

## NSMQ PAST QUESTIONS; CHEMISTRY (01)

What is the most likely mode of decay for each of the following nuclides?

- Carbon – 15

**Ans: Beta decay**

- Uranium – 238 (atomic number 92)

**Ans: alpha decay**

- Nitrogen – 12

**Ans: positron emission (or electron capture)**

1. 100.0 g of an inorganic compound is found to contain 34.0 g of copper, 15.0 g of nitrogen, and 51.2 g of oxygen. Determine the empirical formula of the compound given that the atomic mass (g/mol) of Cu, N, and O is 64.0; 14.0, and 16.0 respectively.

**Ans: CuN<sub>2</sub>O<sub>6</sub> [OR Cu(NO<sub>3</sub>)<sub>2</sub>]**

$$\text{Cu} = \frac{34.0}{64} = 0.53 \quad \text{N} = \frac{15.0}{14} = 1.1 \quad \text{O} = \frac{51.2}{16} = 3.2 \quad \text{Hence ratio} = 1 : 2 : 6$$

2. 30.1 g of an inorganic compound is found to contain 15.0 g of copper, 7.62 g of sulphur, and 7.58 g of oxygen. Determine the empirical formula of the compound given that atomic masses (g/mol) of Cu, N, and O are 64.0; 14.0, and 16.0 respectively.

**Ans: CuSO<sub>2</sub>**

$$\text{Cu} = \frac{15.0}{64} = 0.234 \quad \text{S} = \frac{7.50}{32} = 0.234 \quad \text{O} = \frac{7.58}{16} = 0.474 \quad \text{Hence ratio} = 1 : 1 : 2$$

3. 40.0 g of an inorganic compound is found to contain 20.4 g of copper, 3.88 g of carbon and 15.6 g of oxygen. Determine the empirical formula of the compound given that atomic masses (g/mol) of Cu, C and O are 64.0; 12.0 and 16.0, respectively.

**Ans: CuCO<sub>3</sub>**

$$\text{Cu} = \frac{20.4}{64} = 0.32 \quad \text{C} = \frac{3.88}{12} = 0.32 \quad \text{O} = \frac{15.6}{16} = 0.98 \quad \text{Hence ratio} = 1 : 1 : 3$$

1. The gaseous molecules, methane and oxygen are mixed in a 2:1 ratio by mass. What is the ratio of gases by volume? Take atomic masses (g/mol) of C, H and O as 12; 1.0 and 16, respectively.

**Ans: 1:1**

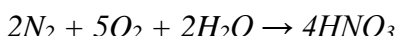
Molecular mass of CH<sub>4</sub> = 16

Molecular mass of O<sub>2</sub> = 32

Hence if present in 2:1 ratio, the number of moles and volume will be the same, hence 1:1

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products in a balanced equation of the reaction: N<sub>2</sub> + O<sub>2</sub> + H<sub>2</sub>O → HNO<sub>3</sub>

**Ans: 13**



3. The elements X and Y have 6 and 3 electrons respectively in their outermost shell. What is likely to be the formula of the compound formed between X and Y?

**Ans: Y<sub>2</sub>X<sub>3</sub>**

1. Determine the most ionic compound in the list below:

CaCl<sub>2</sub>; KCl; MgCl<sub>2</sub>; AlCl<sub>3</sub>; CsCl

**Ans: CsCl**

2. Which of the following compounds will exhibit the most hardness?

MgO; Al<sub>2</sub>O<sub>3</sub>; Na<sub>2</sub>O; CaO; Li<sub>2</sub>O

**Ans: Al<sub>2</sub>O<sub>3</sub>**

3. Which of the following compounds has the highest covalent character?

LiCl; NaCl; BeCl<sub>2</sub>; RbCl; MgCl<sub>2</sub>

**Ans: BeCl<sub>2</sub>**

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1. 0.25 mol of a hydrocarbon with an empirical formula C<sub>3</sub>H<sub>5</sub> has a mass of 41 g. Determine the molecular formula of the compound. Take the atomic mass of carbon and hydrogen (g/mol) as 12 and 1.0, respectively.

**Ans: C<sub>12</sub>H<sub>20</sub>**

Molar mass = 41/0.25 = 164 g/mol

n = 164/41 = 4; Hence molecular formula = C<sub>12</sub>H<sub>20</sub>

2. An organic compound has the formula C<sub>x</sub>H<sub>8</sub>O<sub>4</sub>. If 0.015 mol of the compound has a mass of 1.98 g, determine the value of X, per formula unit of the molecule. Take the atomic mass of carbon, oxygen and hydrogen (g/mol) as 12, 16 and 1.0, respectively.

**Ans: X = 5 carbon atoms**

Molar mass = 1.98/0.015 = 132 g/mol

X = (132-72)/12 = 5

3. Given that one molecule of an organic compound with the empirical formula CH<sub>2</sub>O has a mass of 2.0 × 10<sup>-22</sup> g, determine the molecular formula of the compound. Take the atomic mass of carbon, oxygen and hydrogen (g/mol) as 12, 16 and 1.0 respectively and Avogadro's number as 6.0 × 10<sup>23</sup>.

**Ans: C<sub>4</sub>H<sub>8</sub>O<sub>4</sub>**

Molar mass = 2.0 × 10<sup>-22</sup> × 6.0 × 10<sup>23</sup> = 120 g/mol

n = 120/30 = 4; Hence molecular formula = C<sub>4</sub>H<sub>8</sub>O<sub>4</sub>

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1. Given Avogadro's number as 6.02 × 10<sup>23</sup>, what is the mass present in 1.51 × 10<sup>23</sup> molecules of benzaldehyde, C<sub>7</sub>H<sub>6</sub>O? Take the atomic mass (g/mol) of C, H and O as 12.0, 1.00 and 16.0, respectively.

**Ans: 26.5 g**

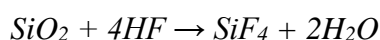
Molecular mass of benzaldehyde = 106 g

Number of moles = 1.51 × 10<sup>23</sup> / 6.02 × 10<sup>23</sup> = 0.25 moles

Mass of benzaldehyde = 0.25 × 106 = 26.5

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction: SiO<sub>2</sub> + HF → SiF<sub>4</sub> + H<sub>2</sub>O

**Ans: 8**



3. How many sigma and pi bonds each are present in methanal?

**Ans: 1 pi bond and 3 sigma bonds**

Identify the following species found on the Periodic Table given the information below:

1. Mass number 33; neutron number 18; number of electrons 18

**Ans: P<sup>3-</sup>**

2. Mass number 55; neutron number 30; number of electrons 22

**Ans: Mn<sup>3+</sup>**

3. Mass number 66; neutron number 36; number of electrons 28

**Ans: Zn<sup>2+</sup>**

1. Determine the percentage of phosphorus present in phosphorus pentoxide (P<sub>2</sub>O<sub>5</sub>) given the relative atomic masses of phosphorus and oxygen as 31 and 16 respectively.

**Ans: 44 %**

$$\text{Molar mass of (P}_2\text{O}_5) = 142 \qquad \text{percentage of P} = \frac{62}{142} \times 100 = 44\%$$

2. Determine the percentage of chromium present in the chromium oxide Cr<sub>2</sub>O<sub>3</sub> given the relative atomic masses of chromium and oxygen as 52 and 16 respectively.

**Ans: 68 %**

$$\text{Molar mass of (Cr}_2\text{O}_3) = 152 \qquad \text{percentage of P} = \frac{104}{152} \times 100 = 68\%$$

3. Determine the percentage of chlorine present in dichlorine hexoxide (Cl<sub>2</sub>O<sub>6</sub>) given the relative atomic masses of Chlorine and oxygen as 35 and 16 respectively.

**Ans: 42 %**

$$\text{Molar mass of (Cr}_2\text{O}_3) = 166 \qquad \text{percentage of P} = \frac{70}{166} \times 100 = 42\%$$

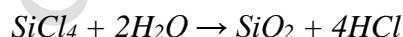
1. Calculate the number of moles of hydrogen gas released when 6.0 moles of Aluminum react with excess hydrochloric acid.

**Ans: 9.0 moles**



2. Determine the **sum** of the stoichiometric coefficients of all reactants and products in a balanced equation of the reaction: SiCl<sub>4</sub> + H<sub>2</sub>O → SiO<sub>2</sub> + HCl

**Ans: 8**



3. Which nuclear species is formed when carbon-14 is bombarded with a proton to produce nitrogen-14?

**Ans: Neutron**

Give the name of the major product formed in each of the following reactions

1. The Reaction of benzene with chlorine in the presence of aluminum chloride

**Ans: chlorobenzene**

2. The reaction of 2-methylpropane with a limited amount of chlorine gas

**Ans: 2-chloro-2-methyl propane**

3. The reaction of butanoic acid and methylamine

**Ans: N-methyl butanamide**

During the production of pure iron,  $\text{Fe}_2\text{O}_3$  reacts with carbon monoxide, CO, according to the reaction:  $\text{Fe}_2\text{O}_3 + 3 \text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$

1. Given that 80 g of  $\text{Fe}_2\text{O}_3$  and 84 g of CO react, determine which reactant is the limiting reagent and by what amount. You are given molecular mass of  $\text{Fe}_2\text{O}_3$  and CO as 160 and 28 g/mol, respectively.

**Ans:  $\text{Fe}_2\text{O}_3$ , limited by 0.50 mol**

$$\begin{aligned} n \text{Fe}_2\text{O}_3 &= 80/160 = 0.50 \text{ mol} & n \text{CO} &= 84/28 = 3.0 \text{ mol} \\ n \text{Fe}_2\text{O}_3 \text{ required} &= \frac{1}{3} \times 3.0 \text{ mol} = 1.0 \text{ mol; but only 0.50 mol present} \end{aligned}$$

2. Given that 80 g of  $\text{Fe}_2\text{O}_3$  and 84 g of CO reacts, determine which reactant is in excess and by what amount. You are given molecular mass of  $\text{Fe}_2\text{O}_3$  and CO as 160 and 28 g/mol, respectively.

**Ans: CO, excess by 1.5 mols**

$$\begin{aligned} n \text{Fe}_2\text{O}_3 &= 80/160 = 0.50 \text{ mol} & n \text{CO} &= 84/28 = 3.0 \text{ mol} \\ n \text{CO required} &= \frac{3}{1} \times 0.50 \text{ mol} = 1.5 \text{ mol; but 3.0 mol present} \end{aligned}$$

3. How many grams of iron will be produced from the reaction of excess  $\text{Fe}_2\text{O}_3$  and 84 g of CO? You are given molecular mass of  $\text{Fe}_2\text{O}_3$  and CO as 160 and 28 g/mol respectively and atomic mass of Fe as 56 g/mol.

**Ans: 112 g**

$$n \text{CO} = 84/28 = 3.0 \text{ mol} \quad n \text{Fe} = \frac{2}{3} \times 3.0 \text{ mol} = 2.0 \text{ mol}$$

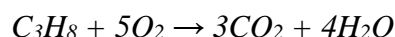
1. How many moles of phosphorus is present in 14.2 g of  $\text{P}_4\text{O}_{10}$ ? Take the atomic mass (g/mol) of phosphorus and oxygen as 31 and 16, respectively.

**Ans:  $n(\text{P}) = 0.20 \text{ mol}$**

$$n(\text{P}_4\text{O}_{10}) = 14.2/284 = 0.050 \text{ mol; P} = 4 \times 0.05 = 0.20 \text{ mol}$$

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction:  $\text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

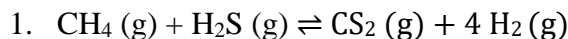
**Ans: 13**



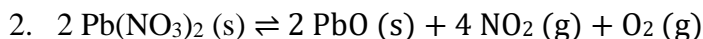
3. How many unpaired electrons are present in the molecule NO?

**Ans: one (1)**

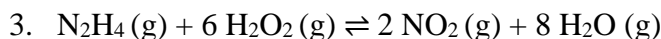
Write the equilibrium constant expression  $K_c$  for the following reversible reactions:



**Ans:  $K_c = \frac{[\text{CS}_2] [\text{H}_2]^4}{[\text{CH}_4] [\text{H}_2\text{S}]}$**



**Ans:  $K_c = [\text{NO}_2]^4 [\text{O}_2]$**



**Ans:  $K_c = \frac{[\text{NO}_2]^2 [\text{H}_2\text{O}]^8}{[\text{N}_2\text{H}_4] [\text{H}_2\text{O}_2]^6}$**

1. What mass of methanoic acid is required to completely neutralise a solution made of  $50.0 \text{ cm}^3$  of  $0.200 \text{ mol dm}^{-3}$  NaOH? Take atomic mass (g/mol) of C as 12; O as 16; H as 1.0.

**Ans: 0.46 g**

Moles of NaOH =  $0.20 \text{ mol dm}^{-3} \times 0.050 \text{ dm}^3 = 0.010 \text{ mol} = \text{moles of HCOOH}$

Mass of HCOOH needed =  $46 \times 0.010 = 0.46 \text{ g}$

2. Calculate the mass of solid that remains when  $200 \text{ cm}^3$  solution of  $\text{Na}_2\text{CO}_3$  of concentration  $0.25 \text{ mol dm}^{-3}$  is heated to dryness. Take the atomic mass (g/mol) of Na as 23; O as 16; and C as 12

**Ans: 5.3 g**

Moles of  $\text{Na}_2\text{CO}_3 = 0.20 \times 0.25 = 0.050 \text{ mol}$

Molar mass =  $106 \text{ g/mol}$ . Hence mass present =  $0.050 \times 106 = 5.3 \text{ g}$

3. What mass of  $\text{Na}_2\text{SO}_4$  must be dissolved in  $100 \text{ cm}^3$  of solution to obtain a concentration of  $0.50 \text{ mol dm}^{-3}$ ? Atomic mass (g/mol) of Na = 23; O = 16; S = 32

**Ans: 7.1 g**

Moles of  $\text{Na}_2\text{SO}_4 = 0.10 \times 0.50 = 0.050 \text{ mole}$

Mass of  $\text{Na}_2\text{SO}_4 = 0.050 \times 142 = 7.1 \text{ g}$

1. Upon combustion,  $0.40 \text{ g}$  of a hydrocarbon produces  $1.1 \text{ g}$  of carbon dioxide. Determine the percentage composition of carbon in the compound. (C = 12; O=16, H = 1.0)

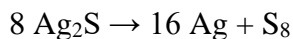
**Ans: 75 %**

Mass of C =  $12/44 \times 1.1 = 0.30 \text{ g}$

% C =  $0.30/0.40 \times 100 = 75 \%$

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction:  $\text{Ag}_2\text{S} \rightarrow \text{Ag} + \text{S}_8$

**Ans: 25**



3. Which of the hybrid orbitals in carbon has the highest percentage of s-character?

**Ans: sp orbital (50%)**

Give the name of the major product formed from the reaction of HBr with each of the following:

1. 1-pentene

**Ans: 2-bromopentane**

2. 2-methyl-2-butene

**Ans: 2-bromo-2-methylbutane**

3. Cyclohexene

**Ans: Bromo cyclohexane (or 1-bromo cyclohexane)**

1. What mass of oxygen is needed to produce 90 g of water given that an excess amount of hydrogen reacts? Take the atomic mass (g/mol) of H and O as 1.0 and 16 respectively.

**Ans: 80 g**

$$\text{Mol of H}_2\text{O} = 90/18 = 5.0 \text{ mol.}$$

$$n \text{ O}_2 = 5.0/2 = 2.5 \text{ mol} \quad \text{Hence mass} = 2.5 \times 32 = 80 \text{ g}$$

2. Determine the mass of  $\text{Na}_2\text{CO}_3$  needed to produce 0.150 mol of carbon dioxide gas in a thermal decomposition reaction. Take the atomic mass (g/mol) of Na, C, and O as 23.0, 12.0 and 16.0 respectively.

**Ans: 15.9 g**

$$\text{Molar mass of Na}_2\text{CO}_3 = 106 \quad \text{since mole ratio is 1:1, mass} = 106 \times 0.150 = 15.9 \text{ g}$$

3. Based on a reaction with solid carbon, determine the mass of oxygen needed to produce 16.8 g of carbon monoxide given that, oxygen is limited. Take the atomic mass (g/mol) of C and O as 12 and 16 respectively.

**Ans: 9.6 g**

$$\text{Mol of CO} = 16.8/28 = 0.60 \text{ mol} \quad \text{mol of O}_2 = 0.60/2 = 0.30 \text{ mol}$$

$$\text{Mass of O}_2 = 9.6 \text{ g}$$

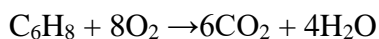
1. Given Avogadro's number as  $6.0 \times 10^{23}$ , how many atoms of oxygen are present in 4.0 moles of  $\text{SO}_3$ ?

**Ans:  $7.2 \times 10^{24}$**

$$\text{Number of atoms} = 6.0 \times 10^{23} \times 4 \text{ mol} \times 3 \text{ O atoms} = 7.2 \times 10^{24}$$

2. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction:  $\text{C}_6\text{H}_8 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

**Ans: 19**



3. What is the maximum number of hydrogen bonds formed by a water molecule in ice?

**Ans: four (4)**

Indicate the values of all quantum numbers permissible for the following orbitals

1. 4p

**Ans:  $n = 4, l = 1, ml = -1, 0, +1$**

2. 3d

**Ans:  $n = 3, l = 2, ml = -2, -1, 0, +1, +2$**

3. 5s

**Ans:  $n = 5, l = 0, ml = 0$**

1. Calculate the solubility in  $\text{mg}/\text{dm}^3$  of  $\text{BaCrO}_4$  at  $25^\circ\text{C}$  given its solubility product is  $1.0 \times 10^{-10}$ . Take the molecular mass of  $\text{BaCrO}_4$  as  $253 \text{ g/mol}$ . 1.0

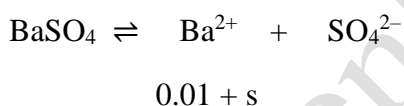
**Ans:  $2.53 \text{ mg}/\text{dm}^3$**

$$\text{Solubility} = \sqrt{1.0 \times 10^{-10}} = 1.0 \times 10^{-5} \text{ mol}/\text{dm}^3$$

$$\text{Solubility in mg}/\text{dm}^3 = 1.0 \times 10^{-5} \times 253 \times 1000 = 2.53 \text{ mg}$$

2. Calculate the molar solubility of  $\text{BaSO}_4$  in a  $0.010 \text{ mol}/\text{dm}^3$  solution of  $\text{Ba}(\text{NO}_3)_2$  given that the solubility product of  $1.1 \times 10^{-10}$ .

**Ans:  $1.1 \times 10^{-8} \text{ mol}/\text{dm}^3$**

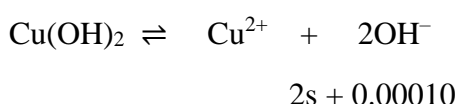


$$\text{Solubility, } s = 1.1 \times 10^{-10} / 0.010 = 1.1 \times 10^{-8} \text{ mol}/\text{dm}^3$$

3. Calculate the molar solubility of  $\text{Cu}(\text{OH})_2$  in a solution of pH 10. Solubility product of  $\text{Cu}(\text{OH})_2$  is  $2.6 \times 10^{-19}$ .

**Ans:  $2.6 \times 10^{-15} \text{ mol}/\text{dm}^3$**

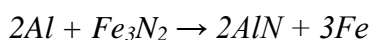
$$\text{OH}^- = 0.00010 \text{ mol}/\text{dm}^3$$



$$\text{Solubility, } s = 2.6 \times 10^{-19} / 0.00010 = 2.6 \times 10^{-15}$$

1. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction:  $\text{Al} + \text{Fe}_3\text{N}_2 \rightarrow \text{AlN} + \text{Fe}$

**Ans: 8**



2. Given that, the atomic masses of manganese and astatine are 55 and 210 respectively, what mass of astatine will have the same number of particles as 2.2 g of manganese?

**Ans: 8.4 g**

$$\text{Moles of Mg} = 2.2/55.0 = 0.040$$

$$\text{Hence equivalent mass of At} = 0.040 \times 210 = 8.4 \text{ g}$$

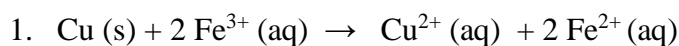
3. To determine the formula of a hydrocarbon, 0.66 g of the hydrocarbon produced 2.2 g of carbon dioxide when burned. Determine the percentage composition of carbon in the compound. (C = 12; O = 16, H = 1.0)

**Ans: 91 %**

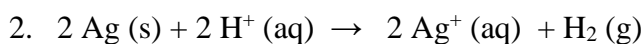
$$\text{Mass of C} = 12/44 \times 2.2 = 0.60 \text{ g}$$

$$\% \text{ C} = 0.60/0.66 \times 100 = 91 \%$$

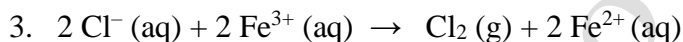
Indicate the cell notation for each of the following cell reactions



**Ans: Cu | Cu<sup>2+</sup> || Fe<sup>2+</sup>, Fe<sup>3+</sup> | Pt**



**Ans: Ag | Ag<sup>+</sup> || H<sup>+</sup> | H<sub>2</sub> | Pt**



**Ans: Pt | Cl<sub>2</sub> | Cl<sup>-</sup> || Fe<sup>2+</sup>, Fe<sup>3+</sup> | Pt**

1. Determine the percent composition of carbon present in nicotine (C<sub>10</sub>H<sub>14</sub>N<sub>2</sub>) given the relative atomic masses of carbon, hydrogen, nitrogen and oxygen as 12, 1.0, 14 and 16 respectively.

**Ans: 74 %**

$$\text{Molar mass of (C}_{10}\text{H}_{14}\text{N}_2) = 162 \quad \text{percentage of C} = \frac{120}{162} \times 100 = 74\%$$

2. Determine the percent composition of carbon present in the alkaloid cytosine (C<sub>11</sub>H<sub>14</sub>N<sub>2</sub>O) given the relative atomic masses of carbon, hydrogen, nitrogen, and oxygen as 12, 1.0, 14 and 16 respectively.

**Ans: 69 %**

$$\text{Molar mass of (C}_{11}\text{H}_{14}\text{N}_2\text{O)} = 190 \quad \text{Percentage of C} = \frac{132}{190} \times 100 = 69\%$$

3. Determine the percent composition of carbon present in the drug, pregabalin (C<sub>8</sub>H<sub>17</sub>NO<sub>2</sub>) given the relative atomic masses of carbon, hydrogen, nitrogen, and oxygen as 12, 1.0, 14 and 16 respectively.

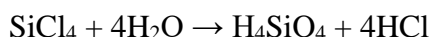
**Ans: 60 %**

$$\text{Molar mass of (C}_8\text{H}_{17}\text{NO}_2) = 159 \quad \text{Percentage of C} = \frac{96}{159} \times 100 = 60 \%$$



1. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction:  $\text{SiCl}_4 + \text{H}_2\text{O} \rightarrow \text{H}_4\text{SiO}_4 + \text{HCl}$

**Ans: 10**



2. Given that 0.20 moles of a compound  $\text{A}_3\text{B}$  weighs 28 g, determine the atomic mass of element A if the atomic mass of element B is 14 g.

**Ans: 42 g/mol**

$$\text{Molecular mass of compound} = 28/0.2 = 140$$

$$\text{Mass of element A} = (140-14)/3 = 42 \text{ g/mol}$$

3. What is the maximum number of hydrogen bonds formed by molecules of trimethylamine?

**Ans: zero (0)**

The contact process for the manufacture of sulfuric acid involves the following equilibrium



State and explain the effect of each of the following actions on the equilibrium of the reaction

1. An increase in pressure

**Ans: Equilibrium will shift toward the formation of more product (right/forward)**

An increase in pressure will favour the side with fewer moles of gas. Mole of reactants is 3 and moles of product is 2, hence pressure will favour formation of product/forward reaction

2. An increase in temperature

**Ans: Equilibrium will shift toward the formation of more reactants (left/backwards)**

Since reaction is exothermic, increase in temperature will favour the formation of reactants

3. A decrease in the amount of oxygen gas

**Ans: Equilibrium will shift toward the formation of more reactants (left/backwards)**

More  $\text{SO}_3$  will breakdown to form  $\text{O}_2$  in order to negate the effect of the reduced concentration of  $\text{O}_2$ .

1. Ethyne reacts with oxygen in a ratio of 2:5. Calculate the enthalpy of bonds broken in this reaction. You are given the following bond energies in kJ/mol:  $\text{C}\equiv\text{C} = 840$ ;  $\text{C}-\text{H} = 415$ ;  $\text{O}=\text{O} = 500$

**Ans: 3500 kJ/mol**

$$2 \text{ C}\equiv\text{C} = 840 \times 2 = 1680$$

$$4 \text{ C}-\text{H} = 415 \times 4 = 1660$$

$$5 \text{ O}=\text{O} = 500 \times 5 = 2500$$

Total bond energy = 5840 kJ/mol

2. Given that 4 moles of  $\text{CO}_2$  and 2 moles of  $\text{H}_2\text{O}$  are produced from the reaction of ethyne and oxygen, calculate the enthalpy of bonds formed in the reaction. You are given the following bond energies in kJ/mol:  $\text{C}=\text{O} = 800$ ;  $\text{H}-\text{O} = 460$ .

**Ans: -8240 kJ/mol** (please ignore negative sign)

$$8 \text{ C=O} = 800 \times 8 = 6400$$

$$4 \text{ H-O} = 460 \times 4 = 1840$$

Total = 8240 kJ/mol

3. Nitrogen triiodide,  $\text{NI}_3$  decomposes to form nitrogen gas and iodide. Calculate the enthalpy change for this reaction. You are given the following bond energies in kJ/mol:  $\text{N-I} = 160$ ;  $\text{N}\equiv\text{N} = 950$ ;  $\text{I-I} = 150$

**Ans: 620 kJ/mol**

*Bonds broken*

$$3 \text{ N-I} = 160 \times 3 = 480$$

*Bonds formed*

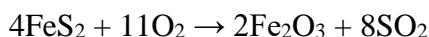
$$\text{N}\equiv\text{N} = 950$$

$$\text{I-I} = 150$$

$$\text{Enthalpy change} = 1100 - 480 = 620 \text{ kJ/mol}$$

1. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction:  $\text{FeS}_2 + \text{O}_2 \rightarrow \text{Fe}_2\text{O}_3 + \text{SO}_2$

**Ans: 25**



2. Given the atomic masses of nitrogen, hydrogen, oxygen and cerium as 14, 1.0, 16, and 140, g/mol respectively, determine the mass of 1.0 mole of ammonium cerium (IV) nitrate,  $(\text{NH}_4)_2\text{Ce}(\text{NO}_3)_6$

**Ans: 546 g/mol**

$$17 \times 2 + 140 + 62 \times 6 = 546 \text{ g/mol}$$

3. Name the nuclide formed when Vanadium-52 undergoes a beta decay?

**Ans: Chromium-52**

Reforming of petroleum helps to convert high molecular weight hydrocarbons into low molecular weight high octane products. Name one major reaction that occurs during catalytic reforming of petroleum.

**Ans:**

- 1. Dehydrogenation**
- 2. Isomerization**
- 3. Cyclization**
- 4. Aromatization**
- 5. Hydrocracking**

1. A molecule of an organic compound contains 8 carbon atoms which account for a total of 60% of its molecular mass. Determine the molecular mass of the compound given that the atomic mass of carbon is 12.

**Ans: 160 g/mol**

$$\text{Total mass of Carbon} = 12 \times 8 = 98 \text{ g}$$

$$\text{Molecular Mass} = (100 \times 96) / 60 = 160 \text{ g/mol}$$

2. A hydrocarbon contains 13 carbon atoms which account for a total of 65 % of its molecular mass. Determine the molecular mass of the compound given that the atomic mass of carbon is 12.

**Ans: 240 g/mol**

Total mass of Carbon =  $12 \times 13 = 156$  g

Molecular Mass =  $(100 \times 156) / 65 = 240$  g/mol

3. An aliphatic diol with molecular mass 174 g/mol contains 10 carbon atoms. Determine the number of hydrogen atoms present in the alcohol given that the atomic mass of carbon is 12, oxygen is 16 and hydrogen is 1.0

**Ans: 22**

Total mass of carbon =  $12 \times 10 = 120$

Mass of oxygen =  $16 \times 2 = 32$

Hence mass of H =  $174 - 152 = 22$

- 
1. How many moles of oxygen atoms are present in 2.4 g of  $S_2O_8$ ? Take the atomic mass (g/mol) of sulphur and oxygen as 32 and 16, respectively.

**Ans: 0.10 mol**

$n(S_2O_8) = 2.4/192 = 0.0125$  mol.  $n(O) = 8 \times 0.0125 = 0.10$  mol

2. The gaseous molecules:  $N_2O$  and  $CO_2$  are mixed in a ratio of 1:3 by mass. What is the ratio of gases by volume? Take atomic masses of N, C and O as 14; 12 and 16, respectively.

**Ans: 1:3**

Molecular mass of  $N_2O = 44$

Molecular mass of  $CO_2 = 44$

Since molecular mass is the same, volume ratio will be same, Hence 1:3

3. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction:  $HNO_3 \rightarrow H_2O + NO_2 + O_2$

**Ans: 11**

$4HNO_3 \rightarrow 2H_2O + 4NO_2 + O_2$  (Accept only integers)

- 
1. Which nuclear species is formed when boron-10 is bombarded with a proton to produce boron-8?

**Ans: Tritium**

2. Identify the nuclear species formed when oxygen-16 is bombarded with nitrogen-14 to produce fluorine-16

**Ans: carbon-14**

3. Identify the nuclear species formed when Neon-20 is bombarded with deuterium to produce an alpha particle.

**Ans: Fluorine-18**

4. Identify the nuclide formed when chlorine-33 undergoes a positron decay?

**Ans: sulphur-33**

Given the following reduction enthalpies, write the standard cell notation for the cell reactions occurring and indicate the value of the emf.

1.  $\text{Cu}^{2+} / \text{Cu}$   $E^{\circ} = 0.337 \text{ V}$   
 $\text{Ag}^{+} / \text{Ag}$   $E^{\circ} = 0.800 \text{ V}$

**Ans:  $\text{Cu} | \text{Cu}^{2+} || \text{Ag}^{+} | \text{Ag}$                       emf = 0.468 V**

2.  $\text{Sn}^{2+} / \text{Sn}$                        $E^{\circ} = -0.137 \text{ V}$   
 $\text{Fe}^{3+} / \text{Fe}^{2+}$                        $E^{\circ} = 0.770 \text{ V}$

**Ans:  $\text{Sn} | \text{Sn}^{2+} || \text{Fe}^{2+}, \text{Fe}^{3+} | \text{Pt}$                       emf = 0.907 V**

3.  $\text{Sn}^{4+} / \text{Sn}^{2+}$                        $E^{\circ} = 0.148 \text{ V}$   
 $\text{Pb}^{4+} / \text{Pb}^{2+}$                        $E^{\circ} = 1.667 \text{ V}$

**Ans:  $\text{Pt} | \text{Sn}^{2+}, \text{Sn}^{4+} || \text{Pb}^{4+}, \text{Pb}^{2+} | \text{Pt}$                       emf = 1.519 V**

4.  $\text{Ti}^{2+} / \text{Ti}$                        $E^{\circ} = -0.163 \text{ V}$   
 $\text{U}^{4+} / \text{U}^{3+}$                        $E^{\circ} = -0.609 \text{ V}$

**Ans:  $\text{Pt} | \text{U}^{3+}, \text{U}^{4+} || \text{Ti}^{2+} | \text{Ti}$                       emf = 0.446 V**

1. Given the atomic masses of magnesium, boron and oxygen as 24, 11, and 16 g/mol respectively, determine the mass of 2.0 moles of magnesium borate,  $\text{Mg}_3(\text{BO}_3)_2$

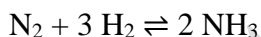
**Ans: 380 g**

$$24 \times 3 + 11 \times 2 = 190 \text{ g/mol}$$

$$\text{Mass of 2.0 moles} = 190 \times 2 = 380 \text{ g}$$

2. Determine the maximum amount (in grams) of ammonia produced when 11.2 g each of hydrogen gas and nitrogen gas react according to the equation:  $\text{N}_2 + 3 \text{H}_2 \rightleftharpoons 2 \text{NH}_3$   
Take atomic mass of nitrogen and hydrogen as 14.0 and 1.00, respectively.

**Ans: 13.6 g**

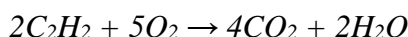


$$n(\text{N}_2) = 11.2/28 = 0.400 \text{ mole}; \quad \text{H}_2 \text{ is in excess}$$

$$\text{mass of NH}_3 = 0.400 \times 17 \times 2 = 13.6 \text{ g}$$

3. Determine the **sum** of the stoichiometric coefficients of all reactants and products present in a balanced equation of the reaction:  $\text{C}_2\text{H}_2 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$

**Ans: 13**



1. What is the change in the oxidation state of the reducing agent present in the reaction:  $\text{Cr}(\text{OH})_3 + \text{Br}_2 \rightarrow \text{CrO}_4^{2-} + \text{Br}^-$

**Ans: +3 to +6 (or a change of +3)**

2. What is the oxidation state of the oxidized form of the reducing agent present in the reaction:  $\text{Cr}_2\text{O}_7^{2-} + \text{C}_2\text{H}_5\text{OH} \rightarrow \text{Cr}^{3+} + \text{CO}_2$

**Ans: +4**

3. How many moles of an ideal gas are present in  $2.5 \text{ dm}^3$  of gas at a temperature of  $27 \text{ }^\circ\text{C}$  and  $100 \text{ kPa}$ ? Take the molar gas constant to be  $8.3 \text{ JK}^{-1}\text{mol}^{-1}$

**Ans: 0.10 mol**

$$PV=nRT$$

$$\text{Mole of gas} = PV/RT = 100000 \times 0.0025 / (8.3 \times 300) = 0.10 \text{ mol}$$

4.  $4.00$  moles of a compound have a mass of  $420 \text{ g}$ . What is the molecular mass of the compound?

**Ans: 105 g/mol**

$$\text{Molecular mass} = 420/4.0 = 115 \text{ g/mol}$$

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