

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.

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(1)

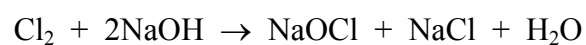
- (iv) Give ONE major use for chlorine.

.....
(1)



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- (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 = $24.0 \text{ dm}^3 \text{ mol}^{-1}$)

(2)

Q1

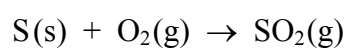
(Total 10 marks)



2. This question is about the manufacture of sulphuric acid, H_2SO_4 .

(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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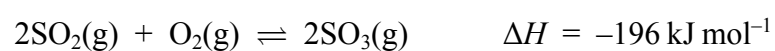
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(3)

(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)



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- (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)



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(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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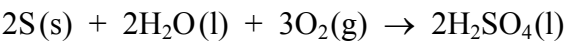
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(2)



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(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
H ₂ O(l)	-286
H ₂ SO ₄ (l)	-814

(2)

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

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(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)

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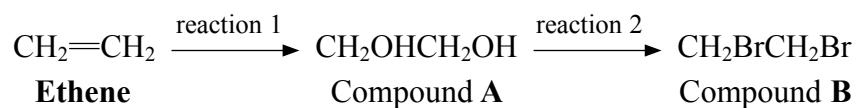
Q3



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



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

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(1)

(ii) Name compound **B**.

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(1)

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

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(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.

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(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.

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(2)

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

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(2)

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

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(1)

- (iv) Give the empirical formula for ethane.

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(1)

QUESTION 4 CONTINUES ON THE NEXT PAGE



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

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(1)

Q4

(Total 15 marks)

TOTAL FOR PAPER: 60 MARKS

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THE PERIODIC TABLE

1 2 3 4 5 6 7 0

Period

Group

1

1	H
Hydrogen	1

Molar mass g mol ⁻¹
Symbol
Name
Atomic number

4	He
Helium	2

7	Li	9	Be
Lithium	3	Beryllium	4
23	Na	24	Mg
Sodium	11	Magnesium	12

11	B	12	C	14	N	16	O	19	F	20	Ne
Boron	5	Carbon	6	Nitrogen	7	Oxygen	8	Fluorine	9	Neon	10
27	Al	28	Si	31	P	32	S	35.5	Cl	40	Ar
Aluminium	13	Silicon	14	Phosphorus	15	Sulphur	16	Chlorine	17	Argon	18

2

19	K	20	Ca
Potassium	19	Calcium	20

3

85	Rb	88	Sr
Rubidium	37	Strontium	38

4

45	Sc	48	Ti
Scandium	21	Titanium	22

5

89	Y	91	Zr
Yttrium	39	Zirconium	40

6

133	Cs	137	Ba
Caesium	55	Barium	56

7

223	Fr	226	Ra
Francium	87	Radium	88

106	Pd	108	Ag	112	Cd
Palladium	46	Silver	47	Cadmium	48

115	In	119	Sn	128	Te
Indium	49	Tin	50	Tellurium	51

127	I	131	Xe
Iodine	53	Xenon	54

204	Tl	207	Pb	210	Po
Thallium	81	Lead	82	Polonium	84

209	Bi	210	At	222	Rn
Bismuth	83	Astatine	85	Radon	86

63.5	Cu	65.4	Zn
Copper	29	Zinc	30

59	Co	59	Ni
Cobalt	27	Nickel	28

56	Fe	55	Mn
Iron	26	Manganese	25

52	Cr	51	V
Chromium	24	Vanadium	23

96	Mo	93	Nb
Molybdenum	42	Niobium	41

101	Ru	101	Tc
Ruthenium	44	Technetium	43

190	Os	186	Re
Osmium	76	Rhenium	75

184	W	181	Ta
Tungsten	74	Tantalum	73

178	Hf	178	Ti
Hafnium	72	Titanium	22

157	Gd	157	Nb
Gadolinium	64	Niobium	41

152	Eu	152	Sm
Europium	63	Samarium	62

144	Nd	144	Pm
Neodymium	60	Promethium	61

141	Pr	141	Ce
Praseodymium	59	Cerium	58

232	Th	232	Pa
Thorium	90	Protactinium	91

238	U	238	Np
Uranium	92	Neptunium	93

242	Pu	242	Am
Plutonium	94	Americium	95

243	Bk	243	Cm
Berkelium	97	Curium	96

251	Cf	251	Es
Californium	98	Einsteinium	99

253	Fm	253	Md
Fermium	100	Mendelevium	101

254	No	254	Lr
Nobelium	102	Lawrencium	103

256	Tm	256	Yb
Thulium	69	Ytterbium	70

167	Er	167	Lu
Erbium	68	Lutetium	71

163	Dy	163	Ho
Dysprosium	66	Holmium	67

159	Tb	159	Ho
Terbium	65	Holmium	67

157	Gd	157	Er
Gadolinium	64	Erbium	68

152	Eu	152	Tm
Europium	63	Thulium	69

144	Nd	144	Yb
Neodymium	60	Ytterbium	70

141	Pr	141	Lu
Praseodymium	59	Lutetium	71

140	Ce	140	Lu
Cerium	58	Lutetium	71