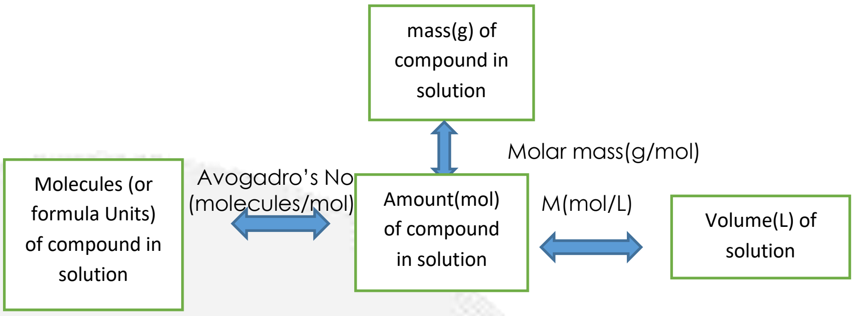
W2	Learning Area	CHEMISTRY 2	Grade Level	GRADE 12
	Quarter	3	Date	March 1 to March 5, 2021

I. LESSON TITLE	**Physical Properties of Solutions**
II. MOST ESSENTIAL LEARNING COMPETENCIES (MELCs)	1. Use different ways of expressing concentration of solutions: percent by mass, mole fraction, molarity, molality, percent by volume, percent by mass/volume and parts per million 2. Perform stoichiometry calculations for reactions in solutions 3. Describe the effect of concentration on the colligative properties of solution
III. CONTENT/CORE CONTENT	Concentration Units and Their Comparison; Colligative Properties of Solutions

IV. LEARNING PHASES	Suggested Timeframe	Learning Activities
A. Introduction ***Panimula***		This lesson focuses on the chemistry of solutions. This will help to provide the learners a thorough understanding of the concept of solutions as well as their everyday life applications. **At the end of this lesson the student shall be able to**: 1. calculate the concentration of a solution using weight percent, weight/volume percent, volume percent, parts per million, molarity, molality, and mole fraction 2. perform stoichiometry calculations for reactions in solution 3. explain the effect of concentration on the colligative properties of solution 4. identify the different colligative properties of solution
B. Development		**I. Concentration of Solutions** How is the concentration of a solution described? Chemists often need to specify precisely how concentrated or dilute a solution is. It is essential to measure how much solute is present in a given volume of solution. The measurement that describes the solution in this way is the **concentration** of the solution. **Concentration of a solution is the amount of solute present in a given amount of solvent.** The most commonly used measurements of concentration are percent by mass, percent by volume, parts per million, percent by mass per volume, molarity, molality, and mole fraction. **1.Percent by Mass.** This expresses the mass of solute per 100 g of solution. Mass of solution is equal to the mass of solute plus the mass of solvent. $\textbf{\% by Mass} = \dfrac{\textbf{Mass of solute X 100}}{\textbf{Mass of solute + Mass of solvent}}$ Sample Problem: Calculate the percentage concentration of a solution that contains 30% by mass of sucrose. Solution : A solution that contains 30% by mass of sucrose means that the solution contains 30 g of sugar and 70 g of water. $\%(m/m) = \dfrac{30\text{ g of sucrose X }100\%}{30\text{ g sucrose} + 70\text{ g water}} = 30\ \%$ by mass of sucrose Practice Problem: Calculate the percentage concentration of a solution that contains 25% by mass of salt. **2.Percent by Volume** = $\dfrac{\textbf{Volume of solute X 100\%}}{\textbf{Volume of Solution}}$ Sample Problem : What is the percent by volume of ethyl alcohol, in the final solution when 85 ml of ethyl alcohol is diluted to a volume of 250 ml with water? Solution : $\%\ (V/V) = \dfrac{85\text{ ml ethyl alcohol X }100\%}{250\text{ ml solution}} = 34\ \%$ ethyl alcohol(V/V) Practice Problem : If 10 ml of pure acetone is diluted with water to a total solution volume of 200 ml, what is the percent by volume of acetone in the solution? **3. Percent by Mass/Volume** = $\dfrac{\textbf{mass of solute X 100\%}}{\textbf{Volume of solution}}$ Sample Problem : A solution contains 2.7 g $CuSO_4$ in 85 ml of solution. What is the percent (mass/volume) of the solution? Solution : $\%(M/V) = \dfrac{2.7\text{ g }CuSO_4}{85\text{ ml solution}} \text{ X } 100\% = 3.18\%\ CuSO_4\ (M/V)$ Practice Problem : Solder flux, available at hardwood stores, contains 16 g of zinc chloride in 50 ml of solution. The solvent is HCl (aq). What is the percentage mass by volume of zinc chloride in the solution? **4. Parts per Million.** PPM is an abbreviation of parts per million. This is a value that represents the part of a whole number in units of 1/1000 000.

		$$Ppm = \frac{\text{mass of solute}}{\text{Mass of sample}} \times 1\ 000\ 000$$ Sample Problem : If there is 0.6 g of As present in 279 g of solution, what is the As concentration in ppm? Solution : $\frac{0.6 \text{ g As}}{279 \text{ g solution}} \times 1000\ 000 = 2{,}150.54$ ppm
		5. Molarity. This is another important unit of concentration in chemistry. It is the ratio of the number of moles of solute dissolved per liter of solution which is mathematically expressed as : $M = \frac{\text{Moles of Solute}}{\text{Liter of solution}}$ Sample Problem : If 7.5 g NaCl is dissolved in water to mark 500 ml solution, what is the molarity of the solution? Solution : Molar Mass of NaCl = 1 Na = 22.99 g/mol + 1 Cl = 35.453 g/mol 58.443g/mol $\text{Mole(n)} = \frac{7.5 \text{ g NaCl}}{58.443 \text{ g/mol}} = 0.13 \text{ mol NaCl}$ $M = \frac{0.13 \text{ molNaCl}}{500 \text{ ml solution}} \times \frac{1000 \text{ ml}}{1L} = 0.26$ M NaCl solution Practice Problem : Calculate the M of each solution: a. 400 g $BaSO_4$ in 5.00 L of solution b. 0.045 mol $NaHCO_3$ in 2100 ml of solution
		6. Molality (m). This is defined as the number of moles of solute per kilogram of solvent which is mathematically expressed as : $m = \frac{\text{no. of moles solute}}{\text{Kilogram solvent}}$ Sample Problem: Calculate the molality of 0.8 moles of H_2SO_4 in 250 g of water. Solution: $m = \frac{0.8 \text{ mol } H_2SO_4}{250gH_2O} \times \frac{1000 \text{ g}}{1 \text{ Kg}} = 3.2$ mol/kg or 3.2 m Practice Problem. Calculate the molality of 1.2 mol of H_2CO_3 in 3.00 g of water
		7. Mole Fraction. The mole fraction is the number of moles of one component divided by the total number of moles in the solution. The component can be either solute or solvent. It is represented by a capital letter **X.** The equation to find the mole fraction of the solute is written as: $X\ solute = \frac{\text{mol of solute}}{\text{Total moles of solution}}$ The equation to find the mole fraction of the solvent is written as : $X\ solvent = \frac{\text{mol of solvent}}{\text{Total moles of solution}}$ The sum of the mole fractions for the solute and solvent must add up to 1. $Xsolute + Xsolvent = \frac{\text{mol solute}}{T(n) \text{ of solution}} + \frac{\text{mol solvent}}{T(n) \text{ of solution}} = 1$ Sample Problem: A solution is made by dissolving 1.20 g KNO_3 in 75.0g of water. Calculate the mole fraction of the solute and solvent. Solution: Step 1. Get the number of moles of solute $nKNO_3 = \frac{\text{mass of } KNO_3}{\text{molar mass of } KNO_3} = \frac{1.20 \text{ g } KNO_3}{101 \text{g/mol } KNO_3} = 0.0119$ mol Step 2. Get the number of moles of solvent $nH_2O = \frac{\text{mass of } H_2O}{\text{molar mass of } H_2O} = \frac{75.0 \text{g } H_2O}{18 \text{ g/mol } H_2O} = 4.1667$mol Step 3. Get the total number of moles T(n) = n solute + n solvent n(solution) = $nKNO_3$ + nH_2O = 0.0119 + 4.17 = 4.18 mol Step 4. Get the mole fraction of solute and solvent $X\ solute(KNO_3) = \frac{0.0119 \text{ mol}}{4.18 \text{ mol}} = 0.00284$ $X\ solvent(H_2O) = \frac{4.17 \text{ mol}}{4.18 \text{ mol}} = 0.99$ Checking: X solute + X solvent =.00284 + 0.99 = 0.993 or 1
		Practice Problem : A solution is made by dissolving 2.5 g KCl in 60.0 g water. Calculate the mole fraction of the solute and solvent.
		II. Stoichiometry Involving Solutions Stoichiometry deals with the relative quantities of reactants and products in chemical reactions. In stoichiometric calculations involving solutions, a given solution's

concentration is often used as a conversion factor. The relationship among mole, mass, molecule, and volume is given below.



The diagram above shows the summary of mass-mole-number-volume relationships in solution. The amount (in moles) of a compound in solution is related to the volume of solution in liters through the molarity (M) in moles per liter and to the number of molecules (or formula units) through Avogadro's number (6.022×10^{23} molecules/mol).

Sample Problem 01. How many milliliters of 1.50 M nitric acid is required to react with 100.0 g of cuprous oxide?

$$\mathbf{14HNO_3 + 3Cu_2O \rightarrow 6Cu(NO_3)_2 + 2NO + 7H_2O}$$

Solution:

$$100.0\ g\ Cu_2O \times \frac{1 mol\ Cu_2O}{143.1\ g} \times \frac{14 mol\ HNO_3}{3 mol\ Cu_2O} \times \frac{1000\ ml\ HNO_3}{1.50 mol\ HNO_3} = 2.18 \times 10^3\ ml HNO_3$$

Sample Problem 02. 60.5 ml of HNO_3 are required to react with 25.0 ml of a 1.00 M Barium hydroxide solution:

$$\mathbf{2HNO_{3(aq)} + Ba(OH)_{2(aq)} \rightarrow 2\ H_2O_{(s)} + Ba(NO_3)_{2(aq)}}$$

Find the molarity of the nitric acid solution.

Solution: $25.0\ ml\ Ba(OH)_2 \times \frac{1L}{10^3 ml} \times \frac{1.00 mol\ Ba(OH)_2}{1L} \times \frac{2\ mol HNO_3}{1 mol Ba(OH)_2} = \underline{0.0500 mol}$

$$M(HNO_3) = \frac{0.0500\ mol\ HNO_3}{0.0605\ L\ solution} = 0.826\ M$$

Practice Problem: 25.0 ml of 0.350 M NaOH are added to 45.0 ml of 0.125 M Copper(II) sulfate. How many grams of copper (II) hydroxide will precipitate?

III. Colligative Properties of Solutions

Colligative properties of solutions are properties of solutions that depends only on the quantity of solute present but not on the kind of solute. There are four (4) colligative properties : **boiling point, freezing point, osmotic pressure, and vapor pressure.**

1.Boiling point. The boiling point of water is 100^{0}C, but if a certain amount of sugar is dissolved in water, the sugar solution will boil at a temperature greater than 100^{o}C. This is because the sugar-water interaction is stronger compared to the water-water interaction in pure water. The boiling point of a solution is always greater than the boiling point of a pure solvent. The greater the quantity of solute present in a given solvent the higher will be the boiling point of the solution. The kind of solute will not affect the increase in boiling point. This is the reason why the burnt caused by a boiling syrup is more painful than that of pure water. This is true because the boiling point of pure syrup is greater than pure water.

2.Freezing point. The freezing point of water is 0^{0}C. If a certain amount of solute like salt is added in water, the freezing point of the solution will be lower than that of pure water. Salt is added to ice where a gallon of ice cream is stored because then the freezing point of the surrounding area of the ice cream will be lowered, thus the ice will not melt. The freezing point of a solution is always lower than the freezing point of pure solvent.

Activity : Chem-Journal:

1.What is the purpose of using rock salt in ice-cream making?

2.Why is salt added to boiling water where pasta is being cooked?

3. Vapor pressure. The particles of pure water will tend to evaporate faster than the particles of water in a solution. This is because the interaction between solute and solvent is stronger than the interaction between solvent and another solvent. Thus, the vapor pressure of a solution is always lower than the vapor pressure of pure solvent.

4. Osmotic pressure. Osmosis is the movement of solvent through the semipermeable membrane from a region of low concentration to a region of high concentration. A semipermeable membrane allows the passage only of certain molecules. In the case of osmosis, a semipermeable membrane allows the passage of solvent but not the solute.

If the semipermeable membrane is placed in between two solutions of different concentration, the solvent will flow from an area of the less concentrated solution moving to the more concentrated solution. The pressure difference resulting from the uneven heights becomes so bigger that the net flow of solvent stops. The pressure required to prevent osmosis is known as the **osmotic pressure.** The greater the concentration of the solution, the higher is the osmotic pressure needed to prevent osmosis.

C. Engagement

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Learning Activity 01. Concentration of Solutions

1. A saline solution is prepared by dissolving 5.04 g of NaCl in 95.0 g of water. Calculate the following:
   a. Mole fraction of the solute and the solvent
   b. % mass of the solute
   c. Concentration of solution in ppm
2. Calculate the Molarity of each of the following solutions:
   d. 185 g of sucrose, $C_{12}H_{22}O_{11}$ in 1.00 L of solution
   e. 6.30 g of HNO_3 dissolved in 255 ml of solution.
3. What is the molality of a solution of 2.50 g H_3PO_4 dissolved in 240 g water?

Learning Activity 02. Solution Stoichiometry

1. How many grams of Calcium phosphate can be produced from the reaction of 2.50 L of 0.250 M calcium chloride and excess of phosphoric acid?
2. What volume of 0.596 M HCl is required to neutralize 30.0 ml of 0.809 M sodium Hydroxide?

Learning Activity 03.

Sweet tea is often made by dissolving a lot of sugar in water, brewing the tea, and then chilling. Explain what happens to the boiling point of water when sugar is added.

D. Assimilation
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The concentration of solutions can be expressed in a variety of ways which are all involved in chemical reactions particularly the quantities of solutions. Colligative properties of solutions depend only on the concentration of solute particles, not on their identity.

V. ASSESSMENT
(Learning Activity Sheets for Enrichment, Remediation or Assessment to be given on Weeks 3 and 6)

A. Concentration Units

1.Complete the following table for aqueous solutions of Aluminum nitrate.

Mass of Solute	Volume of Solution	Molarity
a) 1.672 g	145.0 mL	-----------------
b) 2.544 g	----------------	1.688 M
c) ---------	894 mL	0.729 M

2. Complete the following table for aqueous solutions of caffeine, $C_8H_{10}O_2N_4$.

Molality	Mass Percent Solvent	Ppm Solute	Mole Fraction Solvent
a)			0.900
b)		1269	
c)	85.5		
d) 0.2560			

B. Stoichiometry Calculation of Solutions

1. Nitric acid, HNO_3 is extensively used in the manufacture of fertilizer. A bottle containing 75.0 mL of nitric acid solution is labeled 6.0 M HNO_3.
   a. How many moles of HNO3 are in the bottle ?
   b. A reaction needs 5.00g of HNO3. How many mL of solution are required?
   c. Ten mL of water are added to the solution. What is the molarity of the resulting solution?

VI. REFLECTION

Chem Journal-Write a journal entry about what lis the most important thing you learned today? How can you use your knowledge about solutions in real life?

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