

# PROPOSED GUIDE

NAME..... INDEX NO.....

PS25/1  
CHEMISTRY  
Paper I  
2½ hours

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## ACEITEKA JOINT MOCK EXAMINATIONS, 2023

Uganda Advanced Certificate of Education

CHEMISTRY

PAPER I

2 hours 45 minutes

### INSTRUCTIONS

Answer all questions in section A and six questions in section B.

Any extra question answered will not be marked.

All questions must be answered in the spaces provided.

The Periodic Table with relative atomic masses will be

provided. Illustrate your answers with equations where

applicable. Molar gas constant:  $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$

Molar volume of gas at s.t.p is 22.4 litres

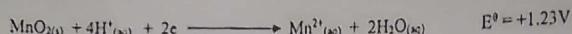
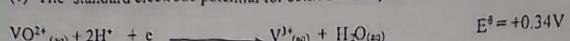
Molar volume of gas at room temperature is 24 litres.

For Examiners Use Only

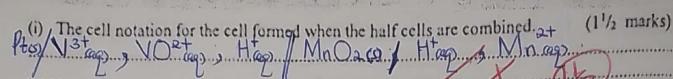
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
5½	4½	6½	5½	4½	6½	5½	0½	0½	0½	0½	0½	0½	0½	0½	0½	0½	0½

SECTION A

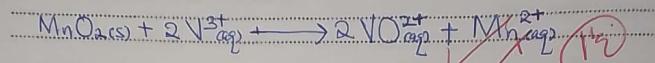
(1) The standard electrode potential for some redox systems are shown below;



(a) Write



(ii) The overall equation for the reaction. (1½ marks)



(b) (i) Calculate the e.m.f of the cell in (a). (1½ marks)

$$E_{\text{cell}} = E_{\text{right}} - E_{\text{left}} \\ = 1.23 - 0.34 \\ = +0.89\text{V}$$

(ii) State whether the cell reaction in (a)(ii) is feasible or not.

Give a reason for your answer. (1 mark)

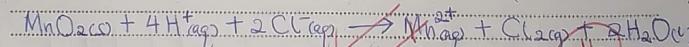
The cell reaction is feasible since e.m.f of the cell is positive.

(2) (a) To a mixture of manganese (IV) oxide and solid sodium chloride was added a few drops of concentrated sulphuric acid and the mixture warmed.

(i) State what was observed.

A brown solid dissolves forming a colourless solution and bubbles of a greenish-yellow gas.

(ii) Write equation for the reaction that took place. (1½ marks)

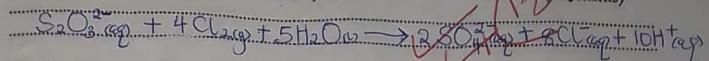


(b) Excess of the gaseous product formed in (a) was bubbled through aqueous solution of sodium thiosulphate.

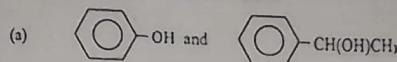
(i) State what was observed.

A pale greenish-yellow gas dissolves forming a colourless solution.

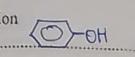
(ii) Write equation for the reaction that took place. (1½ marks)

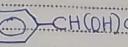


(3) Name the reagent that can be used to distinguish between the following pair of compounds. State the observations made.



Reagent Neutral iron(III) chloride solution. (1 mark)

Observation with  : Purple/violet colouration. (2 marks)

with  : No observable change. (0)

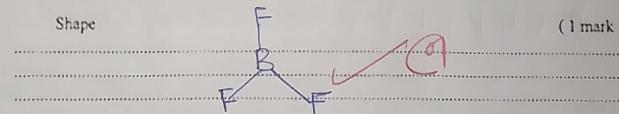
(b) CH<sub>3</sub>CH<sub>2</sub>CHO and CH<sub>3</sub>COCH<sub>2</sub>CH<sub>3</sub>

Reagent Ammonical silver nitrate solution and warm. (1 mark)

Observation with CH<sub>3</sub>CH<sub>2</sub>CHO : Silver mirror deposit. (2 marks)

with CH<sub>3</sub>COCH<sub>2</sub>CH<sub>3</sub> : No observable change. (0)

(4) (a) Draw and name the shape of boron trifluoride.



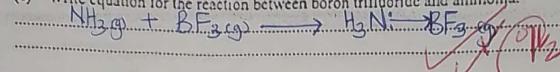
Name of the shape Trigonal planar. (1½ mark)

(b) Comment on polarity of boron trifluoride and explain your answer. (2½ marks)

Boron trifluoride is non-polar.  
Boron trifluoride has a trigonal planar shape in which the dipole moments of (polarized) of the boron-fluorine bond cancel out since the boron-fluorine bonds are symmetrically arranged.

2½

(c) Write equation for the reaction between boron trifluoride and ammonia. (1 mark)



(d) Vegetable oils are used as raw materials in manufacture of soap.

(i) Explain what is meant by the term vegetable oil. (1 mark)  
It is an ester of propane-1,2,3-triol and a long chain carboxylic acid obtained from plants.

Q1

(ii) Name any one source from which vegetable oil can be obtained. (1/2 mark)

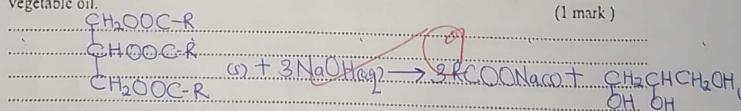
Sunflower

1/2

(iii) Describe briefly how soap is obtained from vegetable oil. (2 marks)  
Vegetable oil is boiled with excess concentrated sodium hydroxide solution while stirring until the oil completely dilutes to form a saturated solution.  
Concentrated sodium chloride solution is added to salt out soap.  
Soap is skimmed off, purified and dried.

Q2

(iv) Write general equation for the reaction leading towards formation of soap from vegetable oil. (1 mark)



(6) (a) Explain what is meant by the term order of a reaction. (1 mark)  
It is the sum of powers to which the molar concentrations of reactants are raised in an experimentally determined rate equation.

Q1

(b) The rate equation for a reaction between substances A, B and C is in the form; Rate =  $k[A]^x[B]^y[C]^z$

Experiment	Initial concentration of A (mol l <sup>-1</sup> )	Initial concentration of B (mol l <sup>-1</sup> )	Initial concentration of C (mol l <sup>-1</sup> )	Initial rate (mol l <sup>-3</sup> s <sup>-1</sup> )
1	0.10	0.20	0.20	$8.0 \times 10^{-5}$
2	0.10	0.05	0.20	$2.0 \times 10^{-5}$
3	0.05	0.10	0.10	$1.0 \times 10^{-5}$
4	0.10	0.10	0.10	$2.0 \times 10^{-5}$

Use the data in the table to determine the order of reaction with respect to A, B and C respectively.

(1½ marks)

(i) A  
Expt 3 ÷ Expt 4

$$\frac{(0.05)^x (0.1)^y (0.1)^z}{(0.1)^x (0.1)^y (0.1)^z} = \frac{1.0 \times 10^{-3}}{2.0 \times 10^{-5}} \therefore \text{The reaction is first order with respect to A}$$

$$\left(\frac{1}{2}\right)^x = \left(\frac{1}{2}\right)^1 \quad \text{Circled 'x'}$$

$$x = 1 \quad \checkmark$$

(ii) B  
Expt 1 ÷ Expt 2

$$\frac{(0.1)^x (0.2)^y (0.2)^z}{(0.05)^x (0.1)^y (0.2)^z} = \frac{8.0 \times 10^{-5}}{2.0 \times 10^{-3}} \therefore \text{The reaction is first order with respect to B}$$

$$4^y = 4 \quad \text{Circled 'y'}$$

$$y = 1 \quad \checkmark$$

(iii) C  
Expt 2 ÷ Expt 3

$$\frac{(0.1)^x (0.05)^y (0.2)^z}{(0.05)^x (0.1)^y (0.1)^z} = \frac{2.0 \times 10^{-5}}{1.0 \times 10^{-3}} \therefore \text{The reaction is first order with respect to C}$$

$$2^z = 2 \quad \text{Circled 'z'}$$

$$z = 1 \quad \checkmark$$

(c) Determine the value of rate constant  
Using expt 1

(1 mark)

$$8 \times 10^{-3} = K(0.1)(0.1)(0.2)$$

$$K = \frac{8 \times 10^{-3}}{(0.1)^2 \times 0.2} = 4 \text{ mol}^{-2} \text{ L}^2 \text{ s}^{-1}$$

Q1

(7) (a) Explain what is meant by the term first ionization energy. (1 mark)

I.e. the minimum amount of energy required to remove one mole of electrons from one mole of gaseous atoms to form one mole of unipositively charged gaseous ions.

Q2

(b) The first, second, third and fourth ionization energies of element M are; 800, 2400, 3700 and 25000 KJ mol<sup>-1</sup> respectively.

State and explain the trend in variation in ionization energies of element M. (2½ marks)

Ionization energy increases from the first to the fourth. Even after ionisation, the number of electrons decreases but the number of protons remains constant which decreases screening effect but nuclear charge remains constant.

As a result, the effective nuclear charge increases which increases the nuclear attraction towards the remaining electrons. This causes an increase in the energy needed to remove the next electron.

(c) (i) State the type of bond and structure that exists in the chloride formed by element M.

Type of bond Ionic bond / Electrovalent bond (½ mark)

Structure Giant ionic structure (½ mark)

(ii) Give reason for your answer in (c).

The chloride of M is formed by transfer of electrons from an atom of M to chlorine atom.

Q3

(8) Lithium and magnesium show similarities in some of their chemical properties however their carbides react differently with water.

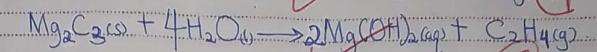
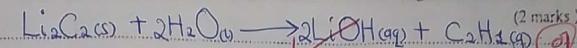
(a) State reasons why the chemical properties of lithium resemble that of magnesium.

Lithium and magnesium atoms have similar atomic radii. (1½ marks)

Lithium ion and magnesium ion have similar charge density and polarising power.

Lithium and magnesium atoms have similar electro negativity.

(b) Write equations for the reactions of carbides of lithium and magnesium with water.



(9) (a) (i) State Graham's law of gaseous diffusion.

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

(ii) Compound T with formula  $\text{Ni}(\text{CO})_x$ , takes 46 minutes to diffuse through a porous medium. An equal volume of oxygen takes 19.90 minutes to diffuse through the same medium under the same conditions. The vapour density of T is 85.35.

Accept

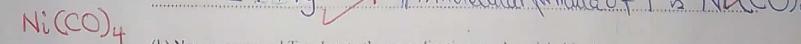
Determine the molecular formula of T. (3 marks)

$$\frac{\text{Ni}(\text{CO})_x}{\text{O}_2} = \frac{\text{Mr}_T}{\text{Mr}_{\text{O}_2}}$$

$$58.7 + 28x = 170.7$$

$$x = \frac{112}{28}$$

$$x = 4$$



Molecular formula of T is  $\text{Ni}(\text{CO})_4$ .

(b) Name compound T and state the co-ordination number of nickel in the compound.

Name Tetra carbonyl nickel (O) (1½ marks)

Co-ordination number. 4 (1½ marks)

## SECTION B

(10) (a) Explain what is meant by the term steam distillation. (1 mark)

~~The technique of isolating a volatile component which is immiscible with water from its non-volatile impurities at a temperature below the boiling point of each component by bubbling steam through the mixture.~~

(ii) Compound Y contains carbon, hydrogen and nitrogen. On analysis of 0.86g of compound Y produced 5.28g of carbon dioxide and 224cm<sup>3</sup> of nitrogen measured at s.t.p. Determine the empirical formula of Y.

Element : C H N			
mass	1.44	0.14	0.28
molar	1.44	0.14	0.28
	12	1	14
male ratio	0.12	0.14	0.02
	0.12	0.14	0.02
	0.02	0.02	0.02
mass of H <sub>2</sub>	0.28	0.14	0.28
	0.28	0.14	0.28
Empirical formula of Y is C <sub>6</sub> H <sub>7</sub> N	6	7	1

(b) A mixture of compound Y and water was steam distilled. The mixture boiled at 96°C at 760 mm Hg. The saturated vapour of water at 96°C is 722 mm Hg. The distillate contains 78.61% by mass water. Determine the;

(i) molecular mass of Y

$$\frac{\text{mass of } Y}{\text{mass of H}_2\text{O}} = \frac{M_{\text{Y}}}{M_{\text{H}_2\text{O}}} \quad (2 \text{ marks})$$

$$\frac{100 - 78.61}{78.61} = \frac{(760 - 722) \text{ mm Hg}}{722 \times 18}$$

$$n = \frac{93}{93} = 1$$

$$M_{\text{Y}} = 722 \times 18 \times 21.39 = 93 \quad \therefore \text{Molecular formula of Y is C}_6\text{H}_7\text{N}$$

(ii) molecular formula of Y.

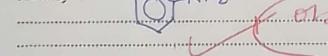
$$(C_6H_7N)_n = 93 \quad (1 \text{ mark})$$

$$(12 \times 6)n + 7n + 14n = 93$$

$$n = 93/93 = 1 \quad \therefore \text{molecular formula of Y is C}_6\text{H}_7\text{N}$$

(c) (i) Compound Y forms white precipitate with bromine water.

Identify Y

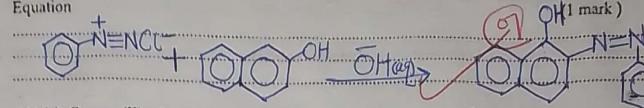


Accept  
phenylamine  
Rej: Aniline

(ii) Cold concentrated hydrochloric acid and sodium nitrite was added to compound Y and to the resultant solution was added naphthalen-2-ol in presence of sodium hydroxide solution. State what was observed and write equation for the reaction that takes place between the resultant solution and 2-naphthalen-2-ol.

Observation Red precipitate is formed ✓ (1/1 mark)

Equation ✓ (1 mark)



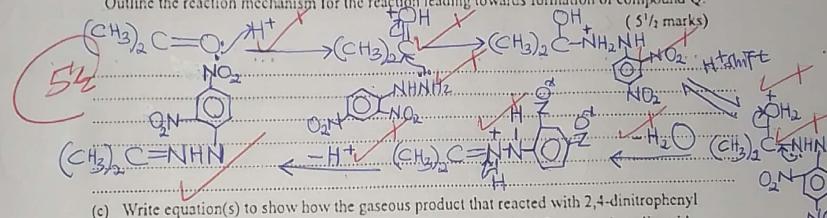
(11) (a) Copper (II) ethanoate was strongly heated until there was no further change.

(i) State what was observed A green solid turns to a black residue (1 mark)

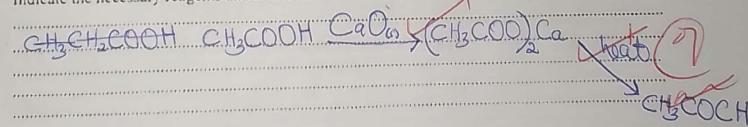
(ii) Write equation for the reaction that took place. (CH<sub>3</sub>COO)<sub>2</sub>Cu(OH)<sub>2</sub> → CuO(s) + CO<sub>2</sub>(g) + CH<sub>3</sub>COCH<sub>3</sub>(l) (1 1/2 marks)

(b) When the gaseous product formed in (a) was passed through 2,4-dinitrophenyl hydrazine in acidic media a compound Q was formed. (1/2)

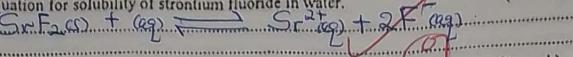
Outline the reaction mechanism for the reaction leading towards formation of compound Q.



(c) Write equation(s) to show how the gaseous product that reacted with 2,4-dinitrophenyl hydrazine in acidic media to form compound Q can be synthesized from a carboxylic acid. Indicate the necessary reagents and conditions. (1 mark)



(12) (a) Strontium fluoride is a sparingly soluble salt.  
(i) Write equation for solubility of strontium fluoride in water. (1 mark)



(ii) Write the expression for solubility product of strontium fluoride. (1 mark)

$$K_{sp} = [\text{Sr}^{2+}][\text{F}^-]^2$$

(b) The solubility of strontium fluoride in water at 25°C is 0.109 g dm<sup>-3</sup>.

Calculate the solubility product of strontium fluoride  
 $M_w(\text{SrF}_2) = 87.6 + 19 \times 2$   
 $= 125.6$

molal of  $\text{SrF}_2$  in 1 L =  $(0.109)$   
 $(125.6)$   
 $= 8.6783 \times 10^{-4}$  mol dm<sup>-3</sup>

$$[\text{Sr}^{2+}] = 8.6783 \times 10^{-4} \text{ mol dm}^{-3}; [\text{F}^-] = 2 \times 8.6783 \times 10^{-4} \text{ mol dm}^{-3}$$

(c) Calculate the solubility of strontium fluoride in 0.1M aqueous solution of strontium nitrate (1/2 marks)

Let solubility of  $\text{SrF}_2$  in  $\text{Sr}(\text{NO}_3)_2$  be  $y$ .  
 $[\text{Sr}^{2+}] = y + 0.1$

But since  $yK < 0.1$ ,  $y + 0.1 \approx 0.1$

$$\Rightarrow [\text{Sr}^{2+}] = 0.1 \text{ M}$$

$$[\text{F}^-] = 2y$$

(d) State and explain what would happen to the solubility of strontium fluoride when

potassium fluoride is added.

Solubility would decrease since a common ion, fluoride ion is added which suppresses the ionization of strontium fluoride.

(e) State one application of solubility product. (1/2 marks)

Used to determine the Used to predict precipitation of hydroxides.

(13) (a) A compound R contains by mass 90.66% lead and the rest oxygen. Molar mass of compound R is 684.9.

(i)	Determine the empirical formula of R.	(2 marks)
	Empirical formula of $\text{O}_2 = (100 - 90.66) = 9.34\%$	
	Element Pb O	
	Composition : 90.66 9.34	Smallest ratio : 0.438 0.584
	Moles : $\frac{90.66}{207} \quad \frac{9.34}{16}$	$0.438 \quad 0.438$
	$= \frac{0.438}{0.438} \quad \frac{0.584}{0.438}$	$(1.333) \times 3$
		3 4
		$\text{Pb}_3\text{O}_4$
		(Empirical formula of R is $\text{Pb}_3\text{O}_4$ )

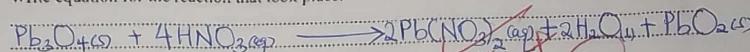
(ii) Calculate the molecular formula of R.

$$\begin{aligned} (\text{Pb}_3\text{O}_4)_n &= 684.9 \\ (207 \times 3)n + (16 \times 4)n &= 684.9 \\ n &= \frac{684.9}{685} = 1 \end{aligned}$$

Molecular formula of R is  $\text{Pb}_3\text{O}_4$

(b) Compound R was warmed together with dilute nitric acid until there was no further change.

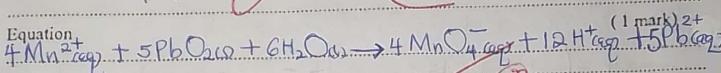
Write equation for the reaction that took place. (1½ mark)



(c) The mixture formed in (b) was filtered and the residue was added to aqueous solution of manganese nitrate then followed by concentrated nitric acid.

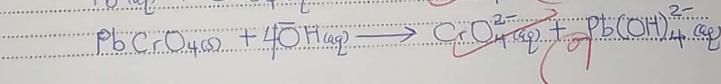
State what was observed and write equation for the reaction that took place.

Observation: A purple solution is formed (1½ mark)



(d) To the filtrate obtained in (c) was added ammonium chromate solution followed by sodium hydroxide solution. State what was observed and write equation(s) for the reaction(s) that took place.

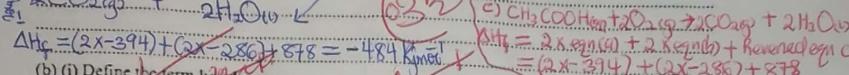
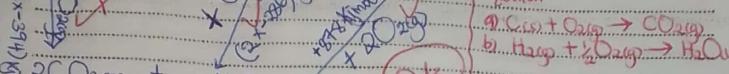
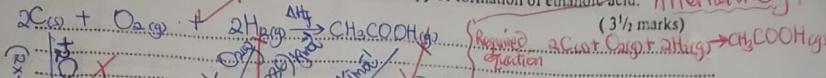
Observation: A yellow precipitate soluble in sodium hydroxide solution (1 mark)



(14) (a) (i) Explain what is meant by the term enthalpy of formation. (1 mark)

~~Is the enthalpy change that occurs when one mole of a compound is formed from its constituent elements in their normal physical states at 1 atmosphere and 298 K.~~

(ii) Given that the heat of combustion of carbon, hydrogen and ethanoic acid are; -394, -286 and -878 respectively. Calculate the enthalpy of formation of ethanoic acid. Alternatively,



(b) (i) Define the term bond energy.

~~If the energy absorbed when one mole of covalent bonds is broken into its free gaseous atoms~~ (1 mark)

OR If the energy given out when one mole of covalent bonds is formed from its constituent gaseous atoms.

(ii) The enthalpies of atomization of carbon, oxygen and hydrogen are; 721, 249 and 218 KJ mol<sup>-1</sup> respectively while the bond energies of C-C, C=O, C-O and O-H are; 347, 743, 358 and 463 KJ mol<sup>-1</sup> respectively.

Use the information given above to calculate the bond energy of C-H in ethanoic acid in (a) ii.

$$\Delta H_f = \sum B.E_{(bonds \ broken)} + \sum B.E_{(bonds \ formed)} \quad (3\frac{1}{2} \text{ marks})$$

$$\begin{aligned} \Delta H_f &= 2(721) + 2(249) + 2(218) + (-347 + -743 + -358 + -463 + 3(C-H)) \\ &= -484 \end{aligned}$$

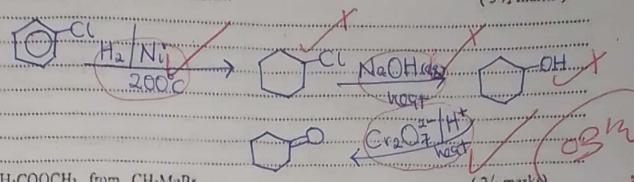
$$3(C-H) = 216 + 484$$

$$\begin{aligned} (C-H) &= \frac{700}{3} \\ &= -233.3 \text{ KJ/mol} \end{aligned}$$

(15) Write equations to show how the following synthesis can be carried out. In each case indicate the necessary conditions and reagents.

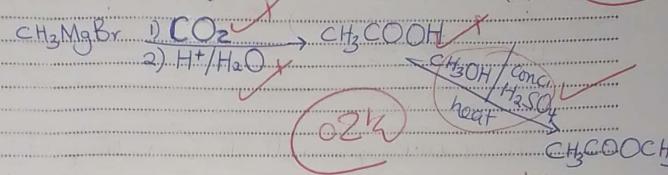
(a) Cyclohexanone from chlorobenzene.

(3½ marks)



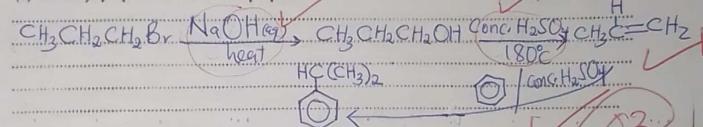
(b)  $\text{CH}_3\text{COOCH}_3$  from  $\text{CH}_3\text{MgBr}$ .

(2½ marks)



(c) 2-Phenyl propane from 1-bromo propane.

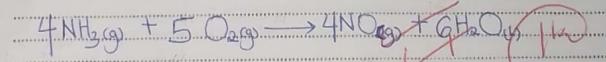
(3 marks)



(16) (a) During manufacture of nitric acid ammonia is catalytically oxidized.

(1½ marks)

(i) Write equation for the reaction.



(ii) Name the catalyst used.

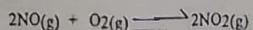
Platinum (½ mark)

(iii) State other two specific optimum conditions employed.

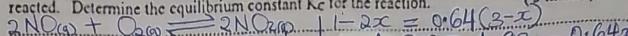
(1 mark)

500°C  
200 atmospheres

(b) 1 mole of nitrogen monoxide gas formed in (a) was heated together with 2 moles of oxygen in one litre closed vessel and the reaction that took place is as shown below;



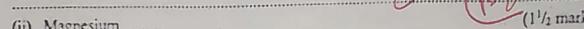
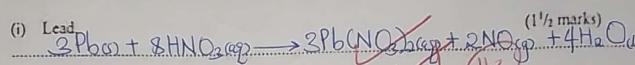
When equilibrium was attained it was established that 36% of the nitrogen monoxide had reacted. Determine the equilibrium constant  $K_c$  for the reaction. (3 marks)



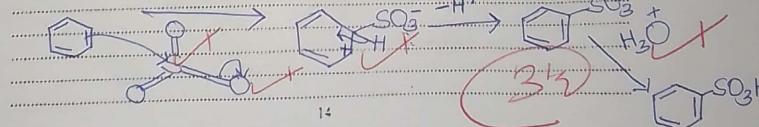
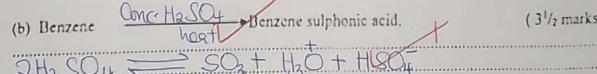
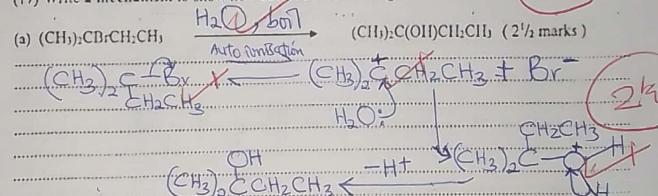
Initial moles	1 mole	2 moles	$\text{O}_2$	$1-2x$	$1-2x = 0.64(3-x)$
If $x$ moles reacted:	$-2x$	$-x$	$+2x$	$1-2x$	<i>Ignore since moles reacted are negative.</i>
Equilibrium moles:	$(1-2x)$	$(2-x)$	$+2x$	$1-2x$	<i>marks transferred</i>

Equilibrium concentration:	$\frac{1-2x}{V}$	$\frac{2-x}{V}$	$\frac{2x}{V}$	$\frac{1-2x}{V}$
At equilibrium	$\frac{1-2x}{(1-2x+2-x+2x)}$	$= \frac{1-2x}{(1-2x+2-x+2x)}$	$\text{NO}_2$	$\text{O}_2$

(c) Write equation for the reaction of warm moderately concentrated nitric acid with;

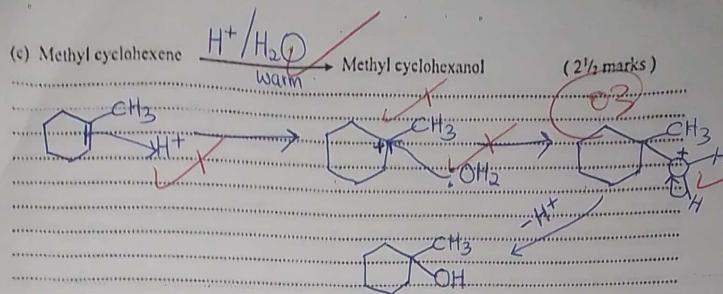


(17) Write a mechanism to show how each of the following conversions can be effected



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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 Sa 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54		
133 Cs 55	137 Ba 56	139 La 57	178 Lif 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 Tl 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Ra 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 Tb 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		