

233/2

CHEMISTRY

(Theory)

Mar. 2022 – 2 hours

Paper 2



Name Index Number

Candidate's Signature Date

Instructions to candidates

- Write your name and index number in the spaces provided above.
- Sign and write the date of examination in the spaces provided above.
- Answer all the questions in the spaces provided in the question paper.
- Non-programmable silent electronic calculators and KNEC mathematical tables may be used.
- All working must be clearly shown where necessary.
- This paper consists of 16 printed pages.
- Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.
- Candidates should answer the questions in English.

For Examiner's Use Only

Question	Maximum Score	Candidate's Score
1	11	
2	11	
3	11	
4	11	
5	13	
6	11	
7	12	
Total Score	80	



- (a) Table 1 gives the properties of two compounds, A and B.

Table 1

A	B
white, crystalline, efflorescent	white, crystalline, deliquescent

State and explain the observation made when each of the compounds is left exposed in air:

- (i) Compound A (2 marks)

changes from crystalline to a powder. ✓
 loses water of crystallisation. ✓

- (ii) Compound B (2 marks)

forms a solution. ✓
 Absorbs water vapour from atmosphere
 & dissolves. ✓

- (b) In an experiment to determine the formula of hydrated magnesium sulphate, a sample was heated in a crucible until a constant mass was obtained. The results are shown in Table 2.

Table 2

Mass of crucible	25.62 g
Mass of crucible + solid before heating	28.08 g
Mass of crucible + solid after heating	26.82 g

Using the information in Table 2, determine the formula of the hydrated salt

(Mg = 24.0; S = 32.0; O = 16.0; H = 1.0)

(3 marks)

	$MgSO_4$	H_2O
Mass(g)	1.20	1.26 ✓
Moles	$\frac{1.20}{120}$	$\frac{1.26}{18}$ ✓
	0.01	0.07 ✓
	0.01	0.01 ✓
	1	7 ✓
	$MgSO_4 \cdot 7H_2O$	✓

- (c) Figure 1 shows analysis of an alloy containing two metals.

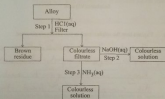


Figure 1

- (i) Give the name of another product formed in step 1. (1 mark)

Hydrogen gas, H_2 ✓

- (ii) Write the formula of the complex ion present in the colourless solution obtained in step 2. (1 mark)

$[Zn(OH)_4]^{2-}$ ✓

- (iii) Identify the metals in the alloy. (2 marks)

Zn ✓

Cu ✓

2. The flow chart in Figure 2 shows the processes involved in the manufacture of sulphuric(VI) acid.

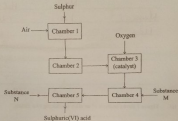


Figure 2

- (a) Explain how the sulphur used in this process is obtained. (2 marks)

Through Frasch process where pipes drilled into sulphur deposits. Superheated water pumped through external pipe to melt sulphur. Hot compressed air forced through the inner pipe to push molten sulphur through the middle pipe to the surface.

- (b) Give one advantage of using air in chamber 1 instead of using oxygen gas. (1 mark)

Air is cheap / economical / available

(c) Identify substances:

(i) M



(1 mark)

(ii) N



(1 mark)

(d) (i) In chamber 2, drying and purification take place. Give a reason why this is necessary.

(1 mark)

Impurities in the gas poison the catalyst ✓

(ii) The reaction in chamber 3 is highly exothermic.

I. Explain why high temperature is required for the reaction in chamber 3.

(1 mark)

to increase the rate of the rxn as the particles gain KE for successful collisions/frequent collisions. ✓

II. State how the heat produced in chamber 3 can be utilized in this process.

(1 mark)

Recycled to pre heat SO_2 and O_2 gases. ✓

(e) Give a reason why this method of manufacture is known as 'contact process'. (1 mark)

The formation of SO_3 in chamber 3 occurs when SO_2 and O_2 come into contact with each other on the surface of the catalyst. ✓

(f) Emission of gases in the sulphuric(VI) acid plant may lead to environmental pollution.

(i) State the evidence that could be used to show that the sulphuric(VI) acid plant causes pollution.

(1 mark)

corrosion of structural vegetation, shrubs, crops, stone building start wearing ✓

- (ii) Explain how the pollution identified in 2(i)(i) can be controlled. (1 mark)

Scrubbing the gases through NaOH , KOH , Ca(OH)_2
Recycling unused gases.

3. (a) Chemical reactions occur as a result of collisions of particles. Give a reason why not all collisions are effective. (1 mark)

Colliding particles may not possess sufficient
K.E. / activation energy //
Particula may not collide in the right orientation

- (b) State and explain how the following factors affect the rate of reaction:

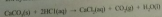
- (i) Surface area of reactants. (1 mark)

increase in SA of solid increases rate of rxn //
because more particles are exposed / available
resulting in collisional frequency / collisions.

- (ii) Pressure. (1 mark)

As pressure brings the molecules of
gaseous reactants closer to each other /
increases collisional frequency / rate of rxn //
decrease in vol of gas.

- (c) In an experiment to determine the rate of a reaction, marble chips were added to excess 2M hydrochloric acid. The equation for the reaction is:

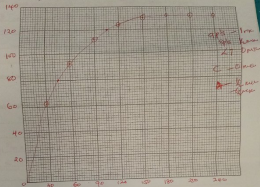


The volume of carbon(IV) oxide produced was measured at 25 °C and recorded after every 30 seconds. Table 3 shows the results obtained.

Table 3

Time (seconds)	0	30	60	90	120	150	180	210	240
Volume of CO_2 (cm^3)	0	62	92	115	124	130	132	133	133

- (ii) On the grid provided, plot a graph of volume of carbon(IV) oxide (vertical axis) against time (horizontal axis). (3 marks)



- (ii) Using the graph, determine the rate of reaction at the:

I. 45th second.

(1 mark)

tangent ✓

gradient of tangent ✓

II. 105th second.

(1 mark)

tangent at 105 ✓

gradient of tangent ✓

- (iii) Give a reason for the differences in the two rates.

(1 mark)

At 100th second the concentration of acid & mass of marble chips is less than at 40th second causing reduction in rate of reaction. A higher rate 40th than 100th. ✓

- (iv) Using the graph, determine the mass of marble chips that reacted

(2 marks)

(Ca = 40.0; C = 12.0; O = 16.0)

Molar gas volume at room temperature and pressure = 24000 cm³.

$$V_{\text{molar}} = 24000 \text{ cm}^3$$

$$? = 1330 \text{ cm}^3$$

$$\text{No. of moles} = \frac{1330 \text{ cm}^3}{24000} \Rightarrow 0.0554 \times 10^{-3} \text{ moles of CO}_2$$

$$\text{moles of CaCO}_3 = \text{moles of CO}_2 \Rightarrow 0.0554 \times 10^{-3} \text{ moles}$$

$$\text{PM} = 100 \text{ g}$$

$$0.0554 \times 10^{-3} \times 100 \text{ g}$$

$$\Rightarrow 0.0554 \text{ g} \quad \checkmark$$

4. (a) Sea water contains approximately 3% sodium chloride. Describe how sodium chloride is obtained from sea water. (3 marks)

put sea water in a beaker and boil (heat) / evaporate / heat a saturated solution.

Allow the water to evaporate. ✓

Crystals are formed. ✓

Some water is trapped in a solution & though to remove this a positive current is used to solidify the crystals and the liquid is allowed to drain out (and solid left is washed and dried).

- (b) The solubility of sodium chloride is 36.2 g in 100 g of water at room temperature. Determine the concentration in moles per litre of a saturated aqueous sodium chloride at room temperature ($\text{Na} = 23.0$, $\text{Cl} = 35.5$; density of water = 1.0 g cm^{-3}). (2 marks)

REL. NaCl \Rightarrow 23 + 35.5 \Rightarrow 58.5 ✓

100g water \Rightarrow 100cm³ of water.

36.2g = 100cm³

? = 1000cm³

$\Rightarrow \frac{36.2 \times 10}{100} \Rightarrow 36.2 \text{ g/l}$ ✓

concentration = 36.2

58.5

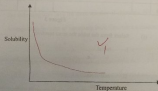
$\div 10 = 6.49 \text{ M}$ ✓

- (c) Ammonia is highly soluble in water.

- (i) Explain how aqueous ammonia is prepared starting with ammonia gas. (2 marks)

*Ammonia gas bubbled through concentrated fuming
sulfuric acid in water is a base. This is to
formate some ammonia solution.*

- (ii) On the axes provided, sketch a curve showing how solubility of ammonia gas varies with temperature. (1 mark)



- (iii) Give a reason for the shape of the curve.

(1 mark)

Solubility decreases with increasing temperature because the gases become more soluble and escape from solution.

- (d) Water hardness is due to the presence of magnesium and calcium ions. Explain how these ions get into sources of water.

(2 marks)

CO_2 dissolves in water to form carbonic acid. This acid reacts with the carbonate rocks of Mg or Ca in the rock. The water contains Ca^{2+} and Mg^{2+} .

5. (a) Figure 3 shows part of a Periodic Table.

						He			
Li	Be				N	O	F	Ne	
Na	Mg				Al	Si		Cl	Ar
K	Ca							Br	
Rb								I	
Cs									

Figure 3

- (i) Select from the table the most reactive:

(1 mark)

I. metal

Cs

II. non-metal

F

(1 mark)

- (ii) Select an element with the highest first ionisation energy.

(1 mark)

He

- (iii) I. Name the method used to obtain argon from its source. (1 mark)

Fractional distillation of liquid air

- II. Give one industrial use of argon. (1 mark)

For tungsten in the filament of a bulb.
In the manufacture of steel as an inert gas.

- (iv) Explain each of the following observations:

- I. The melting point of lithium is higher than that of potassium. (1 mark)

The metallic bonding in lithium is stronger than in potassium.

- II. The melting point of chlorine is lower than that of iodine. (1 mark)

Van der Waals forces are stronger in iodine than in chlorine // intermolecular forces.

- (v) The following ions have the same number of electrons: N^{3-} , Mg^{2+} , O^{2-} , Na^{+}

Arrange them in order of increasing ionic size. Give a reason for the order.

(2 marks)

Mg^{2+} , Na^{+} , O^{2-} , N^{3-}

Radius of positive decreases from Mg to Na
Radius of negative increases from O to N.
* N.

- (b) Use Table 4 to answer the questions that follow.

Table 4

Property	Substance			
	H	I	J	K
Melting point ($^{\circ}\text{C}$)	993	113	-38.9	-85
Boiling point ($^{\circ}\text{C}$)	1695	183	357	-60
Electrical conductivity at room temperature	Does not conduct	Does not conduct	Conducts	Does not conduct
Electrical conductivity in molten state	Conducts	Does not conduct	Conducts	Does not conduct

- (i) Identify the substance which is a gas at room temperature.

Give a reason.

(1 mark)

K. *bp below room temperature*

- (ii) Name the particles responsible for electrical conductivity in substance:

I. H

(1 mark)

ions

II. J

(1 mark)

electrons

- (iii) Identify the type of forces that hold the particles together in:

I. H

(1 mark)

Electrostatic forces / ionic bond / ionic lattice

II. K

(1 mark)

Weak van der Waals forces / intermolecular

6. Figure 4 shows a flow chart involving reactions of some organic compounds.

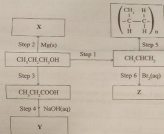


Figure 4

- (a) Write the formula and give the names of compounds:

(i) X

Name _____ Formula _____ (2 marks)

Magnesium propoxide *$(\text{CH}_3\text{CH}_2\text{CH}_2\text{O})_2\text{Mg}$*

(ii) Y

Name _____ Formula _____ (2 marks)

sodium propoxide *$\text{CH}_3\text{CH}_2\text{COONa}$*

(b) Give the reagents and conditions necessary for carrying out:

(i) Step 3.

(1 mark)

KMnO_4 / Aqueous $\text{K}_2\text{Cr}_2\text{O}_7$

Heat / warm / high temperature

(ii) Step 5.

(1 mark)

Propane

Catalyst
(Pt, Ni)
Zigzag line

High temperature / high pressure (2-400 atm)
(2-300-500 K)

(c) Step 1 can be carried out using concentrated sulphuric(VI) acid and heat. Name another reagent and conditions that can be used to carry out Step 1. (1 mark)

Al_2O_3 (Alumina) / Silicon acid / SiO_2

low / high temp

low / high

(d) Give the name of the type of reaction that takes place in:

(i) Step 1.

(1 mark)

hydration ✓

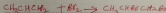
(ii) Step 5.

(1 mark)

polymerisation ✓

(e) (i) Write an equation for the reaction in step 6.

(1 mark)

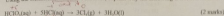


(ii) State the observations made in step 6.

(1 mark)

Bromine / orange bromine turns colourless

- (a) Using the oxidation numbers of chlorine, explain why the following is a redox reaction.



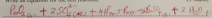
ON of Cl is $+3$ in HClO_2 , -1 in HCl and 0 in Cl_2 .
 Chlorine in HClO_2 is reduced from $+3$ to 0
 while chlorine in HCl is oxidised from -1 to 0 .

- (b) Use the following standard reduction potentials to answer the questions that follow:

	Half cell reactions	E°/V
I	$\text{PbSO}_4(\text{s}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s}) + \text{SO}_4^{2-}(\text{aq})$	-0.36
II	$\text{PbO}_2(\text{s}) + \text{SO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O}(\text{l})$	+1.69
III	$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
IV	$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
V	$\text{MnO}_4^{2-}(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	+1.51
VI	$\text{O}_2(\text{g}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2\text{O}_2(\text{aq})$	+0.68
VII	$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44
VIII	$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.34

- (i) The half cells I and II are combined to form an electrochemical cell.

- I. Write an equation for the cell reaction. (1 mark)



- II. Calculate the e.m.f of the cell. (1 mark)

$$E^\circ = +1.69 - (-0.36) \\ = +2.05 \text{ V}$$

- (ii) Draw a labelled diagram for the electrochemical cell formed using half cells III and IV. (3 marks)



- (iii) State and explain the observations made when a few drops of acidified potassium manganate(VII) are added to hydrogen peroxide. (3 marks)

Purple colour turns colourless. MnO_4^- is reduced to Mn^{2+} .
Bubbles of gas / effervescence / fizzing. H_2O_2 oxidised to oxygen gas.

- (iv) Coating iron with zinc is a more effective way of corrosion prevention than coating it with copper. Explain. (2 marks)

Zinc is more reactive than iron.
Iron is more reactive than copper.