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.

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

Note:

- **ppm $_{(mass\ /\ mass)}$, by mass**

  Example: 1mg / 1Kg = 1 ppm (W/W)

- **ppm $_{(volume\ /\ Volume)}$, by volume**

  Example: 1mL/ 1 m^3 = 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 verses ppm solution:

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

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

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

? = 3400 ppm (gram Fe in Hemoglobin)

Preparation of Standard Mg^{2+} Solution:

Dissolve 16.5817 g of MgO (analytical Reagent Grade) in 52 mL of pure HNO3 (70%) and dilute to1 liter with DI water, to make 10000 ppm of Mg.

Calculation:

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

Based on the following label on the HNO_3 container find the molarity (M) of nitric acid:

Nitric Acid (HNO3):
Mass percent: 70.0%
Density: 1.42 g/mL

Solution:

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

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

Next, the volume of 100.0 g of HNO_3 solution is:

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

$$molarity = \frac{1.11\ mol}{70.4\ mL} \times \frac{1000\ mL}{1L} = 15.8\ M \quad \text{Of } HNO_3$$

Find the volume of the concentrated HNO3 to dissolve the MgO solid.
Solution:

$MgO + 2\ HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$

mol of MgO = 16.58 / 40.31 = 0.41 mol
mol of HNO3 = 2 mol of MgO = 0.82 mol

$$\frac{15.8\ mol\ HNO3}{1000} \times \frac{0.82}{?}$$

? = 52.1 mL of HNO3 needs to dissolve 16.58 g of MgO