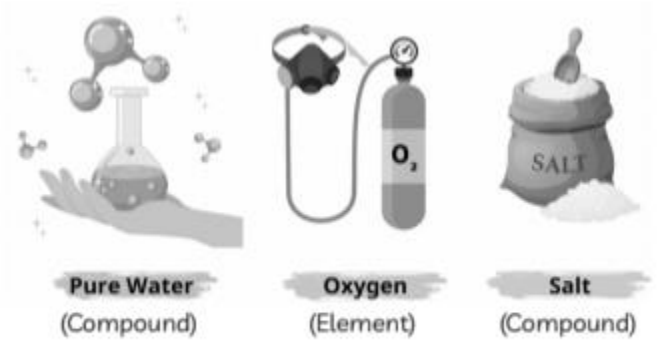
Some Basic Concepts of Chemistry

Case Study Based Questions

Read the following passages and answer the questions that follow:

1. Recent studies have revealed that the simplest form of matter is atoms and elements may also be defined as the pure substance which is made of one kind of atoms. Examples are carbon, sulphur, hydrogen, oxygen, etc. A compound is also a pure substance like element but it is made up of two or more elements. For example, in sodium chloride the two elements sodium and chlorine are present in the ratio of 23:35.5 by mass. Both elements and compounds are pure substances. But on mixing two or more substances in any ratio, mixture results. For example, air is a mixture of different gasses like nitrogen, oxygen, carbon dioxide, water vapour, etc. Further, mixtures are divided into two categories: homogeneous and heterogeneous.



(A) Classify the following as pure substances or mixtures: Graphite and iodized table salt.
(B) Why is tap water considered a mixture while distilled water as a compound?
(C) Why is the gaseous state of ammonia regarded as gas while that of water as vapours?

Ans. (A) Graphite- Pure substance (Element). lodized table salt- Mixture(Heterogeneous)
(B) Tap water constitutes some impurities such as dust particles which are normally mixed with it and not combined chemically. In tap water, the constituents are not present in a fixed ratio and hence, it is a mixture. Distilled water contains only water molecules since it is free from impurities, it is therefore, considered as a compound.
(C) Only the gaseous states of those substances are regarded as vapours which are liquid at room temperature. Since ammonia exists as a gas at room temperature. Hence, its

gaseous state is called gas while water is a liquid at room temperature. Hence, its gaseous state is called vapours.

2. Atoms and molecules are so small in size that it is neither possible to count them individually nor possible to determine their mass. These are counted collectively in terms of Avogadro's number. The mass of Avogadro's number of atoms and molecules is known as gram atomic mass and gram molecular mass respectively. The volume occupied by Avogadro's number of molecules of a gas or vapour is known as molar volume.

(A) Mass of CO2 is 88 g. The number of atoms of oxygen present in it, is:

(a) 2.41 x 1024

(b) 1.2 x 1023

(c) 1.4 x 1023

(d) 2.41 x 1023

(B) Calculate the molecular mass of cane sugar.

(a) 350 g

(b) 361 g

(c) 342 g

(d) 345 g

(C) What will be the number of molecules in one mole of a gas at 100°C and 500 mm pressure?

(a) Less than Avogadro's number

(b) Equal to Avogadro's number

(c) Greater than Avogadro's number

(d) With the change in temperature and pressure, the number of particles will change.

(D) If NA is Avogadro's number, then the number of valence electrons in 70 g of nitride ions (N^3) is:

(a) 42 N_A

(b) 40 N_A

(c) 16 N_A

(d) 45 N_A

(E) Choose the correct mass (in grams) of 11.2 L of N2 at STP.

(a) 13 g

(b) 14.5 g
(c) 14 g
(d) 15 g

Ans. (A) (a) 2.41 x 10^{24}
Explanation: 44.0 g of CO2 contains oxygen atoms
= 2 × 6.022 × 10^{23}
Now, 88.0 g of CO2 contains oxygen atoms
= 2 x 2 x 6.022 × 10^{23}
= 2.41 x 10^{24} atoms
(B) (c) 342 g
Explanation: Molecular mass of cane sugar $C_{12}H_{22}O_{11}$-
= (12 x 12) + (22 × 1) + (16 x 11)
= 342 g
(C) (b) Equal to Avogadro's number
Explanation: The number of molecules in one mole of a gas will be equal to Avogadro's number. However, any change in temperature and pressure will have no influence on the number of particles present.
(D) (b) 40 N_A
Explanation: Moles of N^3- ion

$$= \frac{70}{14}$$

$$= 5 \text{ mol}$$

No. of N^3ions = 5 x Na ions
No. of valence electrons in one,
N^3-ion = 5+3=8
Total no. of electrons
= 5 × 8 × N_A
(E) (c) 14 g
= 40 N_A
Explanation: 22.4 L of N_2 at STP weighs
= 28.0 g
11.2 L of N_2 at STP weighs

$$= \frac{28}{22.4} \times 11.2$$

$$= 14.0 \text{ gm}$$

3. A binary solution is made up of two liquids that are entirely miscible with each other. In a binary solution, the component with the lowest concentration is known as the solute, while the component with the highest concentration is known as the solvent. One mole of the solute a 1 molar solution. A 1 molal solution is one in which one mole of solute is dissolved in one kilogram of solvent. The number of moles of a given component to the total number of moles in the solution is referred to as the mole fraction.

(A) 6.02×10^{20} molecules of urea are present in 100 mL of its solution. The concentration of the solution is:

(a) 0.02 M
(b) 0.01 M
(c) 0.001 M
(d) 0.1 M

(B) What will be the mole fraction of glycol $C_2H_4(OH)_2$ in a solution containing 45 g of water and 56 g of glycol?

(a) 0.31
(b) 0.50
(c) 0.26
(d) 0.10

(C) The value of molality for pure water is:

(a) 55.55
(c) 52
(b) 52.6
(d) 25

(D) What is the mass per cent of the carbon in ethanol?

(a) 59

(b) 42

(c) 45

(d) 52

(E) What is the correct advantage for using molality over molarity?

(a) Molarity does not depend upon temperature.

(b) Molality does not depend upon temperature.

(c) Molality depend on temperature.

(d) None of the above

Ans. (A) (b) 0.01 M

Explanation:

$$\text{Number of moles} = \frac{\text{Molecules of urea}}{\text{Avogadro's number}}$$

$$= \frac{6.02\times10^{20}}{6.02\times10^{23}}$$

$$= 10^{-3}$$

$$\text{Molarity} = \text{Number of moles of solute/ volume of solution}$$

$$= \frac{10^{-3}}{0.1} = 0.01M$$

(B) (c) 0.26

Explanation: Mole fraction of glycol

$$= \frac{\text{No. of moles of glycol}}{\text{No. of moles glycol} + \text{No. of moles of water}}$$

$$= \frac{\frac{56}{62}}{\frac{56}{62}+\frac{45}{18}}$$

$$= \frac{0.9}{0.9+2.5} = 0.26$$

(C) (a) 55.55

Explanation: Molality

$$= \frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}}$$

Molality for a water molecule

$$= \frac{\frac{45}{18}}{\frac{45}{1000}} = 55.55 \text{ m}$$

(D) (d) 52

Explanation: Molecular mass of ethanol

= 2 x 12 +6 x 1 + 16

= 46 u

The mass per cent of carbon

$$= \frac{\text{Mass of Carbon}}{\text{Mass of Ethanol}} = \frac{24}{46} \times 100 = 52\%$$

(E) (b) Molality does not depend upon temperature.

Explanation: Molality is favored over molarity as the unit of concentration because molality is a function of temperature and changes with temperature but molarity is independent of temperature so it stays the same. The mass of the solvent is also independent of temperature so it remains constant.

4. The reactants react according to the balanced chemical equation. Quite often, these are not present in the same proportions as is required by the equation; some may be present in a lesser amount while the others may be present in excess than the stoichiometric amounts. The reactant which is present in a lesser quantity is known as a limiting reagent or limiting reactant

since it limits the participation of the other reactants in the reaction and also the product of the reaction. For example, in the combustion of methane with oxygen methane is the limiting reactant because oxygen is always available

more than the amount of methane. Amount of carbon dioxide and water formed also depends upon the amount of methane and not oxygen.

(A) Find the number of moles of lead (II) chloride formed as a result of the reaction between 6.5 g of PbO and 3.2 g of HCL.

(B) 14g hydrogen and 80 g oxygen were filled in a steel vessel and exploded. The amount of water produced in the reaction will be?

(C) Why is it necessary to balance a chemical equation?

Ans. (A)

$$PbO + 2HCl \rightarrow PbCl_2 + 2H_2O$$

1 mole 2 moles 1 mole 2 moles

$$\frac{6.5}{224}\text{mol} \quad \frac{3.2}{36.5}\text{mol}$$

0.029 mol 0.087 mol

So, PbO is the limiting reactant.

= 0.029 mol of $PbCl_2$ is formed.

(B)

$$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}$$

1 mole 0.5 mole 1 mole

$$14 \text{ g of } H_2 = \frac{14}{2}\text{mole} = 7 \text{ mol}$$

80 g of O_2

$$= \frac{80}{32}\text{mole} = 2.5 \text{ mol}$$

So, O_2 is the limiting reagent.

Since 0.5 mole of oxygen from water
= 1 mol

So, 2.5 mol of oxygen form water

$$= \frac{1}{0.5} \times 2.5$$

$$= 5 \text{ mol}$$

(C) A chemical equation has to be balanced in order to satisfy the law of conservation of mass. According to the law, there is no change in mass when the reactants changeinto the products. Therefore, the chemical equation has to be balanced.