Chemistry

Second edition

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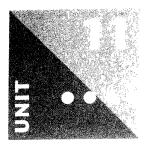
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Solutions and Solubility

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Objectives

- Examines solvent miscibility and immiscibility
- Explains the idea of solubility product
- Looks at distribution ratios and gas solubility
- Discusses osmosis and its applications
- Introduces colloids

Solubility

A **solution** is a mixture consisting of a **solvent** (the 'dissolver') and the **solute** (the substance that is being dissolved). For example, if we dissolve sugar in water, the water is the solvent, the sugar the solute and the sugary water is the solution. If we keep adding sugar to some water, a point will be reached when the water will not be able to hold any more sugar. The solution is now said to be **saturated**. Adding more sugar simply results in sugar settling on the bottom of the container. Raising the temperature of the solution allows the water to hold more sugar before it becomes saturated. Many solids, like sugar, are more soluble at higher temperatures, although the reverse usually applies to gases, which are less soluble in hot water than in cold water.

Rules of solubility

The word 'polar' was introduced in Unit 5 (see page 71). A polar substance is a substance that contains ions or consists of polar molecules. A polar solvent is a solvent which consists of polar molecules.

We start by reminding ourselves of the following:

- **1.** If a *polar substance* dissolves, it dissolves only in *polar solvents*.
- 2. If a non-polar substance dissolves, it dissolves only in non-polar solvents.

These generalizations are summarized in the rule *like dissolves like*. Solvents may be placed in order of polarity by testing their solubility in each other. The order of

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SOLUBILITY

 Table 11.1
 Polarity of common solvents – in order of

 increasing polarity with heptane the least polar and water

 ne most polar

Solvent	Formula	Density at 25°C/g cm ⁻³	
		0.69	
Heptane	CH ₃ (CH ₂) ₅ CH ₃	0.68	
Hexane	CH ₃ (CH ₂) ₄ CH ₃	0.66	
Cyclohexane	C ₆ H ₁₂	0.77	
Tetrachloromethane ¹	CCI ₄	1.58	
Methyl benzene ²	C ₆ H₅CH₃	0.86	
Ethoxyethane ³	C ₂ H ₅ OC ₂ H ₅	0.71	
Dichloromethane	CH ₂ Cl ₂	1.32	
Propan-2-ol	CH ₃ CH(OH)CH ₃	0.78	
Tetrahydrofuran	C₄H ₈ O	0.89	
Trichloromethane ⁴	CHCI3	1.48	
Ethanol ^s (absolute)	CH ₃ CH ₂ OH	0.79	
Ethyl ethanoate ⁶	CH ₃ COOC ₂ H ₅	0.90	
Propanone ⁷	CH ₃ COCH ₃	0.79	
Methanol ⁸	СН _з ОН	0.79	
Ethanenitrile ⁹	CH3CN	0.78	
Dimethyl sulfoxide	CH ₃ SOCH ₃	1.10	
Water	H ₂ O	1.00	

Alternative names: ¹Carbon tetrachloride, ²Toluene, ³Diethyl ether, ⁴Chloroform, ⁵Ethyl alcohol, ⁶Ethyl acetate, ⁷Acetone, ⁸Methyl alcohol, ⁹Acetonitrile.

solvents in Table 11.1 was obtained in this way. Of the common solvents, water is the most polar and the hydrocarbons heptane and hexane the least polar.

Miscibility

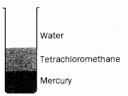
If, when two solvents are mixed, a single layer (consisting of a solution of the two solvents) is produced, the solvents are said to be **miscible**. If two layers are produced and both layers consist of pure solvent, the liquids are said to be **immiscible** (Fig. 11.1). If two layers are produced, the solvent with the lowest density floats on the top.

The word 'layer' is often replaced by the word **phase**. Thus, a mixture of hexane and water produces two phases.

Table 11.2 shows which pairs of common solvents are miscible, with \bullet denoting mmiscibility. For example, the table shows that water is immiscible with trichloromethane and with ethyl ethanoate.

Partially miscible solvents

Tew solvents are truly immiscible, and even though two liquids may not appear to fnix, there will still be a tiny amount of each solvent present in the other layer. Table 1.3 shows the solubilities of organic solvents in water, and of water in organic solvents. The units of the solubilities are grains of organic solvent per 100 g of saturated vater, and grams of water per 100 g of saturated organic solvent.



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Fig. 11.1 Three immiscible liquids—tetrachloromethane, mercury and water: mercury (density 13.6 g cm⁻³ at 25°C) sinks to the bottom; tetrachloromethane (density 1.6 g cm⁻³) occupies the middle position; and water (density 1.0 g cm⁻³) floats on top.