9.2.1: Solutions of Solids Dissolved in Water

Learning Objectives

- Explain how temperature influences solubility of solids.

The **solubility** of a substance is the amount of that substance that is required to form a saturated solution in a given amount of solvent at a specified temperature. Solubility is often measured as the grams of solute per 100 g of solvent. The solubility of sodium chloride in water is 36.0 g per 100 g water at 20°C. The temperature must be specified because solubility varies with temperature. For gases, the pressure must also be specified. Solubility is specific for a particular solvent. We will consider solubility of material in water as solvent.

The solubility of the majority of solid substances increases as the temperature increases. However, the effect is difficult to predict and varies widely from one solute to another. The temperature dependence of solubility can be visualized with the help of a **solubility curve**, a graph of the solubility vs. temperature (Figure 9.2.1.4).

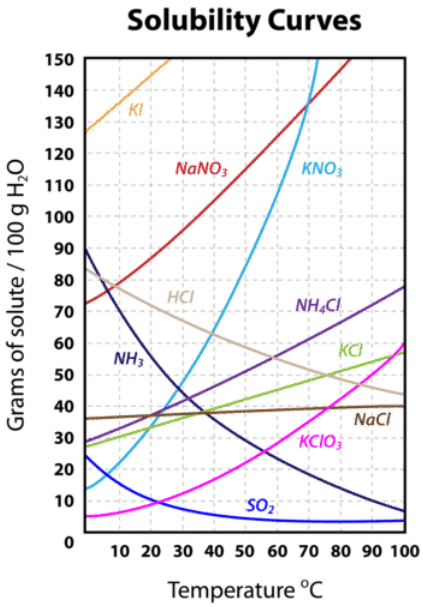

Figure 9.2.1.4: Solubility curves for several compounds.

Notice how the temperature dependence of NaCl is fairly flat, meaning that an increase in temperature has relatively little effect on the solubility of NaCl. The curve for KNO_3, on the other hand, is very steep and so an increase in temperature dramatically increases the solubility of KNO_3.

The trends for gas solubility in aqueous solution are often different than those for solids. You may notice on the graph that there are several substances—HCl, NH_3, and SO_2— which have solubility that decreases as temperature increases. They are all gases at standard pressure. Additionally, changes in pressure can affect solubility of gases whereas they generally have little or no effect on solubility of solids. Trends of gas solubility will be discussed in the next subsection.

Solubility curves can be used to determine if a given solution is saturated or unsaturated. Suppose that 80 g of KNO_3 is added to 100 g of water at 30°C. According to the solubility curve, approximately 48 g of KNO_3 will dissolve at 30°C. This means that the solution will be saturated since 48 g is less than 80 g. We can also determine that there will be $80 - 48 = 32$ g of undissolved KNO_3 remaining at the bottom of the container. Now suppose that this saturated solution is heated to 60°C. According to the curve, the solubility of KNO_3 at 60°C is about 107 g. Now the solution is unsaturated since it contains only the original 80 g of dissolved solute. Now suppose the solution is cooled all the way down to 0°C. The solubility at 0°C is about 14 g, meaning that $80 - 14 = 66$ g of the KNO_3 will re-crystallize.

Summary

- The solubility of a solid in water usually increases with an increase in temperature.

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