

# The Nature of Liquids

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## Section 10.2

- Liquid particles are always in motion, Liquid particles are free to slide past one another
  - Gases and liquids can both FLOW
  - However, liquid particles are attracted to each other, whereas gases are not

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## Section 10.2

### The Nature of Liquids

- Particles of a liquid spin and vibrate while they move, thus contributing to their average kinetic energy
  - But, most of the particles do not have enough energy to escape into the gaseous state; they would have to overcome their intermolecular attractions with other particles

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## Section 10.2 The Nature of Liquids

- The intermolecular attractions also reduce the amount of space between particles of a liquid
  - Thus, liquids are more dense than gases
  - Increasing pressure on liquid has hardly an effect on its volume

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## Section 10.2 The Nature of Liquids

- Increasing the pressure also has little effect on the volume of a solid
  - For that reason, liquids and solids are known as the condensed states of matter
- Water in an open vessel or puddle eventually goes into the air

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## Section 10.2 The Nature of Liquids

- The conversion of a liquid to a gas or vapor is called vaporization
  - When this occurs at the surface of a liquid that is not boiling, the process is called evaporation
  - Some of the particles break away and enter the gas or vapor state; but only those with the minimum kinetic energy

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## Section 10.2 The Nature of Liquids

- A liquid will also evaporate faster when heated
  - Because the added heat increases the average kinetic energy needed to overcome the attractive forces
  - But, evaporation is a cooling process
- Cooling occurs because those with the highest energy escape first

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## Section 10.2 The Nature of Liquids

- Particles left behind have lower average kinetic energies; thus the temperature decreases
  - Similar to removing the fastest runner from a race- the remaining runners have a lower average speed
- Evaporation helps to keep our skin cooler on a hot day, unless it is very humid on that day. Why?

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## Section 10.2 The Nature of Liquids

- Evaporation of a liquid in a closed container is somewhat different
  - no particles can escape into the outside air
  - When some particles do vaporize, these collide with the walls of the container producing vapor pressure

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## Section 10.2 The Nature of Liquids

- Eventually, some of the particles will return to the liquid, or condense
- After a while, the number of particles evaporating will equal the number condensing- the space above the liquid is now saturated with vapor
  - A dynamic equilibrium exists
  - Rate of evaporation = rate of condensation

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## Section 10.2 The Nature of Liquids

- Note that there will still be particles that evaporate and condense
  - There will be no NET change
- An increase in temperature of a contained liquid increases the vapor pressure- the particles have an increased kinetic energy, thus more minimum energy to escape

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## Section 10.2 The Nature of Liquids

- The vapor pressure of a liquid can be determined by a device called a manometer
- The vapor pressure of the liquid will push the mercury into the U-tube
- A barometer is a type of manometer

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## Section 10.2 The Nature of Liquids

- We now know the rate of evaporation from an open container increases as heat is added
  - The heating allows larger numbers of particles at the liquid's surface to overcome the attractive forces
  - Heating allows the average kinetic energy of all particles to increase

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## Section 10.2 The Nature of Liquids

- The boiling point (bp) is the temperature at which the vapor pressure of the liquid is just equal to the external pressure
  - Bubbles form throughout the liquid, rise to the surface, and escape into the air

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## Section 10.2 The Nature of Liquids

- Since the boiling point is where the vapor pressure equals external pressure, the bp changes if the external pressure changes
- Normal boiling point- defined as the bp of a liquid at a pressure of 101.3 kPa (or standard pressure)

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## Section 10.2

### The Nature of Liquids

- Normal bp of water = 100 °C
  - However, in Denver = 95 °C, since Denver is 1600 m above sea level and average atmospheric pressure is about 85.3 kPa
  - In pressure cookers, which reduce cooking time, water boils above 100 °C due to the increased pressure

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## Section 10.2

### The Nature of Liquids

- Autoclaves, devices often used to sterilize medical instruments, operate much in a similar way
- Boiling is a cooling process much the same as evaporation
  - Those particles with highest KE escape first

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## Section 10.2

### The Nature of Liquids

- Turning down the source of external heat drops the liquid's temperature below the boiling point
- Supplying more heat allows particles to acquire enough KE to escape- the temperature does not go above the boiling point, the liquid only boils faster

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