Water: The Solvent of Biochemistry

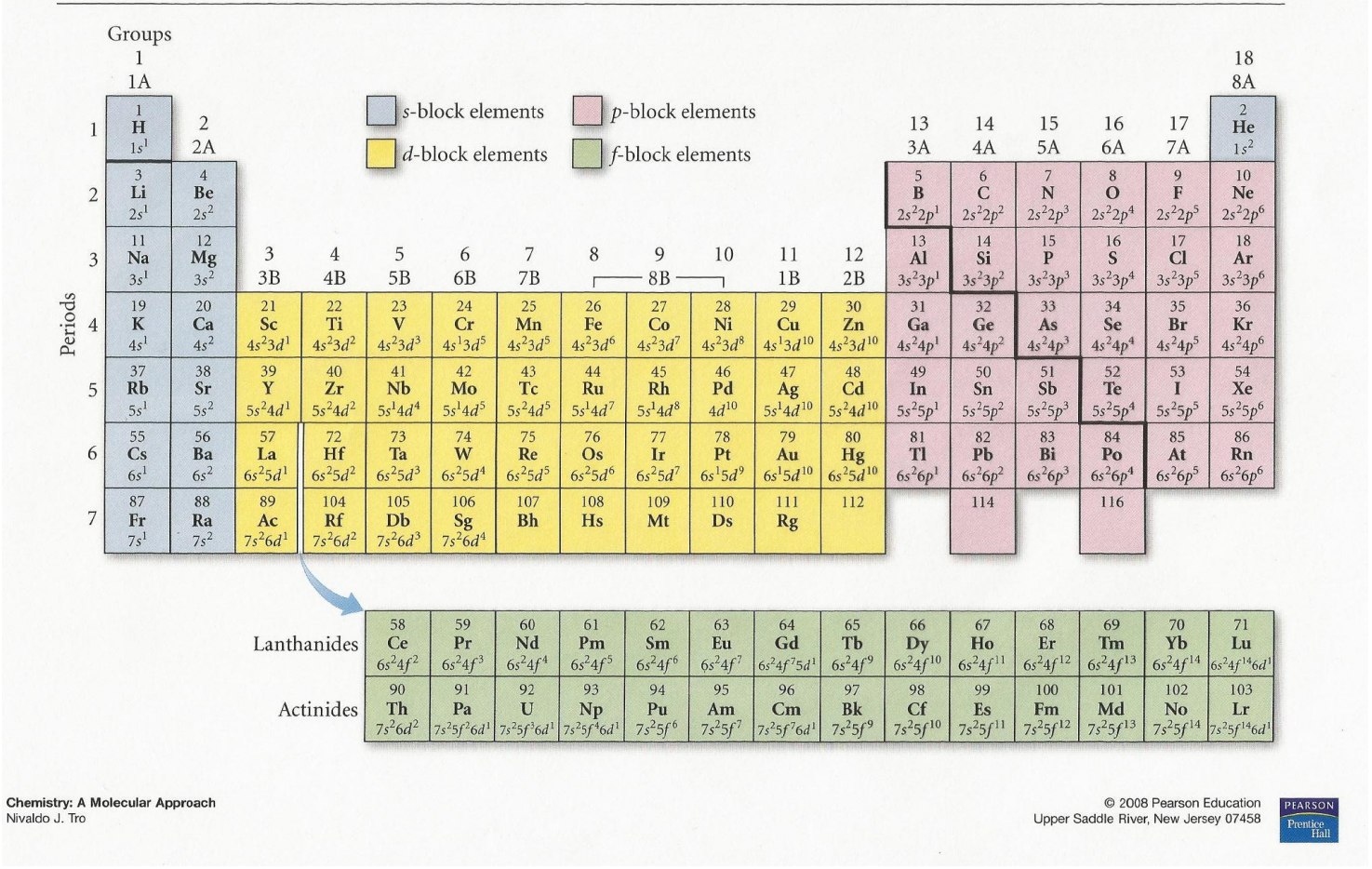
Chapter 2 (Page 47 -71)

Photo courtesy of Amnon Levav

Periodic Table

T-81

Figure 8.7 The *s*, *p*, *d*, and *f* Blocks of the Periodic Table



Chemistry: A Molecular Approach
Nivaldo J. Tro

Comparison of Solvent Properties.

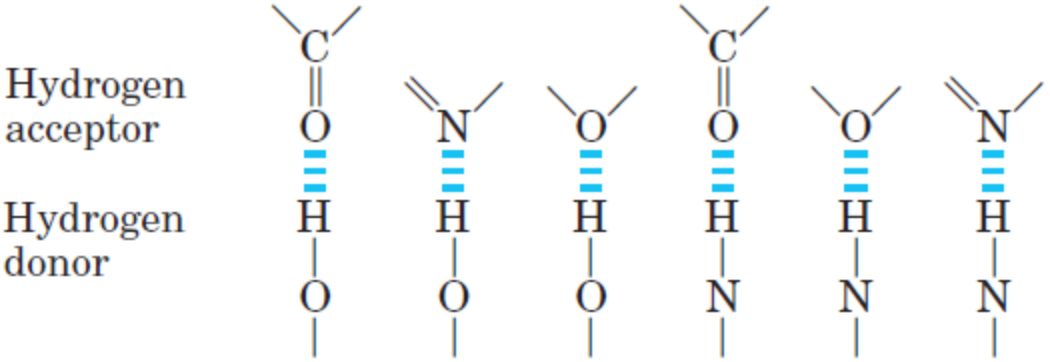
TABLE 2–1 Melting Point, Boiling Point, and Heat of Vaporization of Some Common Solvents

	Melting point (°C)	*Boiling point (°C)*	*Heat of vaporization (J/g)**
Water	0	100	2,260
Methanol (CH_3OH)	−98	65	1,100
Ethanol (CH_3CH_2OH)	−117	78	854
Propanol ($CH_3CH_2CH_2OH$)	−127	97	687
Butanol ($CH_3(CH_2)_2CH_2OH$)	−90	117	590
Acetone (CH_3COCH_3)	−95	56	523
Hexane ($CH_3(CH_2)_4CH_3$)	−98	69	423
Benzene (C_6H_6)	6	80	394
Butane ($CH_3(CH_2)_2CH_3$)	−135	−0.5	381
Chloroform ($CHCl_3$)	−63	61	247

*The heat energy required to convert 1.0 g of a liquid at its boiling point, at atmospheric pressure, into its gaseous state at the same temperature. It is a direct measure of the energy required to overcome attractive forces between molecules in the liquid phase.

Hydrogen Bonds in Polar Molecules

A



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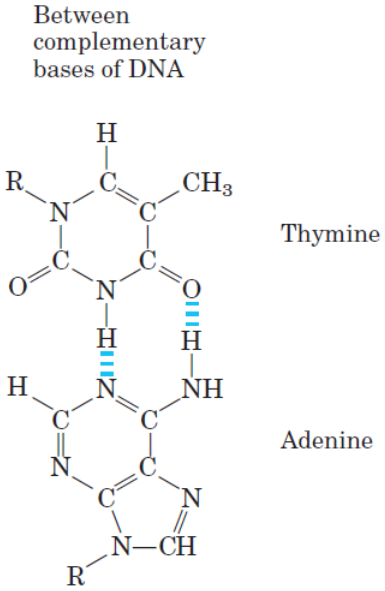

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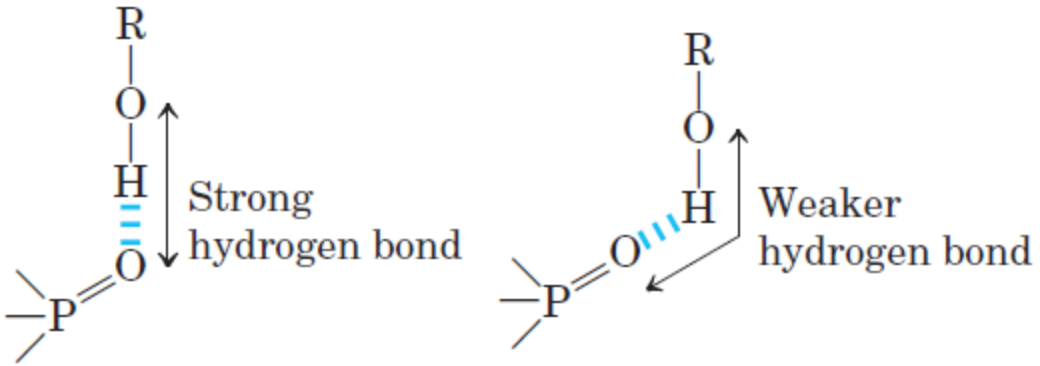
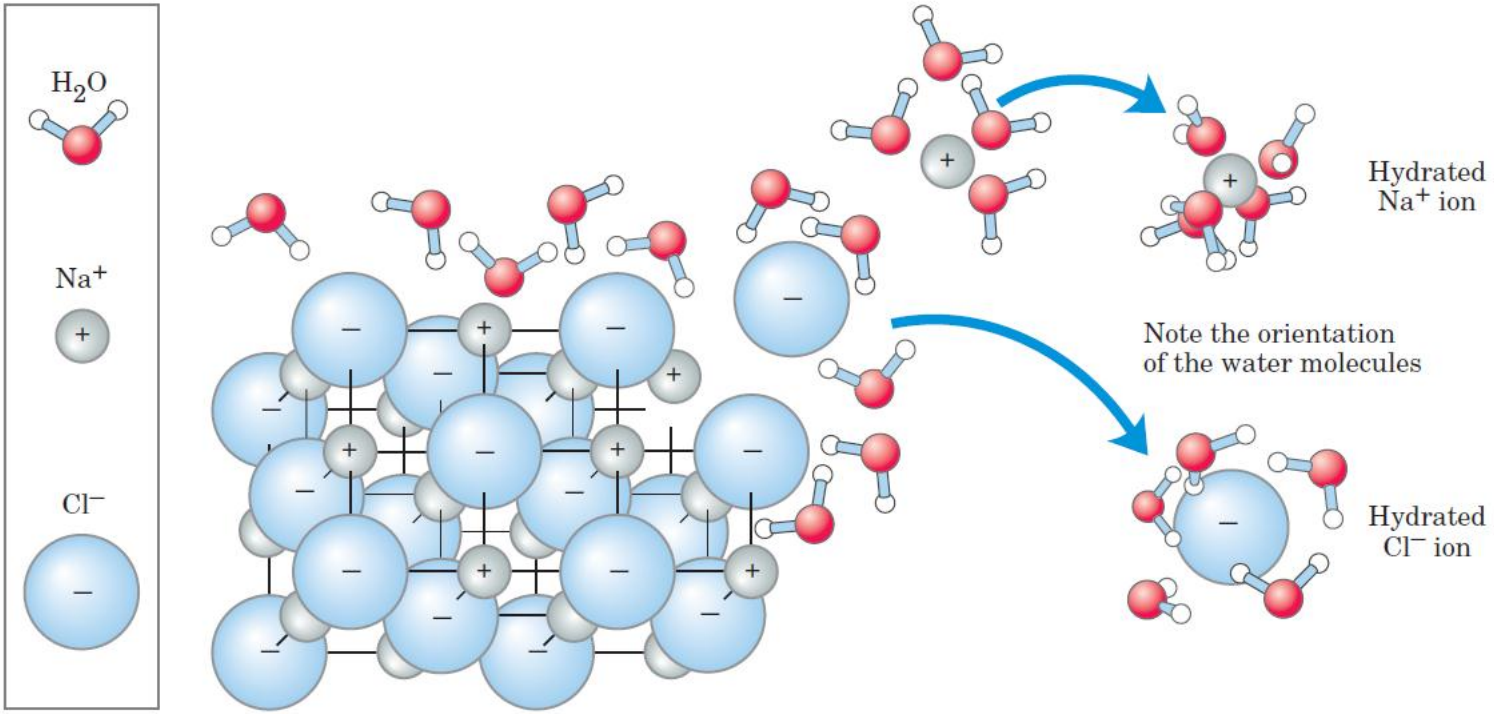
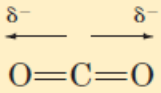
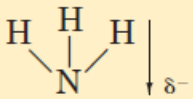
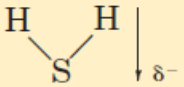


Water dissolves Ionic Compounds

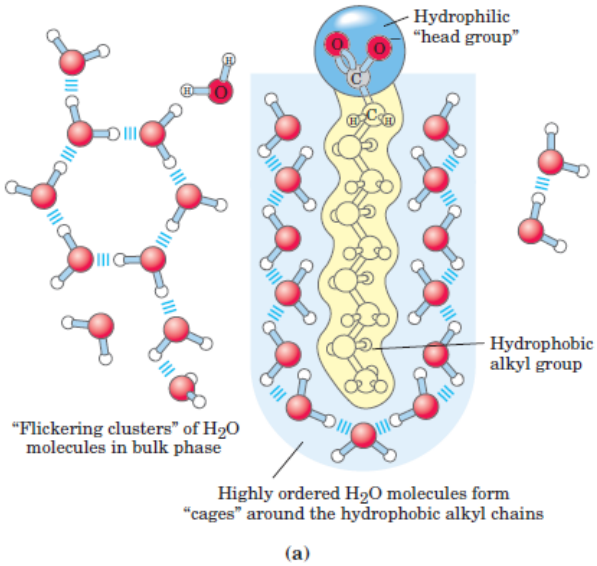


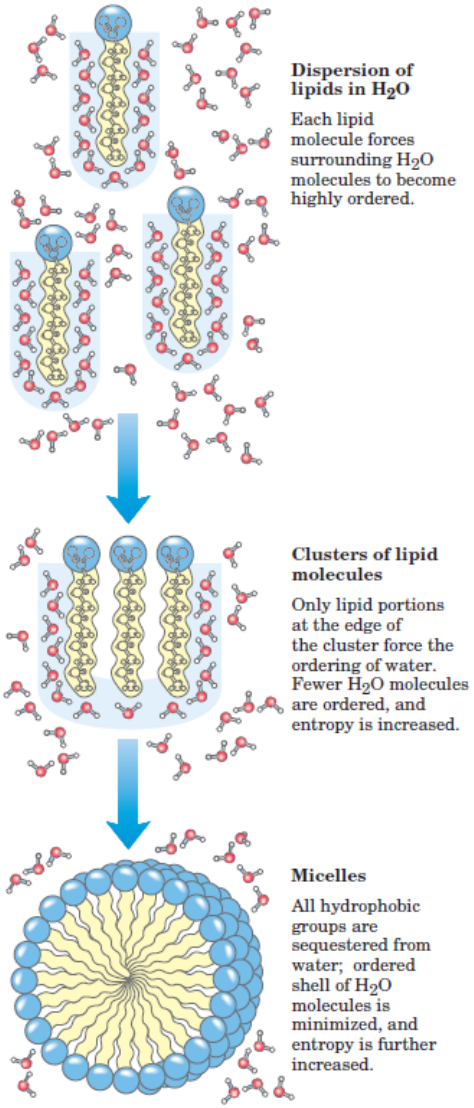
Nonpolar Molecules are Poorly Soluble in Water

TABLE 2-3 Solubilities of Some Gases in Water

Gas	*Structure**	*Polarity*	*Solubility in water (g/L)*†
Nitrogen	N≡N	Nonpolar	0.018 (40 °C)
Oxygen	O=O	Nonpolar	0.035 (50 °C)
Carbon dioxide		Nonpolar	0.97 (45 °C)
Ammonia		Polar	900 (10 °C)
Hydrogen sulfide		Polar	1,860 (40 °C)

The Interaction of Amphipathic Compounds and Water



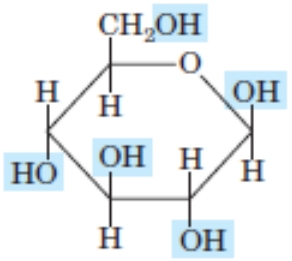


Polar, Nonpolar, and Amphiphatic Biomolecules

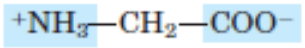
TABLE 2–2 Some Examples of Polar, Nonpolar, and Amphipathic Biomolecules (Shown as Ionic Forms at pH 7)

Polar

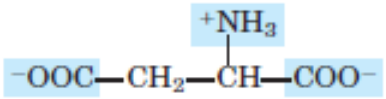
Glucose



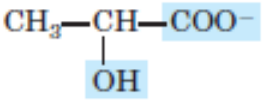
Glycine



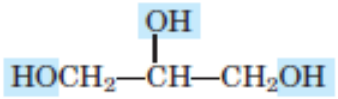
Aspartate



Lactate

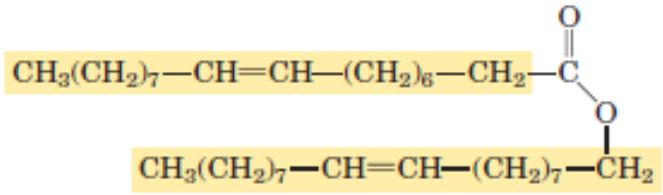


Glycerol



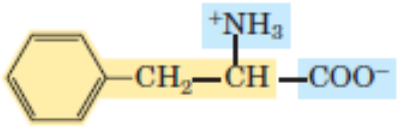
Nonpolar

Typical wax

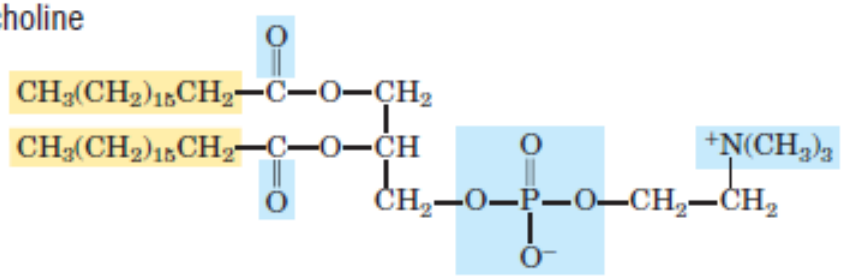


Amphipathic

Phenylalanine



Phosphatidylcholine



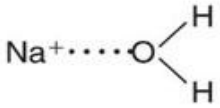
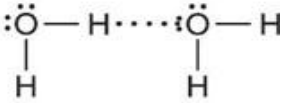
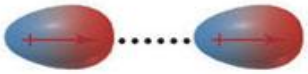
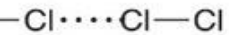
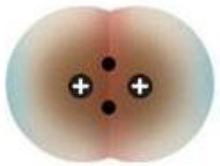
Polar groups Nonpolar groups

van der Waals Radius

TABLE 2–4 van der Waals Radii and Covalent (Single-Bond) Radii of Some Elements

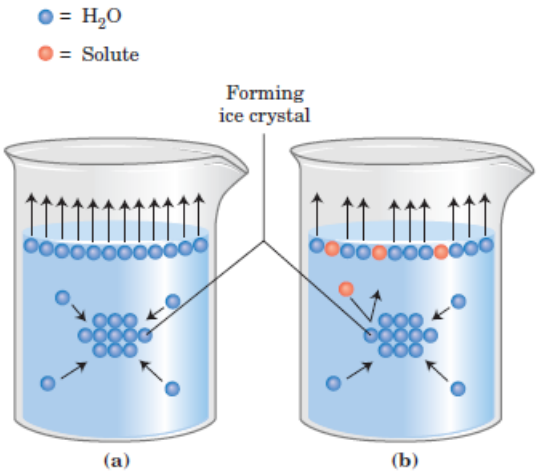
Element	*van der Waals radius (nm)*	*Covalent radius for single bond (nm)*
H	0.11	0.030
O	0.15	0.066
N	0.15	0.070
C	0.17	0.077
S	0.18	0.104
P	0.19	0.110
I	0.21	0.133

Comparion of Covalent and Noncovalent Interactions

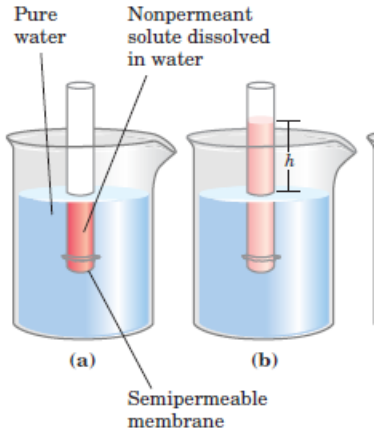
Force	Model	Basis of Attraction	Energy (kJ/mol)	Example
Noncovalent Interactions				
Ion-dipole		Ion charge–dipole charge	40–600	
H bond		Polar bond to H–dipole charge (high EN of N, O, F)	10–40	
Dipole-dipole		Dipole charges	5–25	
Ion–induced dipole		Ion charge–polarizable e^- cloud	3–15	
Dipole–induced dipole		Dipole charge–polarizable e^- cloud	2–10	
Dispersion (London)		Polarizable e^- clouds	0.05–40	
Covalent		Nuclei–shared e^- pair	150–1100	

Solutes affect the Colligative Properties of Water

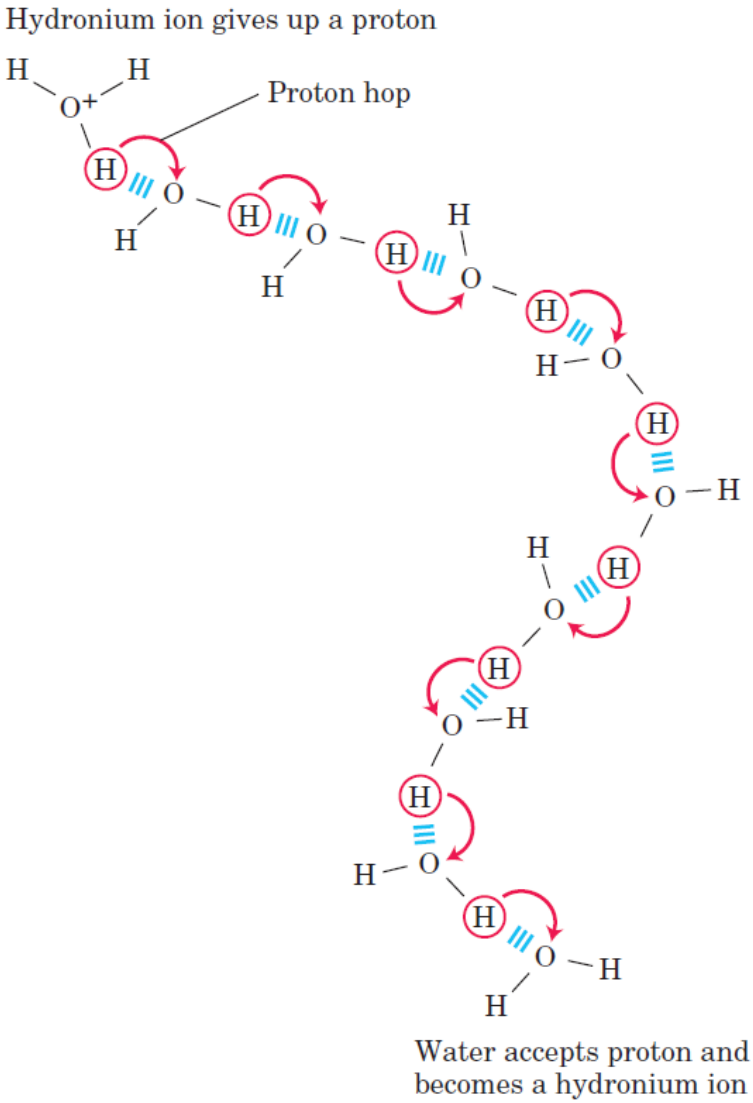
- Solute influence on vapor pressure, boiling point, and freezing point.



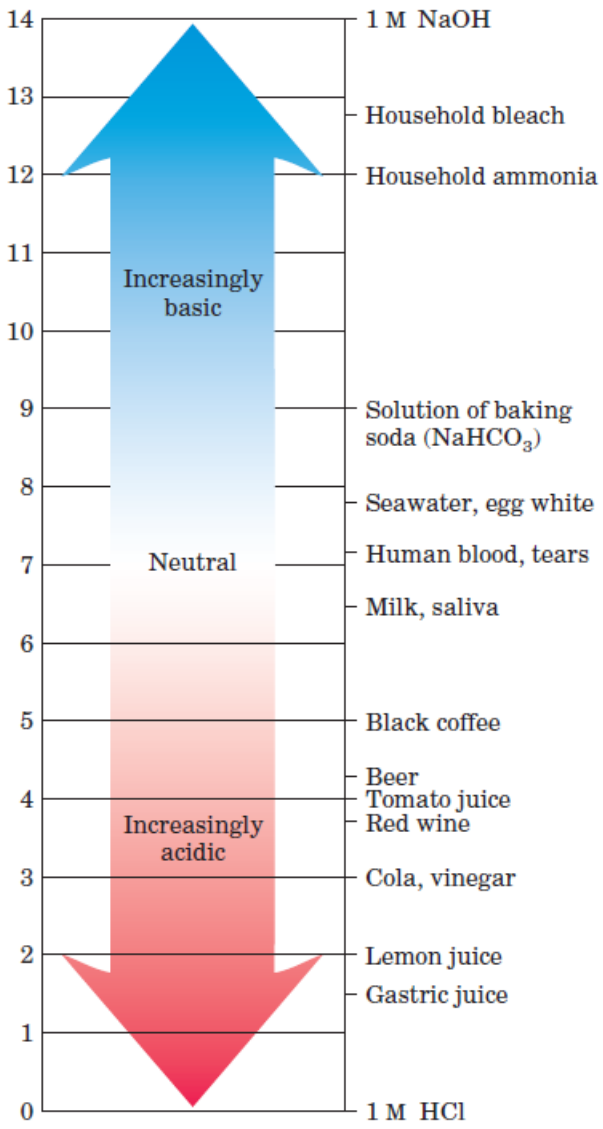
- Osmosis



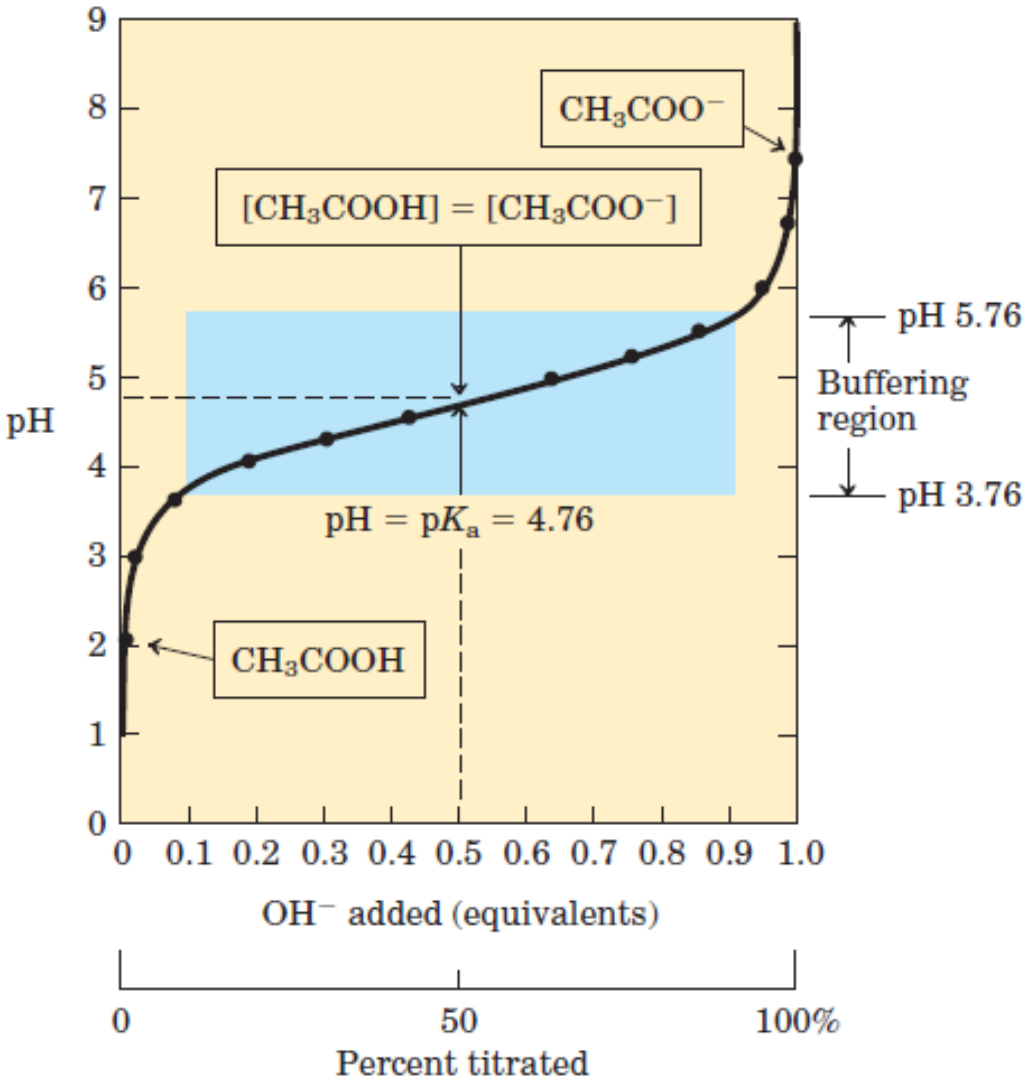
“Proton hopping” in Water



The pH of some Aqueous Fluids



Titration Curve for a Weak Acid



Buffering by Acetic Acid

$$K_w = [H^+][OH^-]$$