# Solutions and Solubility

## Part 2- Problem Solving

Step by Step Problems

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You will be able to learn how to solve each of the problems based upon Solution Calculations with CONFIDENCE!

Remember, if at any point you do not understand the concepts and/or solutions, please pause the video and go back through it.

# Practice Problems for Solutions

Have scratch paper, pen/pencil and a calculator handy

On the TEAS exam, you will only have access to a 4-function calculator so be sure to also memorize the common powers.

10^3= 1,000
10^4= 10,000
10^5= 100,000
10^6= 1,000,000
10^7= 10,000,000
10^8= 100,000,000
10^9= 1,000,000,000

# ppm (Parts Per Million)

**Definition**
Parts per million (ppm) is a unit of concentration that denotes the number of parts of solute per million parts of solution.

**Formula**:

$$\text{ppm} = \frac{mass\ of\ solute}{mass\ of\ solution} \text{ x } 10^6$$

Use this formula when calculating volume when both the solute and solution are in volume units.

$$\text{ppm} = \frac{volume\ of\ solute}{volume\ of\ solution} \text{ x } 10^6$$

**Usage**: Used for very low concentrations, such as pollutants in air or water, nutrient levels in soils.

# ppm (Parts Per Million)

## Practice Problem #1

**Problem 1: PPM Calculation**

A factory releases 0.5 grams of a pollutant into a lake containing 1,000,000 grams of water. What is the concentration of the pollutant in ppm?

**A) 0.05 ppm**
**B) 0.5 ppm**
**C) 5 ppm**
**D) 50 ppm**

**Formula**:

$$\text{ppm} = \frac{mass\ of\ solute}{mass\ of\ solution} \times 10^6$$

# ppb (Parts Per Billion)

**Definition**

Parts per billion (ppb) is a unit of concentration that denotes the number of parts of solute per billion parts of solution.

**Formula**:

$$\textbf{ppb} = \frac{mass\ of\ solute}{mass\ of\ solution} \times 10^9$$

Use this formula when calculating volume when both the solute and solution are in volume units.

$$\textbf{ppb} = \frac{volume\ of\ solute}{volume\ of\ solution} \times 10^9$$

**Usage**: low-level concentrations, often in cases where the presence of a substance must be measured with extreme sensitivity, such as toxicology.

# ppb (Parts Per Billion)

## Practice Problem #2

**Problem 2: PPB Calculation**

A water sample contains 0.2 micrograms of lead in 2 liters of water. What is the concentration of lead in ppb?

**A) 0.1 ppb**
**B) 0.2 ppb**
**C) 0.4 ppb**
**D) 1.0 ppb**

**Formula**:

$$\text{ppb} = \frac{mass\ of\ solute}{mass\ of\ solution} \times 10^9$$

Use this formula when calculating volume when both solute and solution units are in volume.

$$\text{ppb} = \frac{volume\ of\ solute}{volume\ of\ solution} \times 10^9$$

# ppt (Parts Per Thousand)

**Definition**

Parts per thousand (ppt) is a unit of concentration that denotes the number of parts of solute per thousand parts of solution.

**Formula**:

$$\text{ppt} = \frac{mass\ of\ solute}{mass\ of\ solution} \times 10^3$$

Use this formula when calculating volume when both the solute and solution units are in volume.

$$\text{ppt} = \frac{volume\ of\ solute}{volume\ of\ solution} \times 10^3$$

# ppm (Parts Per Million)

## Practice Problem #3

**Problem 3: PPT Calculation**

An ocean sample contains 35 grams of salt in 1,000 grams of seawater. What is the concentration of salt in ppt?

**A) 3.5 ppt**
**B) 35 ppt**
**C) 350 ppt**
**D) 3500 ppt**

**Formula**:

$$\text{ppt} = \frac{mass\ of\ solute}{mass\ of\ solution} \times 10^3$$

# Molarity (M)

It is defined as the number of moles of solute per liter of solution.

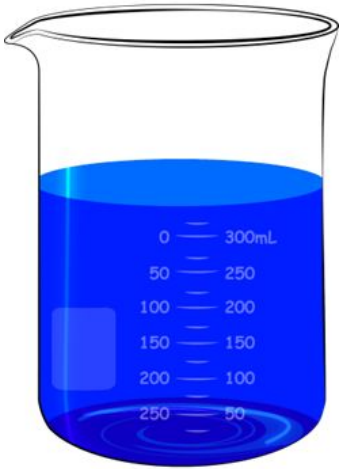
**Formula:** Molarity (M) = $\frac{moles\ of\ solute}{Liters\ of\ solution} = \frac{mol}{L}$

**Example:** A 1 M solution of sodium chloride (NaCl) contains 1 mole of NaCl dissolved in 1 liter of water.

There are also **2 additional formulas** you can derive from the Molarity formula.

$moles\ of\ solute$ = Molarity $(\frac{mol}{L})$ x Liters of solution

Volume, L (V) = $\frac{moles\ of\ solute}{Molarity} = \frac{mol}{mol/L}$



# Molarity (M)

## Practice Problem #5a

What is the molarity (M) of 90.0 g of NaOH in 0.250 L of NaOH solution?

**Formula:**

$$\text{Molarity (M)} = \frac{moles\ of\ solute}{Liters\ of\ solution} = \frac{mol}{L}$$

To solve this problem, you must first convert 60.0 g of NaOH to moles but using the molar mass of NaOH to do this. To calculate the molar mass of the NaOH, you must do the following:
NaOH = 22 + 16.00 + 1.0 = 40 g/mol

# Molarity (M)

## Practice Problem #5b

A nurse needs to prepare 500 mL of a 0.9 M sodium chloride (NaCl) solution for an intravenous (IV) drip. How many moles of NaCl are required to make this solution?

**Formula:**

*moles of solute* = Molarity (M) x Liters of solution

Step 1: Convert mL to L

# Molarity (M)

## Practice Problem #5c

A pharmacist needs to prepare a 0.1 M solution of glucose (C6H12O6) to administer 0.2 moles of glucose to a patient. What volume of the 0.1 M glucose solution is required?

**Formula:**

$$\text{Volume, L (V)} = \frac{moles\ of\ solute}{Molarity} = \frac{mol}{mol/L}$$

# Mass Percent

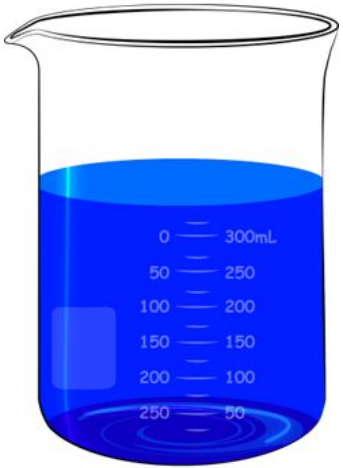
## (% by mass)

It is defined as the mass of the solute divided by the total mass of the solution, multiplied by 100%.

**Formula:**

$$\text{Mass percent (m/m)} = \frac{mass\ of\ solute\ \ (g)}{mass\ of\ solute\ (g) + mass\ of\ solvent\ (g)} \times 100\%$$

$$= \frac{mass\ of\ solute\ \ (g)}{mass\ of\ solution\ (g)} \times 100\%$$



# Mass Percent

## (% by mass)

### Practice Problem #6

What is the mass percent of NaOH in a solution prepared by dissolving 30.0 g of NaOH in 120.0 g NaOH?

**Formula:**

$$\text{Mass percent (m/m)} = \frac{mass\ of\ solute\ \ (g)}{mass\ of\ solute\ (g) + mass\ of\ solvent\ (g)} \text{ x } 100\%$$

$$= \frac{mass\ of\ solute\ \ (g)}{mass\ of\ solution\ (g)} \text{ x } 100\%$$

# Mass Percent

# (% by mass)

## Practice Problem #6

The topical antibiotic ointment Neosporin is 3.5% (m/m) neomycin solution. How many grams of neomycin are in a tube containing 100 g of ointment?

**Formula:**

$$\text{Mass percent (m/m)} = \frac{mass\ of\ solute\ (g)}{mass\ of\ solute\ (g) + mass\ of\ solvent\ (g)} \times 100\%$$

$$= \frac{mass\ of\ solute\ (g)}{mass\ of\ solution\ (g)} \times 100\%$$

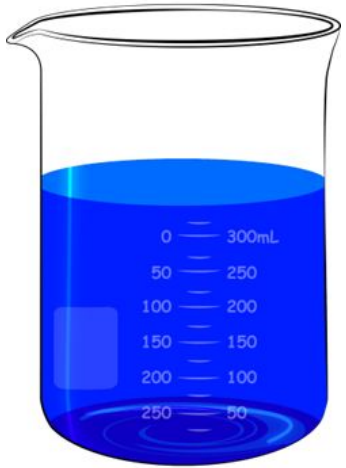
# Volume Percent

## (% by volume)

Used for liquid-liquid solutions and is the volume of solute divided by the total volume of the solution, multiplied by 100%.

**Formula:**

$$\text{Volume percent (v/v)} = \frac{volume\ of\ solute}{volume\ of\ solution} \text{ x } 100\%$$



# Volume Percent

## (% by volume)

### Practice Problem #7

A bottle contains 59 mL of vanilla extract solution. If the extract contains 49 mL of alcohol, what is the volume percent (v/v) of the alcohol in the solution?

**Formula:**

$$\text{Volume percent (v/v)} = \frac{volume\ of\ solute}{volume\ of\ solution} \times 100\%$$

# Volume Percent

# (% by volume)

## Practice Problem #8

What is the volume percent (v/v) of Br2 in a solution prepared by dissolving 15 mL of liquid bromine (Br2) in the solvent carbon tetrachloride (CCl4) to make 500 mL of solution?

**Formula:**

$$\text{Volume percent (v/v)} = \frac{volume\ of\ solute}{volume\ of\ solution} \times 100\%$$

# Dilution

Dilution is the process of reducing the concentration of a solute in a solution, usually by adding more solvent. The key aspect of dilution is that the amount of solute remains constant; only the total volume of the solution changes.

Grams of moles of solute = grams or moles of solute
*Concentrated solution* *Diluted solution*

C1V1 = C2V2
*Concentrated solution* *Diluted solution*

C1 is the initial concentration of the solution.
V1 is the initial volume of the solution.

C2 is the final concentration after dilution.
V2 is the final volume after dilution.

Note: If C1 increases, then V1 will decrease.
If C2 decreases, then V2 will increase.

This means they are inversely proportional to each other.
As one variable INCREASES, the other variable will DECREASE.

# Dilution

## Practice Problem #9

A doctor orders 1000. mL of a 35.0% (m/v) glucose solution.  If you have a 60.0% (m/v) glucose solution, how many millimeters would you use to prepare 1000. mL of 35.0% (m/v) glucose solution?

**Formula:**

$C_1V_1 = C_2V_2$

*Concentrated solution* *Diluted solution*

**Given:**

C1 is the initial concentration of the solution.
V1 is the initial volume of the solution.
C2 is the final concentration after dilution.
V2 is the final volume after dilution.

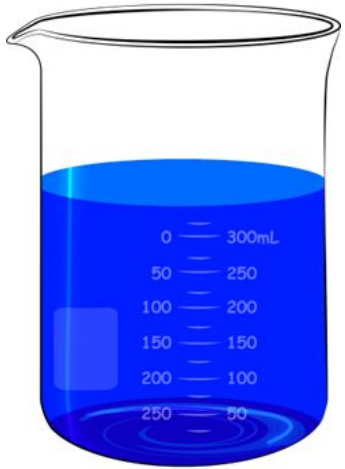
# Molality (m)

It is defined as the number of moles of solute per kg of solvent.

**Formula:** $\text{Molality } (m) = \frac{moles\ of\ solute}{kg\ of\ solvent} = \frac{mol}{kg}$

**Independence:** Molality is independent of temperature because it relies on the mass of the solvent, which does not change with temperature.

**Common Use:** Molality is often used in scenarios where temperature changes are involved, such as in colligative properties (e.g., boiling point elevation and freezing point depression).



# Molality (m)

## Practice Problem #10

What is the molality of a solution containing 35.5 g of the nonelectrolyte glucose (C6H12O6) in 0.500 kg of water?

**Formula:** $\text{Molality } (m) = \frac{moles\ of\ solute}{kg\ of\ solvent} = \frac{mol}{kg}$

To solve this problem, you must first convert 35.5 g of NaOH C6H12O6 to moles but using the molar mass of C6H12O6 to do this. To calculate the molar mass of the C6H12O6, you must do the following:

C6H12O6 = (6x12.01) + (12x1.01) + (6x16.00)
= 72.06 + 12.12 + 96.00 = 180.18 g/mol

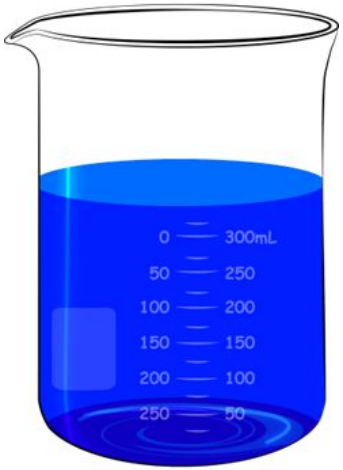
# Molarity vs Molality

## What's the difference?

Molarity (M) and molality (m) are both measures of the concentration of a solution, but they differ in how they are calculated and the conditions under which they are used.

**Key Differences:**

01. **Units:**
    a) Molarity is expressed in moles per liter (mol/L).
    b) Molality is expressed in moles per kilogram (mol/kg).
02. **Dependence on Temperature:**
    a) Molarity changes with temperature because it depends on volume, which can expand or contract.
    b) Molality does not change with temperature since it depends on mass.
03. **Application:**
    a) Molarity is typically used for reactions in solutions, where volumes are measured and controlled.
    b) Molality is used in experiments where temperature changes might affect the concentration, such as in studies of colligative properties.



# Comparing Solubility of Different Substances

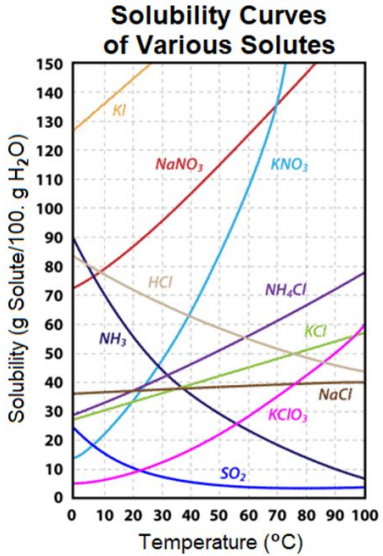
**Question:** At 30°C, which substance is more soluble according to their solubility curves: ammonium chloride (NH4Cl) or sodium nitrate (NaNO3)?

**A) Ammonium chloride (NH4Cl)**

**B) Sodium nitrate (NaNO3)**

**C) Both have the same solubility**

**D) Neither substance is soluble at this temperature**



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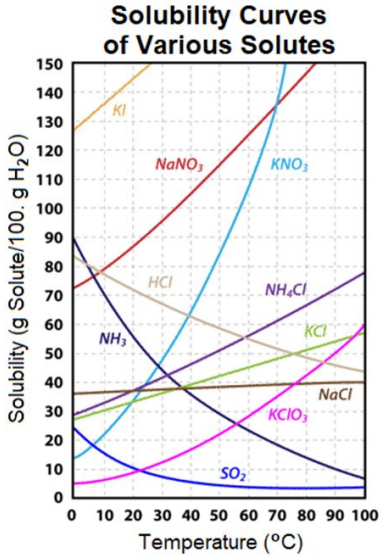


# Saturation Point Determination

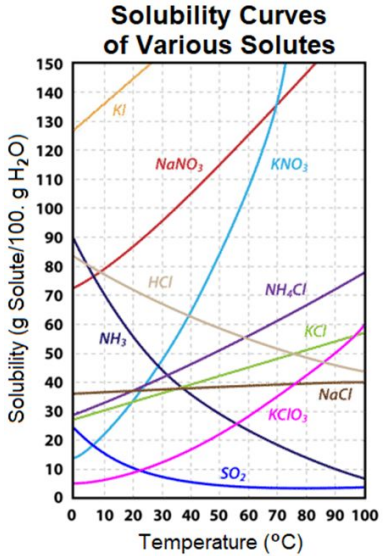
**Question:** If 50 grams of potassium chloride (KCl) are dissolved in 100 grams of water at 50°C, is the solution saturated, unsaturated, or supersaturated?

**A) Saturated**

**B) Unsaturated**

**C) Supersaturated**

**D) Insoluble**



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