Question 21. The following data were obtained when dinitrogen and dioxygen react together to form compounds:

	Mass of dinitrogen	*Mass of dioxygen*
(i)	*14 g*	*16 g*
(ii)	*14 g*	*32 g*
(iii)	*28 g*	*32 g*
(iv)	*28 g*	*80 g*

(a) Which law of chemical combination is obeyed by the above experimental data? Give its statement.

(b) Fill in the blanks in the following conversions:

(i) 1 km = ... mm = ... pm *(ii) 1 mg = ... kg = ...ng*

(iii) 1 mL = ... L = ... dm^3

Answer:

(a) Fixing the mass of dinitrogen as 28 g, masses of dioxygen combined will be 32,64, 32 and 80 g in the given four oxides. These are in the ratio 1 : 2 : 1 : 5 which is a simple whole number ratio. Hence, the given data obey the law of multiple proportions.

(b) (i) $1\ \text{km} = 1\ \text{km} \times \frac{1000\ \text{m}}{1\ \text{km}} \times \frac{100\ \text{cm}}{1\ \text{m}} \times \frac{10\ \text{mm}}{1\ \text{cm}} = \mathbf{10^6\ mm}$

$$1\ \text{km} = 1\ \text{km} \times \frac{1000\ \text{m}}{1\ \text{km}} \times \frac{1\ \text{pm}}{10^{-12}\ \text{m}} = \mathbf{10^{15}\ pm}$$

(ii) $1\ \text{mg} = 1\ \text{mg} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{kg}}{1000\ \text{g}} = \mathbf{10^{-6}\ kg}$

$$1\ \text{mg} = 1\ \text{mg} \times \frac{1\ \text{g}}{1000\ \text{mg}} \times \frac{1\ \text{ng}}{10^{-9}\ \text{g}} = \mathbf{10^{6}\ ng}$$

(iii) $1\ \text{mL} = 1\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} = \mathbf{10^{-3}\ L}$

$$1\ \text{mL} = 1\ \text{cm}^3 = 1\ \text{cm}^3 \times \frac{1\ \text{dm} \times 1\ \text{dm} \times 1\ \text{dm}}{10\ \text{cm} \times 10\ \text{cm} \times 10\ \text{cm}} = 10^{-3}\ \text{dm}^3.$$

Question 22.

If the speed of light is 3.0 x 108 ms^{-1}, calculate the distance covered by light in 2.00 ns.

Answer:

$$\text{Distance covered} = \text{Speed} \times \text{Time} = 3.0 \times 10^8\ \text{ms}^{-1} \times 2.00\ \text{ns}$$

$$= 3.0 \times 10^8\ \text{ms}^{-1} \times 2.00\ \text{ns} \times \frac{10^{-9}\ \text{s}}{1\ \text{ns}} = 6.00 \times 10^{-1}\ \text{m} = \mathbf{0.600\ m}$$

Question 23. In the reaction, $A + B_2 \rightarrow AB_2$, identify the limiting reagent, if any, in the following mixtures

(i) 300 atoms of A + 200 molecules of B

(ii) 2 mol A + 3 mol B

(iii) 100 atoms of A + 100 molecules of B

(iv) 5 mol A + 2.5 mol B

(v) 2.5 mol A + 5 mol B

Answer:

(i) According to the given reaction, 1 atom of A reacts with 1 molecule of B

∴ 200 molecules of B will react with 200 atoms of A and 100 atoms of A will be left unreacted. Hence, B is the limiting reagent while A is the excess reagent.

(ii) According to the given reaction, 1 mol of A reacts with 1 mol of B
∴ 2 mol of A will react with 2 mol of B. Hence, A is the limiting reactant.
(iii) No limiting reagent.
(iv) 2.5 mol of B will react with 2.5 mol of A. Hence, B is the limiting reagent.
(v) 2.5 mol of A will react with 2.5 mol of B. Hence, A is the limiting reagent.

Question 24. Dinitrogen and dihydrogen react with each other to produce ammonia according to the following chemical equation:
(i) N_2 (g) + $3H_2$(g) → $2NH_3$ (g)
(ii) Will any of the two reactants remain unreacted?
(iii) If yes, which one and what would be its mass?
Answer:

(*i*) 1 mol of N_2 *i.e.*, 28 g react with 3 mol of H_2, *i.e.*, 6 g of H_2

∴ 2000 g of N_2 will react with $H_2 = \frac{6}{28} \times 200\ g = 428.6\ g$. Thus, N_2 is the limiting reagent while H_2 is the excess reagent.

2 mol of N_2, *i.e.*, 28 g of N_2 produce NH_3 = 2 mol = 34 g

∴ 2000 g of N_2 will produce $NH_3 = \frac{34}{28} \times 2000\ g = \mathbf{2428.57\ g}$

(*ii*) H_2 will remain unreacted.
(*iii*) Mass left unreacted = 1000 g – 428.6 g = 571.4 g

Question 25. How are 0.50 mol Na_2CO_3 and 0.50 M Na_2CO_3 different?
Answer: Molar mass of Na_2CO_3= 2 x 23 + 12 + 3 x 16 = 106g mol^1 0.50 mol Na_2CO_3 means 0.50 x 105 g = 53 g 0. 50 M Na_2CO_3 means 0.50 mol, i.e., 53 g Na_2CO_3 are present in 1 litre of the solution.

Question 26. If ten volumes of dihydrogen gas reacts with five volumes of dioxygen gas, how many volumes of water vapour could be produced?
Answer:
H_2 and O_2 react according to the equation
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
Thus, 2 volumes of H_2 react with 1 volume of O_2 to produce 2 volumes of water vapour. Hence, 10 volumes of H_2 will react completely with 5 volumes of O_2 to produce 10 volumes of water vapour.

Question 27. Convert the following into basic units:
(i) 28.7 pm
(ii) 15.15 s
(iii) 25365 mg
Answer:

$$(i)\ 28.7\ pm = 28.7\ pm \times \frac{10^{-12}\ m}{1\ pm} = \mathbf{2.87 \times 10^{-11}\ m}$$

$$(ii)\ 15.15\ \mu s = 15.15\ \mu s \times \frac{10^{-6}\ s}{1\ \mu s} = \mathbf{1.515 \times 10^{-5}\ s}$$

$$(iii)\ 25365\ mg = 25365\ mg \times \frac{1\ g}{1000\ mg} \times \frac{1\ kg}{1000\ g} = \mathbf{2.5365 \times 10^{-2}\ kg}$$

Question 28. Which one of the following will have largest number of atoms?
(i) 1 g Au (s) (ii) 1 g Na (s) (iii) 1 g Li (s) (iv) 1 g of Cl_2(g)
(Atomic masses: Au = 197, Na = 23, Li = 7, Cl = 35.5 amu)
Answer:

(*i*) 1 g Au = $\frac{1}{197}$ mol = $\frac{1}{197}$ × 6.02 × 10^{23} atoms

(*ii*) 1 g Na = $\frac{1}{23}$ mol = $\frac{1}{23}$ × 6.02 × 10^{23} atoms

(*iii*) 1 g Li = $\frac{1}{7}$ mol = $\frac{1}{7}$ × 6.02 × 10^{23} atoms

(*iv*) 1 g Cl_2 = $\frac{1}{71}$ mol = $\frac{1}{71}$ × 6.02 × 10^{23} molecules = $\frac{2}{71}$ × 6.02 × 10^{23} atoms

Thus, **1 g of Li** has the largest number of atoms.

Question 29. Calculate the molarity of a solution of ethanol in water in which the mole fraction of ethanol is 0.040.

Answer:

$x_{C_2H_5OH} = \frac{n(C_2H_5OH)}{n(C_2H_5OH) + n(H_2O)} = 0.040$ (*Given*) ...(*i*)

The aim is to find number of moles of ethanol in 1 L of the solution which is nearly = 1 L of water (because solution is dilute)

No. of moles in 1 L of water = $\frac{1000\text{ g}}{18\text{ g mol}^{-1}}$ = 55.55 moles

Substituting n (H_2O) = 55.55 in eqn (*i*), we get

$$\frac{n(C_2H_5OH)}{n(C_2H_5OH) + 55.55} = 0.040$$

or 0.96 n (C_2H_5OH) = 55.55 × 0.040 or n (C_2H_5OH) = 2.31 mol

Hence, molarity of the solution = **2.31 M.**

Question 30.

What will be the mass of one ^{12}C atom in g?

Answer:

1 mol of ^{12}C atoms = 6.022 × 10^{23} atoms = 12 g

Thus, 6.022 × 10^{23} atoms of ^{12}C have mass = 12g

∴ 1 atom of ^{12}C will have mass = $\frac{12}{6.022 \times 10^{23}}$ g = **1.9927 × 10^{-23} g**

********** END **********