Chapter: Some Basic Concepts of Chemistry

Importance and scope of chemistry

Question 1

Express the following in S.I units:

a) 125 pounds, the average weight of an Indian boy

b) 14 lb/m^2 (atmospheric pressure)

c) 5'8" , the average height of ramp models

Ans.

a) 125 lbs = $\frac{125 \times 454}{1000} = 56.75 kg$. (1 lb = 454g)

b) 14 lb/m^2 = $\frac{14 \times 100 \times 100}{2.205 \times 2.54 \times 2.54} = 9841.3\ kg/m^2$ (1' = 2.54cm and 1 kg = 2.205 pounds)

c) 5'8" = 68" = $\frac{68 \times 2.54}{100} = 1.7272\ cm$ (1' = 12" and 1" = 2.54 cm).

Question 2

Classify the following substances as elements, compounds and mixtures. In case of mixtures clearly indicate whether the mixture is homogenous or heterogeneous and also explain how would you separate them?

a) Iron

b) Salt and water

c) Glass powder, iron filings and sugar

d) Distilled water

Ans.

a) Iron is an element

b) Salt and water are a homogenous mixture which can be separated by distillation, in this process salt remains as residue.

c) Glass powder, iron filing and sugar are a heterogeneous mixture. To separate the constituents dissolve the mixture in water, sugar dissolves. Now filter to separate undissolved glass powder and iron filings. Glass powder and iron filings can be separated with the help of a magnet. Sugar can be recovered from solution by evaporation.

d) Distilled water is a compound.

Question 3

What are significant figures? Give the number of significant figures in each of the following?

a) 2.56×10^3

b) 165

c) 2.05

d) 5000

e) 0.00256

Ans.

The number of significant figures in a measurement is the number of figures that are known with certainty plus one that is uncertain, beginning with one non-zero digit.

a) Number of significant figures in $2.56 \times 10^3 = 3$

b) Number of significant figures in 165=3 (all non-zero digits are significant).

c) Number of significant figures in 2.05 = 3 (zero's between non zero digits are significant)

d) Number of significant figures in 5000 = 1 (if a number ends in zero's that are not to the right of a decimal, the zeros may or may not be significant.)

e) Number of significant figures in 0.00256 = 3 (zero's to the left of the first non-zero digit in the number are non significant.)

Question 4

Express the following in SI units:

A) 93 million miles

B) 5 feet 2 inches

Ans.

A) 1 mile = 1.6×10^3 m, therefore

93 million miles = $93 \times 10^6 \times 1.60 \times 10^3$ m

$=1.49 \times 10^{11}$ m

B) 5 feet 2 inches= $5 \times 12 + 2 = 62$ inches

$=62 \times 2.54 \times 10^{-2}$ m

$= 157.48 \times 10^{-2}$ m = 1.5748 m.

Question 5

What is the mass (mg) of a zinc block whose dimensions are 2.0" $\times$ 3.0" $\times$ 5.0" and whose density is 2.5g /cm^3? (Given1.0"= 2.54 cm.)

Ans.

Total volume of a zinc block = $2.0 \times 3.0 \times 5.0 = 76.20$

Hence mass in grams = density $\times$ volume

$= 2.5 \times 76.20 = 190.500$g

$= 1.905 \times 10^2$g

Question 6

Differentiate between the mass and weight of a substance.

Ans.

Mass of a substance is defined as the amount of matter present in it while weight of an object is defined as the force exerted by gravity on an object. The mass of a substance is constant where as the weight may vary from one place to another due to change in gravity.

Question 7

The mass of a sample of an atom of hydrogen is 1.008 amu. What is the mass of 32 atoms of hydrogen?

Ans.

The mass of 32 atoms of hydrogen would be = 32 $\times$ 1.008 = 32.256 amu. Here the result is rounded off to four significant figures because 1.008 has four significant figures.

Question 8

Sapphire weighs 563 carats. If one carat is equal to 200mg, what is the weight of the gemstone in grams?

Ans.

weight of one carat = 200 mg

Therefore weight of 563 carats = $\frac{200}{1000} x 563 = 112.6 g$

Question 9

Name the two chemical substances used in air conditioning.

Ans.

Liquid ammonia or liquid sulphur dioxide are used in air conditioning.

Question 10

Name two life saving drugs which are used in cancer therapy.

Ans.

Taxol and cisplatin are used in cancer therapy.

Mole concept

Question 1

10 ml of HCl solution produced 0.1435 g of AgCl when treated with excess of silver nitrate solution. What is the molarity of acid solution? (Atomic mass of Ag = 108).

Ans.

The chemical equation of the reaction is:

$$\underset{36.5}{HCl} + AgNO_3 \rightarrow \underset{143.5\,g}{AgCl} + HNO_3$$

Amount of HCl mg required to produce 0.1435 g AgCl

$= \frac{36.5}{143.5} \times 0.1435 = 0.0365\ g$

Thus 10.0 ml HCl contains HCl = 0.0365 g

$= \frac{0.0365}{36.5} = 10^{-3}\ moles$

Hence, molarity of HCl

$= \frac{10-3}{10} \times 1000 = 0.1M.$

Question 2

Gastric juice contains 3.0 g of HCl per litre. If a person produces about 2.5 litres of gastric juice per day, How many antacid tablets each containing 400 mg of Al(OH)3 are needed to neutralize all the HCl produced in one day.

Ans.

$$\underset{78\,g}{Al(OH)_3} + 3HCL \rightarrow \underset{109.5\,g}{AlCl_3} + 3H_2O$$

Amount of HCl produced

= 3.0 ×2.5 = 7.5

Amount of $Al(OH)_3$ required

Question 4

How many litres of oxygen are required for the complete combustion of 125 litres of ethylene (C_2H_2)?

Ans.

$2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_20$

5 Moles of O_2 is required for the combustion of 2 moles of C_2H_2

Volume of O_2 required $= 125 \times \frac{5}{2} = 313l.$

Question 5

Calculate the mass percent of carbon present in ethyl alcohol (C_2H_5OH).

Ans.

Molar mass of ethanol = $2 \times 12.01 + 6 \times 1.008 + 16 = 46.068$

Mass percent of carbon = $\frac{24.02}{46.068} \times 100 = 52.14\%$

Question 6

Calculate the volume occupied by 6.023×10^{22} molecules of ammonia?

Ans.

Volume occupied by 6.023×10^{23} molecule of ammonia at STP = 22.4 Litres

Therefore the volume occupied by 6.023×10^{22} molecules of ammonia at STP

$$= \frac{22.4}{6.023 \times 10^{23}} \times 6.023 \times 10^{22} = 2.24l$$

Question 7

How are 0.50 mol Na_2CO_3 and 0.50 M Na_2CO_3 different?

Ans.

0.50 mol Na_2CO_3 means, 0.50×10^6 = 53g of Na_2CO_3 where as 0.50 M Na_2CO_3 means 1 litre solution of sodium carbonate contains 0.5 moles of sodium carbonate.

Question 8

Calculate the number of moles of carbon dioxide which contain 8g of oxygen.

Ans.

In CO_2, 32 g of oxygen is present in 1 mole of CO_2 Therefore 8 g of oxygen is present in

$= \frac{1\times 8}{32} = 0.25\,mol\ of\ CO_2$

Question 9

Calculate the numbers of moles present in 7.9 mg of calcium (atomic mass of calcium = 40).

Ans.

$$\text{Number of moles} = \frac{\text{massingrams}}{\text{atomic mass}} = \frac{7.9\times10^{-3}}{40} = 1.975\times10^{-4}$$

Question 10

What is the molar volume of water at 273 K? (Density of water =1.00g cm^{-3})

Ans.

Molar mass of water=18g

Molar volume = $\frac{mass}{density} = \frac{18\,g}{1.00\,g\,cm^{-3}} = 18\,cm^3.$

Question 1

What were the limitations of Dalton's atomic theory? Explain in detail.

Ans.

The main failures of Dalton atomic theory are:

(1) It failed to explain how atoms of different elements differ from each other i.e. It did not tell anything about structure of the atom.

(2) It could not explain how and why atoms different elements combine with each other to form compound atoms or molecules.

(3) It failed to explain the nature of forces that bind together different atoms in a molecule.

(4) It failed to explain Gay Lussac's law of combining volumes.

(5) It did not make any distinction between ultimate particle of an element that takes part in reactions (atoms) and ultimate particle that has independent existence (molecule).

Question 2

A chloride of phosphorus contains 22.57% P. Phosphine contains 8.82% hydrogen and hydrogen chloride gas contain 97.26% chlorine. Show that the data illustrates law of reciprocal proportions:

Ans.

i) In phosphorus chloride,

P = 22.57 %, Cl = 77.43%

ii) In phosphine,

P = 91.18%, H= 8.82%

22.57 parts by mass of P combine with H

$= \frac{8.82}{91.18} \times 22.57 = 2.18$

Thus, ratio of the masses of Cl and H which combine with fixed mass (22.57 parts) of phosphorus separately, is

77.43: 2.18 or 35.5: 1

iii) In hydrogen chloride

Cl= 97.26% H= 2.77%

Thus, ratio of masses of Cl and H when they combine with each other is

97.26: 2.77 or 35.5: 1

iv) Ratio 1: Ratio 2is:

$$\frac{35.5}{1} \times \frac{1}{35.5} = 1:1$$

This shows a simple whole number ratio.

Question 3

1.375 g of cupric oxide was reduced by heating in a current of hydrogen and the weight of copper that remained was 1.098g. In another experiment 1.179 g of copper was dissolved in nitric acid and the resulting copper nitrate was converted into cupric oxide by ignition .the weight of cupric oxide formed was 1.476 g. which law of chemical combinations does this data state?

Ans.

In first experiment:

Copper oxide = 1.375 g

Copper left = 1.098 g

Therefore oxygen present = 1.375 – 1.098g = 0.277 g

Hence % of oxygen present in CuO = $\frac{0.277 \times 100}{1.375} = 20.14.$

Second experiment:

Copper taken = 1.179 g

Copper oxide formed = 1.476 g

Therefore oxygen present = 1.476-1.179g = 0.297 g

Hence % of oxygen of CuO = $\frac{0.297 \times 100}{1.476} = 20.12$

Since percentage of oxygen is the same in both the above cases, so the law of constant composition is illustrated.

Question 4

Carbon forms two gaseous oxides .One of these oxides contains 42.8% carbon while the other contains 27.27% carbon .Explain which law of chemical combination this data illustrates. State this law.

Ans.

The ratio of oxygen in the two compounds is 1:2 so this compound follows law of multiple proportions. According to this law when two elements combine with each other to form two or more than two compounds, the masses of one of the elements which combine with fixed mass of the other, bear a simple whole number ratio to the other.

Question 5

What is the molecular weight of a substance whose vapour density is 4? (CH_4 = 1)?

Ans.

Vapour density of CH_4 referred to hydrogen = $\frac{16}{2} = 8$

Vapour density of the substance referred to CH_4 = 4

So, Vapour density of the substance referred to hydrogen = 4 × 8 = 32

Molecular mass of the substance = 2 × vapour density = 2 × 32 = 64

Question 6
The molecular mass of methane and oxygen are 16 and 32 respectively. If one litre of methane at S.T.P contains N molecules, what will be the number of molecules in 5 L of oxygen at S.T.P?
Ans.
According to Avogadro's law equal volumes of all gases under similar conditions of temperature and pressure contain equal number of molecules. So 5 L of oxygen at S.T.P contains 5N molecules.

Question 7
Give two applications of Avogadro's Law?
Ans.
Avogadro's law is helpful in developing the relationship between:
a) Molecular mass and vapour density
b) Mass and volume of the gas.

Question 8
Which law of chemical combinations is applied in balancing a chemical equation?
Ans.
In balancing a chemical equation, law of conservation of mass is applied.

Question 9
In a chemical reaction one part of element A combines with two part of element B. In another reaction six parts of the element C combines with four parts of the element B. If A and C combine then the ratio of their weights can be calculated by which law?
Ans.
According to the law of reciprocal proportions the weights of two elements combining with a fixed amount of the third element will bear the same ratio (or simple multiple of it) in which

Now, the ratio of X: O in second oxide = $\frac{3.1}{3.1}:\frac{7.73}{3.1}$ $or\ 1:2.5\ or\ 2:5$

Hence, the formula of second oxide is X_2O_5

Question 3

What is the simplest formula of the compound which has the following percentage composition?

Carbon 80% and Hydrogen 20%. If the molecular mass is 30, calculate its molecular formula.

Ans.

Calculation of empirical formula:

Element	Percentage	Atomic mass	Relative number of moles	Simple ratio	Simplest whole number ratio
C	80	12	$\frac{18}{12}=6.66$	$\frac{6.66}{6.66}=1$	1
H	20	1	$\frac{20}{1}=20$	$\frac{20}{6.66}=3$	3

Therefore Empirical formula is CH_3

Calculation of molecular formula:

Empirical formula mass = 12 ×1 + 1 ×3 = 15

n = $\frac{Molecular\ mass}{Empirical\ formula\ mass}=\frac{30}{15}=2$

Molecular formula = Empirical formula ×2

= $CH_3 \times 2 = C_2H_6$

Question 4

Balance the following equations:

i) $Fe + H_2O \rightarrow Fe_3O_4 + H_2$
ii) $KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + H_2O + O_2$
iii) $I_2 + HNO_3 \rightarrow HIO_3 + NO_2 + H_2O$
iv) $Zn + HNO_3 \rightarrow Zn(NO_3)_2 + N_2O + H_2O$

Ans.

i) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$
ii) $4KMnO_4 + 6H_2SO_4 \rightarrow 2K_2SO_4 + 4MnSO_4 + 6H_2O + 5O_2$
iii) $I_2 + 10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$
iv) $4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$.

Question 5

Calculate the molarity of a given NaOH solution which contains 2.00 g of NaOH per litre of solution.

Ans.

Molar mass of NaOH = $\frac{2.00}{40.00}\ mole\ NaOH = 0.05\ mole\ NaOH$

Molarity = $\frac{Mole\ of\ solute}{Volume\ of\ solution\ in\ litres} = \frac{0.05}{1} = 0.05M.$

Question 6

What volume of 10M HCl should be diluted with water to prepare 2.00L of 5M HCl?

Ans.

In case of dilution,

$M_1V_1 = M_2V_2$

10 M HCl 5 M HCl

$10 \times V_1 = 5 \times 2.00$

$V_1 = \frac{5 \times 2.00}{10} L = 1.00 L$

Question 7

Calculate the molecular formula of a gaseous compound whose 1 volume requires 2 volumes of O_2 for combustion and gives 2 volumes of CO_2 and 1 volume of N_2 after it.

Ans.
According to the question

$X + 2O_2 \longrightarrow 2CO_2 + N_2$

Since the product has 2 atoms each of C and N more than that of reactant, these must be present in X. Hence X is C_2N_2.

Question 8

The empirical formula of an organic compound containing carbon and hydrogen is CH_2. The mass of one litre of this organic gas is exactly equal to that of one litre of N_2. What is the molecular formula of the gas?

Ans.
The molecular mass of the gas = Molecular mass of nitrogen = 28
Empirical formula mass of the gas=14

$n = \frac{Molecular\ mass}{Emperical\ formula\ mass} = \frac{28}{14} = 2$

Hence the molecular formula = $(CH_2)_2$

Question 9

In a compound of chromium, the number of atoms of Cr and O are 4.8×10^{10} and 9.6×10^{10} respectively. What is the empirical formula of the compound?

Ans.
The ratio of atoms of Cr and O = $4.8 \times 10^{10} : 9.6 \times 10^{10} = 1 : 2$
Hence empirical formula of the compound = CrO_2

Question 10

How is empirical formula of a compound related to its molecular?

Ans.
The empirical formula of a compound gives the simplest whole number ratio of atoms of various elements present in the molecule of a compound.
Molecular formula= Empirical formula x n.

Question 1

2.5 moles of sulphuryl chloride were dissolved in water to produce sulphuric acid and hydrochloric acid. How many moles of KOH will be required to completely neutralize the solution?

Ans.
$SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$

Mol of HCl produced from 2.5 moles of SO_2Cl_2 = 5 mol

Mol of H_2SO_4 produced from 2.5 moles of SO_2Cl_2 = 2.5 mol

$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$;

$HCl + KOH \rightarrow KCl + H_2O$

Now, 5 mol of H_2SO_4 require KOH = 2.5 mol

∴ Total KOH required = 10 + 2.5 = 12.5 mol.

Question 2

Two acids H_2SO_4 and H_3PO_4 are neutralized separately by the same amount of an alkali when sulphate and dihydrogen orthophosphate are formed respectively. Find the ratio of masses of H_2SO_4 and H_3PO_4 [at mass P = 31]

Ans.

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$

$H_3PO_4 + NaOH \rightarrow NaH_2PO_4 + H_2O$

Equivalent of alkali = 1 g equivalent of H_2SO_4 = 1 g equivalent of H_3PO_4

∴ The two acids must react in the ratio of their equivalent masses.

Equivalent mass of H_2SO_4 = $\frac{98}{2} = 49$

Equivalent mass of H_3PO_4 = $\frac{98}{1} = 98$

Hence ratio of masses of H_2SO_4: H_3PO_4 = 49:98 =1:2.

Question 3

What is the mass of 2 litre sample of water containing 25% heavy water (D_2O) in it by volume? Density of water is 1.0 g cm^{-3} where as that of D_2O is 1.06 g cm^{-3}.

Ans.

Total volume of sample = 2L

$$\therefore \text{Volume of } D_2O = \frac{2000 \times 25}{100} = 500 \text{ ml}$$

Volume of H_2O =- 2000-500 = 1500 ml

Mass of H_2O = 1500 ×1 = 1500g

Mass of D_2O = 500 × 1.06 = 530 g

Total mass = 1500 + 530

= 2030g or 2.03 kg.

Question 4

Differentiate between molar mass and equivalent mass of a substance?

Ans.

The mass of one mole of particles is called molar mass. The number of entities (atoms or molecules) contained in a molar mass is equal to 6.023×10^{23}.

The number of parts by weight of a substance that combines with or displaces 1.008 parts by weight of hydrogen or 8.0 parts of oxygen or 35.5 parts of chlorine is called its equivalent weight. Or the quantity of a substance in grams numerically equal to its equivalent weight is called its gram equivalent weight.

Question 5

What is the amount of copper obtained from 100 g of copper sulphate? (Atomic mass of Cu = 63.5 u)

Ans.

Molar mass of $CuSO_4$ = 63.5+ 32 + 4 × 16 =159.5g

Also,

$CuSO_4 = Cu$

159.5 63.5

Thus, 159.5 g of $CuSO_4$ shall give Cu = 63.5g

Hence Cu that can be obtained from 100 g of $CuSO_4$ = $\frac{63.5 \times 100}{159.5} \times 100\, g = 39.81 g$

Question 6

How many grams of oxygen (O_2) are required to completely react with 0.200 g of hydrogen (H_2) to yield water (H_2O)?

Ans.

The balanced equation for the reaction is:

$$\begin{array}{ccccc} 2H_2 & + & O_2 & \rightarrow & 2H_2O \\ 2\text{mol} & & 1\text{mol} & & 2\text{mol} \\ 4\text{g} & & 32\text{g} & & 36\text{g} \end{array}$$

4 g of H_2 requires oxygen = 32g

0.200 g of H_2 requires oxygen = $\frac{32}{4} \times 0.200 = 1.6\,g$

Question 7

What is the vapour density of a gas if its molecular mass is 22?

Ans.

Molecular mass = 2 $\times$ vapour density = 2 $\times$ 22 = 44.

Question 8

What is the atomic weight of an element whose specific heat is 0.214 cal/gm?

Ans.

According to Dulong pettits law,

Atomic heat capacity of elements (metals) = 6.4 cal mol^{-1} = gram atomic mass × specific heat.

$= \frac{6.4}{0.214} = 30$

Question 9

What is the molecular mass of a compound if 20% nitrogen is present in it?

Ans.

Assuming that a molecule of the compound contains at least one nitrogen atom, then

molecular mass of the compound = $\frac{100 \times 14}{20} = 70$

Thus, molecular mass of a compound is either 70 or multiple of it.

Question 10

Why do atomic masses of most of the elements in atomic mass units involve fractions?

Ans.

Atomic masses of most of the elements in atomic mass units involve fractions because atomic mass of an element is the average of relative masses of its various isotopes. While taking average, the result appears as a fraction.

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