Solubility Worksheet

Different types of Solubility

Ionic

polar } molecular
nonpolar

Intermolecular attractive forces

Stronge ↑

Cation $\oplus$ Anion $\ominus$	Ionic
R-OH R-NH_2	H - bonding
polar	dipole - dipole
non-polar	Van der Waal forces (London forces)

Guiding factor

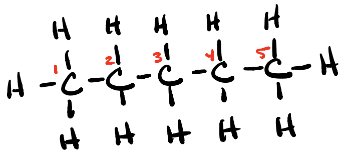
"Like dissolves like"

non-polar Solvents dissolve non-polar Solutes

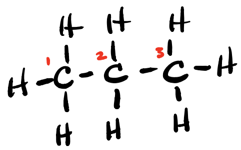
polar Solvents dissolve polar Solutes

Different types of dissolving

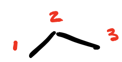
non-polar

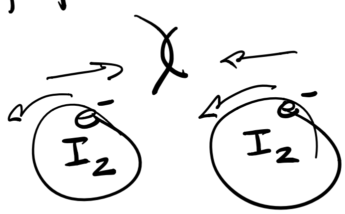


pentane Solvent

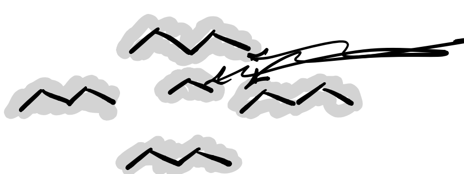


propane Solute





Van de waals force
Induce dipole



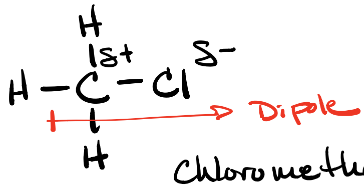
attractive forces

(London forces)
Van der Waal

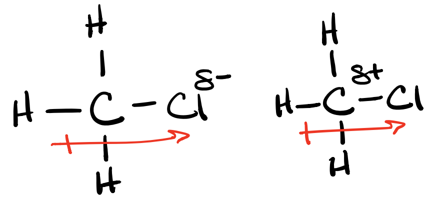
Molecular
Solubility

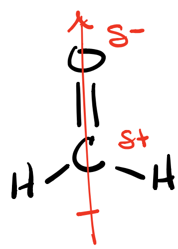
No dissociation

Dipole - Dipole



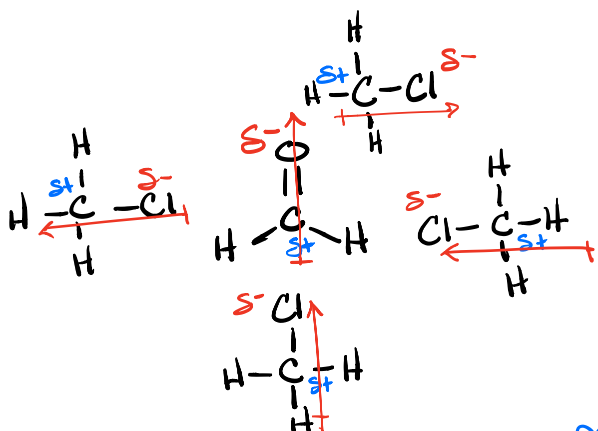
Chloromethane
Solvent





formaldehyde
solute

Solution



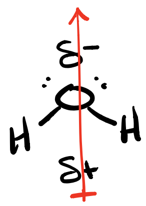
Dipole-Dipole

Molecular Solubility

No Dissociation

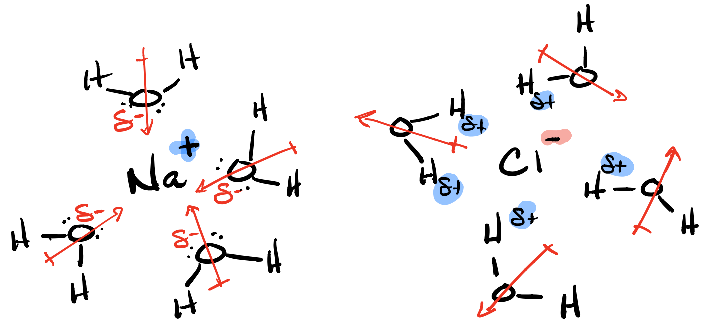
Ionic Solution

$Na^{\oplus}$ $Cl^{\ominus}$ $\Rightarrow$ NaCl Ionic Solute



Solvent Polar Solvent

$NaCl_{(s)} \xrightarrow{H_2O}$



dissociation

How do we make & Measure a Solution?

$$\text{Concentration} = \frac{\text{amount of Solute}}{\text{amount of Solution (Solute + Solvent)}}$$

Part

Whole

$$\text{Molarity} = \frac{\text{moles of Solute}}{\text{Liters of Solution}} = \text{moles}/\text{L} = \underline{\text{M}}$$

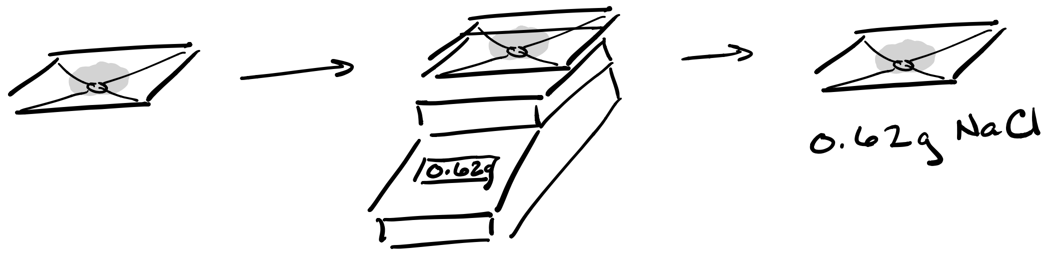
% v/v = Volume percent

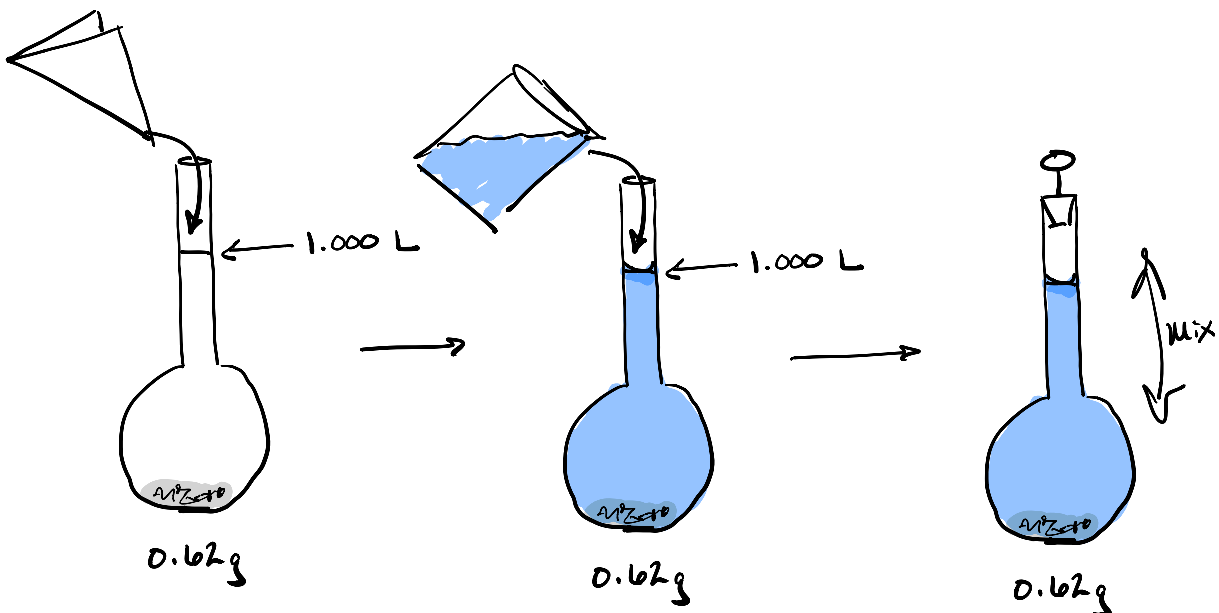
$$\frac{\text{gal or L or mL Solute}}{\text{gal or L or mL Solution}} \times 100 = \%\ \text{v/v}$$

% w/v = mass to Volume percent

$$\frac{\text{g Solute}}{\text{mL Solution}} \times 100 = \%\ \text{w/v}$$

Solution of NaCl in H_2O





Volumetric glassware

0.62g NaCl (Solute)

1.000 L Solution

Na	22.99	g/mole
Cl	35.45	g/mole
NaCl	58.44	g/mole

moles NaCl

$$\overset{2}{0.62\,g} \times \frac{1 \text{ mole NaCl}}{\underset{4}{58.44}\,g \text{ NaCl}} = 0.010609171 \text{ moles NaCl}$$

$$\boxed{0.11 \text{ moles NaCl}}$$

$$\text{Molarity} = \frac{\text{moles Solute}}{\text{L Solution}} = \frac{\overset{2}{0.11} \text{ moles NaCl}}{\underset{4}{1.000} \text{ L Solution}}$$

all mean the Same

$$= 0.11 \text{ moles/L NaCl}$$

$$= \frac{0.11 \text{ moles}}{\text{L}} \text{ NaCl}$$

$$= 0.11 \ \underline{M} \text{ NaCl}$$

Activity 17 – Solutions Worksheet

Name____________________________

Section____________ **Date**_______

Questions and Problems

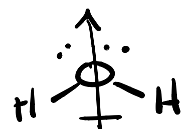
For written answers, use complete sentences. For calculations, clearly ***show your work*** *and report your final answer with the correct number of significant figures.*

✓ 1. NaCl is more soluble in water than I_2. Explain.

Like disolves Like

$\overset{+}{Na}\overset{-}{Cl}$ Ionic

I–I non-polar



polar

*Look at H_2O/NaCl dissolving in notes

✓ 2. How does an unsaturated solution differ from a saturated one?

✓ 3. The solubility of sucrose (common table sugar) at 70 °C is 320. g/100. g H_2O.

a) How much sucrose can dissolve in 250.0 g of water at 70 °C?

b) Will 620.0 g of sucrose dissolve in a teapot that contains 200.0 g of water at 70 °C? Explain.

solubility ratio

✓ 4. If the solubility of sucrose at 0 °C is 180. g/100. g H_2O, will 300.0 g of sucrose dissolve in a pitcher of 150.0 g of iced tea at 0 °C? If not, how many grams will dissolve?

Same { w/v = weight / volume; m/v = mass / volume }

w/w % = mass solute (g) / mass solution (g) × 100

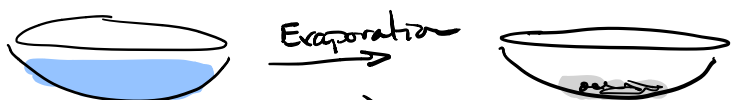
w/v % = mass solute (g) / volume solution (mL) × 100

5. What is the difference between a mass/mass percent concentration and a mass/volume percent concentration? Show an example of both, using sucrose as the solute and water as the solvent, and 15.5 as the numerical value of the percentage.

15.5 % Sucrose w/w % vs. 15.5 % Sucrose w/v %

✓ 6. A 15.0 mL sample of sodium chloride solution that has a mass of 15.78 g is placed in an evaporating dish and evaporated to dryness. The residue has a mass of 3.26 g. Calculate the following concentrations for the NaCl solution.

a) mass/mass (m/m) percent



Solution (H_2O + NaCl)

Volume solution 15mL

mass solution 15.78g

NaCl

3.26g

$$\frac{\text{g NaCl}}{\text{g Solution}} \times 100 =$$

b) mass/volume (m/V) percent

$$\frac{\text{g NaCl}}{\text{mL Solution}} \times 100 =$$

c) molarity

Given

$$\frac{\text{g NaCl}}{\text{mL Solution}}$$

Desired

$$\frac{\text{moles NaCl}}{\text{L Solution}}$$

7. A 3.0 % (m/V) KI solution has a volume of 25.0 mL. Calculate the concentration of this solution in units of M (moles/L).

Road Map

$$3.0\%\ m/v = \frac{3.0\ g\ KI}{100\ mL\ Solution} \longrightarrow \frac{moles\ KI}{L\ solution} = \underline{M}$$

Desired Equality Given

8. How many grams of a 25% (m/m) NaCl solution contain 150.0 g of NaCl?

Road Map 25 g NaCl = 100 g Solution

g NaCl ⟶ g Solution

9. What is the molarity of a solution that contains 80.0 g of NaOH dissolved in 500.0 mL of solution?

Road Map

$$\frac{g\ NaOH}{mL\ Sol} \longrightarrow \frac{moles\ NaOH}{L\ solution}$$

Desired Equality Given

10. How many milliliters of a 2.50 M $MgCl_2$ solution contain 17.5 g of $MgCl_2$?

Road Map 2.50 moles $MgCl_2$ = 1 L Solution

$$g\ MgCl_2 \xrightarrow{molar\ mass} moles\ MgCl_2 \xrightarrow{M} L\ Sol \xrightarrow{metric\ unit} mL\ Sol$$

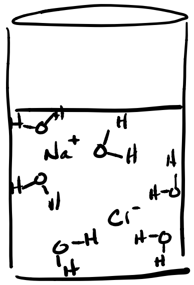
11. Calculate the osmolarity (moles of particles per Liter of solution) of a 0.750 M solution of Calcium chloride ($CaCl_2$). Assume that $CaCl_2$ is a strong electrolyte (i.e. ionizes completely).

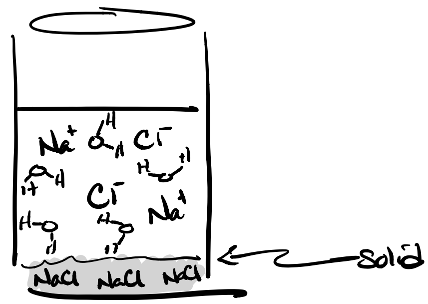
$$\frac{3\ moles\ ions}{1\ mole\ CaCl_2} \qquad 1\ CaCl_{2(s)} \xrightarrow{H_2O} \underbrace{1\ Ca^{2+}_{(aq)} + 2\ Cl^-_{(aq)}}_{3}$$

Road Map

$$\frac{0.750\ moles\ CaCl_2}{1\ L\ Sol} \longrightarrow \frac{moles\ particles}{L\ sol}$$

Saturated vs Unsaturated Solutions





Unsaturated

- Many more H_2O molecules than solute ions
- The solution can hold more NaCl

Saturated

- No more solute can dissolve into solvent
- Solid sits on the bottom of container

Temperature dependant

$$\xrightarrow[\text{Increase Solubility}]{\text{Increase temperature}}$$

3. The solubility of sucrose (common table sugar) at ~~70~~ 60 °C is ~~320~~ 285. g/100. g H_2O.

a) How much sucrose (desired) can dissolve in 250.0 g (Given) of water at 70 °C?

Solubility = Conversion factor

g Solute = g H_2O

Road map

g H_2O ⟶ g Sucrose

$$250.0\,g\,H_2O \times \frac{285\,g\,Sucrose}{100.\,g\,H_2O} = 712.5\,g\,Sucrose \text{ @ } 60°C = \boxed{713\,g\,Sucrose}$$

4 3 3

b) Will 620.0 g of sucrose dissolve in a teapot that contains 200.0 g of water at ~~70~~ 60 °C? Explain.

one way to solve ⟹ Compare ratio

we Have

$$\frac{620.0\,g\,Sucrose}{200.0\,g\,H_2O} = \frac{3.1\,g\,Sucrose}{1\,g\,H_2O} = ?$$

Higher ratio than allowed

Solubility

$$\frac{285\,g\,Sucrose}{100.0\,g\,H_2O} = \frac{2.85\,g\,Sucrose}{1\,g\,H_2O}$$

Maximum Solubility

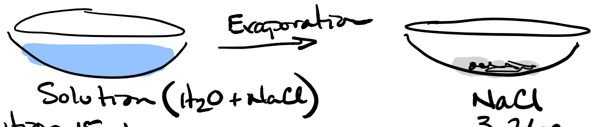
⟹ No 620g will not dissolve

*2nd way

g H_2O ⟶ g Sucrose (maximum)

$$200.0\,g\,H_2O \times \frac{285\,g\,Sucrose}{100.0\,g\,H_2O} = 564\,g\,Sucrose\ max$$

No. 200g H_2O can hold a maximum of 564g Sucrose. 620g is too much and will not dissolve entirely



Volume solution 15mL
mass solution 15.78g

Calculating Molarity

$$\frac{\text{g NaCl}}{\text{mL Solution}} \longrightarrow \frac{\text{moles NaCl}}{\text{L Solution}}$$

$$\frac{\overset{3}{3.26}\ \cancel{\text{g}}\ \text{NaCl}}{\underset{3}{15.0}\ \cancel{\text{mL}}\ \text{Solution}} \times \frac{1\ \text{mole NaCl}}{\underset{4}{58.44}\ \cancel{\text{g}}\ \text{NaCl}} \times \frac{\overset{\text{def}}{1000}\ \cancel{\text{mL}}\ \text{Solution}}{1\ \text{L Solution}}$$

$$= 3.26 \div 15.0 \times 1 \div 58.44 \times 1000 \div 1 = 3.718913 \ \frac{\text{mol}}{\text{L}}$$

$$\boxed{= 3.72\ \text{mole NaCl} / \text{L solution}}$$

Osmolarity $= \dfrac{\text{moles of particles (ions or molecules)}}{\text{L solution}}$

Molarity

no dissociation

Osmolarity

$$1\,\underline{M} = \frac{1 \text{ mole ethanol}}{\text{L solution}} \times \frac{1 \text{ mole particle}}{1 \text{ mole ethanol}} = \frac{1 \text{ mole particle}}{1 \text{ L sotion}} = 1\,\underline{OsM}$$

Do Dissociate

$Na^+ + Cl^-$

$$1\,\underline{M}\ NaCl = \frac{1 \text{ mole } NaCl}{1 \text{ L sol}} \times \frac{2 \text{ mole ions}}{1 \text{ mole } NaCl} = \frac{2 \text{ mole particles}}{1 \text{ L sol}} = 2\,\underline{OsM}$$

$Ca^{2+} + 2Cl^-$

$$1\,\underline{M}\ CaCl_2 = \frac{1 \text{ mole } CaCl_2}{1 \text{ L sol}} \times \frac{3 \text{ mole ions}}{1 \text{ mole } CaCl_2} = \frac{3 \text{ mole particles}}{1 \text{ L sol}} = 3\,\underline{OsM}$$