

Answer ALL the questions. Write your answers in the spaces provided.

1. (a) Chlorine and sodium hydroxide are manufactured by the electrolysis of a concentrated aqueous solution of sodium chloride, using a membrane cell.

(i) State the materials from which the anode and cathode are made.

Anode material

Cathode material (2)

(ii) Write the ionic half-equations for the reactions at the anode and at the cathode.

Anode

Cathode (2)

(iii) Write the overall **ionic** equation for this process.

..... (1)

(iv) Give ONE major use for chlorine.

..... (1)



- (b) The reaction used in the production of sodium chlorate(I), NaOCl, is shown by the following equation.



- (i) Complete the following, for the reaction above:

Species oxidised Oxidation product

Species reduced Reduction product

(2)

- (ii) Calculate the minimum volume of chlorine required to produce a solution containing 100 g of sodium chlorate(I).

(molar volume of chlorine under the conditions of this experiment = 24.0 dm³ mol⁻¹)

(2)

Q1

(Total 10 marks)

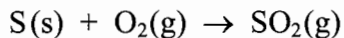
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2. This question is about the manufacture of sulphuric acid, H₂SO₄.

(a) The first stage in the manufacture of sulphuric acid is the combustion of sulphur.

The following equation shows the reaction taking place when the standard enthalpy of combustion of sulphur is measured.



Define the term **standard enthalpy of combustion**.

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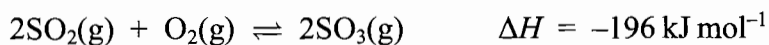
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(3)

(b) In the second stage of the manufacture of sulphuric acid, sulphur dioxide is oxidised to sulphur trioxide as shown in the following equation:



(i) State the temperature and pressure used for this reaction and identify the catalyst.

Temperature

Pressure

Catalyst

(3)



(ii) Explain, in terms of collision theory, why the rate of a reaction is increased by increasing the temperature and by the addition of a catalyst.

Temperature

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.....

Catalyst

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(4)



(iii) State and explain the effect, if any, of increasing the temperature on the equilibrium yield of sulphur trioxide.

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(2)

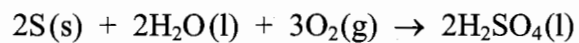
(iv) State and explain the effect, if any, of an increased pressure on the equilibrium yield of sulphur trioxide.

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(2)



- (c) The following equation represents the overall reaction for the manufacture of sulphuric acid from sulphur, oxygen and water.



Use the data below to calculate the enthalpy change for this reaction.

Substance	ΔH_f^\ominus / kJ mol^{-1}
$\text{H}_2\text{O}(\text{l})$	-286
$\text{H}_2\text{SO}_4(\text{l})$	-814

(2)

- (d) State ONE large-scale use of sulphuric acid.

.....

(1)

Q2

(Total 17 marks)



3. (a) (i) State TWO features that members of a homologous series have in common.

.....

(2)

(ii) Name the homologous series to which propene belongs.

.....

(1)

(iii) Propene can be converted into a mixture of 2-chloropropane (as the major product) and 1-chloropropane.

Classify the reaction involved and identify the reagent required.

Classification

Reagent

(2)

(b) (i) 1-chloropropane can be converted into butanenitrile, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$.

Classify the reaction involved. Identify the reagent required and state ONE essential condition.

Classification

Reagent

Condition

.....

(3)

(ii) Define the term **structural isomers**.

.....

(2)



(iii) Draw the **full** structural formula of any structural isomer of butanenitrile, showing **all** the bonds.

(1)

(c) 1-chloropropane and 1-bromopropane both react with ammonia to give 1-propylamine.

State and explain, in terms of bonding and kinetics, which of 1-chloropropane and 1-bromopropane would react faster with ammonia.

.....

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.....

(3)

(d) 1-chloropropene, $\text{CH}_3\text{CH}=\text{CHCl}$, can be polymerised to form poly(1-chloropropene).

Draw the repeat unit of poly(1-chloropropene).

(2)



(e) Explain why 1-chloropropene exists as two different geometric isomers, but propene does not.

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(2)

(Total 18 marks)

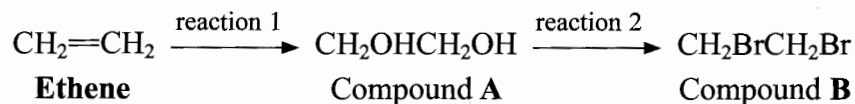
Q3



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4. (a) Consider the following series of reactions.



(i) Identify the reagent required for **reaction 1**.

.....
(1)

(ii) Name compound **B**.

.....
(1)

(iii) Identify the **TWO** reagents required for **reaction 2**.

.....
.....
(2)

(iv) Compound **A** can be oxidised by heating with an acidified solution of potassium dichromate(VI).

Give the colour change that would be observed and draw the full structural formulae of **TWO** possible oxidation products, showing all bonds.

Colour from **to**

Oxidation products

(3)



(v) Suggest the name **or** formula of a compound that would be obtained if compound **B** were reacted with ethanolic potassium hydroxide.

.....
(1)

(b) (i) Compound **B** can be produced by reacting **ethane** with bromine in the presence of ultra-violet light.

Suggest why a good yield of compound **B** would **not** be obtained and identify another organic product that would be formed during the reaction.

.....

(2)

(ii) Write an equation for the complete combustion of ethane.

.....
(2)

(iii) Define the term **empirical formula**.

.....

(1)

(iv) Give the empirical formula for ethane.

.....
(1)

QUESTION 4 CONTINUES ON THE NEXT PAGE



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- (v) Give the formula of an alkane, containing more than one carbon atom, whose molecular and empirical formulae are the same.

(1)

(Total 15 marks)

Q4

TOTAL FOR PAPER: 60 MARKS

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THE PERIODIC TABLE

Period 1 2 3 4 5 6 7 0 Group

4	He Helium	2
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Molar mass g mol ⁻¹
Symbol
Name
Atomic number

1	H Hydrogen	1
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Period

7	Li Lithium	Be Beryllium	B Boron	C Carbon	N Nitrogen	O Oxygen	F Fluorine	Ne Neon										
3	Na Sodium	Mg Magnesium	Al Aluminium	Si Silicon	P Phosphorus	S Sulphur	Cl Chlorine	Ar Argon										
11	K Potassium	Ca Calcium	Sc Scandium	Ti Titanium	V Vanadium	Cr Chromium	Mn Manganese	Fe Iron	Co Cobalt	Ni Nickel	Cu Copper	Zn Zinc	Ga Gallium	Ge Germanium	As Arsenic	Se Selenium	Br Bromine	Kr Krypton
19	Rb Rubidium	Sr Strontium	Y Yttrium	Zr Zirconium	Nb Niobium	Mo Molybdenum	Tc Technetium	Ru Ruthenium	Rh Rhodium	Pd Palladium	Ag Silver	Cd Cadmium	In Indium	Sn Tin	Sb Antimony	Te Tellurium	I Iodine	Xe Xenon
37	Cs Caesium	Ba Barium	La Lanthanum	Hf Hafnium	Ta Tantalum	W Tungsten	Re Rhenium	Os Osmium	Ir Iridium	Pt Platinum	Au Gold	Hg Mercury	Tl Thallium	Pb Lead	Bi Bismuth	Po Polonium	At Astatine	Rn Radon
55	Fr Francium	Ra Radium	Ac Actinium															

140	Ce Cerium	Pr Praseodymium	Nd Neodymium	Pm Promethium	Sm Samarium	Eu Europium	Gd Gadolinium	Tb Terbium	Dy Dysprosium	Ho Holmium	Er Erbium	Tm Thulium	Yb Ytterbium	Lu Lutetium			
141	Pr	(147)	Pm	150	Sm	152	Gd	155	Tb	163	Dy	167	Er	173	Lu		
232	Th Thorium	(231)	Pa Protactinium	238	U Uranium	(243)	Am Americium	(245)	Bk Berkelium	(254)	Es Einsteinium	(256)	Md Mendelevium	(254)	No Nobelium	(257)	Lr Lawrencium
90	Th	91	Pa	92	U	95	Am	97	Bk	99	Es	101	Md	102	No	103	Lr

