Concentration

SCH 3U

Learning Goals

By the end of this lesson students will be able to:

- Solve problems related to the concentration of solutions
- Performing calculations involving moles, and express the results in various units (ppm, ppb)

Concentration of Solutions

- Concentration- the ratio of the quantity of solute to the quantity of solution or solvent; usually quantity of solute per unit volume of solution.
  - g/g of H_2O, g/L of H_2O
- A solution with a relatively high quantity of solute compared to the volume of solution is a concentrated solution
- A solution with a relatively low quantity of solute compared to the volume of solution is a dilute solution

Concentration

Usually found on consumer products:

$$P_{m/v} = M_{Solute} / V_{Solution} \times 100\%$$

- Example a product label of a hydrogen peroxide bottle may indicate 6% M/V. This means that 6g of every 100mL of solution is the solute: hydrogen peroxide.

$$P_{v/v} = V_{Solute} / V_{Solution} \times 100\%$$

- Example: Label on a bottle of isopropyl alcohol states: 50% by volume This means that 50mL out of every 100mL of solution is the solute: isopropyl alcohol

$$P_{M/M} = M_{Solute} / M_{Solution} \times 100\%$$

- Example, 5% M/M benzoyl peroxide is an active ingredient in many face creams. This means about 5 g of every 100g is benzoyl peroxide

Sample Problem

20g of herbicide is dissolved in water and the resultant solution has a volume of 55ml. What is the mass/volume percent?

$$P_{m/v} = \frac{M_{Solute}}{V_{Solution}} \times 100\%$$

$$= \frac{20g}{55ml} \times 100\%$$

$$= 36\%_{m/v}$$

What is the concentration of the pesticide in g /100 ml?

$$P_{m/v} = \frac{M_{Solute}}{V_{Solution}} \times 100\%$$

$$= \frac{20g}{100ml} \times 100\%$$

$$= 20\%_{m/v}$$

The recommended concentration of pesticide is 20%$_{m/v.}$ How much herbicide would you need to add to make 1.5 L of solution?

$$P_{m/v} = \frac{M_{Solute}}{V_{Solution}} \times 100\%$$

20% → 20/100 → 0.2

$$0.2 = \frac{X\text{g}}{1500\text{ml}}$$

$X = 0.2 \times 1500\text{ml}$

$X = 300\text{g}$

Sample Problem 2

Rubbing alcohol is 70% by volume propanol. How much propanol would be in 500 ml of rubbing alcohol?

$$P_{v/v} = \frac{V_{Solute}}{V_{Solution}} \times 100\%$$

$$70\% = \frac{V_{Solute}}{500ml} \times 100\%$$

$$0.7 = \frac{V_{Solute}}{500ml}$$

$$V_{Solute} = 0.7 \times 500ml = 350ml$$

Sample Problem 3

The concentration of gold of is measured in Karats with 24k being pure gold. Calculate karat value for a piece of gold that contains 2.86 g of gold and has a total mass of 4.9 g.

$$P_{m/m} = \frac{M_{Solute}}{M_{Solution}} \times 100\%$$

$$= \frac{2.86g}{4.9g} \times 100\%$$

$$= 58\%_{m/m}$$

PPM and PPB

- Chemists often work with concentrations that are extremely low
- For this reason very dilute concentrations are often expressed in:
  - Parts per million (ppm)
  - Parts per billion(ppb)
  - Even parts per trillion(ppt)

PPM and PPB

1 kg = 1/ 1 000 g = 1/ 1 000 000 mg

1 kg = 0.001 g = 0. 000 001 mg

1 mg/L = 1 ppm

The # of mg of solute per (kg or L) of solution = #ppm

The following table summarizes common mass ratios for solutions and solids.

Unit	Solutions		Solids	
ppm	mg/L	µg/mL	mg/kg	µg/g
ppb	µg/L	ng/mL	µg/kg	ng/g
ppt	ng/L	pg/mL	ng/kg	pg/g

PPM and PPB

A solute concentration of:

1 ppm = 1g of solute / 1 000 000 (g or mL) of solution

To make this easier to work with:

$$\frac{m_{solute}}{m_{solution}} = \frac{Xg}{10^6\ g_{solution}}$$

$$ppm = \frac{m_{solute}}{m_{solution}} \times 10^6$$

$$ppb = \frac{m_{solute}}{m_{solution}} \times 10^9$$

Sample Problem

When the water of local beaches reaches 60 ppm E.coli bacteria health regulations say it must be closed. If a 5 liter water sample is found to contain 0.7 mg of E. coli bacteria does the beach need to be closed?

$$c_{ppm} = \frac{m_{solute}}{m_{solution}} \times 10^6$$

$$ppm = \frac{0.0007g}{5000mL} \times 10^6$$

$$= 0.00000014\ g/mL \times 10^6$$

$$= 0.14ppm$$

Conversions

Assume: 1g = 1ml

0.7mg / 1000g → 0.0007g

5L * 1000ml → 5000ml

Sample Problem

When the water of local beaches reaches 60 ppm E.coli bacteria health regulations say it must be closed. If a 5 liter water sample is found to contain 0.7 mg of E. coli bacteria does the beach need to be closed?

Unit	Solutions	
ppm	mg/L	µg/mL

$$ppm = \frac{m_{solute}}{m_{solution}}$$

$$ppm = \frac{0.7mg}{5L}$$

= 0.14 mg/L

= 0.14ppm

Summary

- Mass/ Volume: $P_{m/v} = M_{Solute} / V_{Solution} \times 100\%$
- Volume/volume: $P_{v/v} = V_{Solute} / V_{Solution} \times 100\%$
- Mass/Mass: $P_{m/m} = M_{Solute} / M_{Solution} \times 100\%$

- ppm: parts per million
  - 1ppm = 1g of solute / 1 000 000 (g or mL) of solution

- ppb: parts per billion
  - 1ppb = 1g of solute/1 000 000 000 (g or mL) of solution

Homework

- Complete the Exit Card
- Complete Worksheet