CHEMISTRY DAILY PLAN

Class: **Date:**

Subject: ***Factors That Affect Solubility*** **Time:**

MAXIMUM RANDOMNESS AND MINIMUM ENERGY

As explained before, there are two factors that fix the state of equilibrium. One of these factors is the energy and the other is randomness. The equilibrium results from a balance between minimum energy and maximum randomness.

A) RANDOMNESS:

Liquid solutions are more random than solids. In solvents, the dissolving process destroys the regular (produced) crystal lattice of solids. The dissolving process, therefore, increases randomness. The tendency toward maximum randomness tends to cause solids dissolve.

The gaseous state is more random than the liquid state. Because the molecules in gaseous state move (freely through a larger space. When a gas dissolves in a liquid, randomness decreases. Unlike solids, the tendency toward maximum randomness Favors the gas phase and opposes the dissolution of a gas.

In general, decomposition of large molecules (particles) into smaller molecules (or ions) increases randomness.

B) MINIMUM ENERGY:

Minimum energy opposes randomness. The solid state of a substance has the least energy when compared with liquid or gas state but it is the most random. Hence, the tendency toward minimum energy favors precipitation. To increase randomness, solids tend to dissolve. To lower energy, solids tend to precipitate.

When gas molecules enter a liquid, they come close to the solvent molecules and they attract each other. So the potential energy decreases. Unlike solids, the dissolution of a gas releases heat. As a result, the tendency toward minimum energy favors the dissolving process.

EXAMPLE 2 Maximum Randomness

Problem : Given the following reactions. Explain whether the tendency toward maximum randomness favors reactants or products.

a) $BaSO_{4\,(s)} \Leftrightarrow Ba^{2+}_{(aq)} + SO_4^{-2}{}_{(aq)}$

b) $CaCO_{3\,(s)} \Leftrightarrow CaO_{(s)} + CO_{2\,(g)}$

c) $H_2O_{(g)} \Leftrightarrow H_2O_{(l)}$

d) $N_2O_{(g)} \Leftrightarrow N_2O_{(aq)}$

e) $2SO_{3(g)} \Leftrightarrow 2SO_{2\,(g)} + O_{2\,(g)}$

TEMPERATURE

Increasing the temperature always increases the randomness. Therefore, *the solubility of most solids increases with increase in temperature.* But there are some exceptions. For example the solubilities of anhydrous Na_2SO_4, $CaCO_3$, $CaSO_4$, and $Ce_2(SO_4)_3.9H2O$ decrease with increasing temperature. A major component of some boiler scale is calcium sulfate, which is less soluble in hot water than in cold water. When water is heated in your teapot, a precipitation of $CaSO_4$, $CaCO_3$,... etc occurs to form a boiler scale.

In the case of gases, we find a contrast to the behavior of solids. The solubility of gases decreases as temperature is raised. Because the gas phase is always more random than the liquid phase. For example, 1.713 L CO_2 dissolve in 1 L water at 1 atm and 0 °C, but only 0.878 L dissolve at 20 °C. Most gases can be expelled from solvents by boiling their solutions.

On the other hand, the dissolution of most solids is endothermic. But the dissolution of gases is exothermic. See the following examples.

$$NaCl_{(s)} + 0.93 \text{ kcal} \Leftrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$$

$$Cl_{2\,(g)} \Leftrightarrow Cl_{2\,(aq)} + 6.0 \text{ kcal/mol (at 20 °C and 1 atm)}$$

If we assume that the entropy (randomness) of solutions for two gases is about the same, then the gas with the larger negative $\Delta H°$ solution is more soluble.

PRESSURE

The effect of pressure on the solubility of solids and liquids is negligible but *the solubility of gases increases with increasing the pressure on it.* This can be explained by Le Chatelier's Principle. Consider the dissolution of CO_2 gas in soft drinks,

$$CO_{2(g)} \Leftrightarrow CO_{2(aq)}$$

If the partial pressure of CO_2 is increased, the system tries to decrease the pressure. This is possible when some of CO_2 is dissolved.

If there is a reaction between gas and solvent, the solubility of the gas also increases. When ammonia gas is dissolved in water, it reacts with water in the following way and this reaction increases the solubility of NH_3 in water.

$$NH_{3(g)} + H_2O_{(l)} \Leftrightarrow NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$