The Creature Collage of Science and Commerce Abbottabad

Instructor: Gul Naz **Class**: 1st year **Chapter**: 1

Subject: Chemistry **Stoichiometry**

Q.1 Calculate the grams atoms in 0.4 gm of potassium.

Ans.

Gram atoms of potassium =

= = 0.01 grams atoms

Q.2 23 grams of sodium and 238 gram of uranium have equal number of atoms in them.

Ans.

Mass of sodium = 23 gms= 1mole=6.02 x 1023 atoms

Mass of uranium = 238g=1 mole= 6.02x 1023 atoms

Both the substances have equal number of atoms because they have same no.of moles.

Q.3 Mg atom is twice heavier than that of carbon.

Ans.

The atomic mass of Mg is 24 which is to twice as mass as compared to the atomic mass of carbon i.e. 12. So Mg atom is twice heavier than that of carbon.

Q.4 180 grams of glucose and 342 gram of sucrose have the same number of molecules but different number of atoms present in them.

Ans.

180 grams of glucose ($C_6H_{12}O_6$) and 342 grams of sucrose ($C_{12}H_{22}O_{11}$) are their molar masses indicating one mole of each (glucose and sucrose) one mole of a substance contains equal number of molecules i.e. 6.02 x 1023.

Mass of glucose ($C_6H_{12}O_6$)=180g=1mole=6.02x1023molecules

=24NAatoms

Mass of Sucrose ($C_{12}H_{22}O_{11}$)=342g=1mole=6.02 x 1023 molecules

=45NAatoms

Q.5 4.9 g of H_2SO_4 when completely ionized in water have equal number of positive and negative ions, but the number of positively charged ions are twice the number of negatively charged ions.

Ans.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$$

When one mole of H_2SO_4 ionizes, it produces $2H^+$ and

SO_4^{-2} ions. Hydrogen ions contains +1 charge while sulphate ions have – 2 charge. Hydrogen ions are twice in number than that of SO ion. Charges on both ions are equal (with opposite sign). Similarly ions produced by complete ionization of 4.9 grams of H_2SO_4 in water will have equal +ve and –ve charges but the number of H^+ ions are twice than number of negatively charged sulphate ions.

Q.6 One mg of K_2CrO_4 has thrice the number of ions than the number of molecules when ionized in excess of water.

Ans. $K_2CrO_4 \rightarrow 2K^+ + CrO_4^{-2}$

When K_2CrO_4 ionizes in water, its one molecule gives three ions i.e. two K^+ and one CrO_4^{-2} (chromate) ions. The ratio between the number of molecules and number of ions than the number of molecules when ionized in water.

Q.7 Two grams of H_2, 16g of CH_4 and 44 gram of CO_2 occupy separately the volumes of 22.414 dm^3 at STP, although the sizes and masses of molecules of three gases are very different from each other.

Ans.

One mole of gas at STP occupies a volume of 22.4 dm^3 sizes and masses of molecules of different gas do not affect the volume. Normally it is known that in the gaseous state, the distance between the molecules is 300 times greater that their diameter. Therefore two grams of H_2, 16 grams of CH_4 and 44 grams of CO_2 (1 mole of each gas) separately occupy a volume of 22.4 dm^3. This is called molar volume.

$2gH_2 = 1mole$, $16gCH_4 = 1$ mole, $44gCO_2 = 1$ mole

$1mole = 22.414dm^3$

Q.8 Define Stoichiometry ?

Ans.

Stoichiometry is the branch of chemistry which gives a quantitative relationship between reactants and products in balanced chemical equation.

Q.9 What is limiting reactant? How does it control the quantity of the product formed? Explain with three examples. /Many chemical reactions taking place in our surroundings involve limiting reactants give examples?

Ans.

The reactant which controls (limits) the amount of product formed during a chemical reaction is called limiting reactant. In our surrounding many chemical reactions take place which involve limiting reactants some of these reactions are:

(i) Burning of coal to form CO_2---Coal is limiting reactatnt $C + O_2 \rightarrow CO_2$

(ii) Burning of sui gas to form CO_2 and H_2O

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

(iii) Rusting of iron----iron is limiting reactant

In above reactions oxygen is always in excess, while other reactants are consumed earlier. So other reactants are limiting reactants.

Q.10 One mole of H_2O has two moles of bands, three moles of atoms, ten moles of electron and twenty–eight moles the total fundamental particles present in it.

Ans.

One molecule of H–O–H has two bounds between hydrogen and oxygen. There are three atoms i.e. two H atoms and one O atom, therefore one mole of H_2O contains two moles of bonds and three moles of atoms (2 moles of H atoms and one mole of O atoms).

Similarly, there are eight elections in oxygen and one electron in each of the two, H atoms one molecule of H_2O so has 10 electrons, so one mole of water contains 10 moles of electrons. There are 28 moles of all fundamental particles in one mole of water i.e.

10 moles of electrons.

10 moles of protons.

8 moles of neurons (8 neutrons in oxygen and there is no neutron in hydrogen) 28 moles of fundamental particles.

Q.11 One mole of H_2SO_4 should completely react with two moles of NaOH. How does Avogadro's number help to explain it?

Ans.

The balanced chemical equation between H_2SO_4 and NaOH

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + H_2O$

$H_2SO_4 \rightarrow 2H^+ + SO_4^{-2}$

$2NaOH \rightarrow 2Na^+ + 2OH^-$

$2H^+ + 2OH^- \rightarrow 2H_2O$

2NA 2NA

This is an acid base reaction, one mole of H_2SO_4 releases two moles of H^+ ion in solution. It needs two moles of OH ions for complete neutralization. So two moles of NaOH which releases two moles of OH are required to react with one mole of H_2SO_4. One mole of H_2SO_4 releases twice the Avogadro's number of H^+ ions and it will need the Avogadro's number of OH ions for complete neutralization.

Q.12 N_2 and CO have same number of electrons, protons and neutrons.

Ans.

Both N_2 and CO have same number of electrons, protons and neutrons as it is clear from the following explanation.

For N_2 No. of electrons in $N_2 = 7 + 7 = 14$

No. of protons in $N_2 = 7 + 7 = 14$

No. of neutrons $= 7 + 7 = 14$

For CO number of electrons

in C = 6

No. of electrons in O = 8

Total no. of protons = 6 + 8 = 14

No. of neutrons in C = 6

No. of neutrons in O = 8

Total no. of neutrons = 6 + 8 = 14

Q.13 How many molecule, of water are in 12 gram of ice?

Ans.

Mass of ice (water) = 12.0 gm

Molar mass of water = 18 g/mol

No. of molecules of water

=

=

No. of molecules of water = 0.66 x 6.02 x 1023

= 3.97 x 1023

Q.14 Differentiate between limiting and non–limiting reactant ?

Ans. Limiting Reactant:

A limiting reactant is a reactant and that controls the amount of the product formed in a chemical reaction.

Non–Limiting Reactant:

The reactant which produces the excess amount of the product is called non–limiting reactant.

Q.15 Distinguish between actual yield and theoretical yield ?

Ans. Actual Yield:

The amount of the products obtained in a chemical reaction is called actual yield based on experiment.

Theoretical (Experiment) Yield:

The amount of the products calculated from the balanced chemical equation is called theoretical yield.

Q.16 What do you mean by percent yield? Give its significance ?

Ans.

The yield which is obtained by dividing actual yield with theoretical yield and multiplying by 100 is called percent yield.

% yield = x 100

Significance:

(i) % yield indicates the efficiency of reaction.

(ii) More is the percent yield higher will be the efficiency of reaction.

Q.17 Why actual yield is less than the theoretical yield?

Ans.

(a) Side reaction may takes place

(b) All the reactant may not be converted into products

(c) Mecahanical loss may occur like during

e.g Filtration, evaporation, crystallization, distillation etc.

Q.18 Calculate the mass of 10–3 moles of MgSO4.

Ans.

MgSO4 is an ionic compound. We will consider its formula mass instead of molecular mass.

Number of moles of substance

=

Formula mass of MgSO4 = 120 gm/ml

Number of moles of MgSO4 = 10–3 moles

Applying formula

10–3 =

Mass of MgSO4 = 120 x 10–3 = 0.12 moles

Q.19 Define Avogadro's number ?

Ans.

Avogadro's number is the number of atoms, molecules and ions in one gram atom of an element, one gram molecule of a compound and one gram ion of substance, respectively. It is equal to 6.02 x 1023.

Q.20 Define mole ?

Ans.

The molecular mass of a substance expressed in grams is called molecule or gram mole or simply the mole of a substance.

Moles of substance =

1 mole of water = 18.0 g

1 mole of H2SO4 = 98.0 g

Q.21 Define isotopes ?

Ans.

Atoms of the same element which have different masses but same atomic numbers are called isotopes. For example carbon has three isotopes.

12C6 13C6 14C6 and expressed as C–12, C–13 and C–14. Similarly hydrogen has three isotopes H H H called protium, deuterium and tritium.

Q.22 Define (i) ions (ii) Positive ion (iii) Negative ion.

Ans. Ion

As specie having positive or negative charges are called ions. For example Cl–1, NO, Na+, Ca++.

Positive Ion (Cation):

A specie has +ve charge is called positive ion and attracted towards Cathode . For example Na+, K++, Ca++.

Negative Ion (Anion)

A specie which has negative charge is called negative ion and attracted towards anode . For example F–1,Cl–1,Br–1andS–2P–3,C–4,SO, Cr2O, CO.

Q.23 Define and explain the molecular ion ?

Ans.

When a molecule loses or gains an electron, molecular ion is formed. For example CH4+, CO+, N2+. Cationic molecular, ions are more abundant than anionic ions.

The molecular ions find applications of in calculation of molecular mass of a compound. The molecular ions also help in the determination of structure of macro molecules.

The break down of molecular ions obtained from the natural products can give important information about their structure.

Q.24 What do understand by the relative atomic mass ?

Ans.

Relative atomic mass is the mass of an atom of element as compared to the mass of an atom of carbon taken as 12.

The unit used to express the relative atomic mass is called atomic mass unit (amu). It is th of the mass of one carbon atom. The relative atomic mass of 12C6 is 12.00 amu. The relative atomic mass of H is 1.0078 amu.

Q.25 Define Gram atom ?

Ans.

The atomic mass of an element expressed in grams is called gram atom of an element.

Number of gram atoms of a meter an element

=

For example 1 gram atom of hydrogen = 1.008 gm

1 gram atom of carbon = 12.00 gm

1 gram at of uranium = 238 gm

Q.26 Define gram ion ?

Ans.

The ionic mass of an ionic specie expressed in grams is called one gram ion or one mole of ions.

Number of gram ions =

1 gram ion of OH^{-1} = 17 grams

1 gram ion of SO = 96 gram

1 gram ion of CO = 60 gram

Q.27 Define gram formula and moles ?

Ans.

The formula mass of an ionic compound expressed in grams is called gram formula of the substance.

Number of gram formula or moles of a substance

=

1 gram formula of NaCl = 58.50 gms

1 gram formula of Na_2CO_3 = 106 gm

1 gram formula of $AgNO_3$ = 170 gm

The atomic mass, molecular mass, formula mass or ionic mass of the substance expressed in grams is called moles of those substances.

Q.28 Define molar volume ?

Ans.

The volume occupied by one mole of an ideal gas at standard temperature and pressure (STP) is called molar volume. The volume is equal to 22.414 dm3.

Q.29 Define and explain atomicity ?

Ans.

The number of atoms present in a molecule is called the atomicity. The molecule can be monoatomic, diatomic and triatomic etc. If the molecule contains one atom it is monoatomic, if it contains two atoms it is diatomic, and if it contains three atoms it is triatomic. Molecules of elements may contain one two or more same type of atoms. For example He, Cl_2, O_3, P_4, S_8. The molecules of compounds consist of different kind of atoms. For example HCl, NH_3, H_2SO_4, $C_6H_{12}O_6$.

Q.30 Define an atom and molecule ?

Ans. Atom:

Atom is now defined as the smallest particle of an element, which may or may not have independent existence. For example He and Ne atoms have independent existence. While atoms of hydrogen, nitrogen and oxygen do not exist independently.

Molecule:

A molecule is the smallest particle of a pure substance(element or Compound) which can exist independentally. For example N_2, O_2, Cl_2, HCl, NH_3 and H_2SO_4 are examples of molecules.

Q.31 What do you mean by empirical formula and molecular formula? How they are related to each other ?

Ans. Empirical Formula:

It is the simplest formula that gives information about the simple ratio of atoms present in a compound.

In an empirical formula of a compound $A_x B_y$, there are X atoms of an element A and y atoms of an element B.

Molecular Formula:

The formula of a substance which is based on the actual molecule is called molecular formula. It gives the usual number of atoms present in the molecule. For example molecular formula of benzene is C_6H_6, while that of glucose is $C_6H_{12}O_6$. The molecular formula and empirical formula are related to each other by the following relationship.

Molecular formula = n x (Empirical formula)

Where "n" is simple integer.

Q.32 Is it true many compounds have same empirical and molecular formula ?

Ans.

There are many compounds, whose empirical formulas and molecular formulas are the same. For example H_2O, CO_2, NH_3 and $C_{12}H_{22}O_{11}$ have the same empirical and molecular formulas. Their simple multiple n is unity. Actually value of "n" is the ratio of molecular mass and empirical formula mass.

n =

Q.33 Ethylene glycol is used in automobile antifreeze. It has 38.7% carbon, 9.7% hydrogen and 51.6% oxygen. Its molar mass is 62 gms $mole^{-1}$. Determine its empirical and molecular formula ?

Ans.

C = 38.7%, H = 9.7%, O = 51.6%

Dividing above %ages by atomic mass.

We get molar ratios

C = = 3.225

H = = 9.7

O = = 3.225

Dividing above molar ratio by least ratio we get atomic ratio.

C = = 1

H = = 3

O = = 1

Empirical formula is CH_3O

Molar mass = 62

Empirical formula mass = 12 + 3 + 16 = 31

Now

n =

= = 2

Molar formula = n x Empirical formula

= 2 x CH_3O

Molecular formula = $C_2H_6O_2$

Hence molecular formula of Ethylene glycol = $C_2H_6O_2$

Q.34 The combustion analysis of an organic compound shows it to contain 65.44% carbon 5.5% hydrogen and 29.06% of oxygen. What is the empirical formula of the compound? If the molecular mass of the compound is 110.15. Calculate the molecular formula of the compound.

Ans.

First of all divide the percentage of each element by its atomic mass to get the number of from atoms or moles.

No. of gram atoms of carbon =

= 5.45 gram atoms of C

No. of gram atoms of hydrogen =

= 5.45 gram atoms of H

No. of gram atoms of oxygen =

= 1.82 gram atoms of 0

Mole ratio C : H : O

4.45 5.45 1.82

Divide number of grams atoms by the smallest number

C : H : O

: :

3 : 3 : 1

Carbon, hydrogen and oxygen are present in the given organic compound in ratio of 3 : 3 : 1. So the empirical formula is C_3H_3O.

In order to calculate the molecular formula first calculate the empirical formula mass.

Empirical formula mass = 3 x 12 + 3 x 1 + 16

= 36 + 3 + 16 = 55.05

Molar mass of the compound = 110.15

h = = = 2

Molecular formula = n x empirical formula

= 2 x C3H3O

= C6H6O2

Q.35 Give relationships, between the amounts of substances and number of particles. There are three useful relationships ?

Ans.

1. Number of atoms of an element = x NA

2. Number of molecules of a compound

= x NA

3. Number of ions of ionic species = x NA

NA is the Avogadro's number. The value is 6.02 x 1023.

Q.36 What are the types of relationships of stoichiometric calculations ?

Ans.

There are three types of relationships of stoichiometric calculations.

1. Mass–Mass Relationship

The relationship in which the mass of one substance is given and the mass of other substance is calculated.

2. Mass–mole or mole–mass relationship

The relationship in which mass of one substance is given and moles of other substance is to be calculated or vice versa.

3. Mass–volume or volume mass relationship

The relationship in which the mass of one substance is given and the volume of other substance is to be calculated or vice versa.

Q.37 Law of conservation of mass has to be obeyed during the stoichiometric calculations ?

Ans.

Stoichiometric calculations are based on balanced chemical equation and equation is balanced on the basis of Law of conservation of mass e.g

$$C+O2 \rightarrow CO$$

In this equation stoichiometric calculations are not possible because it is not a balanced equation and it is not obeying Law of coseravtion.