[total: 20]

3 Magnesium ions, chloride ions and other ions that are found inside a lake from the weathering of soils and rocks in the watershed, the atmosphere, and dissolved gases such as carbon dioxide is the source of "mineral water". The table below shows the composition of ions found inside a typical lake that is a source of mineral water.

Ion	Concentration / mol dm^{-3}
Ca^{2+}	2.00×10^{-4} mol dm^{-3}
Mg^{2+}	2.00×10^{-4} mol dm^{-3}
Cl^{-}	2.00×10^{-4} mol dm^{-3}
HCO_3^{-}	6.00×10^{-4} mol dm^{-3}

(a) From the data in the table shown above, suggest the relative amounts of the following four ionic compounds, $CaCl_2$:$MgCl_2$: $Ca(HCO_3)_2$: $Mg(HCO_3)_2$, in the mineral water respectively. [1]

Mol ratio of $CaCl_2$: $MgCl_2$: $Ca(HCO_3)_2$: $Mg(HCO_3)_2$ = 1 : 1 : 3 : 3 [1]

(b) Various reactions take place in this ecosystem:

Reaction 1 involves the decomposition of aqueous hydrogen carbonate into the lake as shown:

$2HCO_3^-(aq) \rightleftharpoons CO_2(g) + H_2O(l) + CO_3^{2-}(aq)$ **Reaction 1**

Reaction 2 involves the dissolution of calcium carbonate from the rock into its aqueous ions that were released into the lake as shown

$CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + CO_3^{2-}(aq)$ **Reaction 2**

Reaction 3 involves the dissolution of calcium hydrogen carbonate from the rock into its aqueous ions that were released in the lake as shown.

$Ca(HCO_3)_2(s) \longrightarrow Ca^{2+}(aq) + 2HCO_3^-(aq)$ **Reaction 3**

By using the appropriate reactions above, answer **(b)(i), (ii)** and **(iii).**

(i) When a sample of the mineral water was partially evaporated, a white solid was formed and the amount of gaseous carbon dioxide increased. Suggest whether the white solid is calcium hydrogen carbonate or calcium carbonate. [1]

Calcium carbonate [1]

(ii) Hence explain how this process leads to the formation of the white solid. [3]

When mineral water was evaporated, [HCO_3^-] and [CO_3^{2-}] increased, [1pt] but [HCO_3^-] increase to a greater extent [1pt] since there are more moles

Hence POE in **reaction 1** shift to the right [1pt] and increased [CO_3^{2-}] overall.[1pt]

The increase in [CO_3^{2-}] caused POE in **reaction 2** to shift to the left, [1pt] producing $CaCO_3$ (s)
4-5 pt – 3 marks 3 pt – 2 marks 2 pt – 1 mark

(iii) When rainwater containing dissolved carbon dioxide gas had percolated through the rocks, the concentration of calcium ions in mineral water increased. Explain why. [2]

When rainwater percolates through the rock, the carbon dioxide reacts with some of the dissolved CO_3^{2-} from the partial dissolution of calcium carbonates to form HCO_3^- as present in the mineral water. [1]

The decrease in concentration of CO_3^{2-} causes the equilibrium position of **reaction 2** to shift to the right, [1] enabling more carbonate to dissolve to produce the calcium ions present in the mineral water.

(c) A sample of rainwater collected from the lake contains carbonic acid, H_2CO_3(aq).

A conical flask containing 25.0 cm^3 of H_2CO_3 obtained from the lake is titrated against NaOH(aq) with three drops of phenolphthalein indicator. The end point is reached when 20.0 cm^3 of NaOH is added.

He proceeded with two more titrations as described in **(c)(i)** and **(c)(ii)**

(i) In the second titration, the student rinsed a new conical flask with deionised water but forget to dry it with towel paper.

Predict how will the end point compared to that of the first titration? Explain your answer. [2]

It will be the same [1]. The amount of carbonic acid in the conical flask is the same hence it will require the same amount of sodium hydroxide.

(ii) In the third titration, a student added twenty drops of phenolphthalein in the hope to see a more distinct end point colour change.

Predict how will the end point compared to that of the first titration? Explain your answer. [2]

Since indicator is weak acid [1], hence higher volume of sodium hydroxide is required to reach end point [1]

(d) Carbon dioxide exists in equilibrium with the water in our bloodstream and an equilibrium consisting of H_2CO_3 and HCO_3^- is set up.

This pair of compounds forms a natural buffer solution in our bodies.

(i) Define what is meant by a buffer solution. [1]

A solution that resists changes in pH when a small amount of acids or alkalis is added or upon dilution. [1]

(ii) When we exercise, lactic acid is produced in our muscles.

Write one equation to represent how the buffer system works in our body when we exercise. [1]

$HCO_3^- + H^+ \rightarrow H_2CO_3$ [1]

(e) Halogenoalkanes are an important part in the history of humans. They are present in many forms such as antibiotics, refrigerants and polymers.

When one mole of 1-bromo-4-chlorobutane is heated with one mole of aqueous sodium hydroxide, 4-chlorobutan-1-ol is produced but not 4-bromobutan-1-ol.

Explain your answer. [2]

The C-Br bond is weaker than the C-Cl bond [1] as it is longer due to the larger atomic radius of I. Less energy is required to break the bond to form 4-chlorobutan-1-ol [1]

(f) Substitution of alkanes with halogens can be performed to obtain halogenoalkanes in the laboratory.

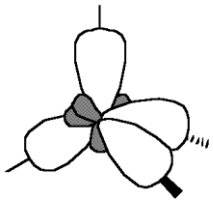
(i) Alkanes are used in increasing quantities as refrigerant instead of chlorofluorocarbons as they do not contribute to ozone depletion.

Suggest one potential hazard of using alkanes instead of chlorofluorocarbons. [1]

Alkanes are flammable.

(ii) Alkanes have carbon atoms which undergo sp^3 hybridisation. Draw a sp^3 hybridised carbon atom. [1]

sp^3 Hybrid Orbitals



[1]

(iii) In terms of electron donating ability, a sp^3 hybridised carbon atom is more electron donating than a sp^2 hybridised carbon atom which is more electron donating than a sp hybridised carbon atom.

By using the above information,explain why $CH_2=CHCO_2H$ is a stronger acid than $CH_3CH_2CO_2H$ [3]

The carbon atoms in the $CH_2=CHCO_2H$ are sp^2 hybridised.
While the type of hybridisation in C atom of CH_3CH_2COOH is sp^3
[1 mark for both correctly identified hybridisation]

Since sp^2 is less electron donating than sp^3 C [1],

hence the negative charge on oxygen of anion of $CH_2=CHCO_2^-$ is less intensified (or $CH_3CH_2CO_2^-$ is more destabilised and less stable than anion of $CH_2=CHCO_2^-$) and more stable [1] than $CH_3CH_2CO_2^-$

resulting in higher percentage of H^+ formed for $CH_2=CHCO_2H$

[total:20]

End of paper