

Warm up

Given a constant kinetic energy, list the following gases in order of increasing velocity.

$\text{H}_2\text{O}(\text{g})$        $\text{CO}_2(\text{g})$        $\text{CH}_4(\text{g})$        $\text{NH}_3(\text{g})$

What is a liquid?

-a form of matter with a definite volume and takes the shape of its container

Kinetic-Molecular Theory and Liquids

-particles are in constant motion

-particles are closer together so the attractive forces are not overcome by their motion (as in a gas)

The intermolecular forces that involved include:

- dipole-dipole
- London dispersion
- Hydrogen bonding

NOTE: Some molecules at the surface of a liquid can overcome these forces and become a gas.

KMT cont.

- particles are not bound together in fixed positions and they move about constantly
  - hence, liquids are a fluid (just like gases)

## Density

- much more dense than gases due to the closer arrangement of the molecules
- nearly as dense as the solid state
  - most liquids are about 10% less dense than their solid state

NOTE: there are exceptions, such as water which is less dense as a solid than a liquid

## Compressibility

- liquids are relatively incompressible
  - liquid water at 293 K compressed by a pressure of 1000 atm has a volume of 96% of its volume at 1 atm

## Diffusion

-much like gases, liquids will diffuse into one another but at a slower rate due to intermolecular forces

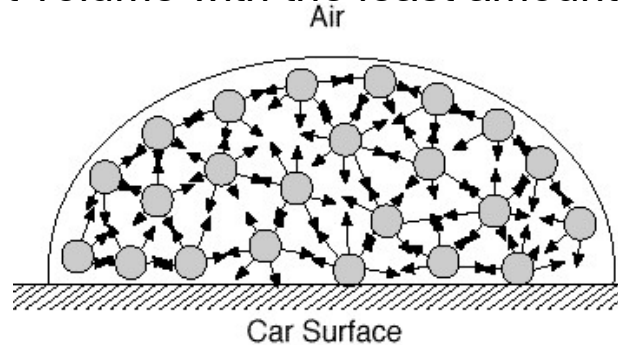
-an increase in temperature, which will increase the KE, thus increasing the velocity of the particles, will increase the rate of diffusion

## Surface Tension

- this property is common to all liquids

-defined: a force that tends to pull adjacent parts of the liquid's surface together, thereby decreasing surface area to the smallest possible size

Water has really high surface tension due to its hydrogen bonding. The molecules on the surface will H-bond to other molecules on the surface and to molecules just beneath the surface, but not with the air. This is why water droplets form in a spherical shape - it has the highest volume with the least amount of surface area.



Molecules inside a water drop are attracted in all directions. Drops on the surface are attracted to the sides and inward.

## Capillary action

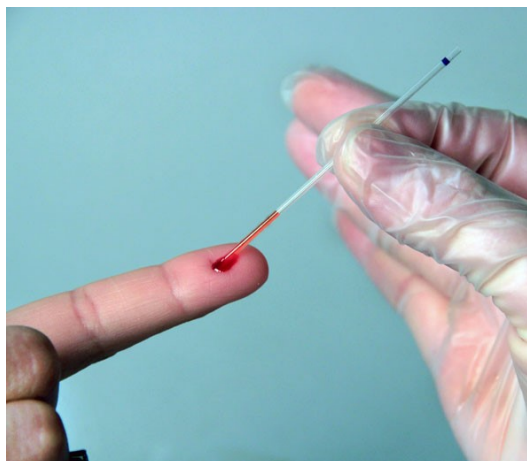
-the attraction of the surface of a liquid to the surface of a solid

-capillary action is closely related to surface tension

-capillary action will cause a liquid to climb (against gravity), especially in a small tube until an equilibrium is reached between the capillary action and gravity.

## Examples of capillary action

- meniscus in a graduated cylinder
- collection of blood (for an iron test)



## Changing to a gas

- Vaporization: the process by which a liquid or solid changes to a gas
- Evaporation: the process by which particles escape from the surface of a nonboiling liquid and enter the gas state
  - evaporation occurs when some molecules have higher than average KE and are able to overcome the intermolecular forces

## Importance of evaporation

- in nature, it is crucial to the water cycle
  - fresh water from the oceans evaporate leaving behind the salt and other minerals
  - in tropical areas evaporation happens more rapidly causing the surface water to be saltier

## Perspiration

- sweating cools your body by absorbing body heat and taking that energy with it as it evaporates

## Boiling

- is the change of the liquid to bubbles of vapor that appear throughout the liquid.
- Boiling is not the same thing as evaporation.

NOTE - we will discuss boiling in more detail later in this unit.

## Becoming a solid

- cooling a liquid lowers the average KE
- the physical change of a liquid to a solid by removal of energy as heat is called **freezing** or **solidification**

## Questions (homework)

- 1) Describe the liquid state according to the KMT.
- 2) Explain why liquids in a test tube form a meniscus.
- 3) The evaporation of liquid water from the surface of the Earth is an important step in the water cycle. How do water molecules obtain enough kinetic energy to escape into the gas state?



