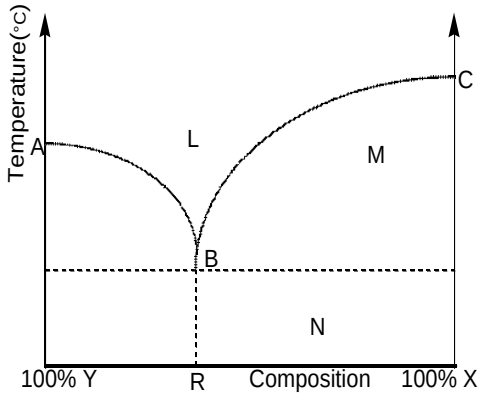
KAMSSA 2022 CHEMISTRY
PAPER 1

1. Beryllium, Magnesium & Calcium are **group II** elements.
   a) Write the general outer configuration of the elements. (01 mark)
   ……**ns^2** ✔……
   b) Each of these elements reacts with carbon to form a carbide. Write the equation for the reaction which occurs when each carbide reacts with water.
   ✔ (4½ marks)
   $MgC_2(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + 2HC{\equiv}CH(g)$ ✔
   $Be_2C(s) + 4H_2O(l) \rightarrow 2Be(OH)_2(aq) + CH_4(g)$ ✔✔
   $CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + 2HC{\equiv}CH(g)$ ✔✔

2. a) Complete the following nuclear reactions.
   i. $^{9}_{4}Be + \gamma \longrightarrow {}^{8}_{4}Be + {}^{1}_{0}n$ ✔ (01 mark)
   ii. $^{19}_{9}F + {}^{1}_{0}n \longrightarrow \ldots\ldots {}^{16}_{7}N \ldots$ ✔ $+ {}^{4}_{2}He$ (01 mark)
   b) It takes 5 days for 0.025mg of Bismuth-214 to disintegrate into 0.0125mg of Bismuth-210.Calculate the time required for 0.016mg Bismuth-214 to change into 0.001mg Bismuth-210. (03 marks)
   $In(\frac{No}{Nt}) = \Lambda t$ ✔ t= $In(\frac{0.016}{0.001} / 0.1386)$ ✔
   $\Lambda = In(\frac{0.025}{0.0125}) / 5$ ✔ t = 20 days
   $= 0.1386\ day^{-1}$

3. **Aluminium** and **Phosphorus** form compounds in the oxidation states of **3**.
   a) Briefly explain in terms of the electronic configuration why aluminum conducts electricity while all the common allotropes of phosphorus do not.
   (03 marks)
   … **Aluminium** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ has delocalized ✔ un paired electrons that free and mobile that conduct electricity ✔where as phosphorous P $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ its electrons in all its allotropes are localized ✔/ bound to the nucleus thus can not conduct electricity
   ……
   b) Write the equation for the reaction between each element with sodium hydroxide solution.
   (03 marks)
   $2\ Al(s) + 2OH^-(aq) + H_2O(l) \longrightarrow 2\ [Al(OH)_4]^-(aq) + 3H_2(g)$ ✔
   $2\ P_4(s) + 3OH^-(aq) + 3H_2O(l) \longrightarrow 3H_2PO_2^-(aq) + PH_3(g)$ ✔✔

4. The **temperature-composition** diagram for a system containing two components **X** and **Y** is shown below.



   a) State what each of the following represent. (½ marks@)
      i. Regions:
         L: liquid mixture ✔

M: solid X + liquid mixture ✓
N: solid X and solid Y (eutectic mixture). ✓

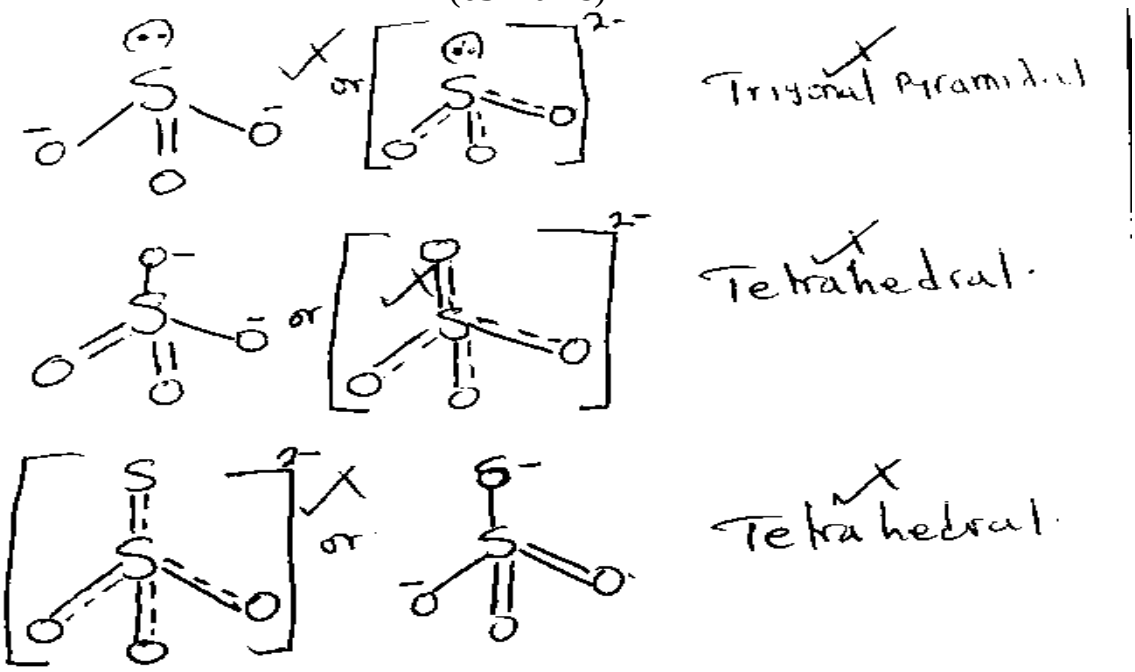
ii. Points:
A: freezing/ melting point of pure Y ✓
B: Eutectic ✓
C: freezing/ melting point of pure X ✓

iii. Curves:
AB: Variation in melting of Y with composition ✓
BC: Variation in melting of X with composition ✓

iv. State what would happen when a mixture of composition **R** is heated. (½ marks)

Its composition remains constant ✓

5. a) Draw the **structure** and name the **shape** of the following anions. (03 marks)



b) Name the reagent(s) which can be used to distinguish between SO_3^{2-} and SO_4^{2-} ions. State what would be observed.

Reagent(s): (01 mark)

Barium nitrate solution followed by dilute nitric acid ✓

Or Acidified potassium manganite (vii) solution

Observation(s): (01 mark)

SO_3^{2-} -white precipitate dissolves with effervescence of a colourless gas ✓
SO_4^{2-} -white precipitate insoluble in the acid
SO_3^{2-} -purple solution turns colourless
SO_4^{2-} - no observable change ……

6. Complete the following equations and in name the main organic product. (04 marks)

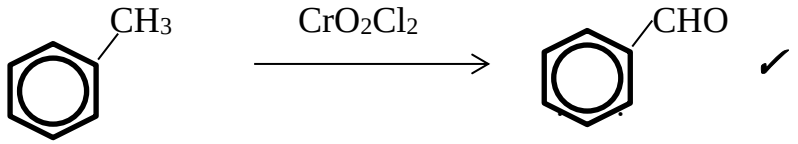
(a) $CH_3CH{=}C(CH_3)_2 \xrightarrow{H_3O^+ / \text{Warm}} CH_3CH_2COH(CH_3)_2$ ✓

Name: 2 – methylbutan-2-ol ✓

HBr

(b) —Br ⟶ —Br_2 ✔

Name: 1,1-dibromocyclohexane

(c) 

✔

Name: Benzanal/ Benzylaldehyde

(d) $CH_3C \equiv CH \xrightarrow{Br_2/H_2O} CH_3COCH_2Br$ ✔

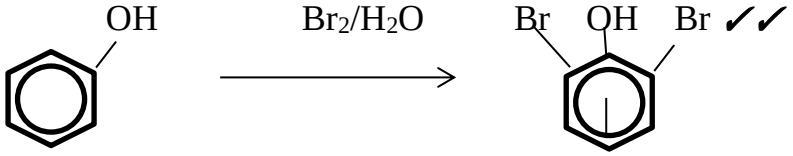
Name: 1-bromopropanone

7. **Phenol** was added to **bromine water**.

a) (i) State what **was observed**. (01 mark)

white precipitate ✔

(ii) Write an equation for the reaction. (1½ marks)



✔✔

b) Name a **reagent** which can be used to distinguish between phenol and cyclohexanol. State what would be **observed** if the reagent is treated with each compound.

Reagent: (01 mark)

Neutral iron (iii) chloride solution ✔

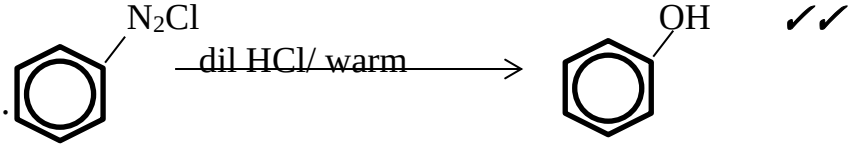
Or **acidified potassium manganite (vii) solution**

Observations: (01 mark)

Phenol violet coloration ✔ and cyclohexane no observable change with neutral iron (iii) chloride solution

Phenol no observable change and cyclohexane purple solution turns colourless with (acidified potassium manganite (vii) solution

c) Write an equation showing how phenol may be prepared from benzene diazonium chloride. (1½ marks)



✔✔

8. a) State **Graham's** law of gaseous diffusion. (01 mark)

The rate of diffusion of a gas is inversely proportional to the square root of its density at constant temperature and pressure.. ✔

b) Nickel forms a carbonyl; $Ni(CO)_n$. Deduce the **value of n** if carbon monoxide diffuses **2.46 times** faster than the carbonyl compound.

(03arks)

let the rate of diffusion of Ni(CO)4 be x. Mr of CO = (12+ 6)= 28

rate for CO IS 2.46x

from $\frac{R_{Ni(CO)n}}{R_{CO}} = \sqrt{\frac{Mr_{CO}}{Mr_{Ni(CO)n}}}$ ✔

$$\frac{x}{2.46x} = \sqrt{\frac{28}{Mr_{Ni(CO)n}}}$$

$Mr_{Ni(CO)n}$ = 169.4 ✔

58.7 + 28n = 169.44

28n = 110

n = 4✓

c) State the:

i. **Oxidation state** of Nickel in the compound. (0½ mark)

0✓

ii. **Co-ordination numbers** of Nickel in the compound. (0½ mark)

4✓

9 State what would be observed and write an equation between the following compounds and the reagent commonly used in identifying organic compounds.

a) Neutral iron (III) chloride and phenol. (02 marks)

Observation:

Violet colourarion/ purple colouration✓

Equation:

C_6H_5OH (l) + $FeCl_3$ (aq) $\longrightarrow$ $C_6H_5OFeCl_2$(s) + HCl(g) ✓

b) Sodium nitrite in presence of concentrated hydrochloric acid and ethyl methylamine. (02 marks)

Observation:

Oily yellow solution✓

Equation:

$CH_3CH_2NHCH_3 \xrightarrow{NaNO_3/conc\ HCl} CH_3CH_2N(CH_3)N{=}O$ ✓

c) Fehling's solution and ethanal. (02 marks)

Observation:

Reddish- brown precipitate ✓

Equation:

CH_3CHO (aq) + Cu^{+2}(aq) + ^{-}OH(aq) $\longrightarrow$ CH_3COO- + Cu2O(s) ✓

SECTION B (54 MARKS)

Attempt any **six** questions

10 a) A compound **Z** contains **19.15%** nitrogen, **43.5%** oxygen and the **rest** being manganese.

(i). Calculate the **empirical formula** of Z. (1½ marks)

%age of Mn = (100 – (19.15 + 43.3) = 37.35%

Elements	Mn	N	O
Moles	37.35/54.9	19.15/14	43/16✓
	=0.68	=1.37	=2.72
Mole ratio	0.68/ 0.68	1.37/ 0.68	2.72 /0.68✓
	=1	=2.0	=3.998
	1	2	4

Empirical formula is MnN_2O_4✓

(ii) **10.0g** of Z in **1000.0g** of water lowered to freezing point of water by **0.127°C**. Calculate the **molecular formula** of Z. (**K_f** for water is **1.86°C/mol/kg**) (02 marks)

0.127°C was caused by 10.0g

1.86°C was caused by (10 x 1.86)/ 0.127✓

146.46g

$(MnN_2O_4)n = 146.46 = 146.9n/146.9 = 146.46/146.9$

$n = 0.997, n = 1$ ✓ molecular formula is MnN_2O_4

b) **Z** was dissolved in water to form a **pink solution** and divided in to two parts. State would be **observed** and **write equation** for the reaction that took place when:

i. Acidified potassium manganite (VII) solution was added to the first part. (02 marks)

Observation:

Purple solution turns colourless ✓

Equation:

$2MnO_4^-(aq) + 6H^+(aq) + 5NO^{2-}(aq) \longrightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(l)$ ✓

ii. Concentrated nitric acid and lead (IV) oxide was added to the second part and the mixture boiled. (02 marks)

Observation:

Colourless solution purple ✓

Equation:

$Mn(NO_2)_2(aq) + PbO_2(s) + HNO_3(aq) \rightarrow HMnO_4(aq) + Pb(NO_3)_2(aq) + H_2O(l)$ ✓

11. a) Distinguish between **first electron affinity** and **first ionization energy** (02 marks)

First Electron Affinity is the heat energy evolved when one mole of electrons is added to one mole of isolated gaseous atoms of an element to form one mole of singly charged (univalent) gaseous anions (uninegatively charged gaseous ion ✓ while First ionization energy is the minimum amount of energy required to remove one mole of electrons from one mole of isolated/free gaseous atoms to form one mole of singly charged or univalent gaseous cations (unipositively charged gaseous ions) ✓

b) The first electron affinity of sodium is **-71kjmol^{-1}** while the electron affinity of magnesium is **+50.2kjmol^{-1}**. Explain. (03 marks)

The first electron for sodium $1s^2\ 2s^2\ 2p^6\ 3s^1$ is removed from a neither fully filled nor half filled orbital that are thermodynamically unstable thus with a strong aattraction for the electron to be added while Magnesium $1s^2\ 2s^2\ 2p^6\ 3s^2$ ✓ has a fully filled 2s orbital with two electrons which is thermodynamically stable ✓ and so it cannot accommodate the electron being added. The added electron is repelled by the stable 2s orbital electrons ✓

c) The table below shows the successive ionization energies of elements **R** and **Q**.

	Successive ionization energies(kjmol^{-1})							
Element	1st	2nd	3rd	4th	5th	6th	7th	8th
R	736	1450	7740	10500	13600	18000	21700	25600
Q	1060	1900	2920	4960	6280	21200	25900	30500

i. State the group in the periodic table to which **R** and **Q** belong (01 mark)

R (II)

Q (IV) ✓

ii. Write the equation for the reaction between (02 marks)

- **R** and oxygen

  $R(s) + O_2(g) \longrightarrow MO$ ✓
- **Q** and chlorine

  $Q(s) + 2Cl_2(g) \longrightarrow QCl_4(l)$ ✓

iii. Write an equation for the reaction between the chloride of **Q** and water (01 mark)

$QCl_4(l) + H_2O(l) \longrightarrow Q(OH)_4(s) + 4HCl(g)$ ✓

Or $SnCl_4(l) + 2H_2O(l) \longrightarrow QO_2(s) + 4HCl(aq)$

12. a). Define the following terms: (01 mark@)

(i) Lattice energy.

Is the heat absorbed when 1 mole of an ionic compound is broken into its constituent gaseous ions ✓

Or Is the heat liberated when 1 mole of an ionic compound is formed into its constituent gaseous ions.

(ii) Standard heat of formation of a substance.

Is the heat change that occurs when 1 mole of compound is formed from its constituent element in their standard states at standard temperature and pressure. ✓

b) The standard heat of formation of phosphorus trichloride is **-306KJ/mol**. The bond dissociation energy and enthalpy of atomization of chlorine and phosphorus are **314** & **242KJ/mol** respectively.

i. Draw a **Born-Haber** cycle for the formation of phosphorus trichloride. (02 marks)

$\frac{1}{4} P_4(s) + {}^3/_2 Cl_2(g) \xrightarrow{DH_{formation}} PCl_3(s)$

$DH = 242$ atm $Cl = {}^3/_2 x 314$ $DH_3 = ?$ ✓✓

$P(g) + 3Cl(g)$

ii. Use your cycle to calculate the P-Cl **bond energy**. (02 marks)

Enthalpy of formation = DH atm of P + DH atm of Cl_2 + DH_3

$306 = 242 + 3/2 \times 314 + DH_3$ ✓

$DH_3 = -1019\ Kjmol^{-1}$

For P – Cl $= -1019/3 = -339.67\ kjmol^{-1}$ ✓

iii. Calculate the standard heat of formation of ethane if the standard heats of combustion of graphite, hydrogen and ethane are **-403**,**-285** and **-1395 KJ/mol** respectively. 03 marks)

DHf of ethane = DHC of CO2 + DHC Of H2 +- DHC C2H6 ✓

= (-403 X2) + (-3 X 285) – (-1395) ✓

= -806 + – 855 – -1395

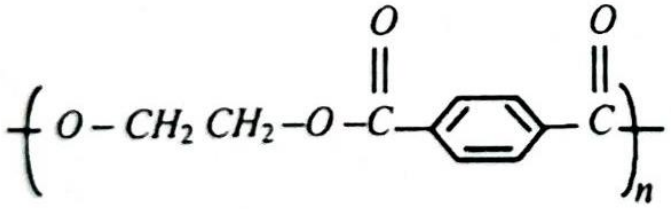
$= -266\ kjmol^{-1}$ ✓

13. a) Differentiate between addition and condensation polymers. (02 marks)

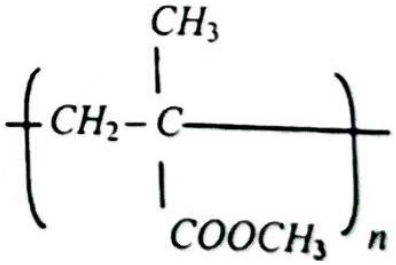
Addition polymers are polymers formed by repeated uniting of simple molecules(monomers) to form large molecules called polymers having same empirical formular as the monomers. ✓While are condensation polymers are polymers formed by repeated uniting of simple molecules(monomers) to form large molecules called polymers with loss of simple molecules . ✓

b) The structure formulae of two polymers **R** and **T** are shown below.

R



T



Name the polymer. (@01 mark)

i. R: Polyster ✔
ii. T: Polymethyl - 2 –methylpropenoate or perspex ✔

c).Write the structural formula (e) of monomer(s) of the polymers R and T respectively. (03marks)

R- ethan-1,2-diol ✔and benzene -1, 4- dioc acid ✔
T- Methyl-2-methylpropenoate ✔

d).Give one use of: (01 mark@)

i. R: Making plastic bottles, ropes, nets, clothes ✔
ii. T: Aeroplane window, lenses, packaging ✔

14. a) Write the name and formula of one ore from which aluminium can be extracted. (½ mark@)

Name:
Bauxite ✔
Formula of the ore:
$Al_2O_3.2H_2O$ ✔

b) (i). Describe how the ore is **purified.** (04 marks)

The ore is crushed, roasted ✔to convert iron (ii) to iron (iii) oxide
Then heated with concentrated sodium hydroxide, ✔aluminium oxide and silicon oxide dissolves leaving the basic iron (iii) oxide.

$Al_2O_3(s) + 3H_2O(l) + 2OH^-(aq) \longrightarrow 2\,Al(OH)_4^-(aq)$ ✔

The insoluble material are are filtered off. The filtrate is treated with carbon dioxide or seeded with aluminium hydroxide to precipitate out aluminium hydroxide which is then heated with to form pure aluminium oxide.

$Al(OH)_4^-(aq) + CO_2(g) \longrightarrow Al(OH)_3(s) + CO_3^{2-}(aq) + H_2O(l)$ ✔

$2Al(OH)_3(s) \longrightarrow Al_2O_3(s) + H_2O(l)$

(ii).Describe the reaction of aluminium metal with acids. (04 marks)

With hot dilute acids slowly to form aluminuim salt and hydrogen gas

$2Al(s) + 6H^+(aq) \longrightarrow 2\,Al^{3+}(aq) + 3H_2(g)$ ✔

With hot concentrated acids rapidly with sulphuric acid aluminium forms salt, sulphur dioxide and water, does not react with concentrated nitric acid.

$2Al(s) + 6H_2SO_4(l) \longrightarrow Al_2(SO_4)_3(aq) + 3SO_2(g) + H_2O(l)$ ✔

15. Compound **F** contains **62.1%** carbon, **10.3%** hydrogen, the rest being oxygen.

a) Calculate the **empirical formula of F**. (03 marks)

%age of O = 100 – (62.1 + 10.3) = 27.6% ✔

Elements	C	H	O
Moles	62.1/12	10.4/1	27.6/16
	=5.2	=10.4 ✔	=1.725
Mole ratio	5.2/ 1.725	10.4/ 1.725	1.725/1.725
	=3.014	=6.028	=1
	3	6	1

Empirical formula C_3H_6O ✓

b) **F** distils in steam at **98°C** and **1.01 X 10^5Nm^2**.If the vapour pressure of water at **98°C** is **9.5 X 10^4Nm^2**.

i. Calculate the **molecular mass of F** if the distillate contained **16.67%** by mass of **F**. (02 marks)

Let the total mass be X

$$\frac{mass\ of\ F}{Mass\ of\ water} = \frac{molar\ mass\ of\ F\ x\ vapour\ pressure\ of\ F}{Molar\ mass\ of\ water\ x\ vapour\ pressure\ of\ water}$$ ✓

$\frac{16.67}{100-16.67} = \frac{Mr\ x\ (101000-95000)}{18\ x\ 95000}$. ✓

$\frac{16.67}{83.33} = \frac{6000Mr}{1710000}$ ✓

Mr = 57

ii. Determine the **molecular formula** of F. (01 mark)

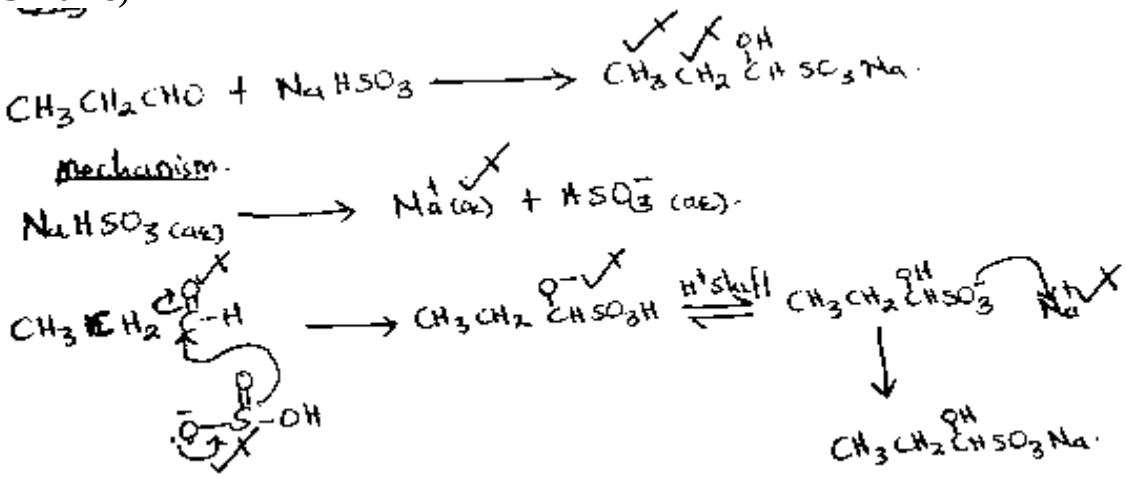
$(C_3H_6O)n = 57$ ✓

(58) n = 57

n = 0.98, = 1

Molecular formula C_3H_6O ✓

c) **F** formed a grey precipitate when treated with ammoniacal silver nitrate. Write **equation** and outline a **mechanism** for the reaction between F and sodium hydrogen sulphite solution. (03 marks)



16. When heated, carbon dioxide gas decomposes according to the equation below.

$2CO_{2(g)} \rightleftharpoons 2CO_{(g)} + O_{2(g)}$, $\Delta H = -ve$

If at a certain temperature and **1 atmospheric pressure**, **60%** of the original carbon dioxide **gas remained undissociated**.

a) Calculate the **equilibrium constant, Kp** for the reaction. (05 marks)

Species	CO_2	CO	O_2
Initial moles	2	0	0
Equilibrium moles	2 – 0.4=1.6 ✓	2x 0.4	2x0.4 ✓
Equilibrium partial pressure	$\frac{1.6}{2.8}x1$	$\frac{0.8}{2.8}x\ 1$ ✓	$\frac{0.4}{2.8}x1$
	=0.571	=0.286	= 0.143

$K_P = \frac{P_{CO}^2 . P_{O2}}{P_{CO2}^2}$ ✓

$K_P = \frac{(0.286)2\ .0.143}{0.571^2}$ ✓

$K_P = 0.358$ atm

b) State and explain the effect of:

i. Increasing the pressure to **2 atmospheres** on the equilibrium concentration of oxygen gas. (02 marks)

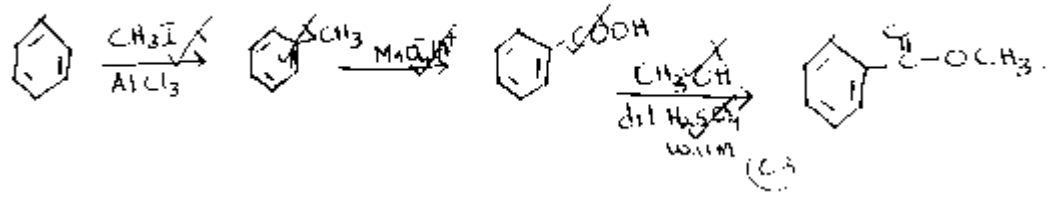
An increase in pressure shifts the equilibrium position from right to left ✓ i.e the backward reaction is favoured thus oxygen molecules react with carbon monoxide to form carbon dioxide. ✓

ii. Carrying out the decomposition at a lower temperature on the value of the equilibrium constant, Kp. (02 marks)

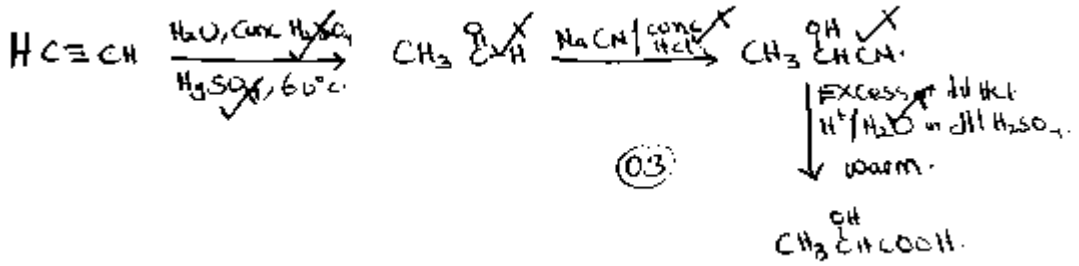
An increase in temperature favours the backward reaction ✓ i.e it shifts the equilibrium position from right to left thus an increase in temperature results into a decrease in the value of equilibrium constant because the amount of products is lower than that of reactants ✓

17. Write equations to show how the following compounds can be synthesized and in each case indicate the conditions of reaction.

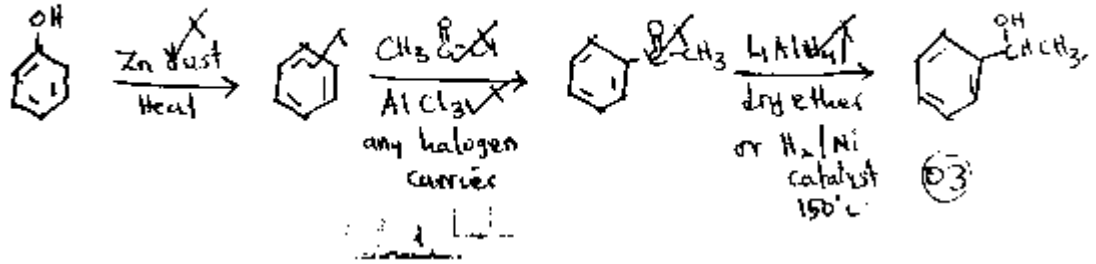
(a) Methylbenzoate from benzene (03 marks)



(b) 2-hydroxypropanoic acid from ethyne (03 marks)



(c) 1-phenylethanol from phenol (3marks)



THE PERIODIC TABLE

1	2											3	4	5	6	7	8
1.0 H 1																1.0 H 1	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	20.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.4 Cl 17	40.0 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52.0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.7 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	98.9 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 TI 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

139 La 57	140 Ce 58	141 Pr 59	144 Nd 60	147 Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	162 Dy 66	165 Ho 67	167 Er 68	169 Tm 69	173 Yb 70	175 Lu 71
227 Ac 89	232 Th 90	231 Pa 91	238 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	254 Es 99	257 Fm 100	256 Md 101	254 No 102	260 Lw 103

END