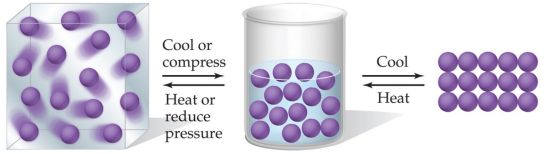
Aim: Intermolecular Forces and Vapor Pressure

Do Now: You are given 3 substances at room temperature: a wooden block, water, and carbon dioxide. In which of these substances are the molecules most strongy attracted to each other? Explain your reasoning.

1

States of Matter

The main differences between states of matter is the distance between particles and the arrangement of the particles.



Gas	Liquid	Crystalline solid
Total disorder; much empty space; particles have complete freedom of motion; particles far apart	Disorder; particles or clusters of particles are free to move relative to each other; particles close together	Ordered arrangement; particles are essentially in fixed positions; particles close together

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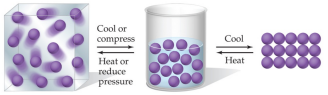
The States of Matter



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Gas	Assumes both the volume and shape of its container Is compressible Flows readily Diffusion within a gas occurs rapidly
Liquid	Assumes the shape of the portion of the container it occupies Does not expand to fill container Is virtually incompressible Flows readily Diffusion within a liquid occurs slowly
Solid	Retains its own shape and volume Is virtually incompressible Does not flow Diffusion within a solid occurs extremely slowly

- The state or phase a substance is in (solid, Liquid, or gas) at a particular temperature and pressure depends on two factors
  - The kinetic energy of the particles
  - The strength of the attractions between the particles (intermolecular forces)

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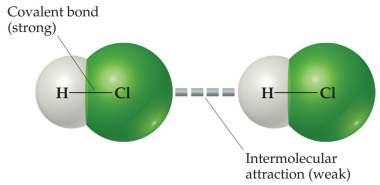
Intermolecular Forces



The attractions between molecules are not nearly as strong as the attraction between atoms in chemical bonds

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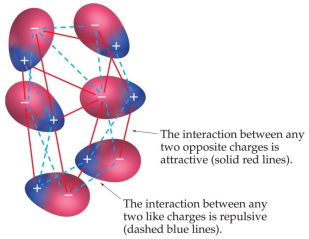
Dipole-Dipole Interactions



- The attraction between polar molecules
  - The positive end of one is attracted to the negative end of the other and vice-versa.

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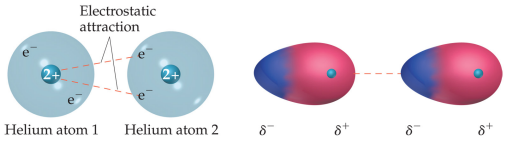
London Dispersion Forces



London dispersion forces, or dispersion forces, are attractions between the temporary dipoles of nonpolar molecules.

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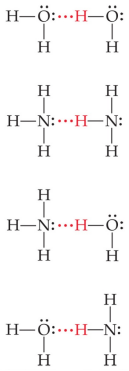
Hydrogen Bonding

- The dipole-dipole interactions experienced when H is bonded to N, O, or F are unusually strong
- We call these interactions hydrogen bonds



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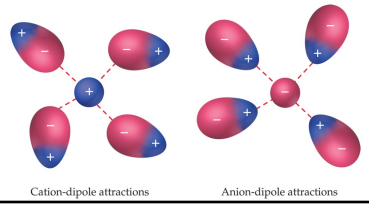
(Ion-Dipole Interactions)

- A fourth type of force, ion-dipole interactions are an important force in solutions of ions.
- The strength of these forces is what makes it possible for ionic substances to dissolve in polar solvents.



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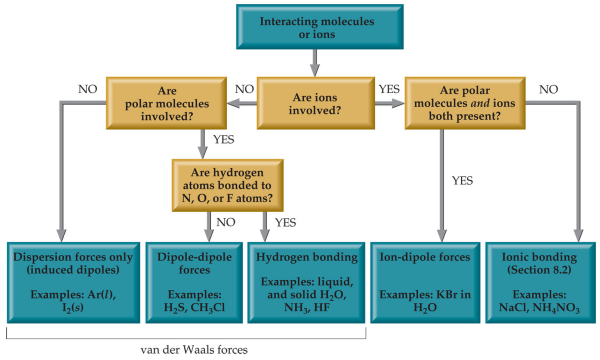
Summarizing Intermolecular Forces



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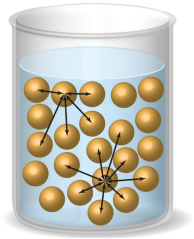
Intermolecular Forces Affect Many Physical Properties



The strength of the attractions between particles can greatly affect the properties of a substance or solution, such as:

- Phase a room temp.
- Melting/Freezing point
- Boiling Point
- Vapor Pressure

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Boiling Point

- The temperature at which a liquid substance boils and turns into gas
- Substances with stronger IMF have higher b.p.
  - More energy needs to be added to the system to weaken the attractive forces that are holding the molecules together.

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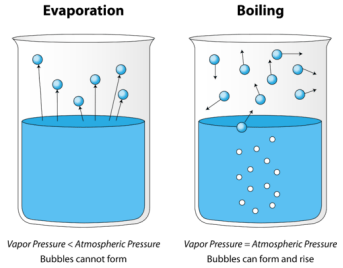
Vapor Pressure

- At room, some molecules in a liquid have enough energy to escape into the gas phase(evaporations)
- As heat is added and temperature rises, more molecules are able to enter the gas phase



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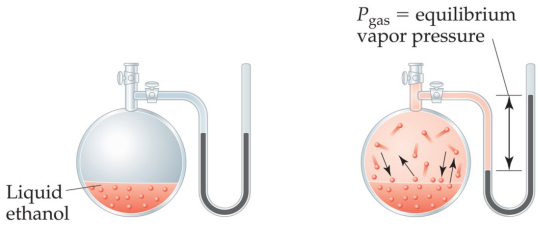
Vapor Pressure

As more molecules escape the liquid, the pressure they exert increases



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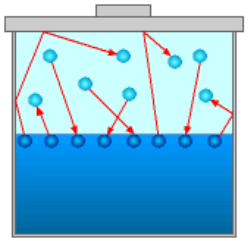
Vapor Pressure

- Vapor pressure is the pressure exerted on a liquid as more liquid turns into gas



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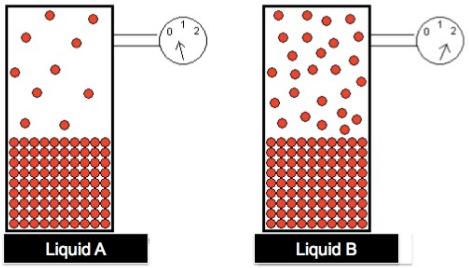
Two liquids in closed containers.
Which container has the higher vapor pressure?



To which container does more heat need to be added to turn more particles into the gas phase?

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Rubbing Alcohol vs Water

- At room temperature, rubbing alcohol evaporates more easily than water.
- As the rubbing alcohol evaporates, more liquid is turning into vapor; therefore, there is a build up of vapor pressure.
- Since rubbing alcohol evaporates so easily, it does not require a lot of heat to boil, so rubbing alcohol has a lower boiling point than water.

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Relationship between Vapor Pressure and Boiling Point

- Substances that have high vapor pressure (vaporize easily) have lower boiling points than substances that have low vapor pressure (do not vaporize easily) and have higher boiling points
  - Weak IMF → High vapor pressure → low boiling point
  - Strong IMF → Low vapor pressure → high boiling point

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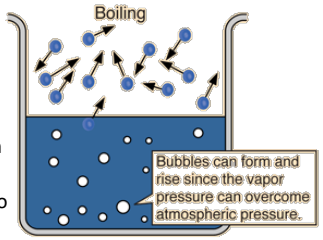
Vapor Pressure and Boiling Point

- When you heat a liquid, the particles in the liquid absorb the heat which increases the kinetic energy. The increase in the kinetic energy allows more particle to enter the gas phase. The particles escape the liquid and collide with the walls of the container which increases the pressure on the container from the gas particles.
- When the pressure from the vapor is equal to the external pressure, the liquid can start boiling.



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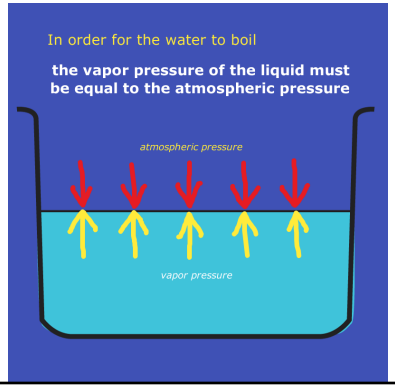
Vapor Pressure and Boiling Point



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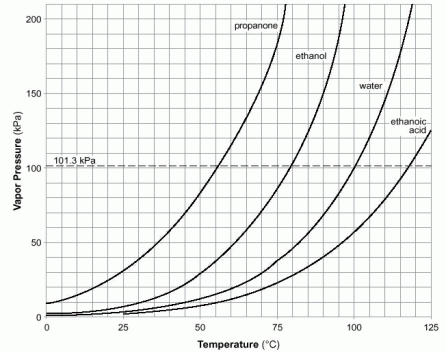
Vapor Pressure and Boiling Point

- The boiling point of a liquid is the temperature at which its vapor pressure equals atmospheric (external) pressure
- The **normal boiling point** is the temperature a substance changes from liquid to gas when the vapor pressure equals standard pressure 101.3 kpa



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How to read Table H

- Table H shows the relationship between the temperature a substance boils and its vapor pressure when a susbance starts to boil.

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Table H and IMF

- The stronger the intermolecular forces are between molecules in a substance, the higher the boiling point.
- Which substance has the highest b. p. at any given pressure? Lowest b.p.?
- Which substance has the strongest IMF? Weakest?

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How to use table H

- The y-axis is vapor pressure. When the vapor pressure is equal to the pressure outside (atmospheric pressure) the substance is allowed to boil.
- X-axis is temperature. It refers to the boiling points.
  - At any given vapor pressure, propanone has the lowest b.p and ethanoic acid has the highest b.p
- Substances that have a higher b.p at a given vapor pressure have stronger IMF.
  - Ethanoic has the strongest IMF
- Substances that have a lower b.p at a given vapor pressure have a weaker IMF.
  - Propanone has the weakest IMF

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Table H Questions

1. Define the term vapor pressure.
2. What is the vapor pressure of water at 100o C?
3. What is the vapor pressure of ethanoic acid at 120o C?
4. What is the vapor pressure of propanone at 75o C?
5. Compare the vapor pressure of the four liquids at 70o C.

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