Unit 4: Solutions and solubility
Lesson 3: Concentrations of Solutions

$$\text{concentration} = \frac{amount\ of\ solute}{amount\ of\ solution\ (no\ including\ solute)}$$

Concentration: the ratio of solute in a solution

Dilute solution: having a low amount of solute

Concentrated solution: having a high amount of solute

Calculating Concentrations: There are 3 basic ways to express concentration

- Percent concentrations
- Very low concentrations (ppm or ppb)
- Molar concentrations

1. Percent concentrations

- mass of solute to volume of solution expressed as percentage
- % concentration can be in the following 3 ways:
  - $\boldsymbol{percent(m/v) = \frac{mass\ of\ solute\ in\ g}{volume\ of\ solution\ in\ mL}\ \mathbf{x\ 100\%}}$
  - $\boldsymbol{percent(m/m\ \ or\ w/w) = \frac{mass\ of\ solute\ in\ g}{mass\ of\ solution\ in\ g}\ \mathbf{x\ 100\%}}$
  - $\boldsymbol{percent(v/v) = \frac{volume\ of\ solute\ in\ mL}{volume\ of\ solution\ in\ mL}\ \mathbf{x\ 100\%}}$
  - $\boldsymbol{percent(w/v) = \frac{mass\ of\ solute\ in\ g}{volume\ of\ solution\ in\ mL}\ \mathbf{x\ 100\%}}$

Example 1: What is the %w/w of copper in an alloy when 10.0 g of copper is mixed with 250 g of zinc?

Example 2: A solution contains 6.5 g of NaCl in 250 g of water. Calculate the % by mass of NaCl.

Example 3: What is approximate %v/v if 30.0 mL of pure ethanol is added to 250 mL of water?

Example 4: Describe how you would make 600.0 g of a 15% by mass sugar solution. We assume the density of solution is approximately 1g/mL.

Example 5: How much pure water should be added to 15.0 mL of pure acetic acid to make a 5.0% solution of acetic acid?

2. Very low concentration

- Useful for extremely dilute solutions
- $\boldsymbol{parts\ per\ million\ (ppm) = \frac{mass\ of\ solute\ in\ gram}{mass\ of\ solution\ in\ gram} \mathbf{x\ 10^6}}$
- $\boldsymbol{parts\ per\ billion\ (ppb) = \frac{mass\ of\ solute\ in\ gram}{mass\ of\ solution\ in\ gram} \mathbf{x\ 10^9}}$
- $\boldsymbol{parts\ per\ trillion\ (ppt) = \frac{mass\ of\ solute\ in\ gram}{mass\ of\ solution\ in\ gram} \mathbf{x\ 10^{12}}}$

$$1\ \text{ppm} = 1\ \text{g}/10^6\ \text{g} = 1\ \text{g}/10^6\ \text{mL} = 1\ \text{g}/1000\ \text{L} = 1\ \text{mg/L}$$

$$1\ \text{ppb} = 1\ \text{g}/10^9\ \text{g} = 1\ \text{g}/10^6\ \text{L} = 1\ \text{mg}/1000\ \text{L}$$

$$1\ \text{ppt} = 1\ \text{g}/10^{12}\ \text{g} = 1\ \text{g}/10^9\ \text{L} = 1\ \text{mg}/10^6\ \text{L}$$

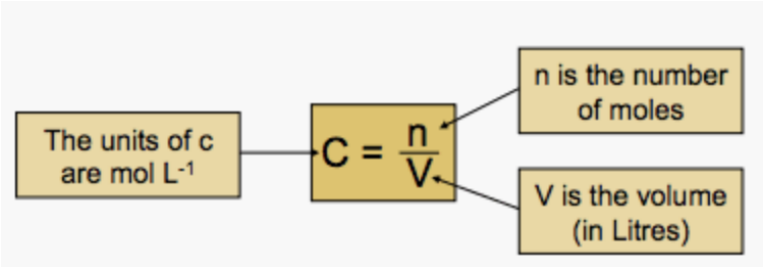
Example 6: Health Canada's guideline for the maximum Hg content in fish is 0.5 ppm. If a 1.6 kg fish is found to Contain 0.6 mg of Hg, is it safe to eat?

Table 2 Measure of Concentration

Name	Abbreviation	Equation	Application
percentage volume/volume	% V/V	$c_{v/v} = \frac{v_{solute}}{v_{solution}} \times 100\ \%$	liquid–liquid mixtures
percentage weight/volume	% W/V	$c_{w/v} = \frac{m_{solute}}{v_{solution}} \times 100\ \%$	solid–liquid mixtures
percentage weight/weight	% W/W	$c_{w/w} = \frac{m_{solute}}{m_{solution}} \times 100\ \%$	solid–liquid or solid–solid mixtures
parts per million	ppm	$c_{ppm} = \frac{m_{solute}}{m_{solution}} \times 10^6\ ppm$	to express small concentrations (e.g., composition of air)
parts per billion	ppb	$c_{ppb} = \frac{m_{solute}}{m_{solution}} \times 10^9\ ppb$	to express very small concentrations (e.g., metal contaminants in water)
parts per trillion	ppt	$c_{ppt} = \frac{m_{solute}}{m_{solution}} \times 10^{12}\ ppt$	to express extremely small concentrations (e.g., traces of medications in water)

3. Molar concentration (Molarity)

- Mainly used in chemistry
- Measured in the number of moles of solute per litre of solvent



Example 7: What is the molar concentration of solution formed by dissolving 50.0 g mol of a substance with molar mass of 25g/mol in 2.0 L of solution?

Example 8: How many moles of sugar are required to make a 0.50 M, 250mL sugar-water solution?

Example 9: How many grams of NaOH are required to make 75 mL of 1.75 M solution?

Homework:

Nelson Textbook:

pg400-401. #Practice 1 – 4;

pg402. #Questions 1, 4, 5, 6, 11;

pg408. #Practice 1 – 4;

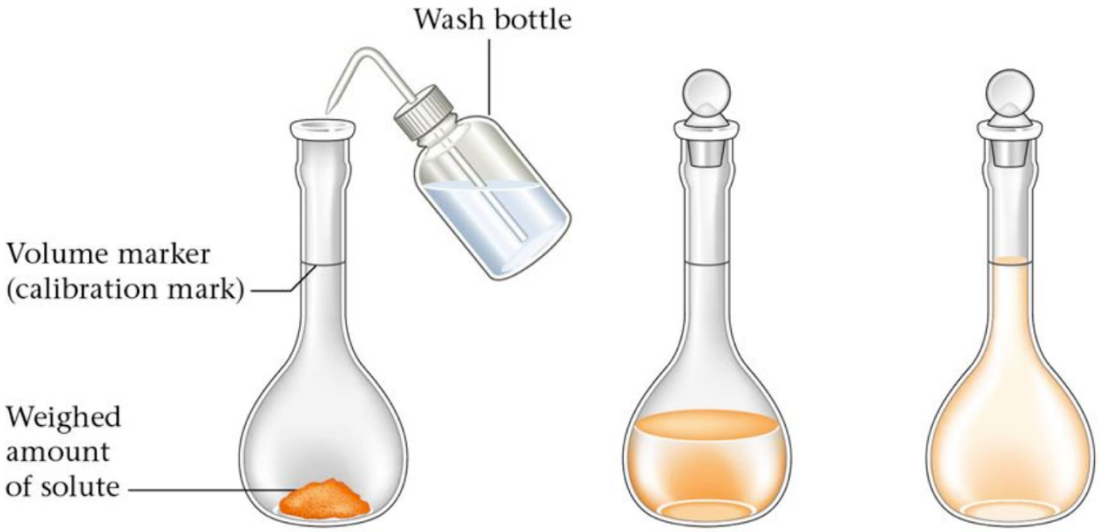
pg408. Practice 1 – 3;

pg411. #Questions 1 – 3, 7

Unit 4: Solutions and solubility
Lesson 4: Preparing solutions in the laboratory (8.7)

Preparation of a standard solution from a SOLID: Often to get solid chemicals to react they must be dissolved in solution (usually water).
It is therefore often necessary to create a **standard solution** when performing an experiment.

(a solution for which the exact concentration is known)



Example 1: What mass of sodium hydroxide would you need to dissolve in 500 mL of water to create a 2.0M solution?

Preparation of a standard solution by Dilution: Sometimes you may already have a standard solution that is too concentrated for your desired experiment. You must therefore dilute your "stock solution" to form a new standard solution.

Consider a 500mL solution of salt water. If we dilute the solution by adding an additional 500 mL of water…

- Has the concentration of salt in the solution changed?
- Has the amount of salt present in the solution changed?

Dilution Formula:

Since the amount of salt does not change, the # of moles of salt is the same in both the initial and final solutions.

Hence: $c_1v_1 = c_2v_2$

Example 2: 750 mL of 2.50 M NaOH stock solution is diluted to 2.00 L. What is the concentration of the diluted solution?

Example 3: What volume of 12.0 M $HCl_{(aq)}$ is required to make a 3.0 L solution of 1.0 M $HCl_{(aq)}$?

Example 4: 500.0 mL of a 6.5 M H_2SO_4 solution is diluted down to 1.5 M. What volume of water was added?

General Safety when Diluting Concentrated Acids:

- Safety goggles and gloves should be worn at all times.
- Always add acid to water, not the other way around.
- Adding water to a concentrated acid causes the water to float on top of the acid which can start to boil and splatter out.

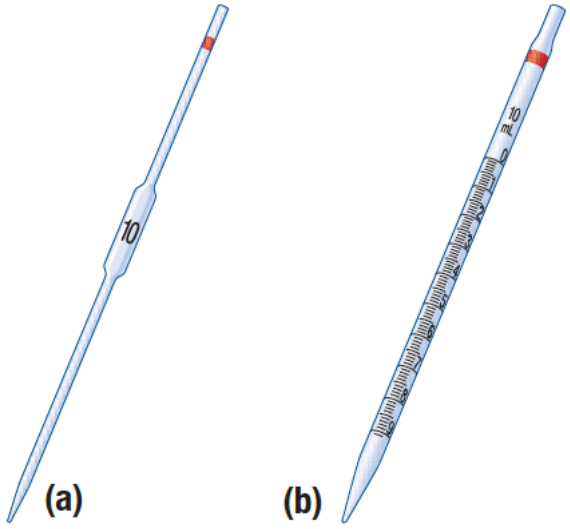


Figure 3 (a) A volumetric pipette can deliver only one specific volume. (b) A graduated pipette can deliver a range of volumes.

Homework: Textbook pg405. #1 – 7