PRESIDENT'S OFFICE
REGIONAL ADMINISTRATION AND LOCAL GOVERNMENTS
SAME AND MWANGA SECONDARY SCHOOLS EXAMINATION SYNDICATE (SAMWASSES)

FORM SIX PRE - MOCK EXAMINATIONS - 2022
CHEMISTRY 01
MARKING SCHEME

1. a) i) Excited state - Is the state of an atom when some of its electron(s) move from lower energy level to higher energy level after gaining heat energy.

   ii) Quanta – Is the minimum amount of energy emitted from the heated metal surface.

   iii) Hydrogen spectrum – Is the electromagnetic radiation emitted by the electron of excited hydrogen while coming to a normal state.

   iv) Line spectrum – Is the spectrum that consists of arrow brightly coloured, parallel lines on a dark background emitted by a low pressurized glowing gas.

$Total\ @\ 00\frac{1}{2} = 02\ marks$

b) i)

n	3									
l	2									
ml	-2		-1		0		+1		+2	
ms	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$

$\therefore The\ total\ number\ of\ electron\ is\ 10.$

ii)

n	4													
l	3													
ml	-3		-2		-1		0		+1		+2		+3	
ms	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$

$\therefore The\ total\ number\ of\ electron\ is\ 14.$

iii)

n	5	
l	0	
ml	0	
ms	$\frac{+1}{2}$	$\frac{-1}{2}$

$\therefore The\ total\ number\ of\ electron\ is\ 2.$

iv)

n	3					
l	1					
ml	-1		0		+1	
ms	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$	$\frac{+1}{2}$	$\frac{-1}{2}$

$\therefore The\ total\ number\ of\ electron\ is\ 6.$

$Table\ @\ 00\frac{1}{2} = 02\ marks$

$Final\ answer\ @\ 00\frac{1}{2} = 02\ marks$

c) Data;

$\lambda = 397.2nm = 397.2\times10^{-9}m$

$n = 2$

$R_H = 1.09678\times10^{7}m^{-1}$

$from\ \ \frac{1}{\lambda} = R_H\left(\frac{1}{n_1^{2}} - \frac{1}{n_2^{2}}\right)$

$\frac{1}{397.2\times10^{-9}} = 1.09678\times10^{7}\left(\frac{1}{n^2} - \frac{1}{2^2}\right)$

$\frac{2.5176\times10^{6}}{1.09678\times10^{7}} = \frac{1}{n^2} - \frac{1}{4}$

$0.2295 + \frac{1}{4} = \frac{1}{n^2}$

$n = \sqrt{0.4795} \approx 1$

$\therefore The\ electron\ begin\ from\ n = 1$ $\quad 02\ marks$

d) $n = 4$ $\quad l = 0$ $\quad ml = 0$ $\quad ms = \frac{+1}{2}$ $\quad 02\ marks$

2. a)

i) When salt is added into water to form a solution, the boiling point of pure water is slightly raised because the salt particles occupy the intestinal space between water and molecules, thus increasing the force of attraction among the molecules in the solution. $(01\ mark)$

ii) * The osmotic pressure of a solution is directly proportional to the concentration of the solute.

$\pi \propto c \quad where\ \pi = osmotic\ pressure$

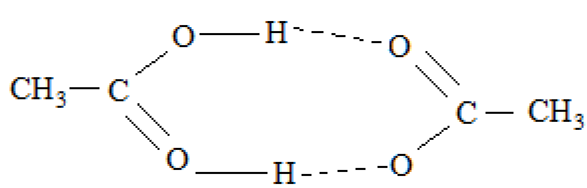
$c = concentration$

* The osmotic pressure of a solution is directly proportional to the absolute temperature

$\pi \propto T$

* The total number of moles of different solute in the same amount of solvent has the same osmotic pressure $(01\ mark)$

iii) * The osmotic pressure method is not enough for determining the relative molecular mass of ethanoic acid in a concentrated solution due to the fact that the method is applicable for non associating solutes, but ethanoic acid has a tendency of existing as dimmers



* Osmotic pressure is applicable when the solution is very dilute. $(01\ mark)$

b) i) Data given

$Mass\ of\ solute\ (w_s) = 22.5g$

$Mass\ of\ solvent\ (w_o) = 450g$

$Molar\ mass\ of\ solute\ \left(m_s\right) = 342g/mol$

$Kf_{\left(H_2O\right)} = 1.86K/molkg$

$Freezing\ point\ of\ depression$

$from\ \ \Delta T_f = \frac{Kf\times w_s}{m_s\times w_o}\times 1000$

$\Delta T_f = \frac{1.86\times 22.4}{342\times 450}\times 1000$

$\Delta T_f = 0.2719°C\ \ (01\ mark)$

Freezing point of the solution
Data;

$F - P_{\left(H_2O\right)} = 0°C$

Therefore

$F.p_{(solution)} = F.p_{\left(H_2O\right)} - \Delta T_f\ \ \ (01\ mark)$

$= (0 - 0.2719)°C$

$=- 0.2719°C$

$\therefore Freezing\ point\ of\ solution\ is\ - 0.2719°C\ \ \ \ (02\ marks)$

ii) The ice will separate first from the solution of cane sugar because it has small freezing point $(- 0.2719°C)$ then the solution of potassium iodide $(chloride)$ $(- 0.048°C)$ $(03\ marks)$

3. a) i) Boyle's law states that The volume of a fixed mass of a gas is inversely proportional to the pressure at constant temperature $(01\ mark)$

$V\propto\frac{1}{P}$

ii) Charles law states that At constant pressure the volume of a fixed mass of the given gas is directly proportional to the absolute temperature $(01\ mark)$

$V \propto T$

b) i) Adding / filling air into tires increases the number of gas particles in the tires, as the result collision of the particles with each other and with the inside walls of the tire causes the pressure to increase. Because of increasing the mass of air particles in the tire is the case of variable mass, hence in this case the pressure is not inversely proportional to volume. $(01\ mark)$

ii) At constant temperature, when the volume of the gas molecules increases, the gas molecules are said to have more space to move. Hence collision between gas molecules or with the wall of the container happens less, often the pressure decreases and vice versa. This is the basis of Boyle's law. $(01\ mark)$

c) i) – The term is added to the observed pressure because the pressure expected or ideal behavior is greater than the real gas pressure under identical conditions.

- The term is subtracted from the volume of the container because real gases have volume of their own. Hence the actual volume for free movement of real gas particles is volume of the container (ideal gas) minus the total volume of all gas molecules. $(01\ mark)$

ii) Real gases are most ideal at high temperature and low pressure.

iii) $n = 0.5mol,\ V = 1L,\ \ T = 298K$

$a = 1.390atmL^2/mol^2$

$b = 0.0391L/mol$

$R = 0.0821atm\left(mol^{-1}K^{-1}\right)$

$$\left[P + a\left(\frac{n}{V}\right)^2\right](V - b) = nRT$$

$$\left[P + 1.39\frac{(0.5)^2}{1^2}\right](1 - 0.5\times0.039)$$

$$P + 0.3475 = \frac{0.5\times0.0821\times298}{1-0.0195}$$

$$P + 0.3475 = 12.476$$

$$P = 12.13atm$$

d) No, carbon dioxide gas has large molecular weight compared to hydrogen. Hence it diffuses through porous pore more slowly compared to hydrogen gas.

4. a) i) The system does not undergo any observable changes
- The rate of forward reaction and reversible reaction are equal
- The system is closed $\left(01\frac{1}{2}\ marks\right)$

ii)

Influence	Equilibrium constant	Equilibrium position
Change in pressure	No changes	Changes
Change in temperature	Changes	Changes
Additional of catalyst	No changes	No changes

$\left(04\frac{1}{2}\ marks\right)$

b) Data given

$V = 40L,\ P = 1atm,\ T = 25°C = 298K,\quad R = 0.0821kg/mol\,atm^{-1}K^{-1}$

$from\ PV = nRT$

$n = \frac{PV}{RT}$

$n = \frac{1\times40}{0.0821\times298} = 1.64moles$

The partial pressure of oxygen in 5L containing

$= \frac{nRT}{V} = \frac{1.64\times0.0821\times298}{5}$

$P'_{O_2} = 8atm$

For helium gas

$V = 12L,\ P = 1atm,\ T = 25°C = 298K,\quad R = 0.0821kg/mol\,atm^{-1}K^{-1}$

$from\ PV = nRT$

$n = \frac{PV}{RT}$

$n = \frac{1\times12}{0.0821\times298} = 0.491 moles$

$P_{He} = \frac{nHe \cdot RT}{V} = \frac{0.491\times0.0821\times298}{5}$

$P_{He} = 2.4 atm$

From Dalton’s law of partial pressure

$P_T = P_{O_2} + P_{He}$

$P_T = 8.0 + 2.4$

$P_T = 10.4 atm$ (04 $marks$)

Hence pressure in tank is $10.4 atm$

5. a) i) On strong heating ethyne reacts with two moles of hydrogen to form ethane in the presence of metallic catalyst like nickel / platinum

$H - C{\equiv}C - H + 2H_2 \quad Pt\ /\ Ni \ \rightarrow_{200°C} \ CH_3CH_3$

ii) At low temperature and dark place, ethyne reacts with two moles of chlorine to produce 1, 1, 2, 2, $tetrachloroethane$

$H - C{\equiv}C - H + 2Cl_2 \quad temp \ \rightarrow_{dark\ place} \ CHCl_2CHCl_2$

iii) Two moles of sodium in ammonia reacts with ethyne to produce disodium ethynide

$H - C{\equiv}C - H + 2Na \quad NH_3 \ \rightarrow Na - C{\equiv}C - Na$ (03 $marks$)

b) Structural formula of ethanol is

$H_3C \quad \backslash \quad C \quad / \ H \ = O$

Since two moles are produced

$H_3C \quad \backslash \quad C \quad / \quad H \;= O + O = \; CH_3 / C \quad \backslash \quad H \quad \rightarrow S\left(CH_3 - C = {}^{H|} \; C_{H|} -\right.$

The possible structure formula of S is $CH_3 - CH = CH - CH_3$ $(01\ mark)$

c) i) Volume of hydrocarbon $C_xH_y = 20cm^3$

Initial volume of oxygen = $140cm^3$

Volume of carbon dioxide absorbed by $NaOH$

$= 110 - 30 = 80cm^3$

Volume of oxygen reacted = $140 - 30 = 110cm^3$

From

$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \quad \rightarrow xCO_2 + \frac{y}{2}H_2O$

For x

$x\left(volume\ of\ C_xH_y = volume\ of\ CO_2\right)$

$20x = 80$

$x = 4$

For x

Volume of oxygen used up

$\left(x + \frac{y}{4}\right) \times volume\ of\ C_xH_y$

$110 = \left(x + \frac{y}{4}\right)20; \quad x = 4$

$4 + \frac{y}{4} = 5.5$

$y = 6$

The molecular formula of $A = C_4H_6$ $(03\ marks)$

ii) When hydrocarbon $A(C_4H_6)$ reacts with ammoniacal copper (I) chloride the compound C_4H_5Cu is formed.

$C_4H_5 + CuCl(NH_3) \rightarrow C_4H_5Cu$

$ie\ \ CH_3 - CH_2 - C{\equiv}CH + CuCl(NH_3) \rightarrow CH_3 - CH_2 - C{\equiv}C - Cu + HCl$

- When compound C_4H_5Cu is reacted with water in the presence of sulphuric acid and mercury (II) Sulphate compound $B(C_4H_8O)$is formed

$C_4H_5Cu + H_2O \quad H_2SO_4 / HgSO_4 \rightarrow C_4H_7OH \rightleftharpoons C_4H_8O$

$ie\ \ CH_3 - CH_2 - C{\equiv}C - Cu + H_2O \quad H_2SO_4 \underset{HgSO_4}{\rightarrow} CH_3 - CH_2 - C_{||\,CH_2} - OH \rightleftharpoons CH_3 - CH_2 - C_{|\,CH_3}$

Hence, structural formula of;

$A = CH_3CH_2 - C{\equiv}CH$

$B = CH_3 - CH_2 - C_{|\,CH_3} = O$ $(03\ marks)$

6. a) The heat of formation of a compound is always constant and is independent of the rate passed during formation of that compound but only depends on the initial and final values $(01\ mark)$

b) i) Standard heat of formation is heat change when one mole of a compound is formed from the constituent elements in their natural state at standard condition

$eg\ \ H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)} \quad \Delta H_f =- 286KJ/mol$

ii) Standard bond dissociation energy is the amount of heat required to break one mole of dissociation molecules into gaseous atoms at standard conditions

$Cl_{2(g)} \rightarrow 2Cl_{(g)}$ $(03\ marks)$

c) Using

$\Delta H_r = \sum \Delta H_f product - \sum \Delta H_f reactant$

$- 643.1 = 2\Delta H_f\left(AlCl_3\right) - \Delta H_f\left(AlCl_6\right)$

$- 732 = \Delta H_f(HCl) - \Delta H_f(HCl)$

$\Delta H_f(HCl) = \frac{-184.11}{2} J/mol =- 92.05KJ/mol$

$Substituting\ \Delta H_f(HCl) =- 92.05KJ/mol$

$- 73.2 = \Delta H_f(HCl) - 92.05$

$\Delta H_f(HCl) =- 165.25KJ/mol$

$from$

$- 1003 = 2\Delta H_f\left(AlCl_3\right) - 6\times(- 165.25)$

$from\ which\ \Delta H_f\left(AlCl_3\right) =- 997.25KJ/mol$

Then,

$- 643.1 = 2\times - 997.25KJ/mol \qquad - \Delta H_f\left(Al_2Cl_6\right)$

$\Delta H_f\left(Al_2Cl_6\right) =- 1351.4KJ/mol$

$\therefore The\ formation\ of\ Al_2Cl_6\ is\ - 1351.4KJ/mol$ (07 $marks$)

7.

i) Alkali metals carbonates are stable on heating than alkali earth metal carbonates although in both cases thermal stability increase with increase in size of the metal ions.
   - Lithium carbonates and alkali earth metal carbonates decomposes on heating into metal oxide and carbon dioxide

$eg\ \ Li_2CO_3 \quad \rightarrow_{\Delta} Li_2O_{(s)} + CO_{2(g)}$

$CaCO_3 \quad \rightarrow CaO + CO_2$

- All other alkali metals do not decompose on heating

$eg\ \ Na_2CO_3 \quad \rightarrow_{\Delta} No\ reaction$

ii) Potassium nitrates reacts with conc sulphuric acid to produce nitric acid which in terns reacts with iron (II) sulphate to give nitrogen monoxide

$KNO_3 + H_2SO_4 \quad \rightarrow KHSO_4 + HNO_3$

$Then$

$2NO_3 + 6FeSO_4 + 3H_2SO_4 \quad \rightarrow 2Fe\left(SO_4\right)_3 + 4H_2O + 2NO$

The nitrogen monoxide produced reacts with some of the remaining iron (II) sulphate to form a dark brown complex $FeSO_4{\cdot}NO$ $(Brown\ ring)$

iii) Aluminium have an empty orbital hence $AlCl_3$ reacts with water by accommodating the lone pair of electrons from water giving a complex compound of aluminium

$AlCl_{3(s)} + 6H_2O \quad \rightarrow \left[Al\left(H_2O\right)_5OH\right]^{2+} + HCl$

- On the other hand, sodium have no empty orbital to accommodate lone pair of electrons from water, hence there is no reaction between $NaCl$ and H_2O instead $NaCl$ dissolves in water giving a neutral solution

$NaCl + H_2O \quad \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

iv) When exposed to air, aluminium forms a strong protective oxide layer over its surface.

$4Al + 3O_2 \quad \rightarrow 2Al_2O_3 \quad (Protective\ coat)$

The protective layer so formed is strong such that conc. Nitric acid cannot break it hence there is no reaction between Al_2O_3 and conc HNO_3. This explains why conc HNO_3 can be kept in aluminium containers.

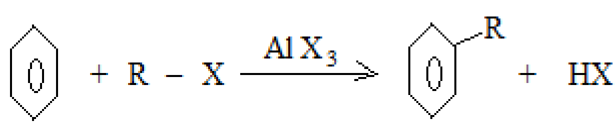
v) $AlCl_3$ is a covalent compound, therefore in its solid or molten state ionized partially to form few free ions which are not sufficient to carry electric charge. But in solution form it undergo hydrolysis to yield HCl which ionizes full to H^+ and Cl^- ions with enough capacity to carry electric charge

$$AlCl_3 \rightleftharpoons Al^{3+} + 3Cl^-$$

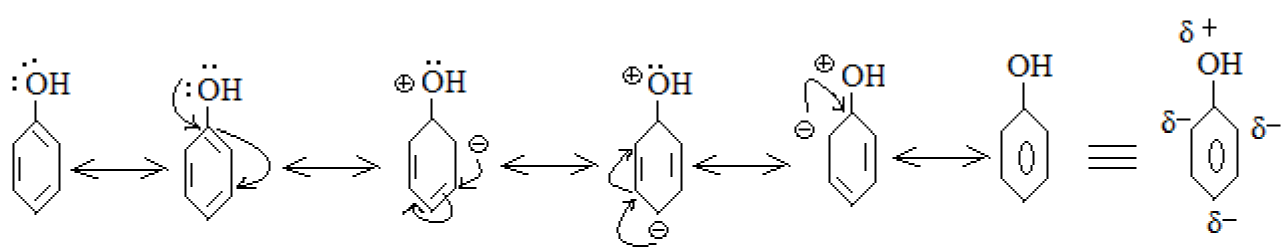
$$H_2O \quad \rightleftharpoons \quad OH^- \downarrow Al(OH)_3 \quad + \quad H^+ \downarrow HCl$$

$(10\ marks\ \ @\ 02 marks)$

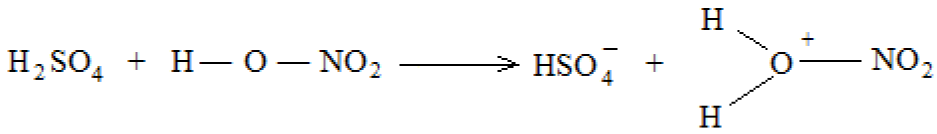
8. a) i) Friedel craft alkylation is the side electrophilic substitution reaction which adds alkyl group to the benzene ring in the presence of Lewis acid catalyst

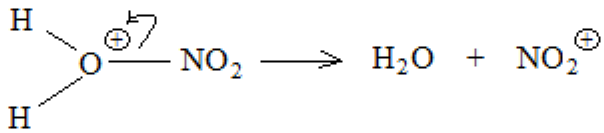


ii) Mesomeric movement is the movement of electron pair within a molecule from one place to another and back to the original place

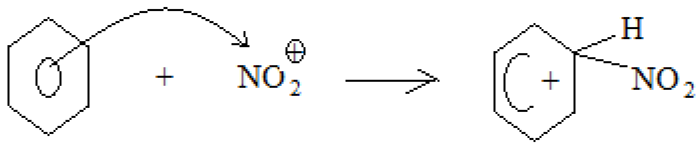


b) Protonation of the HNO_3 to liberate the electrophile

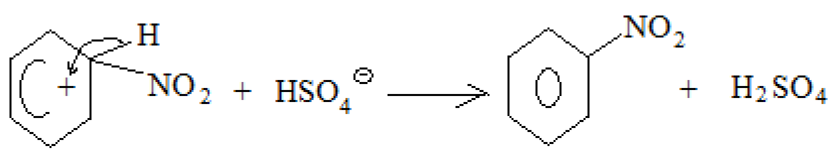




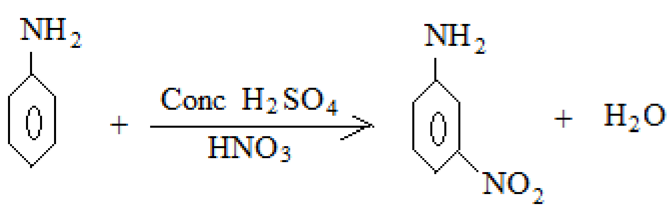
The electrophile formed attacks the benzene ring



Re generation of the H_2SO_4

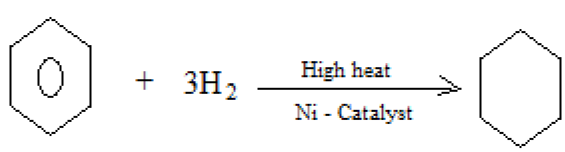


c) i) The ammino group in benzene (aniline) gets protonation to NH_3 group by concentrated sulphuric acid. The NH_3 is the metal directiony group and deactivating group.



Main product (95%)

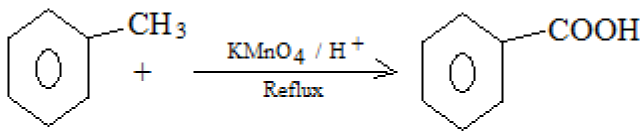
ii) In benzene the $C - C$ π-bond show extra stability due to mesomerism and delocalization effect. High heat is required to overcome this extra stability.



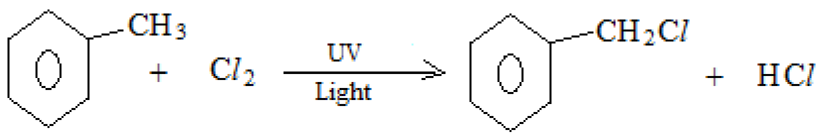
- On the other hand, the $C - C$ π-bonds in hexene are local. Local $C - C$ π-bonds are weak, unstable hence can break down at just small amount of heat like the radiation energycasted by the sun.

$$CH_3 - CH = CH - \left(CH_2\right)_2 - CH_3 + H_2 \quad Ni \quad \rightarrow CH_3 - CH_2 - CH_2 - CH_2 - CH_2 - CH_3$$

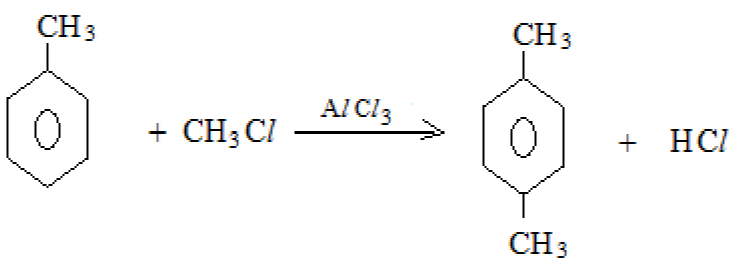
d) i) It will be oxidized into benzoic acid



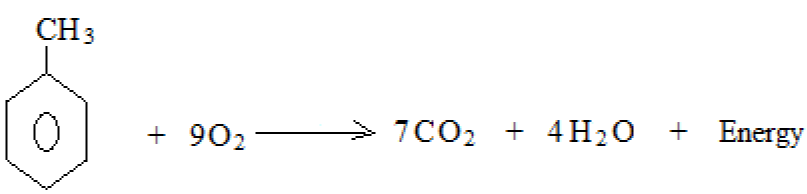
ii) It will undergo free radical substitution reaction at the methyl group to form benzyl chloride



iii) It will undergo Friedel craft methylation to form 2,4 – dimethyl benzene



iv) It will burn to form carbon dioxide and water



$(15\ marks)$

9. a) i) $CH_3CH_2 - \underset{|\,OH}{CH}CH_3$

ii) $CH_3 - CH_2 - CH_2 - CH_3$

iii) $CH_3 - CHCl - CHCl - CH_3$

iv) $CH_3CHClCH(OH)CH_3$

v) $4CO_2 + H_2O$

b) i) $CH_3C\left(CH_3\right)_2CH = CHCH_3$

Correct → 4,4 – dimethyl – 2 – pentene

ii) $CH_3C(CH_3)_2CH(CH_3)CH_3$

Correct→ 2,2,3 – trimethyl butane

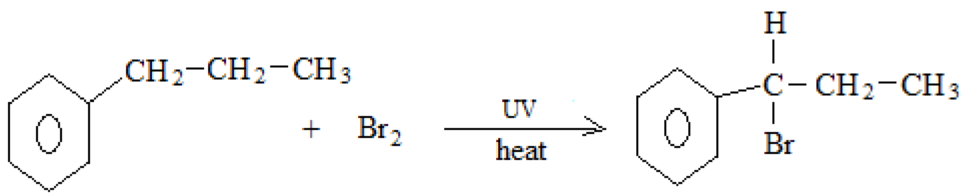
iii) $CH_3CH(CH_3)CH_2CH = CHCH_3$

Correct IUPAC name; 5 – methyl – 2 – hexane

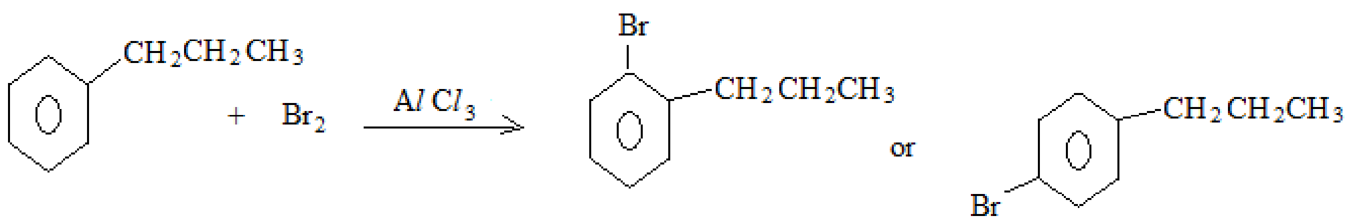
iv) $CH_3CH_2CH(C_2H_5)CH(CH_3)CH_3$

Correct→ 3 – ethyl – 2 – methyl pentane

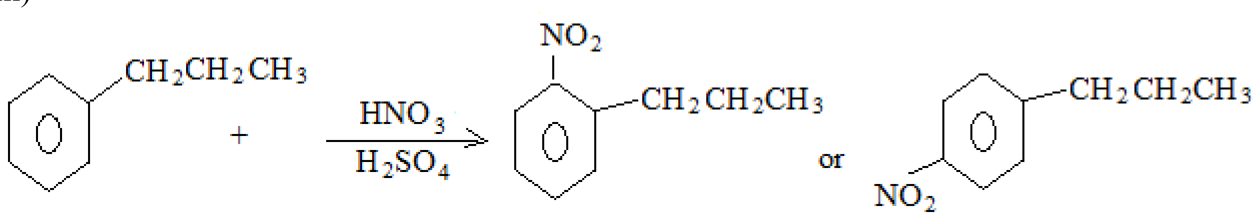
c) i)



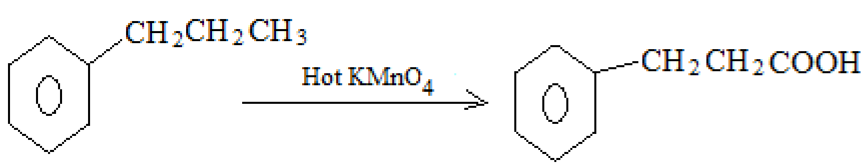
ii)



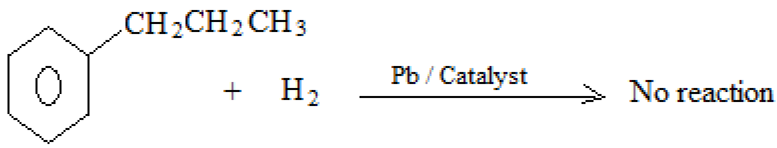
iii)



iv)



v)



* The ring is very strong for these conditions (much more vigorous treatment is required to reduce it via additional reactions) so no reaction occurs

d) $SO_3 + Conc.\,H_2SO_4 \rightleftharpoons S^+O_3H + HSO_4^-$

$(15\ marks)$

10. a) i) Neutralizing value is the capacity of liming materials to neutralize the acidity expressed as percentage by mass of pure calcium carbonate $(01\ mark)$

ii) Agronomic practice is the process of growing plants in the soil or land. $(01\ mark)$

iii) Percentage base saturation is the percentage of the amount of the total exchangeable bases present in the total cation exchange capacity of the soil $(C.E.C)$ $(01\ mark)$

b) Soln

Data given

$Molar\ mass\ of\ Ca(OH)_2 = 74gmol^{-1}$

$Molar\ mass\ of\ CaCO_3 = 100gmol^{-1}$

$Gram\ of\ CaCO_3\ equivalent\ to\ 100g\ of\ lime - x$

$Since\ 1mole\ of\ Ca(OH)_2 \equiv 1mole\ CaCO_3$

$Then,\ 1mole\ of CaCO_3 \equiv 1mole\ of CaCO_3$

$If\ 74gmol^{-1}\ of\ Ca(OH)_2 = 100gmol^{-1}\ of\ CaCO_3$

$100gmol^{-1}\ of\ Ca(OH)_2 = x$

$$x = \frac{100gmol^{-1} \times 100g}{74gmol^{-1}} = 135g$$

But

$$NV = \frac{grams\ of\ pure\ CaCO_3\ to\ 100g\ of\ lime}{100g\ of\ CaCO_3}$$

$$NV = \frac{135g}{100g} \times 100\% = 135\%$$

$Therefore,\ neutralizing\ value\ of\ Ca(OH)_2\ is\ 135\%$ (04 $marks$)

c) Soln

$PBS = 60\% = 0.6$

Recalling

$$PBS = \frac{\sum EB}{C.E.C} \times 100\%$$

$$0.6 = \frac{x}{x+8}$$

$$x = 0.6(x + 8)$$

$$x = 0.6x + 4.8$$

$$\frac{0.4x}{0.4} = \frac{4.8}{0.4} = 12$$

$x = 12$ (02 $marks$)

Then,

$C.E.C = x + 8 \quad where\ x = 12$

$C.E.C = 12 + 8 = 20me$

$\therefore The\ total\ cation\ exchange\ of\ the\ soil\ sample\ is\ 20me$ (03 $marks$)

d) i) The two institutions are;

- The National Environment Management Council ($NEMC$)
- Tanzania Forest Research institute ($TAFORI$) ($01\ mark$)

ii) The effect of water pollution

- Eruption of diseases
- Death of aquatic species
- Bad smell
- Decline of agriculture activities

$(Any\ 4\ =\ 02\ marks)$