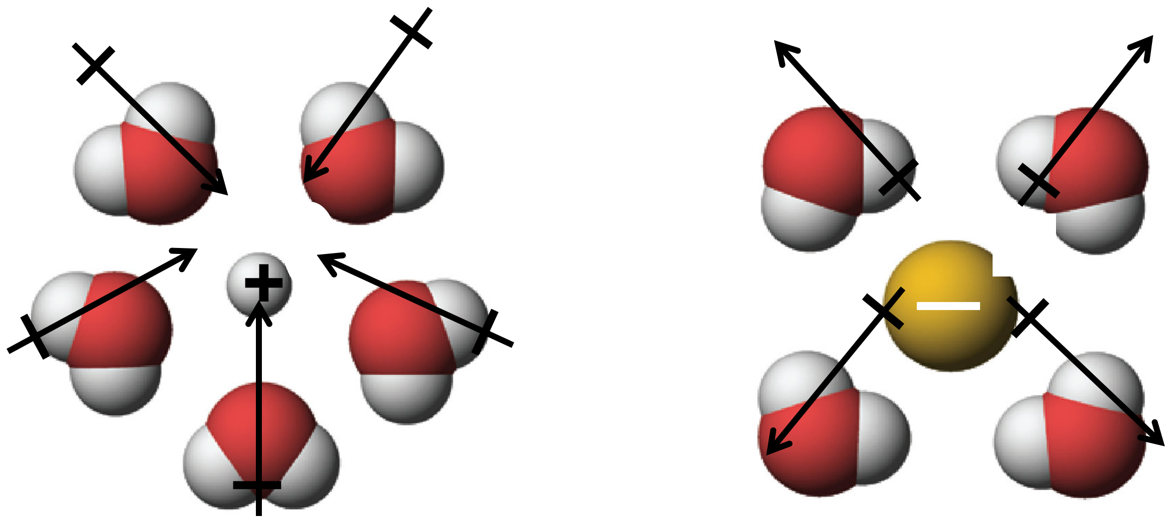
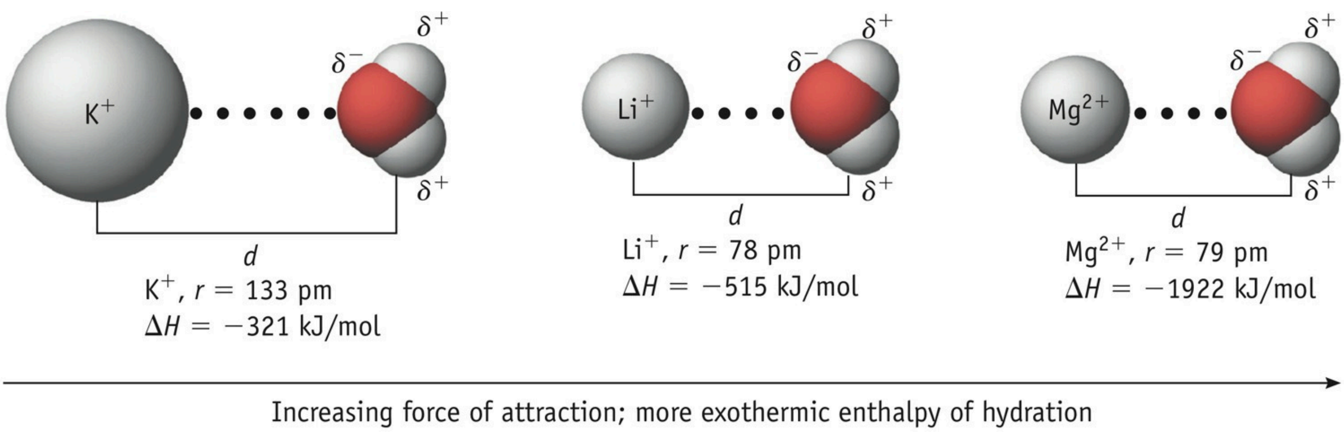
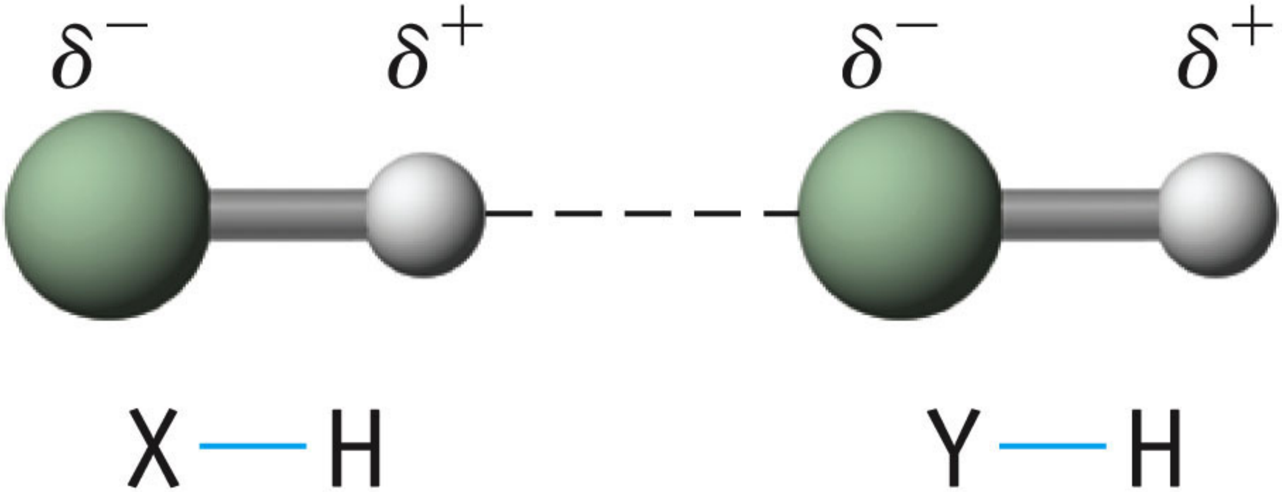
Solvation of Ions

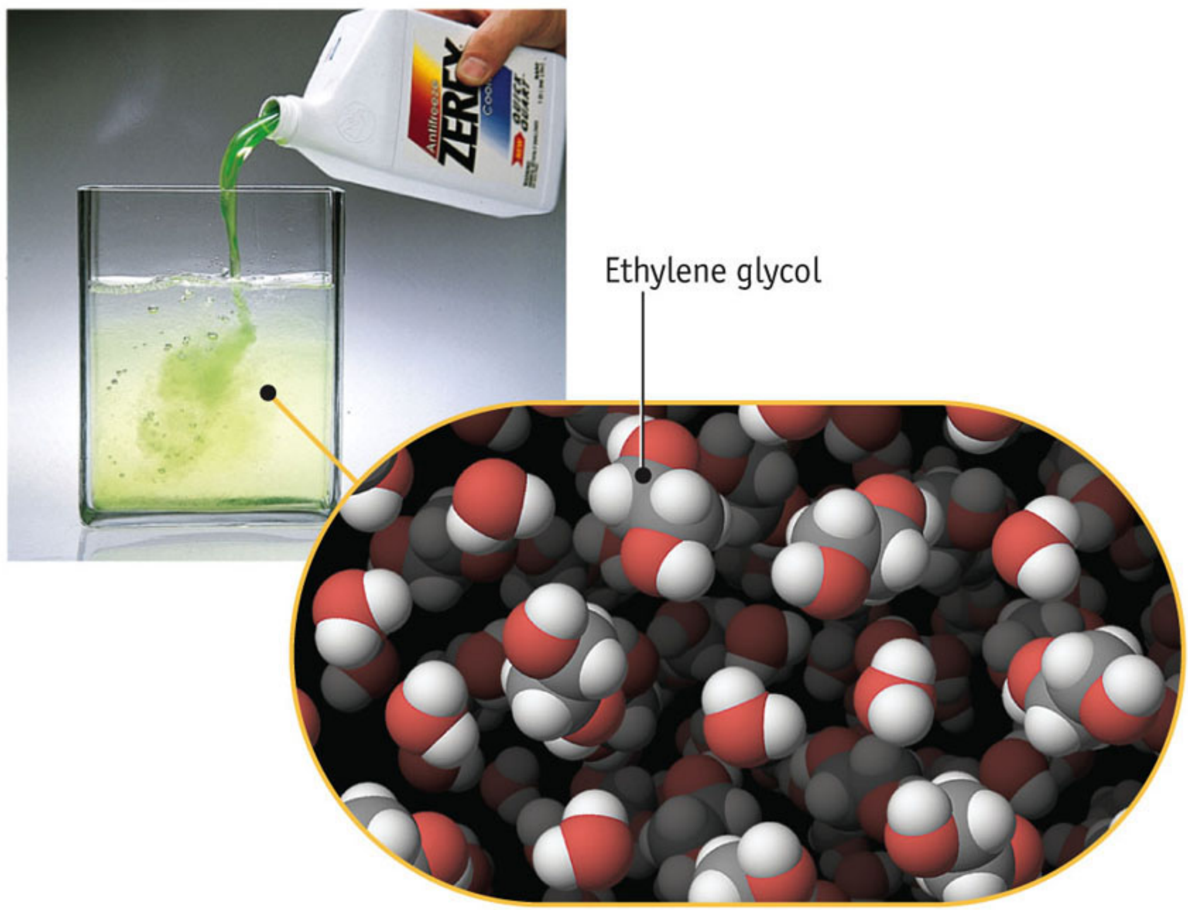


When a *cation* exists in solution, it is surrounded by the *negative* dipole ends of water molecules.

When as *anion* exists in solution, it is surrounded by the *positive* dipole ends of water molecules.

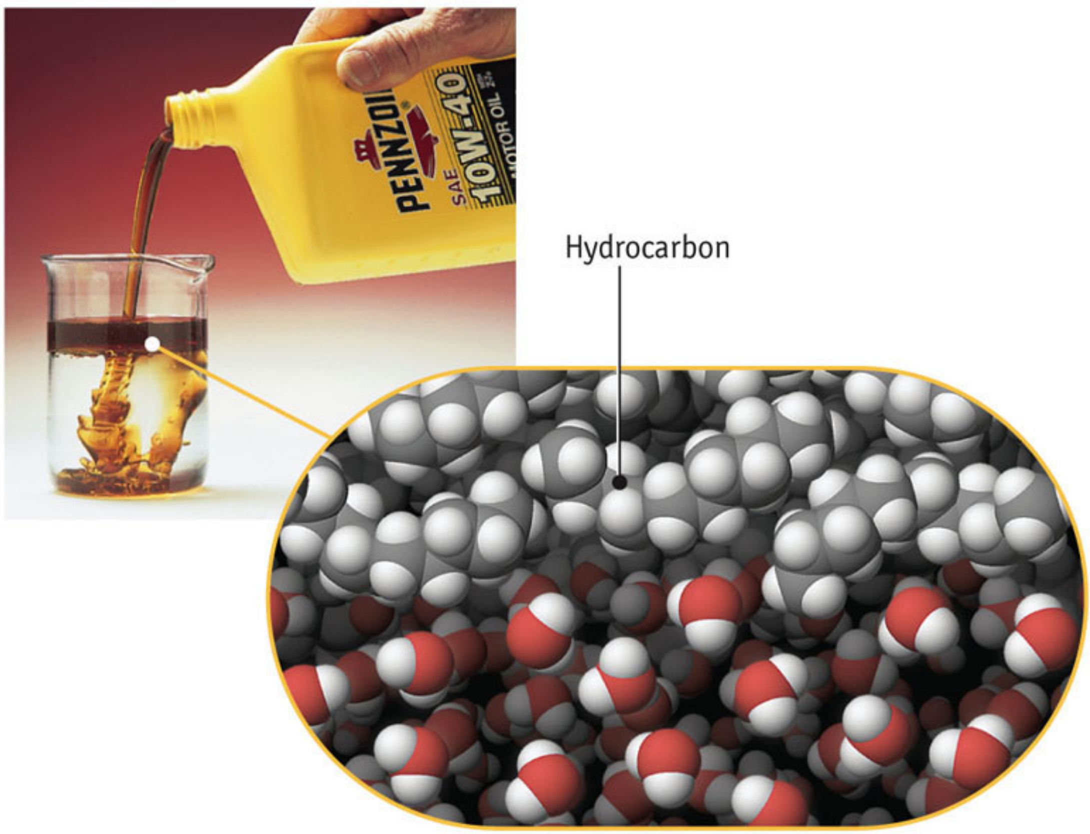

K+
δ−
δ+
δ+
d
K+, r = 133 pm
ΔH = −321 kJ/mol
Li+
δ−
δ+
δ+
d
Li+, r = 78 pm
ΔH = −515 kJ/mol
Mg2+
δ−
δ+
δ+
d
Mg2+, r = 79 pm
ΔH = −1922 kJ/mol
Increasing force of attraction; more exothermic enthalpy of hydration


δ^-
δ^+
δ^-
δ^+
X — H
Y — H



(a) Ethylene glycol ($HOCH_2CH_2OH$), a polar compound used as antifreeze in automobiles, dissolves in water.

Fig. 12-5, p. 560



(b) Nonpolar motor oil (a hydrocarbon) dissolves in nonpolar solvents such as gasoline or CCl_4. It will not dissolve in a polar solvent such as water, however. Commercial spot removers use nonpolar solvents to dissolve oil and grease from fabrics.

Fig. 12-5, p. 560

Dipole – Dipole Forces

Table 11.2 Molar Masses, Boiling Points, and $\Delta_{vap}H°$ of Nonpolar and Polar Substances

NONPOLAR				POLAR			
	M (g/mol)	BP (°C)	$\Delta_{vap}H°$ (kJ/mol)		M (g/mol)	BP (°C)	$\Delta_{vap}H°$ (kJ/mol)
N_2	28	−196	5.57	CO	28	−192	6.04
SiH_4	32	−112	12.10	PH_3	34	−88	14.06
GeH_4	77	−90	14.06	AsH_3	78	−62	16.69
Br_2	160	59	29.96	ICl	162	97	—

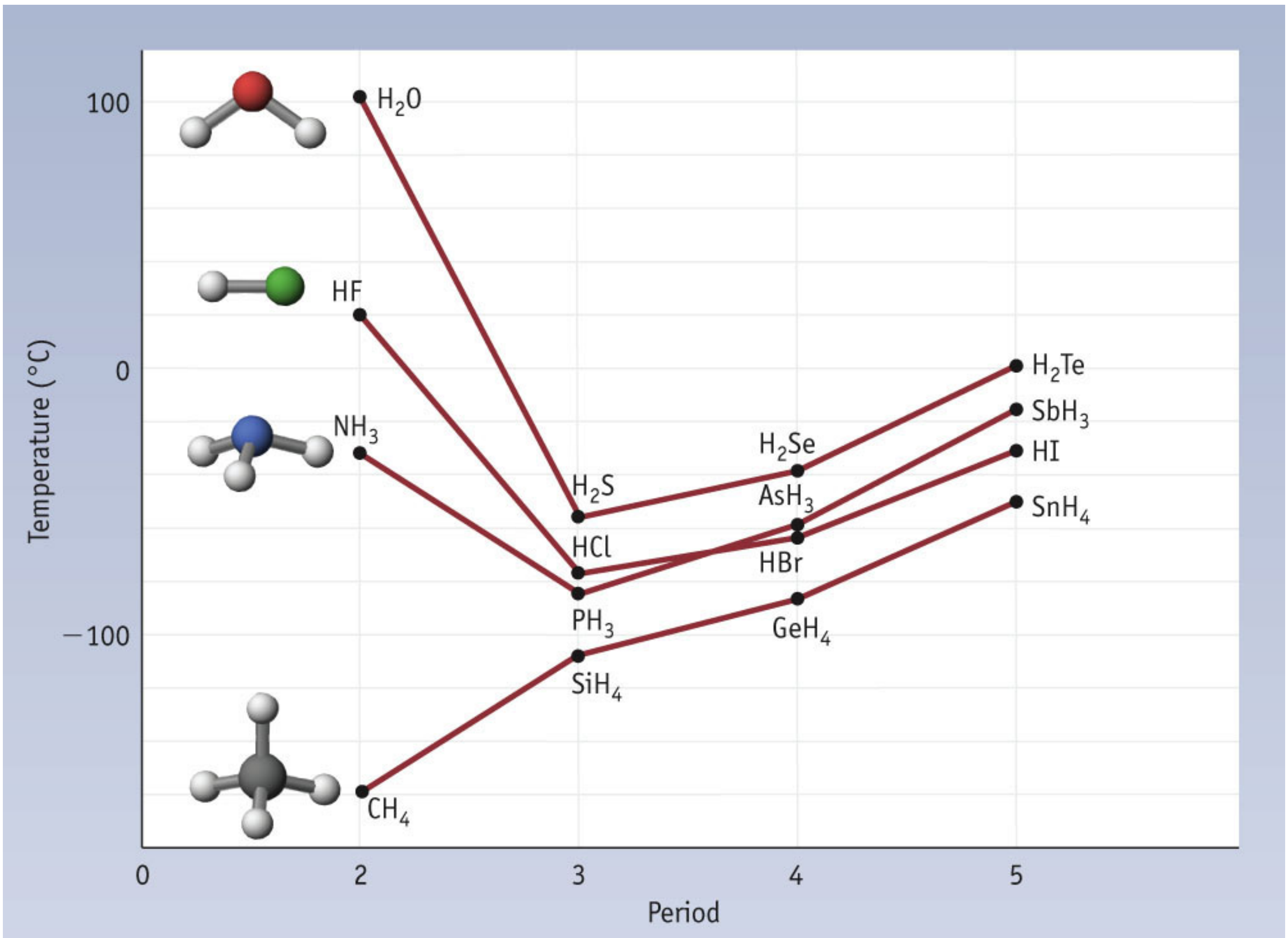
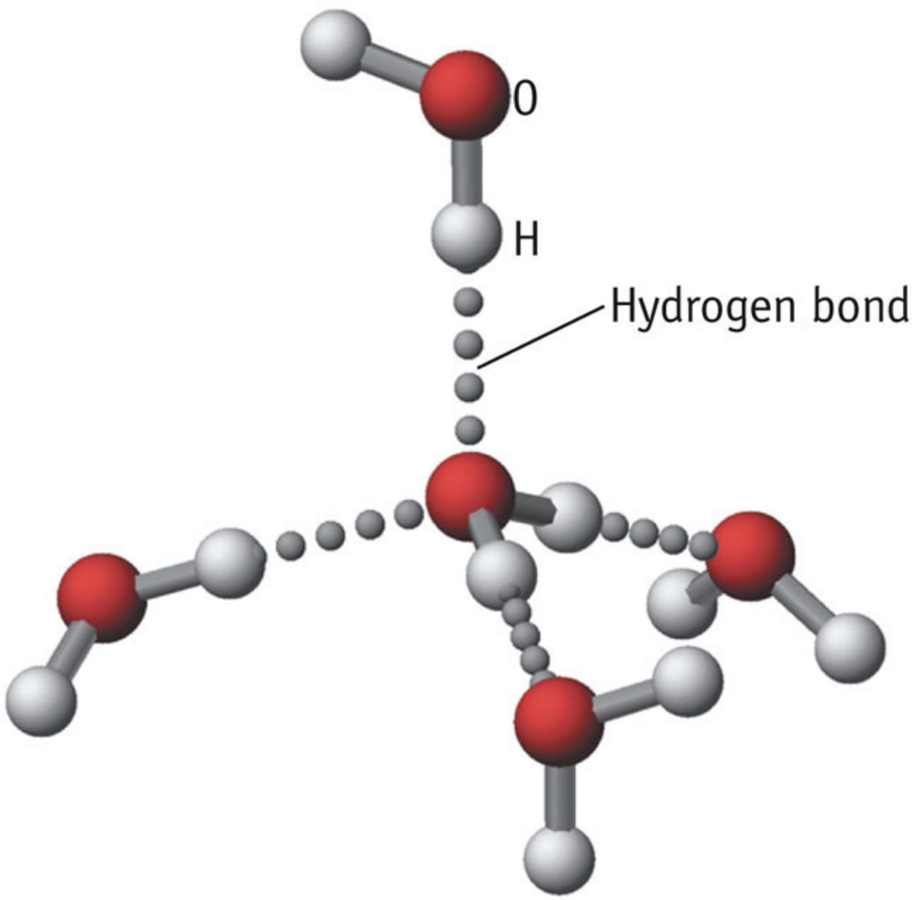

100
0
−100
Temperature (°C)
H_2O
HF
NH_3
CH_4
H_2S
HCl
PH_3
SiH_4
H_2Se
AsH_3
HBr
GeH_4
H_2Te
SbH_3
HI
SnH_4
0
2
3
4
5
Period

Fig. 12-6, p. 561



(a)

Fig. 12-8, p. 564

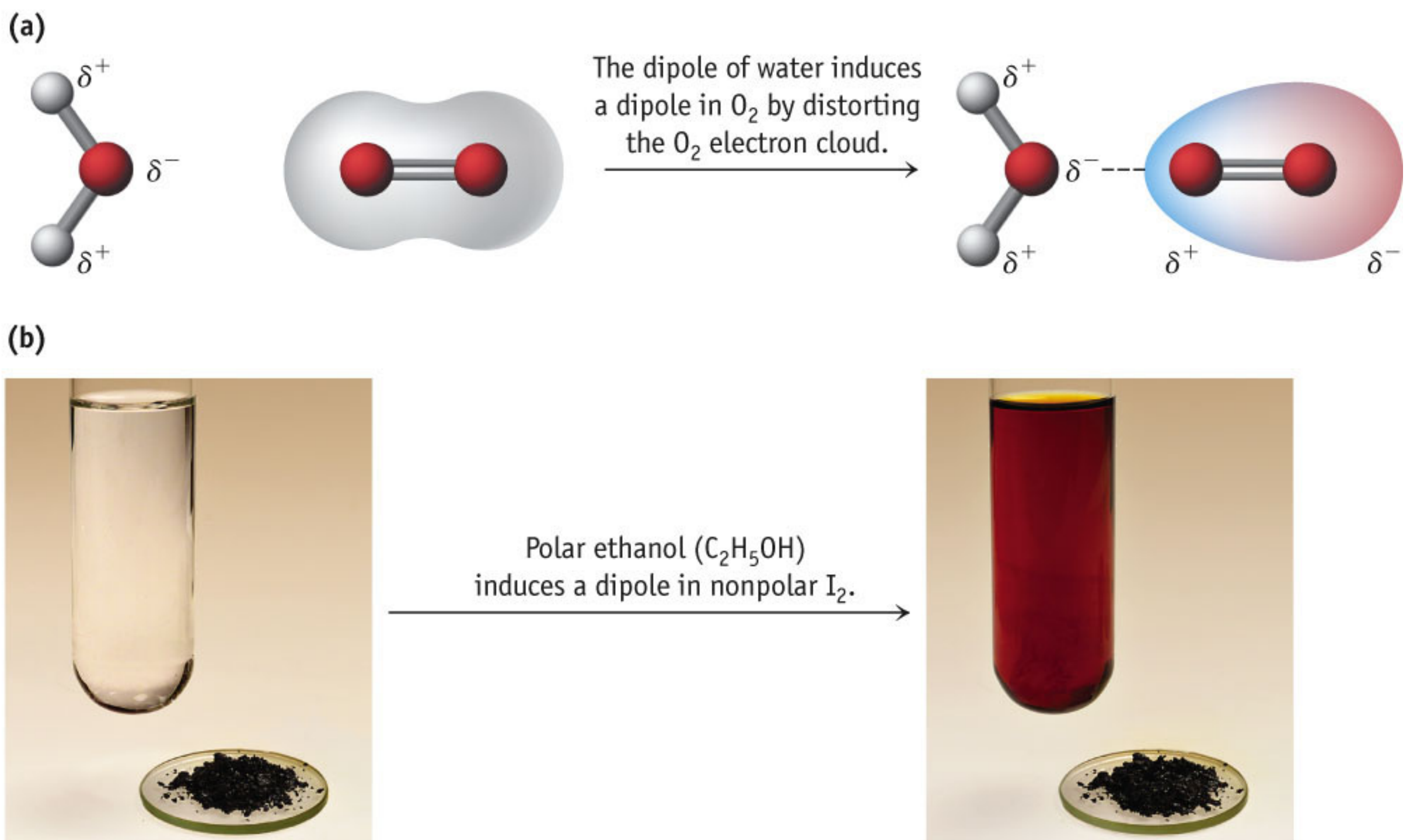
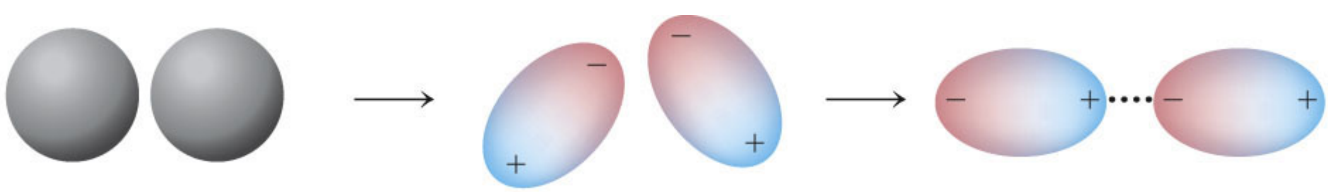


Fig. 12-10, p. 566



Two nonpolar atoms or molecules (depicted as having an electron cloud that has a time-averaged spherical shape).

Momentary attractions and repulsions between nuclei and electrons in neighboring molecules lead to induced dipoles.

Correlation of the electron motions between the two atoms or molecules (which are now dipolar) leads to a lower energy and stabilizes the system.

Fig. 12-11, p. 567

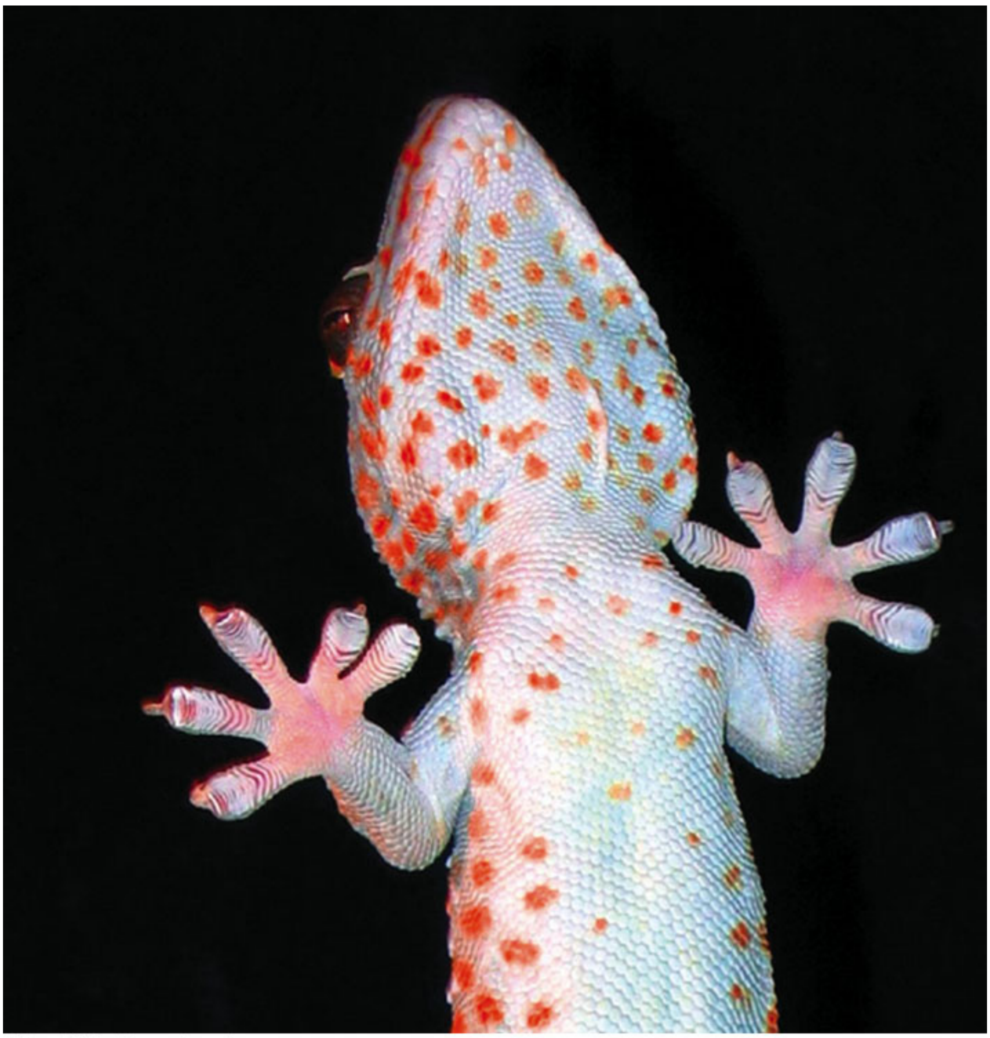


TABLE 12.6 **Molar Enthalpies of Vaporization and Boiling Points for Common Substances***

Compound	Molar Mass (g/mol)	$\Delta_{vap}H°$ (kJ/mol)†	Boiling Point (°C) (Vapor pressure = 760 mm Hg)
Polar Compounds			
HF	20.0	25.2	19.7
HCl	36.5	16.2	−84.8
HBr	80.9	19.3	−66.4
HI	127.9	19.8	−35.6
NH_3	17.0	23.3	−33.3
H_2O	18.0	40.7	100.0
SO_2	64.1	24.9	−10.0
Nonpolar Compounds			
CH_4 (methane)	16.0	8.2	−161.5
C_2H_6 (ethane)	30.1	14.7	−88.6
C_3H_8 (propane)	44.1	19.0	−42.1
C_4H_{10} (butane)	58.1	22.4	−0.5
Monatomic Elements			
He	4.0	0.08	−268.9
Ne	20.2	1.7	−246.1
Ar	39.9	6.4	−185.9
Xe	131.3	12.6	−108.0
Diatomic Elements			
H_2	2.0	0.90	−252.9
N_2	28.0	5.6	−195.8
O_2	32.0	6.8	−183.0
F_2	38.0	6.6	−188.1
Cl_2	70.9	20.4	−34.0
Br_2	159.8	30.0	58.8

*Data taken from D. R. Lide: *Basic Laboratory and Industrial Chemicals,* Boca Raton, FL, CRC Press, 1993.

†$\Delta_{vap}H°$ is measured at the normal boiling point of the liquid.

Table 12-6, p. 572

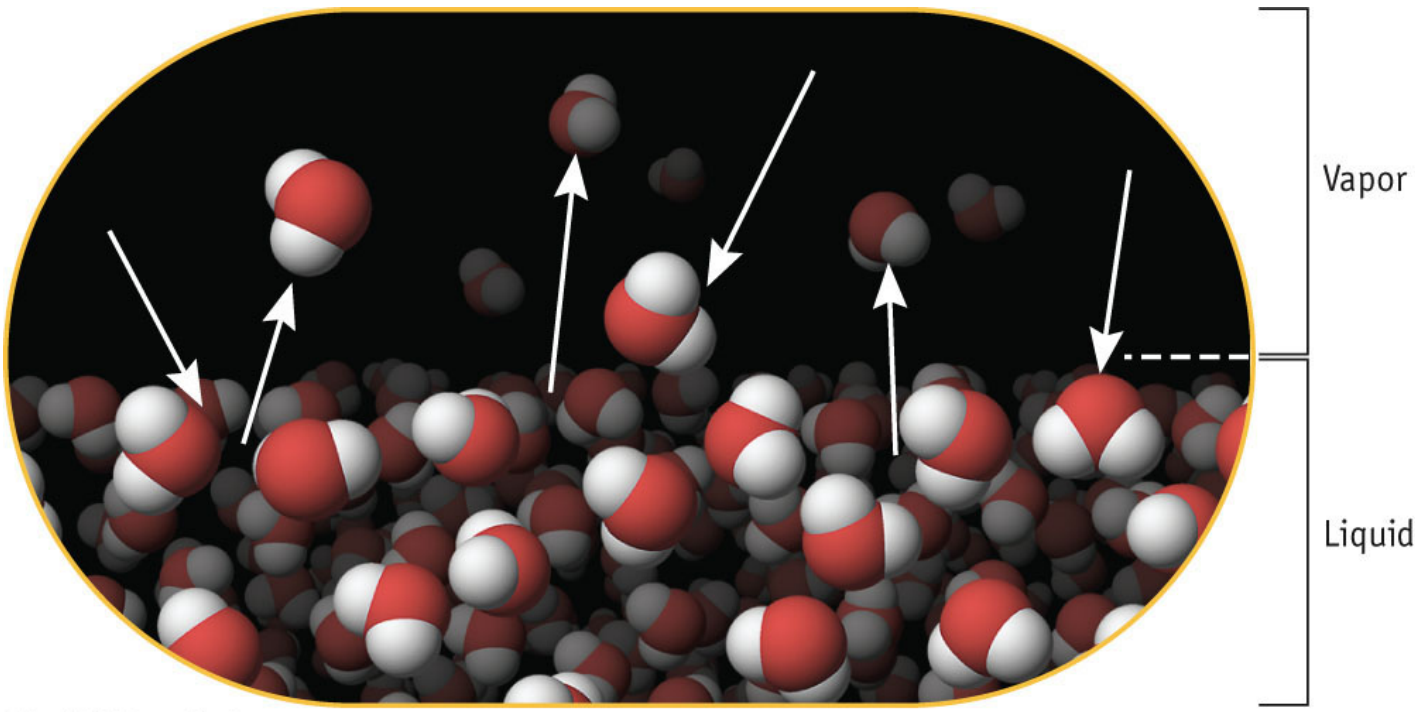


Fig. 12-14, p. 571

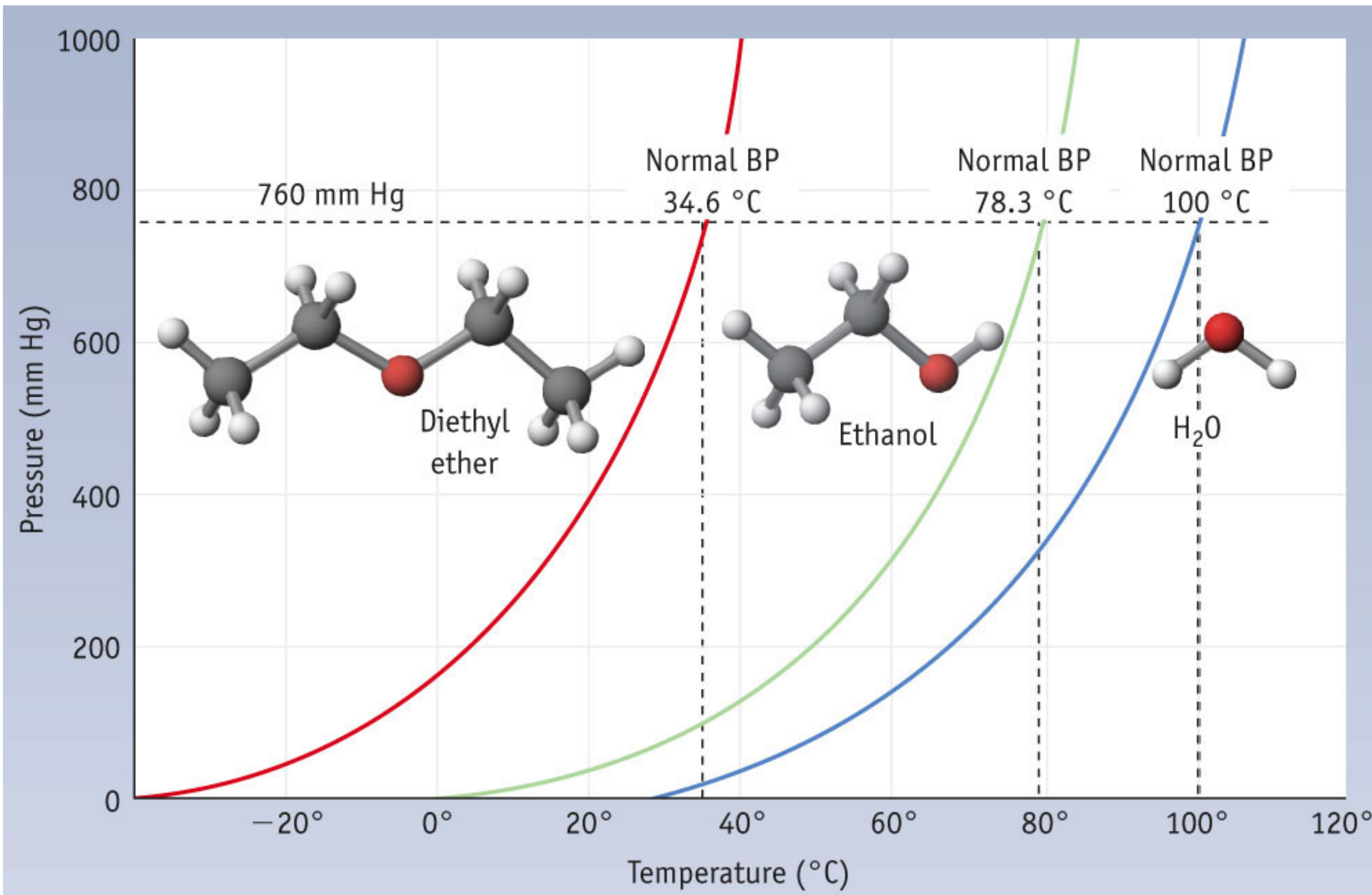


Fig. 12-17, p. 574

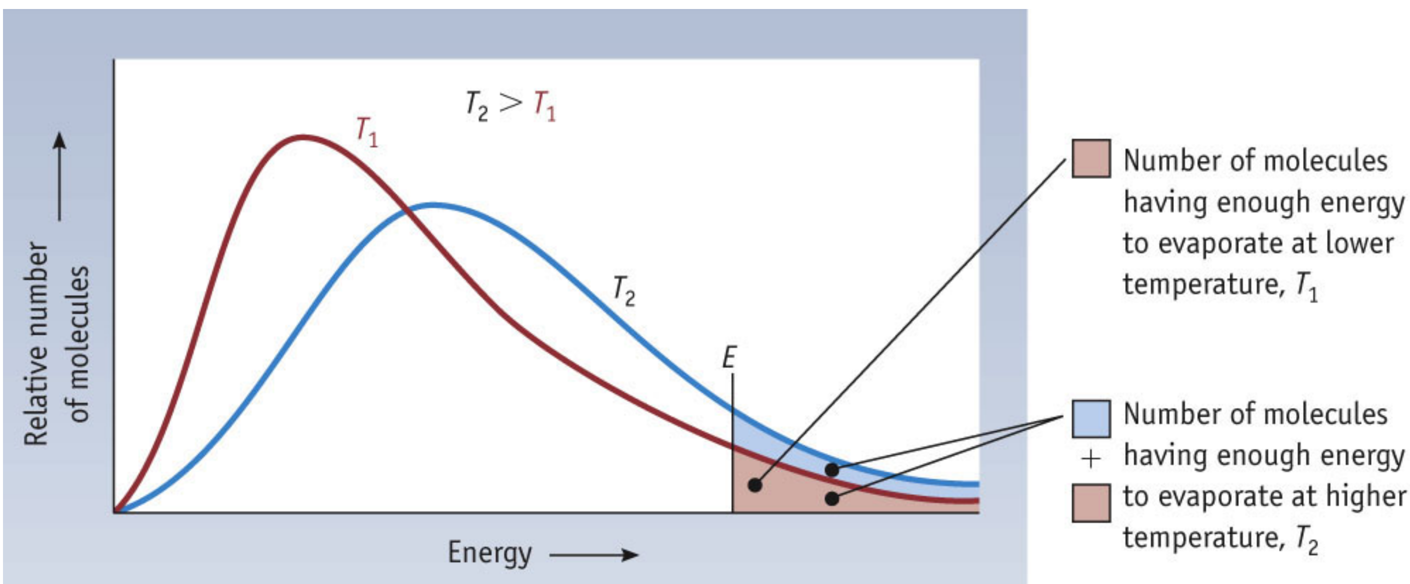


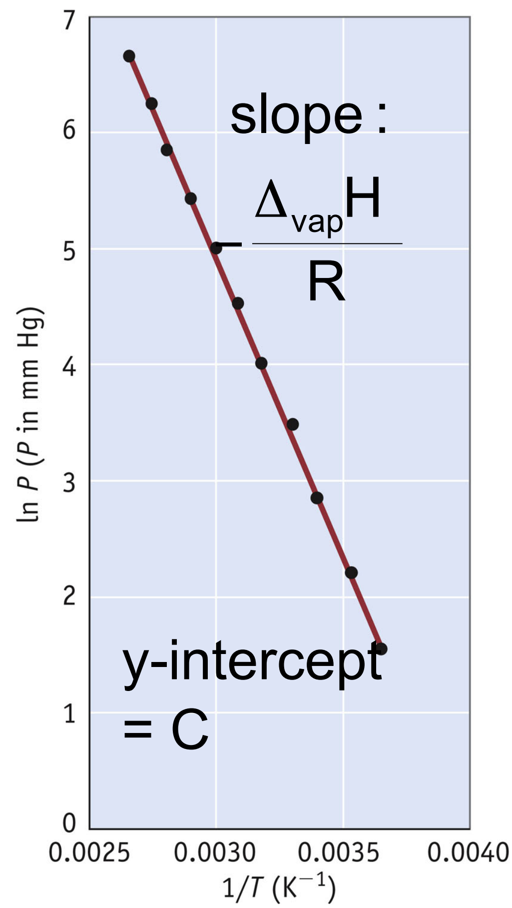
Fig. 12-13, p. 571

The Temperature Dependence of Vapor Pressure Goes As:

$$\ln P_{vap} = -\frac{\Delta_{vap}H^{\circ}}{RT} + C$$

A plot of $\ln P_{vap}$ vs. $\frac{1}{T}$ yields a slope of:

$\Delta_{vap}H^{\circ}$ is related to *T* and *P* by the *Clausius-Clapeyron* equation



Critical Temperature and Pressure for CO_2