Solubility

Sections 8.2-8.3

Solubility

- **Solubility**: the amount of solute that can dissolve in a given amount of solvent
- Usually in **g/100 mL**
- **Unsaturated**: if solution contains less than maximum amount of solute in solvent
- **Saturated**: if solution contains maximum amount of solute in solvent

"Mixability"

- General rules for whether a solute will dissolve in a solvent

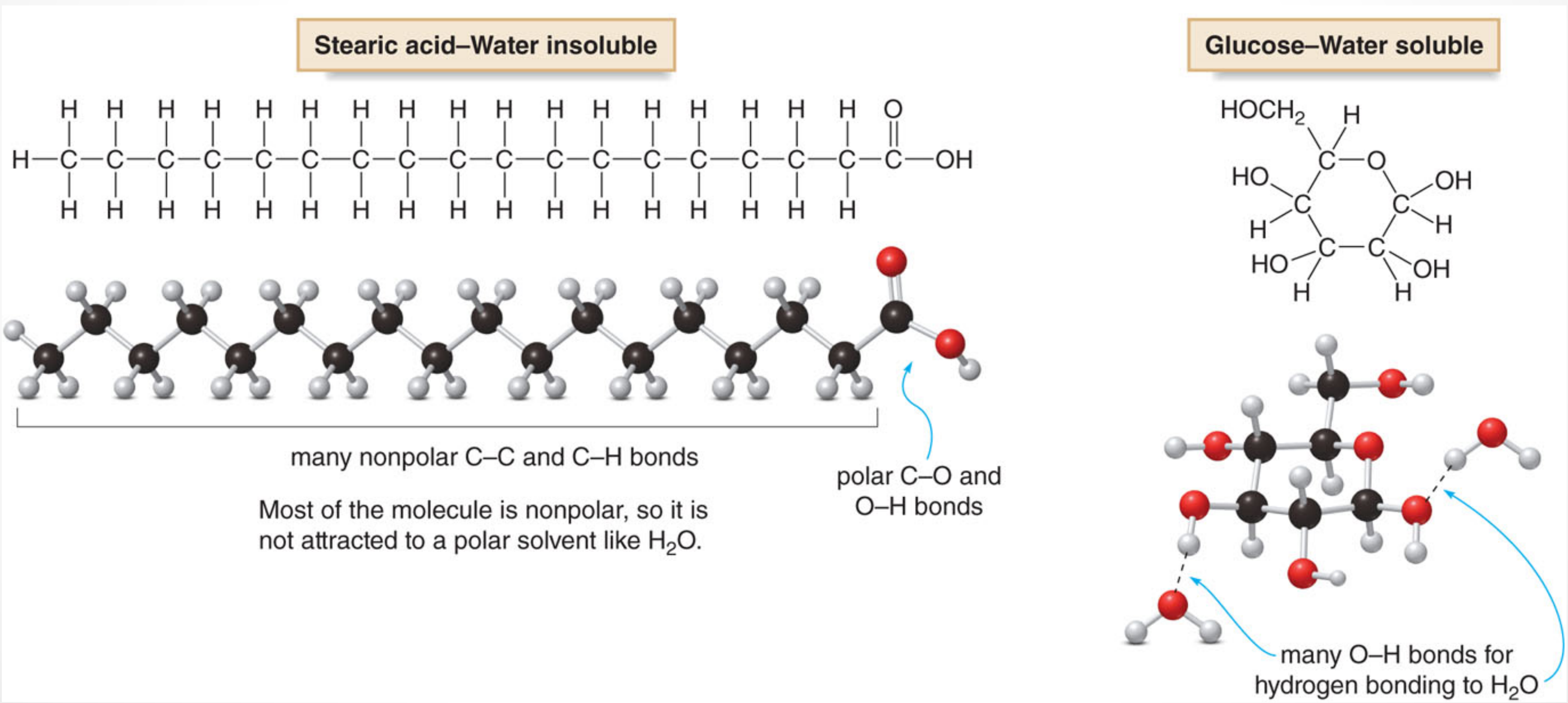
- IMF of solute and solvent must be similar in strength
  - Encourages strong interactions between solute particles and solvent particles

- Think "like dissolves like"

Like Dissolves Like

- Most ionic compounds and polar covalent compounds are soluble in water, a polar solvent
- Nonpolar compounds are soluble in nonpolar solvents
- This is why oil and water don't mix
  - Oil is a nonpolar compound
  - Water is a polar solvent

Like Dissolves Like



Example #1

Which compounds are water soluble?

a. $NaNO_3$

b. CH_4

c. KBr

Example #1 Solved

a. $NaNO_3$: ionic compound – **soluble in water**

b. CH_4: nonpolar covalent compound – **insoluble in water**

c. KBr: ionic compound – **soluble in water**

Ionic Solubility

- In general, ionic compounds are soluble in water
- Then again, some are not
- There is a set of general rules for solubility
  - You needed this for your "ionic solutions lab"

General Rules for Solubility

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
Cl^-	soluble	except Ag^+, Hg_2^{2+}, *Pb^{2+}
I^-	soluble	except Ag^+, Hg_2^{2+}, Pb^{2+}
SO_4^{2-}	soluble	except Ca^{2+}, Ba^{2+}, Sr^{2+}, Hg^{2+}, Pb^{2+}, Ag^+
CO_3^{2-}	insoluble	except Group IA and NH_4^+
PO_4^{3-}	insoluble	except Group IA and NH_4^+
^-OH	insoluble	except Group IA, *Ca^{2+}, Ba^{2+}, Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^+
Na^+	soluble	none
NH_4^+	soluble	none
K^+	soluble	none

*slightly soluble

How to Use Table

- Only need to match one ion, either cation or anion
- "insoluble" means not soluble
- Example: $CaSO_4$
- Ca^{2+} is not listed under ion list, but SO_4^{2-} is
- Generally SO_4^{2-} is soluble, but Ca^{2+} is an exception so $CaSO_4$ is **insoluble**

Example #2

Use the solubility rules to predict whether the following ionic compounds are soluble in water:

a. Li_2CO_3

b. KBr

c. $Ca_3(PO_4)_2$

Example #2 Solved

a. Li_2CO_3: Li^+ is not listed but CO_3^{2-} is
   - Generally CO_3^{2-} is insoluble, but Li^+ is an exception so Li_2CO_3 is **soluble**

b. KBr: K^+ is listed
   - Generally K^+ is soluble with no exceptions so KBr is **soluble**

c. $Ca_3(PO_4)_2$: Ca^{2+} is not listed but PO_4^{3-} is
   - Generally PO_4^{3-} is insoluble, Ca^{2+} is not an exception so $Ca_3(PO_4)_2$ is **insoluble**

Effects on Solubility

- Two factors can affect solubility
- Temperature
- Pressure

Temperature Effects

- For most ionic and molecular solids, solubility increases with temperature
  - Think about adding sugar to tea, vs. iced tea

- For gases, the opposite is true, gas solubility decreases with temperature
  - This is because when temperature is increased the gas particles are moving faster and are less likely to interact and mix with solvent particle
  - Similar to the idea of vapor pressure

Pressure Effects

- Changes in pressure affect a gas's solubility in a liquid
- **Henry's Law**: the solubility of a gas is directly proportional to the partial pressure of the gas above the liquid
- The higher the pressure, the higher the solubility
    - Think about a pressurized can of soda, once the can is opened, the pressure decreases, so the CO_2 gas dissolved in the soda comes out

Example #3

Predict the effect each change has on the solubility of $Na_2CO_3(s)$:

a. Increasing the temperature

b. Decreasing the temperature

c. Increasing the pressure

d. Decreasing the pressure

Example #3 Solved

a. Increasing the temperature: **increase solubility**

b. Decreasing the temperature: **decrease solubility**

c. Increasing the pressure: **no effect**

d. Decreasing the pressure: **no effect**

Example #4

Which pairs of compounds will form a solution?

a. Benzene (C_6H_6) and hexane (C_6H_{14})

b. Na_2SO_4 and H_2O

c. NaCl and hexane

d. H_2O and CCl_4

Example #5

Use the solubility rules to predict whether the following ionic compounds are soluble in water:

a. $MgCO_3$

b. $PbSO_4$

c. $MgCl_2$

d. $CaCl_2$

Example #6

Predict the effect each change has on the solubility of $N_2(g)$:

a. Increasing the temperature

b. Decreasing the temperature

c. Increasing the pressure

d. Decreasing the pressure