are mainly of two types: (*a*) the cations, or acid exchangers, which permit the exchange of the cations in solution (in the tap water) with hydrogen ion from the resin, and (*b*) the anions, or base exchange resins, which permit the removal of anions. These two processes are successively or simultaneously employed to remove cations and anions from water. The processes are indicated as follows, with M^+ indicating the metal or cation (as Na^+) and the X^- indicating the anion (as Cl^-).
Cation exchange:

$$\mathrm{H-\ resin} + M^+ + X^- + H_2O \rightarrow$$

$$\mathrm{M-\ resin} + H^+ + X^- + H_2O\,(\mathrm{pure})$$

Anion exchange:

$$\mathrm{Resin-NH_2} + H^+ + X^- + H_2O \rightarrow$$

$$\mathrm{Resin-NH_2{\cdot}HX} + H_2O\,(\mathrm{pure})$$

Water purified in this manner, referred to as demineralized or deionized water, may be used in any pharmaceutical preparation or prescription calling for distilled water.

Reverse Osmosis

Reverse osmosis is one of the processes referred to in the industry as cross-flow (or tangential flow) membrane filtration (2). In this process, a pressurized stream of water is passed parallel to the inner side of a filter membrane core. A portion of the feed water, or influent, permeates the membrane as filtrate, while the balance of the water sweeps tangentially along the membrane to exit the system without being filtered. The filtered portion is called the permeate because it has permeated the membrane. The water that has passed through the system is called the concentrate because it contains the concentrated contaminants rejected by the membrane. Whereas in osmosis the flow through a semipermeable membrane is from a less concentrated solution to a more concentrated solution, the flow in this cross-flow system is from a more concentrated to a less concentrated solution, thus the term reverse osmosis. Depending on their pore size, cross-flow filter membranes can remove particles defined in the range of microfiltration (0.1 to 2 µm, e.g., bacteria), ultrafiltration (0.01 to 0.1 µm, e.g., virus), nanofiltration (0.001 to 0.01 µm, e.g., organic compounds in the molecular weight range of 300 to 1,000), and reverse osmosis (particles <0.001 µm). Reverse osmosis removes virtually all viruses, bacteria, pyrogens, and organic molecules and 90% to 99% of ions (2).

PREPARATION OF SOLUTIONS

Most pharmaceutical solutions are unsaturated with solute. Thus, the amounts of solute to be dissolved are usually well below the capacity of the volume of solvent employed. The strengths of pharmaceutical preparations are usually expressed in terms of percent strength, although for very dilute preparations, expressions of ratio strength may be used. These expressions and examples are shown in Table 13.4.

The symbol % used without qualification (as with w/v, v/v, or w/w) means percent weight in volume for solutions or suspensions of solids in liquids, percent weight in volume for solutions of gases in liquids, percent volume in volume for solutions of liquids in liquids, and weight in weight for mixtures of solids and semisolids.

Some chemical agents in a given solvent require an extended time to dissolve. To hasten dissolution, a pharmacist may employ one of several techniques, such as applying heat, reducing the particle size of the solute, using a solubilizing agent, and/or subjecting the ingredients to vigorous agitation. Most chemical agents are more soluble at elevated temperatures than at room temperature or below because an endothermic reaction between the solute and the solvent uses the energy of the heat to enhance dissolution. However, elevated temperatures cannot be maintained for pharmaceuticals, and the net effect of heat is simply an increase in the rate of solution rather than an increase in solubility. An increased rate is satisfactory to the pharmacist because most solutions are unsaturated anyway and do not require a concentration of solute above the normal capacity of the solvent at room temperature. Pharmacists are reluctant to use heat to