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CHEMISTRY

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9.4 *Graphical representations.* Show on suitably labeled graphs each of the following: (*a*) the energy distribution of molecules in a liquid; (*b*) the equilibrium vapor pressure of a liquid as a function of temperature; (*c*) the cooling of a gas through the liquid and solid transitions by uniform removal of heat; (*d*) the supercooling of a liquid followed by a "seeding" operation.

9.5 *Phase diagram.* (*a*) Draw the phase diagram for the substance H_2O. Label the various features of the diagram. (*b*) Indicate by a dotted line what happens when H_2O is heated from -30 to $+150°$C. at 1.00 atm. pressure. Describe in words what will be observed, and compare qualitatively with what happens at 1.01 atm. and 0.99 atm.

9.6 *Le Chatelier principle.* Ice is added to warm water in a well-insulated container at atmospheric pressure. The amount of ice in the mixture decreases for a time and then remains constant. (*a*) What is the temperature of the final mixture? (*b*) If the pressure on the ice-water mixture is greatly increased, what will happen to the temperature? (*c*) What will happen to the amount of ice? (*d*) Explain your answers to (*b*) and (*c*) in terms of the principle of Le Chatelier.

9.7 *Heat of fusion.* (*a*) How much heat is required to melt an ice cube weighing 15.0 g.? (*b*) What will be the final temperature produced by the addition of three such ice cubes to 300 ml. of 20°C. water in an insulated container?

9.8 *Heat of fusion.* In comparing attractive forces in solids, why is the molar heat of fusion used instead of the heat of fusion per gram?

9.9 *Equilibrium.* Given a well-stirred mixture of ice and water. If a small amount of either warm water or dry ice is added, the temperature does not change. Explain.

9.10 *Water.* A barrel of water placed in a cellar keeps fruit from freezing in the winter and from spoiling in the summer. Explain.

9.11 *Melting point.* Ice is placed in a sealed container from which all the air has been evacuated. What is the melting point of the ice? Compare this with what would be observed if the container were open to the air.

9.12 *Ice.* A 50-g. ice cube is enclosed in a fine-mesh wire cage and placed at the bottom of a well-insulated container of water at 0°C. After some time has passed, the wire cage contains only liquid water, and 50 g. of ice is floating on the surface. Explain.

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solving one gas in another. Since all gases mix in all proportions, any mixture of gases is homogeneous and is a solution. The kinetic picture of a gaseous solution is like that of a pure gas, except that the molecules are of different kinds. Figure 10.1 represents a gaseous solution of hydrogen and oxygen, where the dark circles represent hydrogen molecules and the white circles represent oxygen molecules. Ideally, the molecules move independently of each other.

Liquid solutions are made by dissolving a gas, liquid, or solid in a liquid. If the liquid is water, the solution is called an *aqueous* solution. The kinetic picture of a sugar-water solution is represented in Fig. 10.2. The white circles represent water molecules, and the dark circles sugar molecules. The sugar molecules are distributed at random throughout the bulk of the solution. It is evident that on this molecular scale the term homogeneous has little significance. However, experiments cannot be performed with less than billions of molecules, so that for practical purposes the solution is homogeneous.

Solid solutions are solids in which one component is randomly dispersed on an atomic or molecular scale throughout another component. An example of a solid solution is shown in Fig. 10.3, where the dark circles represent atoms of one component, and the white circles atoms of the other. As in any crystal, the packing of atoms is orderly, even though there is no particular order as to which lattice points are occupied by which kind of atom. Solid solutions are of great practical importance, since they make up a large fraction of the class of substances known as alloys.

An *alloy* may be defined as a combination of two or more elements which has metallic properties. Sterling silver, for example, is an alloy consisting of a solid solution of copper in silver. In brass, an alloy of copper and zinc, it is possible to have a solid solution in which some copper atoms of the face-centered-cubic structure of pure copper have been replaced by zinc atoms. Some kinds of steel are alloys of iron and carbon and can be considered as solid solutions in which carbon atoms are located in some of the spaces between iron atoms. The iron atoms are arranged in the regular structure of pure iron. It should be pointed out, however, that not all alloys are solid solutions. Some alloys,