

Part Per Million (ppm): In chemistry it is a measure of concentration that is used where low levels of concentration are significant.

- Parts-per notation is a dimensionless quantity.
- To show the quantity being measured, it is sometimes helpful to use the same units in both the numerator and denominator.

$$ppm = \frac{mg \text{ solute}}{mg \text{ solute} + mg \text{ solvent}} \times 10^6, \quad mass_{\text{solute}} \ll mass_{\text{solution}}$$

**Note:**

- **ppm (mass / mass), by mass**  
**Example: 1mg / 1Kg = 1 ppm (W/W)**
- **ppm (volume / Volume), by volume**  
**Example: 1mL / 1 m<sup>3</sup> = 1 ppm (V/V)**
- **ppm (mass/volume)**  
**Example: 1 mg /L = 1 ppm (W/V)**
- **Where: one liter of water has mass of approximately one kilogram.**

A **percentage** is a way to show a proportion or a fraction as a whole number.

Note: A number such as "24%" (24 percent) means:  $\frac{24}{100}$

**Percent versus ppm solution:**

$$10000 \text{ ppm} = \frac{10000}{1000000} = \frac{1}{100} = 1 \%$$

Example:

Hemoglobin (the oxygen carrier protein in red blood cells) contains 0.340% iron by mass; calculate the mass of Fe in ppm.

$$\frac{1\%}{0.340\%} = \frac{10000 \text{ ppm}}{?}$$

? = 3400 ppm (gram Fe in Hemoglobin)

**Preparation of Standard Mg<sup>2+</sup> Solution:**

Dissolve 16.5817 g of MgO (analytical Reagent Grade) in 52 mL of pure HNO<sub>3</sub> (70%) and dilute to 1 liter with DI water, to make 10000 ppm of Mg.

**Calculation:**

$$\frac{10000 \text{ mg Mg}}{L} \times \frac{1 \text{ g Mg}}{1000 \text{ mg Mg}} \times \frac{40.31 \text{ g MgO}}{24.31 \text{ g Mg}} \times 1L = 16.58 \text{ g of MgO}$$

Based on the following label on the HNO<sub>3</sub> container find the molarity (M) of nitric acid:

Nitric Acid (HNO<sub>3</sub>):  
 Mass percent: 70.0%  
 Density: 1.42 g/mL

**Solution:**

(70.0%) means: 70g of 100 g of this solution is pure nitric acid.

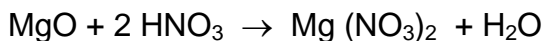
$$\text{mole} = \frac{\text{mass}}{M.W.} = \frac{70.0 \text{ g}}{63.0 \text{ g/mole}} = 1.11 \text{ mole}$$

Next, the volume of 100.0 g of HNO<sub>3</sub> solution is:

$$\text{volume} = \frac{\text{mass}}{\text{density}} = \frac{100.0 \text{ g}}{1.42 \text{ g/cm}^3} = 70.4 \text{ cm}^3$$

$$\text{molarity} = \frac{1.11 \text{ mol}}{70.4 \text{ mL}} \times \frac{1000 \text{ mL}}{1L} = 15.8 \text{ M of HNO}_3$$

Find the volume of the concentrated HNO<sub>3</sub> to dissolve the MgO solid.

**Solution:**

$$\begin{aligned} \text{mol of MgO} &= 16.58 / 40.31 = 0.41 \text{ mol} \\ \text{mol of HNO}_3 &= 2 \text{ mol of MgO} = 0.82 \text{ mol} \end{aligned}$$

$$\frac{15.8 \text{ mol HNO}_3}{1000} \times \frac{0.82}{?}$$

$$? = 52.1 \text{ mL of HNO}_3 \text{ needs to dissolve 16.58 g of MgO}$$