TANZANIA HEADS OF ISLAMIC SCHOOL COUNCIL (TAHISCO)

INTER ISLAMIC MOCK EXAMIMNATION

CHEMISTRY 01

MARKING SCHEME 2026

1. (a) Dalton's atomic theory is primitive due to the following amendments
   (i) Atoms are made up of sub-atomic particles called electrons, protons and neutrons
   (ii) Atoms can be created or destroyed by nuclear reactions (nuclear fission and fussion)
   (iii) Atoms of the same element may have different atomic masses, called isotopes
   (iv) Atoms do not necessarily combine in simple whole number ratios
   01mark @ =04 marks

   (b) Spacing between lines in the hydrogen spectrum decrease as one goes away from the nucleus because the energy difference between energy levels have almost the same energy since they experience lesser nucleus attractive forces. **(03 marks)**

   (c)

(i)	Not possible	n=0 invalid **(01mark)**
(ii)	Possible	All quantum numbers are valid **(01mark)**
(iii)	Possible	All quantum numbers are valid **(01mark)**

2. (a) Given
   Density of a gas, $\gamma = 1.149 g/cm^3$
   Volume of drop, $V = 0.05 cm^3$
   Temperature, $T = 37^oC = 310k$
   Pressure, $\rho = 1$ atm, $V = ?$
   From
   $\rho = \frac{Mass}{Volume}$
   Mass = 1.149 x 0.05
   Mass = 0.05745g **(01mark)**

   (a) Then
   $PV = \frac{mRT}{Mr}$
   $V = \frac{mRT}{PMr}$
   $V = \frac{0.05745 \times 0.0821 \times 310}{1 \times 32}$
   $V = 0.0457 dm^3$
   Therefore, volume produced, V is $0.0457 dm^3$ or $45.7 cm^3$ **(01mark)**

   (b) Given
   Composition of Nitrogen = 87.40?
   Density of compound, $\gamma = 0.977 g/L$

Pressure, ρ = 710mmHg = 0.934atm
Temperature, T = 100°C = 373k
Molecular formula = ?

From, Empirical formula

ELEMENT	**N**	**H**
Percentage composition (%)	87.40	12.60
Relative atomic mass (R.A.M)	14	1
$\frac{Percentage\ composition}{Relative\ atomic\ mass}$	$\frac{87.40}{14} = 6.24$	$\frac{12.60}{1} = 12.6$
Divide by smallest number	$\frac{6.24}{6.24} = 1$	$\frac{12.6}{6.24} = 2.01$
Convert into whole number	1	2

(02 marks)

Empirical formula is NH_2 **(01 mark)**
From
$\rho = \frac{\gamma RT}{mR}$

$Mr = \frac{\gamma RT}{\rho}$

$Mr = \frac{0.977 \times 0.0821 \times 373}{0.934}$

Mr = 32g/mol. **(01mark)**

Then
(Empirical formula)n = Molecular mass
$(NH_2)n = 32$
$(14+2)n = 32$
$16n = 32$
$n = \frac{32}{16}$
n = 2. **(01mark)**

But; (Empirical formula)n = Molecular formula
$(NH_2)n$ = Molecular formula
$(NH_2)_2$ = Molecular formula
Molecular formula = N_2H_4
Therefore, Molecular formula is N_2H_4. **(01mark)**

Given
(c) Volume of chlorine gas, V = $2.50x10^2cm^3$=$0.2dm^3$
Temperature, T = 20°C + 273 = 293k

Total pressure p_T = 1atm
Molar mass pf Cl_2 = 71g/mol
Pressure of water, Pw = 17.5mmHg = 0.023atm
Mass of chlorine, m = ?

From
PV = nRT
$PV = \frac{mRT}{Mr}$
$m = \frac{PVMr}{RT}$
But $P_T = Pw + PCl_2$
$PCl_2 = P_T - Pw$
PCl_2 = 1atm – 0.023atm
PCl_2 = 0.977atm **(01mark)**

Then,
$m = \frac{0.977 \times 0.25 \times 71}{0.0821 \times 293}$
m = 0.721g **(01mark)**

3. (a) (i) High salt (NaCl) intake increases blood osmolarity hence higher blood volume leading to increase in blood pressure. **(01mark)**
   (ii) Since their bodies have higher salt concentrations when transferred to fresh water, osmosis occurs, water enters fish cells causing to swell and die. **(01mark)**
   (iii) NaCl will have higher boiling point elevation than the sugar. Reason: NaCl has higher vant Haff's factor (i) than sugar. **(01mark)**

(b) Data given
Mass, m = 0.00895g
Volume, V = 35.0cm^3 = 0.035L
Osmotic Pressure, π = 0.335mmHg = 4.41x10^{-4}atm
Temperature, T = 25ºC = 298k
Solution
From, Osmotic pressure (π) = $\frac{nRT}{v}$
But $n = \frac{m}{Mr}$ **(01mark)**
Now, $\pi = \frac{mRT}{MrV}$
Then, $Mr = \frac{0.00895 \times 0.0821 \times 298}{4.41 \times 10^{-4} \times 0.035}$ **(01mark)**
Mr = 1.42 x 10^4g/mol **(01mark)**

(c) Data given
Change in temperature, ΔT = 2ºC
Kf = 1.86ºC kg/mol

Mass of water, m = 500g = 0.5g

Dissociation of $CaCl_2$ **(01 mark)**

$CaCl_2 \longrightarrow Ca^{2+} + 2Cl^-$

Vant Hoff's factor of $CaCl_2$, i = 3

Solution

$\Delta Tf = iKfm$

But $m = \frac{\Delta Tf}{iKf}$

$m = \frac{2}{3 \times 1.86} = 0.358 mol/kg$ **(01mark)**

But m = n/mass in kg n = 0.358mol/kgx0.5kg = 0.179 mol

Molar mass of $CaCl_2$ = 40 + (35.5 x 2)

= 111g/mol **(01mark)**

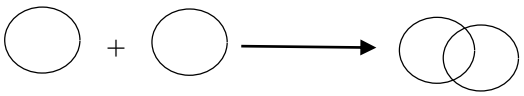
Then moles $\frac{mass}{molar\ mass}$

Mass = 111 x 0.179mol

Mass = 19.9g **(01mark)**

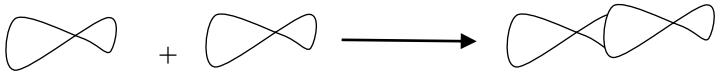
4. (a) There are three types of overlap that result into sigma bond. These overlaps are:

(i) S-S overlap: This overlap over when S-orbital overlap with S-orbatal to form covalent sigma bond.



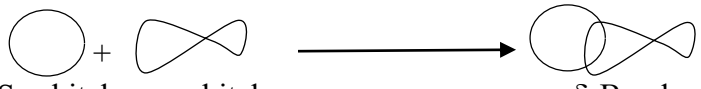
S-orbital S-orbital δ-Bond **(01mark)**

(ii) P- P overlap: This is overlap which occur when p-orbitals overlap each other head to head to form a sigma bond.



P-orbital p-orbital δ-Bond (**01mark)**

(iii) S-P overlap: This is the type of overlap which occur between S-orbital and P-orbital to form sigma bond.



S-orbital p-orbital δ-Bond

(b) (i) SiO_2 exists in three dimensional structure with giant molecular structure made by very strong Si-O bond but CO_2 is a gas because of weak intermolecular forces existing between its molecules due to equal electronegativity.**(01 ½ mark**

(ii) The dipoles present in CO_2 cancel each other hence making it non-polar while the dipoles present in water molecule do not cancel each other thus making it become polar. Or in water due to presence of lone pair **(01 ½ marks)**

(c) The bond between H and Cl is never 100% ionic or covalent as H and Cl have different electronegativities, so when they combine by covalent bonding partial charges exists between H and Cl making the bond partially ionic. **(02 marks)**

(d) (i) Only the orbitals of a central atom undergo hybridization.
(ii) Orbitals of nearly the same energy level combine to form hybrid orbitals
(iii) The numbers of the hybridizing atomic orbitals are always equal to the number of hybrid orbitals.
(iv) The hybrid orbital tends to be scattered in space and farthest apart.
(v) Hybrid orbitals are stronger than non-hybrid orbitals
(vi) During hybridization the number of combined orbitals is as per requirement of the bonding atoms. **(Any two rule 01 @ = 02 marks)**

5. (a) From $Fe(NO_3)_3$ the cation Fe^{3+} is formed which is very small and have high charge density that leads to polarization of water molecules to form $[Fe(H_2O)_6]^{3+}$ complex which on more reaction with water forms $[Fe(H_2O)_5\ OH]^{2+} + H_3O^+$.

This solution in very acidic due to H_2O^+ which reacts with CO_3^{2-} from Na_2CO_3 to form carbonic acid that dissociates to form CO_2 and H_2O.

$$[Fe(H_2O)_6]^{3+} + H_2O \longrightarrow [Fe(H_2O)_5OH]^{2+} + H_3O^+$$

$$[Fe(H_2O)_5OH]^{2+} + H_3O + CO_3^{2-} \longrightarrow [Fe(H_2O)_5OH]^{2+} + H_2CO_3 + H_2O$$

(04 Marks)

(b) (i) Reaction between $PbCO_3$ and dilute HCl

$$PbCO_{3(s)} + 2HCl_{(aq)} \longrightarrow PbCl_{2(s)} + H_2O + CO_{2(g)}$$

Explanation

- Effervescence is due to CO_2 gas produced
- The reactions stop due to insoluble $PbCl_2$ formed that coat the $PbCO_3$ preventing further contact with acid. **(03marks)**

(ii) When potassium is heated in limited supply of oxygen at room, it forms normal oxide.

$$2k_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow K_2O_{(s)}$$

When potassium react with excess oxygen at room temperature, peroxide is formed

$$2k_{(s)} + 0_{2(g)} \longrightarrow k_2O_{2(s)}$$

When potassium reacts with excess oxygen at high temperature, it forms superoxide

$K_{(s)} + O_{2(g)} \xrightarrow{\Delta} KO_{2(s)}$ **(03marks, 01@)**

6. (a) From the formula

Neutralizing value, NV(%) = $\frac{Equivalent\ weight\ of\ CaCO_3}{Equivalent\ weight\ of\ CaO} \times 100$ **(01mark)**

Equivalent weight;

$CaCO_3 = 50$

$CaO = 28$

Solution

$NV = \frac{50}{28} \times 100$

$= 178.6\%$ **(01 mark)**

(b) Effect of water – colloid interactions on soil acidity.

- Organic colloids contain acidic functional group (-COOH) that dissociate in water releasing H^+ ions hence increasing soil acidity.

  -COOH $\rightleftharpoons$ COO- + H^+ **(01 ½ marks)**
- Inorganic colloids absorb cations such as H^+ and Al^{3+}. Hydrolysis of Al^{3+} produce more H^+.

  $Al^{3+} + 3H_2O \longrightarrow Al(OH)_3 + 3H^+$ **(01 ½ Marks)**

(c) Given

Basic cations: $Mg^{2+} = 20$, $Ca^{2+} = 38$, $Na^+ = 40$, $k^+ = 6.0$, $Mn^{2+} = 20$

Total bases = 20 + 38 + 4.0 + 6.0 + 2.0

= 70meq/100g **(01mark)**

Acidic cations; $H^+ = 24$, $Al^{3+} = 8$

Total acidity = 24 + 8

= 32 meq/100g

(i) CEC = ?

From CEC = $\frac{Total\ basic\ cations}{BPS} \times 100$

CEC = $\frac{70}{68.63} \times 100$ **(01mark)**

CEC = 102 meq/100g **(01mark)**

(ii) Quantity of Ca^{2+} in grams

Given

Ca^{2+} = 38meq/100g soil

Solution

From 1 equivalent Ca^{2+} = 20g **(01mark)**

Mass of $Ca^{2+} = \frac{38 \times 20}{1000} = 0.76g$

The mass of Ca^{2+} is 0.76g **(01mark)**

7. (a) (i) Pent-1-ene reacts with Br_2 water then decolorizing the bromine solution while the n-pentane do not react with Br_2 water. **(01mark)**

(ii) Propane do not precipate with $AgNO_3$ in NH_3 while propyne form a precipitate with $AgNO_3$ in NH_3. **(01mark)**

(b) (i) Cis has higher boiling point than trans isomers due to the stronger dipole-dipole interactions. **(02marks)**

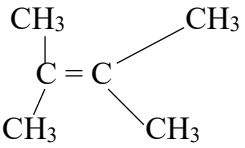
(ii) Ozonolysis of alkane x gives C_3H_6O (two isomers)

- Two C_3H_6O isomers suggests $CH_3C = C\ CH_3$ structure of alkenex

I I

CH_3 CH_3 **(01mark)**

- C_3H_6O can be propanone

The alkene X is  **(01mark)**

(c) Given

$C_5H_{11}Br$(A) + Ethanolic KOH ⟶ B $\xrightarrow{Br_2}$ C Dehydrobromination D

D Na/liquid NH_3 Sodium salt of D Hydrogenation straight chain alkane

Stepwise solution

(i) A ⟶ B (Dehydrohalogenation)

$C_5H_{11}Br \xrightarrow[KOH]{\text{Alcohol}} C_5H_{10} + HBr$

(ii) B ⟶ C (Bromination)

$C_5H_{10} + Br_2 \longrightarrow C_5H_{10}Br_2$

(iii) C ⟶ D (Dehydrohalogenation, elimination)

$C_5H_{10}Br_2 \xrightarrow[KOH]{\text{Alcohol}} C_5H_8 + 2HBr$

(iv) D ⟶ Sodium salt.

Reaction with Na in liquid NH_3 produces alkynide salt and ½ H_2.

(v) D ⟶ Hydrogenation

$C_5H_8 + 2H_2 \longrightarrow C_5H_{12}$ (Pentane)

Now:

A = 2-bromopentane **(01mark)**

B = Pent-2-ene **(01 mark)**

C = 2, 3-dibromopentane **(01mark)**

D = Pent-2-yne **(01mark)**

8. (a) (i) Le-Chatelier's principle states that "when a system in equilibrium is subjected to change, a process is done in order to undo the change happened". **01mark**

(ii) Balanced equilibrium Equation

$$[CO(H_2O)_6]^{2+}_{(aq)} + 4Cl^-_{(aq)} \rightleftharpoons [COCl_4]^{2-}_{(aq)} + 6H_2O_{(L)}$$ **01 mark**

(b) $\frac{1}{2}N_2 + O_2 \rightleftharpoons NO_2$ kP = 2.1 x 10^{-2} atm^{-1} ……. (i)

$N_2 + 2O_2 \rightleftharpoons N_2O_4$ kP = 3.5 x 10^{-2} atm^{-1} ……..(ii) **01mark**

Multiplying equation (i) by 2.

$N_2 + 2O_2 \rightleftharpoons 2NO_2$ kP = $(2.1 \times 10^{-2})^2$ ……. (iii)

Reversing equation (iii)

$2NO_2 \rightleftharpoons N_2 + 2O_2$ kp = $\frac{1}{(2.1\times10^{-2})^2}$ ……. (iv) **01mark**

Adding equation (iv) and (ii)

$2NO_2 \rightleftharpoons N_2+2O_2$

$N_2 + O_2 \rightleftharpoons N_2O_4$ **(01mark)**

Then

$2NO_2 \rightleftharpoons N_2O_4$

Where

Kp = kp(iv) x kp (ii) **(01mark)**

$Kp = \frac{1}{(2.1\times10^{-2})^2} \times 3.5 \times 10^{-2}$

Kp = 7.95 x 10^1 atm^{-1} **(01mark)**

The equilibrium constant, kp for the reaction $2NO_2 \rightleftharpoons N_2O_4$ is 7.95 x 10^1 atm^{-1}.

(c) (i) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

$n_N = \frac{m}{Mr}$

$n_N = \frac{5.6}{28}$ **(00 ½ mark**

$n_N = 0.2\ moles$

$n_H = \frac{m}{Mr}$

$n_H = \frac{2}{2}$

n_H= 1 mole

From

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

Initial 0.2 1 0

Equil. 0.2 – x 1-x 2x **(01 ½ marks)**

But 60% of N_2 dissociated

0.2x0.6 = 0.12

X = 0.12 moles

n_N = 0.2 – 0.12 = 0.08 moles

n_H = 1-(3x0.12) = 0.6 moles

n_{NH3} = 2x0.12 = 0.24 moles **(01 ½ marks)**

Concentration at equilibrium

$$[N_2] = \frac{n_N}{V_N}$$

$$[N_2] = \frac{0.08}{1.2}$$

$[N_2]$=0.067M

$$[H_2] = \frac{n_H}{V}$$

$$[H_2] = \frac{0.64}{1.2}$$

$[H_2]$ = 0.533M

$$[NH_3] = \frac{n_{NH_3}}{V}$$

$$[NH_3] = \frac{0.24}{1.2}$$

$[NH_3]$ = 0.20M **(01 ½ marks)**

From Kc

$Kc = \frac{[NH_3]^2}{[N_2][H_3]^3}$ **(00 ½ mark)**

$$kc = \frac{(0.2)^2}{0.067 \times (0.533)^3}$$

Kc = 3.98dm^6mol^{-2} **(01mark)**

(ii) Kp = kc $(RT)^{\Delta n}$

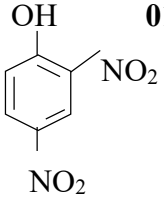
Where Δn is the number of moles of product – number of mole in reactant.

Kp = 3.98 x $(0.0821 \times 473)^{-2}$ **(01mark)**

Kp = 2.64 x 10^{-3} atm^{-2}

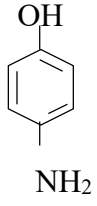
Threfore kp is 2.64 x 10^{-3} atm^{-2} **(01mark)**

9. (a) (i)



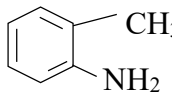
01mark

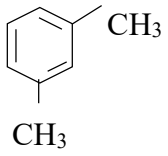
(ii)

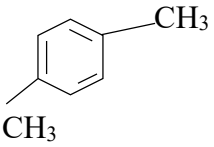


01mark

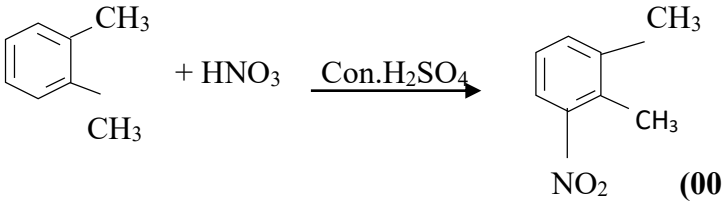
(b) Isomers of dimethylbenzene are:

(i)  1, 2-dimethylbenzene . **(01mark)**

(ii)  1, 3-dimethylbenzene. **(01mark)**

(iii)  1,4-dimethylbenzene **(01mark)**

(c) (i) 1, 2-dimethylbenzene will give one mononitro product. This is because the combined effect of the two methyl groups is to deactivate all sites, position 4 and 5 will be the least deactivated and substitution will occur in these position. **(00 ½ mark)**

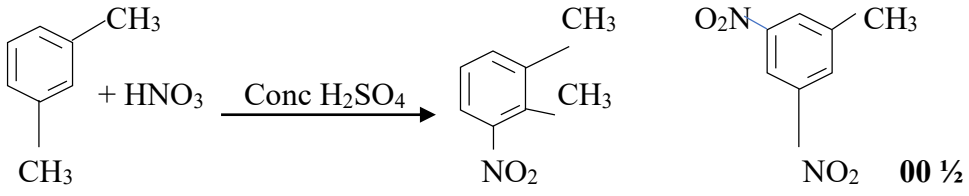


(00 ½ mark)

Since position 4 and 5 are the same position depending on which methyl is taken as number 1, where nitro will be directed at carbon 4 or 5.

(ii) 1,3-dimethylbenzene will yield two substitute products, this is because methyl group at position 1 will activate 2, 4 and 6 as well. Since position 4 and 6 are the same position; so this molecule will give two mononitro products.

00 ½ mark



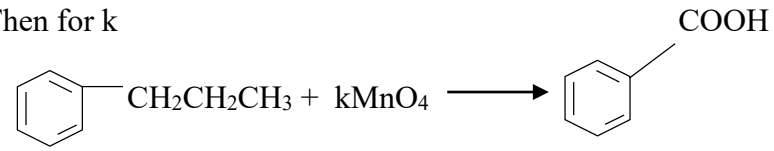
00 ½

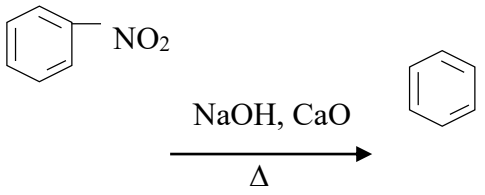
(d) K and L have general formiula C_9H_{12}

$K + KMnO_4 \longrightarrow$ Monocarboxylic acid

$L + KMnO_4 \longrightarrow$ Tricarboxylic acid

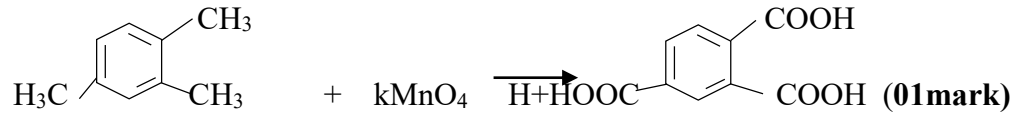
Then for k



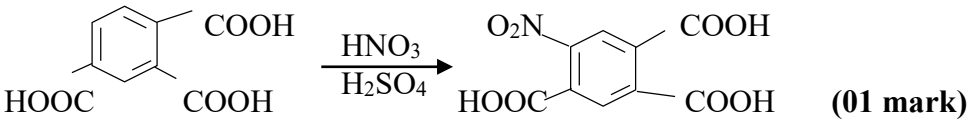


(01mark)

For L

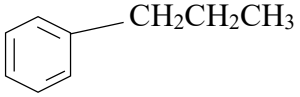


(01mark)

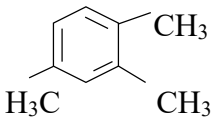


(01 mark)

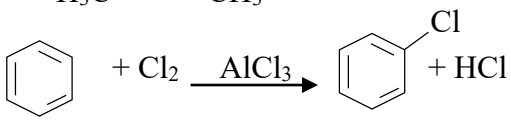
Therefore

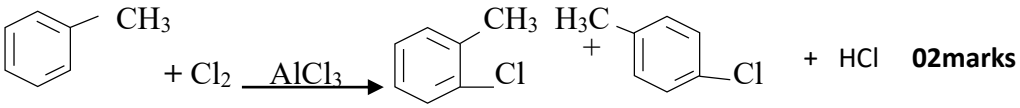
K = 

(01mark)

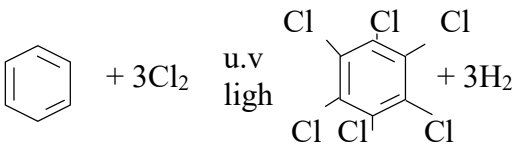
L = 

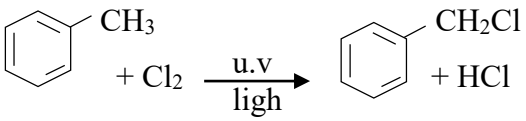
(01mark)

(e) (i) 



02marks

(ii) 



(02marks)

10. (a) Calculating the lattice of $BaCl_2$

Step 1. Born-Haber Cycle

$\Delta Hf = \Delta H$ atom (Ba) + I.E (Ba) + Δ atom(Cl2) + 2. EA Cl+L.E **(01mark)**

Then

$\Delta Hf\ (BaCl_2)$ = - 860kJ/mol

Atomization Ba = +175kJ/mol

$1^{st} + 2^{nd}$ I.E = 550 + 1000 = 1550Kj/mol **(01mark)**

Atomization of Cl_2 = 121 kJ/mol

EA of 2Cl = 2x – 364 = -728kJ/mol

Lattice energy = ?

From the formula above for ΔHf;

-860 = 175 + 1550 + 121– 728 + L.E **(01mark)**

L.E = -1978kJ/mol **(01mark)**

(b) Enthalpy change of combustion of diborane (B_2H_6)

The reaction: $B_2H_6 + 3O_2 \longrightarrow B_2O_3 + 3H_2O$.

Given

- $H_2 + O_2 \longrightarrow H_2O_{(l)}$ ΔH = -286Kj/mol
- $H_2O_{(L)} \longrightarrow H_2O_{(g)}$ ΔH = +44Kj/mol
- $2B + \frac{3}{2}O_2 \longrightarrow B_2O_3$ ΔH = -1273Kj/mol
- $2B + 3H_2 \longrightarrow B_2H_6$ ΔH = +36Kj/mol

Solution

Step 1: Enthalpy of formation of $H_2O_{(g)}$

$\Delta Hf\ (H_2O)_{(g)}$ = -286 = -286kJ/mol x3 = -858, since 3 moles of H_2O is required **(01mark)**

Step 2: Enthalpy of combustion:

$B_2H_6 + O_2 \longrightarrow B_2O_3 + 3H_2O$.

$\Delta H_C = \Delta Hf$ (product- ΔHf (reactacts) **(01mark)**

AH_C = (-1273) + 3 (-286) – 36 **(01mark)**

ΔH = -2167kJ/mol **(01mark)**

(c) Required the average bond enthalpy of N-H

Given

Bond enthalpy H-H = 436kJ/mol

N≡N = 941.3kJ/mol

$\Delta Hf(NH_3)$ = -46kJ/mol

Formation:

$\frac{1}{2}N_2 + \frac{3}{2}H_2 \longrightarrow NH_3$

Step 1: From; ΔHr = Σ Bond broken - ΣBond formed. **(01mark)**

The broken bonds are $N_2 + 3H_2$

$\frac{1}{2}(941.3) + \frac{3}{2}(436) = 1124.65kJ/mol$ **(01mark)**

The bond formed are (N-H)3

Now since ΔHr = ΣBond Broken - ΣBond formed.

-46 = 1124.65– 3x (since /mol of NH_3 has 3N-H) bonds

Then

3x = 1124.65+ 46

3x = 1170.65

x = 390.22kJ/mol **(01mark)**

(d) Required the molar heat of neutralization

VT = $50cm^3$ + $50cm^3$

Molarity = 1.0M

ΔT = 32ºC – 25.5ºC = 6.9ºC

Density, ρ = $1.g/cm^3$

Then mass = 100g

Specific heat capacity = 4.184J/goC

Solution

9 = mcΔT = 100 x 4.184 x 6.9

= 2887J **(02 marks)**

Moles of H+ neutralized

n = 0.05LX 1M = 0.05 mol **(01mark)**

Molar heat of neutralization

$\Delta H = \frac{2887}{0.05}$

ΔHn = 57740J/mol = 57.7kJ/mol. **(01 mark)**

(15%)