# Announcements for Monday, 09DEC2024

- End-of-Semester Surveys due **Monday, 16DEC2024, at 11:59 PM (EST)**

- Week 14 Homework Assignments available on eLearning
  - Graded and Timed Quizzes 12a & 12b – "Gases – Intermolecular Forces" due **Wednesday, 11DEC2024, at 6:00 PM (EST)**

- Final Exam Conflict Requests
  - Due by Friday, 13DEC2024, 11:59 PM
  - See Canvas Announcement from 09DEC2024

- Final Exam is Wednesday, 18DEC2024, 4:00-7:00 PM **(EST)**
  - Coverage: Chapters E-11
  - Exam details and locations will be announced on Canvas

**ANY GENERAL QUESTIONS?** Feel free to see me after class!

Hydrogen Bonding (H-Bonding)

aqueous solution of acetone
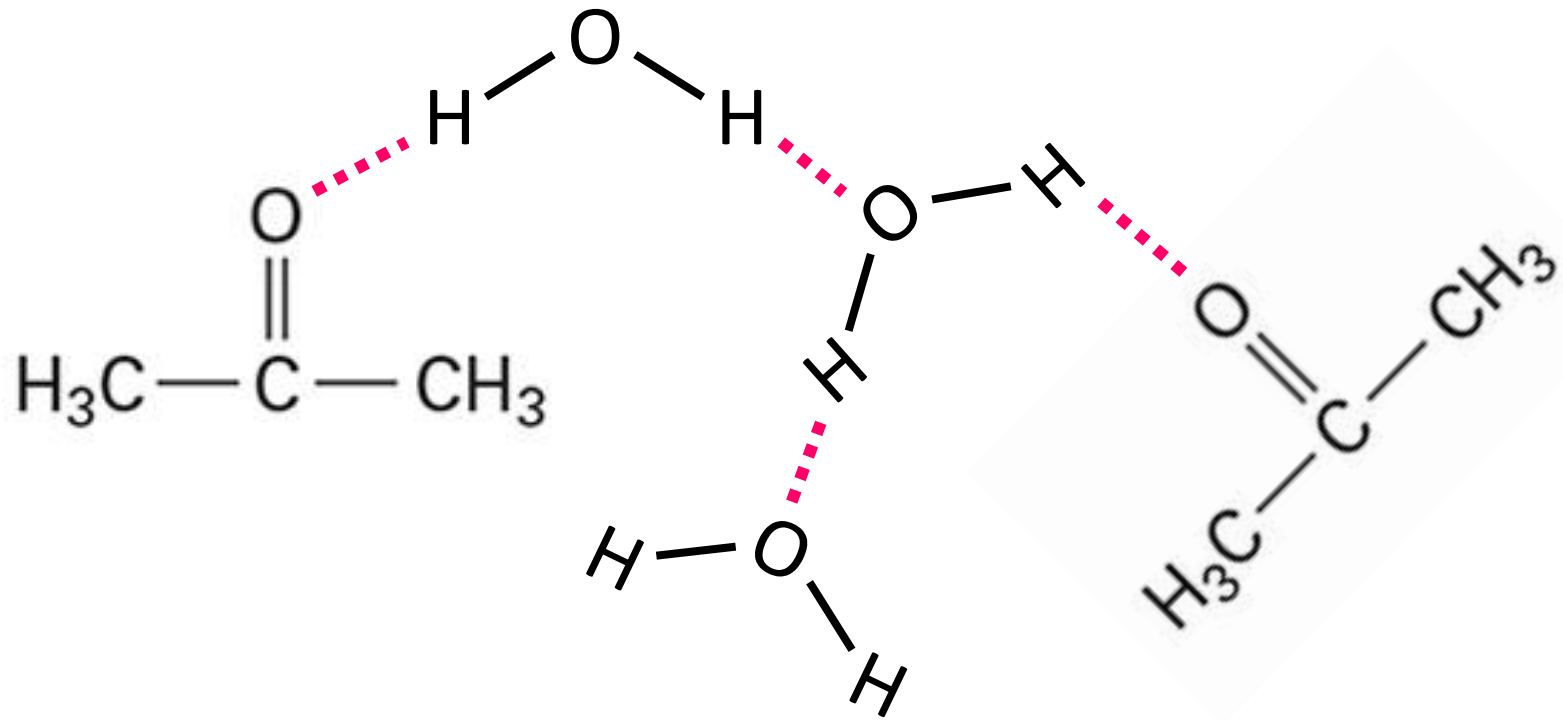
Ion-Dipole Forces

- occurs when an ionic compound is mixed with a polar compound
  - first discussed in Chapter 8
  - example NaCl(s) + $H_2O(\ell)$
- only exhibited in **mixtures**
- stronger than H-bonding
- responsible for the ability of ionic substances to form solutions with water
- more to come in Chapter 13
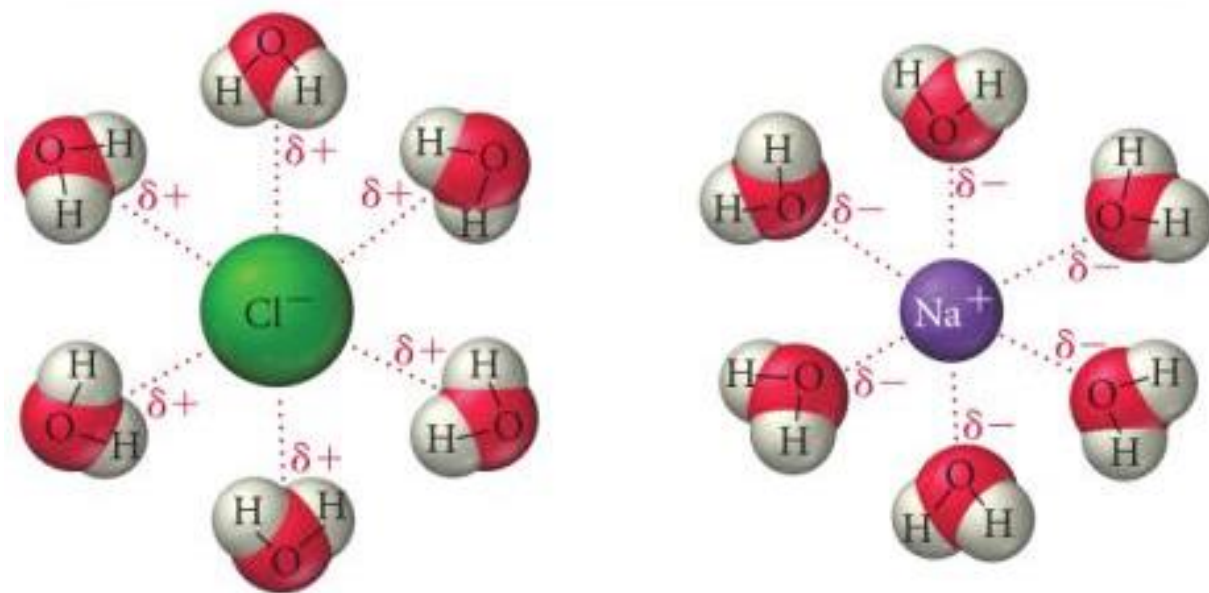
© 2018 Pearson Education, Inc.

dipoles interact with the charges of the ions

Try This

- Identify the most predominant intermolecular forces occurring in **pure samples** of the following matter:

a) $PCl_3(\ell)$ **dipole-dipole**

b) $PCl_5(s)$ **dispersion forces**

c) $HCN(g)$ **dipole-dipole**

d) $Ca(NO_3)_2(aq)$ **ion-dipole**

e) $CH_3NH_2(g)$ **hydrogen bonding**

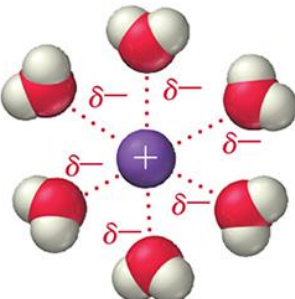f) $C_{10}H_{22}(\ell)$ **dispersion forces**
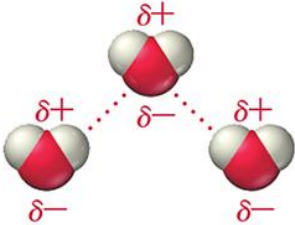
Try This On Your Own

Choose the compound that is most likely a gas at room temperature:

BBr_3 CH_3OH BF_3 $C_{20}H_{40}Cl_2$ CF_3COOH

To Summarize

TABLE 11.4 Types of Intermolecular Forces

Type	Present In	Molecular Perspective	Strength
Dispersion	All molecules and atoms		0.05–20+ kJ/mol
Dipole–dipole	Polar molecules		3–20+ kJ/mol
Hydrogen bonding	Molecules containing H bonded to F, O, or N		10–40 kJ/mol
Ion–dipole	Mixtures of ionic compounds and polar compounds		30–100+ kJ/mol

Physical Properties of Liquids – Surface Tension

- **surface tension =** energy required to increase the surface area of a liquid by a certain amount

- liquids with high surface tensions spread out less easily than liquids with low surface tension

- surfaces of liquids with high surface tensions resist penetration

- surface tension increases as intermolecular forces increase

Physical Properties of Liquids – Viscosity

- **viscosity =** the resistance of a liquid to flow


motor oil

vs.

water

- viscosity increases with increasing strength of IMFs and increasing size of molecules

- viscosity decreases as temperature increases

Physical Properties of Liquids – Capillary Action

- **capillary action =** the ability for a liquid to flow up a narrow tube against the force of gravity

  a balance of two different forces

- **cohesive forces =** between molecules within the liquid

- **adhesive forces =** between molecules in liquid and the surface of the tube
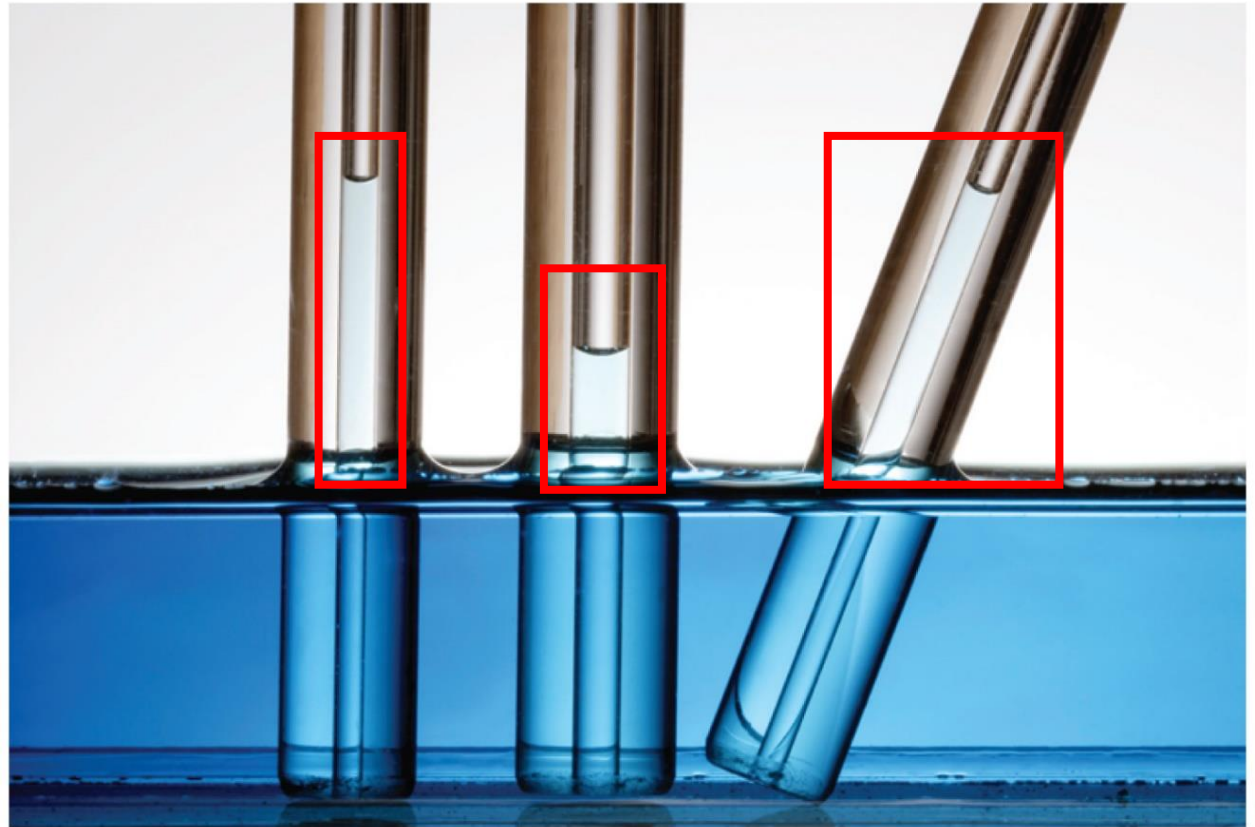
Phase Changes – Vaporization vs. Condensation

- vaporization = (ℓ) → (g)
  - IMFs within the liquid must be overcome
  - endothermic process

- condensation = (g) → (ℓ)
  - IMFs capture molecules from the gas phase
  - exothermic process

rate of vaporization can be increased by

1. increasing the temperature
2. increasing the surface area of the liquid exposed to the air

Heat of Vaporization (ΔH_{vap})

- **ΔH_{vap} =** the amount of energy needed to convert 1 mole of a substance from a liquid to a gas at a given temperature (usually boiling point or room temperature)

- substances with high heats of vaporizations have strong intermolecular forces

TABLE 11.7 Heats of Vaporization of Several Liquids at Their Boiling Points and at 25 °C

Liquid	Chemical Formula	Normal Boiling Point (°C)	ΔH_{vap} (kJ/mol) at Boiling Point	ΔH_{vap} (kJ/mol) at 25 (°C)
Water	H_2O	100.0	40.7	44.0
Rubbing alcohol (isopropyl alcohol)	C_3H_8O	82.3	39.9	45.4
Acetone	C_3H_6O	56.1	29.1	31.0
Diethyl ether	$C_4H_{10}O$	34.6	26.5	27.1

- at 100 °C, $H_2O(\ell) \rightarrow H_2O(g)$ ΔH = **+40.7 kJ/mol**

- for water vapor at 100 °C, $\Delta H_{condensation}$ = **–(ΔH_{vap}) = –40.7 kJ/mol**

- note that these enthalpy changes can be used as conversion factors

For Example

What mass of acetone (C_3H_6O) can be vaporized at 25 °C by 1000. kJ of energy? The enthalpy of condensation for acetone at 25 °C is −31.0 kJ/mol. **1.87 kg**

$\Delta H_{\text{condensation}}$ = **−31.0** kJ/mol, so ΔH_{vap} = **+31.0** kJ/mol

$$1000.\,\text{kJ} \times \frac{1\,\text{mol}\,C_3H_6O}{+31.0\,\text{kJ}} \times \frac{58.08\,\text{g}}{1\,\text{mol}\,C_3H_6O} \times \frac{1\,\text{kg}}{1000\,\text{g}} = \mathbf{1.87\ kg}$$

molar mass
of acetone

Vapor Pressure

- **vapor pressure =** the pressure of a gas in dynamic equilibrium (?!?) with its liquid

- **dynamic equilibrium =** a state in which two opposing physical/chemical processes occur at the same rate
  - at equilibrium the system does not appear to undergo *macroscopic* changes
  - changes at *microscopic* level continue
  - example: vaporization in a sealed flask

- weaker intermolecular forces in liquid = more particles in gas phase = higher vapor pressures

- liquids with weak IMFs are *volatile*
  - acetone in nail polish remover

- increasing temperature = increasing thermal energy of liquid to overcome IMFs = increasing vapor pressure
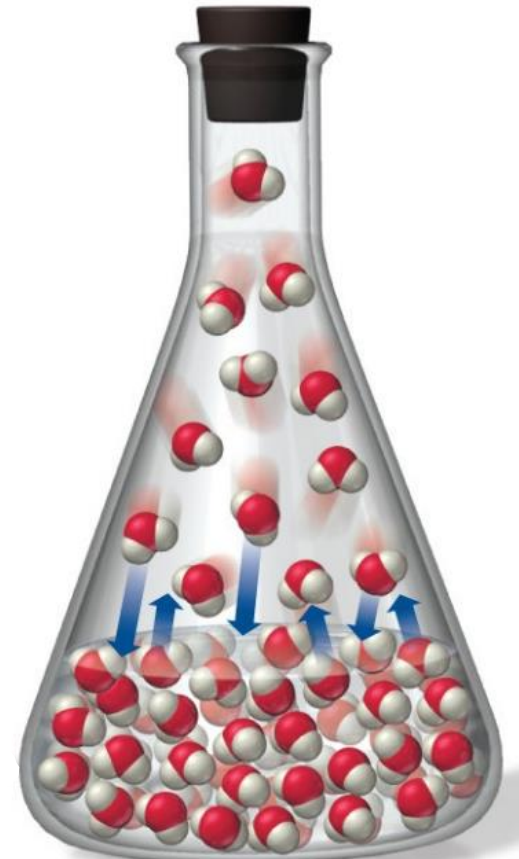
© 2018 Pearson Education, Inc.

water in a closed flask

Vapor Pressure and Boiling Point

- **boiling point of a liquid =** the temperature at which the vapor pressure of a liquid equals the external pressure
  - when external pressure is 1 atm = *normal* boiling point

- when vapor pressure equals external pressure, molecules within the interior of the liquid are able to escape into the gas phase

- if the external pressure around a liquid is reduced, boiling can occur at lower temperatures
  - water boils at approximately 78 °C on Mount Everest (P_{ext} = 0.32 atm)

- the vapor can be converted back into liquid by decreasing temperature and *usually* by increasing pressure