



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 = dm³

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.

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

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

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

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

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

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

Question 22.

If the speed of light is $3.0 \times 10^8 \text{ ms}^{-1}$, calculate the distance covered by light in 2.00 ns.

Answer:

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

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

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

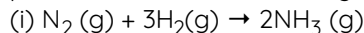
Answer:

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

\therefore 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
 \therefore 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:



(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

\therefore 2000 g of N_2 will react with $\text{H}_2 = \frac{6}{28} \times 2000 \text{ g} = 428.6 \text{ g}$. 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 $\text{NH}_3 = 2 \text{ mol} = 34 \text{ g}$

\therefore 2000 g of N_2 will produce $\text{NH}_3 = \frac{34}{28} \times 2000 \text{ g} = 2428.57 \text{ g}$

(ii) H_2 will remain unreacted.

(iii) Mass left unreacted = $1000 \text{ g} - 428.6 \text{ g} = 571.4 \text{ g}$

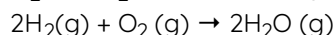
Question 25. How are 0.50 mol Na_2CO_3 and 0.50 M Na_2CO_3 different?

Answer: Molar mass of $\text{Na}_2\text{CO}_3 = 2 \times 23 + 12 + 3 \times 16 = 106 \text{ g mol}^{-1}$
 0.50 mol Na_2CO_3 means $0.50 \times 106 \text{ g} = 53 \text{ g}$
 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



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:

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

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

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

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 $\text{Cl}_2(\text{g})$

(Atomic masses: Au = 197, Na = 23, Li = 7, Cl = 35.5 amu)

Answer:

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

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

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

$$(iv) 1 \text{ g Cl}_2 = \frac{1}{71} \text{ mol} = \frac{1}{71} \times 6.02 \times 10^{23} \text{ molecules} = \frac{2}{71} \times 6.02 \times 10^{23} \text{ atoms}$$

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:

$$x_{\text{C}_2\text{H}_5\text{OH}} = \frac{n(\text{C}_2\text{H}_5\text{OH})}{n(\text{C}_2\text{H}_5\text{OH}) + n(\text{H}_2\text{O})} = 0.040 \text{ (Given)} \quad \dots(i)$$

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)

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

Substituting $n(\text{H}_2\text{O}) = 55.55$ in eqn (i), we get

$$\frac{n(\text{C}_2\text{H}_5\text{OH})}{n(\text{C}_2\text{H}_5\text{OH}) + 55.55} = 0.040$$

$$\text{or } 0.96 n(\text{C}_2\text{H}_5\text{OH}) = 55.55 \times 0.040 \text{ or } n(\text{C}_2\text{H}_5\text{OH}) = 2.31 \text{ mol}$$

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

Question 30.

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

Answer:

$$1 \text{ mol of } ^{12}\text{C} \text{ atoms} = 6.022 \times 10^{23} \text{ atoms} = 12 \text{ g}$$

$$\text{Thus, } 6.022 \times 10^{23} \text{ atoms of } ^{12}\text{C} \text{ have mass} = 12 \text{ g}$$

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

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