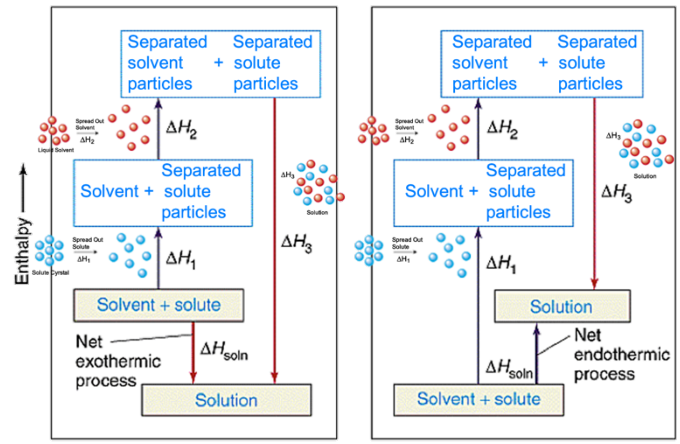
Chem 2 AP Homework #12-1: Solutions & Solubility
Problems pg. 520 # 1, 6, 7, 9, 11, 12, 25, 27, 28, 34, 36, 83, 84

12.1 Distinguish between an unsaturated solution, a saturated solution, and a supersaturated solution.
An **unsaturated solution** contains less solute than a solvent can hold at a given temperature; a **saturated solution** contains the maximum amount of solute that a solvent can hold at a given temperature; a **supersaturated solution** contains more solvent than can be directly dissolved in a solvent at a given temperature.

12.6 Provide a molecular interpretation for the difference between an endothermic and exothermic solution process.
An **endothermic solution process** is one in which $\Delta H_1 + \Delta H_2 > \Delta H_3$ (see right), which occurs when the solute-solvent interaction (ΔH_3) is weaker than the solvent-solvent (ΔH_2) and solute-solute (ΔH_1) interactions. An **exothermic process** is one in which $\Delta H_1 + \Delta H_2 < \Delta H_3$, which occurs when the solute-solvent interaction (ΔH_3) is stronger than the solvent-solvent (ΔH_2) and solute-solute (ΔH_1) interactions.



12.7 Explain why the solution process invariably leads to an increase in disorder.
The solution process always leads to an increase in disorder because there is an increase in the randomness of the arrangement of the particles and a break-down in the long-range arrangements of the particles in the pure materials.

12.9 Why is naphthalene ($C_{10}H_8$) more soluble than CsF in benzene (C_6H_6)?
Naphthalene ($C_{10}H_8$) is more soluble in benzene because CsF is an ionic solid; the ion–ion attractions are too strong to be overcome by the dissolving process in benzene. The ion–induced dipole interaction is too weak to stabilize the ion. Nonpolar naphthalene molecules form a molecular solid in which the only interparticle forces are of the weak dispersion type. The same forces operate in liquid benzene causing naphthalene to dissolve with relative ease (entropy effect, Ch. 16). (Use "Like dissolves like" as a mnemonic, but *not* to explain.)

12.11 Arrange O_2, LiCl, Br_2 and CH_3OH in order of solubility in H_2O.
The order of increasing solubility is: **$O_2 < Br_2 < LiCl < CH_3OH$**. Methanol is *miscible* with water because of strong hydrogen bonding. LiCl is an ionic solid and is very soluble because of the high polarity of the water molecules and strong ion-dipole forces, but has a larger enthalpy of separation than methanol. Both oxygen and bromine are nonpolar and exert only weak dispersion forces. Bromine is a larger molecule and is therefore more polarizable and susceptible to dipole–induced dipole attractions.

12.12 Explain the variations in solubility of the alcohols in the table at right.

Compound	Solubility in Water (g/100g) at 20°C
CH_3OH	∞
CH_3CH_2OH	∞
$CH_3CH_2CH_2OH$	∞
$CH_3CH_2CH_2CH_2OH$	9
$CH_3CH_2CH_2CH_2CH_2OH$	2.7

The longer the C–C chain, the more the molecule "looks like" a hydrocarbon and the less important the –OH group becomes. Hence, the molecule becomes less polar. The –OH group of the alcohols can form strong hydrogen bonds with water molecules, but this property decreases as the chain length increases and the cohesive properties of water become more important.

12.25 How do the solubilities of most ionic compounds in water change with temperature? With pressure?

The **solubilities** of most ionic compounds ***increase*** with ***increasing*** **temperature**; there is **no effect of pressure** on their solubilities.

12.27 3.20 g of a salt dissolves in 9.10 g H_2O to give a saturated solution at 25°C. What is the solubility (in g salt/100 g H_2O) of the salt?

$\frac{3.20 \text{ g salt}}{9.10 \text{ g } H_2O} \times 100 \text{ g } H_2O = 35.2 \text{ g salt}$. Therefore, the solubility of the salt is **35.2 g salt/100 g H_2O**.

12.28 The solubility of KNO_3 is 155 g/100g H_2O at 75°C and 38.0 g at 25°C. What mass of KNO_3 will crystallize out of solution if exactly 100 g of its saturated solution at 75°C is cooled to 25°C? Remember that the solution mass consists of both solute and solvent mass.

$$100.\text{ g saturated soln} \times \frac{155 \text{ g } KNO_3}{255 \text{ g saturated soln}} = 60.8 \text{ g } KNO_3$$

$$\text{Mass } H_2O = 100.\text{ g solution} - 60.8 \text{ } KNO_3 = 39.2 \text{ g } H_2O$$

$$\text{At 25°C, dissolved mass } KNO_3 = 39.2 \text{ g } H_2O \times \frac{38.0 \text{ g } KNO_3}{100 \text{ g } H_2O} = 14.9 \text{ g } KNO_3$$

$$\text{Mass } KNO_3 \text{ crystallized} = 60.8 \text{ g } KNO_3 - 14.9 \text{ g } KNO_3 = \boxed{\mathbf{45.9 \text{ g } KNO_3}}$$

12.34 A student bought a goldfish in a pet shop, brought it home and placed it in water that had been boiled and quickly cooled. Explain why the goldfish was found dead a while later.

When the water was boiled, the water got hotter. Gases are less soluble at hotter temperatures, so there would be less O_2 gas is the heated water. The fish died because there was not enough oxygen in the water.

12.36 A miner working 260 m below sea level opened a carbonated soda during a lunch break. To his surprise, the soda tasted "flat." Shortly afterward, he took an elevator to the surface and continually belched. Why was the soda flat at the bottom of the mine, but the miner continually belched on the trip up to the surface?

According to Henry's law, the solubility of a gas in a liquid increases as the pressure increases ($c = kP$). The soft drink tastes flat at the bottom of the mine because the carbon dioxide pressure is greater and the dissolved gas is not released from the solution. As the miner goes up in the elevator, the atmospheric carbon dioxide pressure decreases and dissolved gas is released from his stomach.

12.83 What are colloids? Referring to Table 12.4, why is there no colloid in which both the dispersed phase and the dispersing medium are gases?

- Colloids are dispersions of particles of one substance (the dispersed phase) throughout a dispersing medium (similar to solvent) made of another substance.
- There are no gas-gas colloids because gas samples mix completely (remember Kinetic Molecular Theory).

12.84 Describe how hydrophilic and hydrophobic colloids are stabilized in water. (See §12.8 in text.)

- Hydrophilic colloids are stabilized by ion-dipole forces or hydrogen-bond formation with water molecules by functional groups on their exterior.
- Hydrophobic colloids can be stabilized by adsorption of ions onto their surface, which can interact with the water molecules. They can also be stabilized by the presence of a hydrophilic group, such as present in soap.