Chemistry 6A F2007

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Wednesday

10/24/07

Reaction Yields:

The quantities of products calculated from balanced chemical equations represent the ***maximum yield*** of product that can be formed according to the reaction stoichiometry.

This maximum corresponds to ***100 % yield***.

It is known as the ***theoretical yield***.

How many grams of ammonia form from the complete reaction of 0.352g of nitrogen with excess hydrogen?

$$N_2(g) \ + 3\ H_2(g) \longrightarrow 2\ NH_3(g)$$

How many grams of ammonia form from the complete reaction of 0.352g of nitrogen with excess hydrogen?

$$N_2(g) \ + 3\ H_2(g) \longrightarrow 2\ NH_3(g)$$

$$0.352\text{g } N_2 \times \frac{\text{mol } N_2}{28.01\text{g } N_2} \times \frac{2\text{mol}NH_3}{\text{mol } N_2} \times \frac{17.04\text{g } NH_3}{\text{mol}NH_3} = 0.427\text{g } NH_3$$

What is the % yield of the reaction if only 0.322g of NH_3 form?

This lesser amount is called the ***"Actual or Experimental" Yield.***

The percent yield is given by the following equation:

$$\%\ \text{Yield} = \frac{\text{Experimental Yield}}{\text{Theoretical Yield}} \times 100$$

From the previous slide:

$$\%\ \text{Yield} = \frac{0.322\text{ g}}{0.427\text{g}} \times 100 \ = 75.4\ \%$$

Chapter 6: The States of Matter

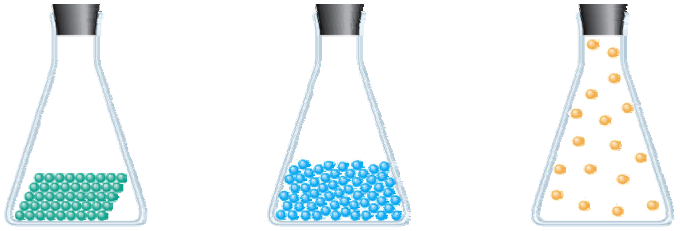
LEARNING OBJECTIVES: *After completing this chapter, you should be able to:*

1. Work with density calculations.
2. Explain the states of matter using the kinetic molecular theory.
3. Use the idea gas laws to determine the effects of temperature, pressure, volume and moles based on changes.
4. Understand the concepts of partial pressure, diffusion, and effusion.
5. Calculate energy changes for heating, cooling, or change of state for a substances.

STATES OF MATTER

- SOLIDS — have rigid shape, fixed volume. External shape can reflect the atomic and molecular arrangement.
- LIQUIDS — have no fixed shape and may not fill a container completely.
- GASES — expand to fill their container.

Solids Liquids Gases



(a) Solid state: The particles are close together and held in fixed positions; they do not need a container.

(b) Liquid state: The particles are close together but not held in fixed positions; they take the shape of the container.

(c) Gaseous state: The particles are far apart and completely fill the container.

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CHARACTERISTIC PROPERTIES OF THE THREE STATES OF MATTER

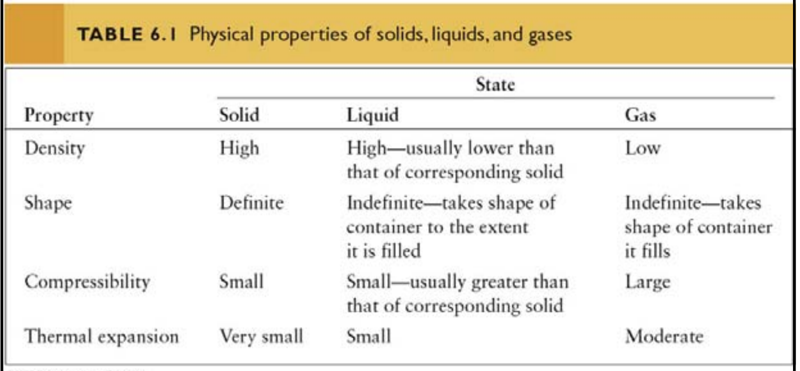

TABLE 6.1 Physical properties of solids, liquids, and gases

	State		
Property	Solid	Liquid	Gas
Density	High	High—usually lower than that of corresponding solid	Low
Shape	Definite	Indefinite—takes shape of container to the extent it is filled	Indefinite—takes shape of container it fills
Compressibility	Small	Small—usually greater than that of corresponding solid	Large
Thermal expansion	Very small	Small	Moderate

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Kinetic Theory (KT) of Gases: Clausius (1857)

Postulates:

◈ A gas is a collection of a very large number of particles that remains in constant random motion.

◈ The pressure exerted by a gas is due to collisions with the container walls

◈ The particles are much smaller than the distance between them.

Kinetic Theory (KT) of Gases: Clausius (1857)

◈ The particles move in straight lines between collisions with other particles and between collisions with the container walls. (i.e. the particles do not exert forces on one another between collisions.)

◈ The average kinetic energy (½ mv^2) of a collection of gas particles is proportional to its Kelvin temperature.

◈ Gas particles collide with the walls of their container and one another without a loss of energy.

Units of Energy

Energy: is the capacity to do work, or supply heat.

Energy = Work + Heat

SI Unit for energy is the "***joule***" abbreviated "J"

$$\frac{kg \cdot m^2}{s^2} = 1\ J$$

Another unit of energy is the "***calorie***"

conversion factor

$$\frac{4.184\ \text{J (exactly)}}{1\ \text{cal}}$$

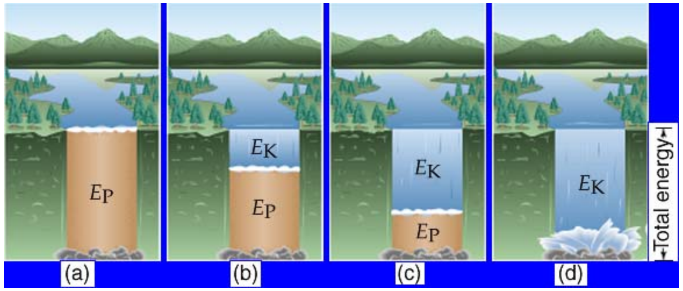
1 cal = 4.184 J (exactly)

A nutritional Calorie:

1 Cal = 1000 cal = 1 kcal

Conservation of Energy

Energy cannot be created or destroyed;
It can only be converted from one form to another.

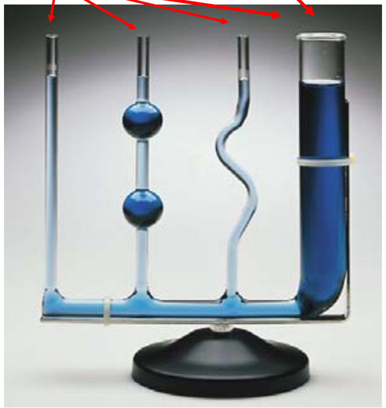


all potential some potential & kinetic all kinetic same pressure at all

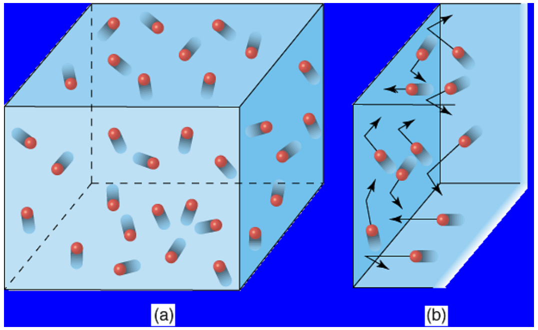
more mass here

When a pressure differential exists, mass moves from the area of high pressure to an area of low pressure.

When there is no differential, mass does not move.



Pressure at the Molecular Level…



(a) Gas particles are in constant random motion.

(b) Pressure is the sum total force of all of the individual collisions between the gas particle and the container walls.

Pressure Measurement Units:

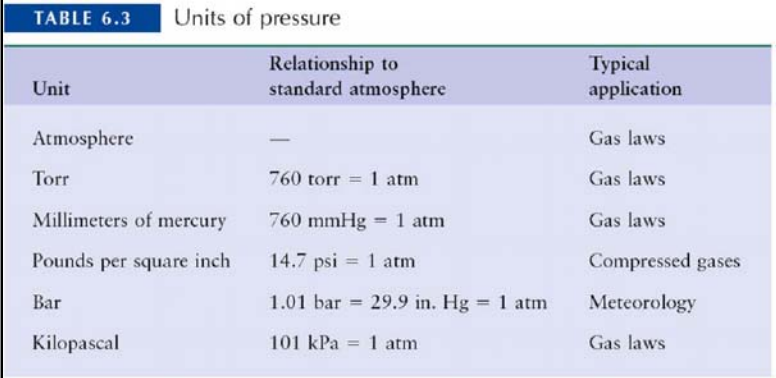


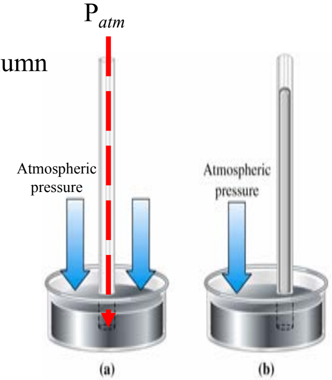
TABLE 6.3 Units of pressure

Unit	Relationship to standard atmosphere	Typical application
Atmosphere	—	Gas laws
Torr	760 torr = 1 atm	Gas laws
Millimeters of mercury	760 mmHg = 1 atm	Gas laws
Pounds per square inch	14.7 psi = 1 atm	Compressed gases
Bar	1.01 bar = 29.9 in. Hg = 1 atm	Meteorology
Kilopascal	101 kPa = 1 atm	Gas laws

760 torr = 1 atm = 760 mm Hg
1 torr = 1 mm Hg

The Barometer

A ***barometer*** is a device that measures pressure in terms of the height of a column of liquid.



When an open tube is placed in the Hg, the pressure inside equals the pressure outside.

no mass movement…

When an evacuated tube is inverted and placed in a reservoir of the liquid,

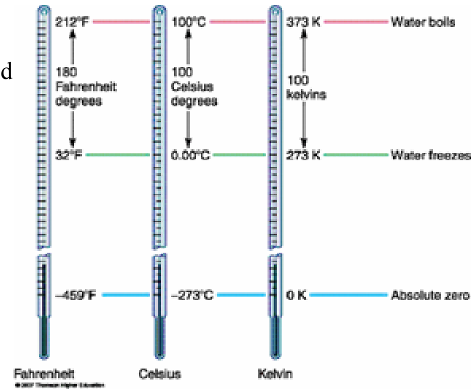
the pressure difference between the atmosphere and the evacuated tube forces the liquid upwards.

A tire has a pressure of 32.0 psi (pounds per square inch) What is the pressure in atm and mm Hg?

$$32.0\ \cancel{\text{psi}} \times \frac{\text{atm}}{14.7\,\cancel{\text{psi}}} = 2.18\text{ atm}$$

$$32.0\ \cancel{\text{psi}} \times \frac{\cancel{\text{atm}}}{14.7\,\cancel{\text{psi}}} \times \frac{760\text{mm Hg}}{1\,\cancel{\text{atm}}} = 1650\text{mm Hg}$$

Gas: Temperature Scales



For gas calculations, we need an ***absolute*** scale, one that does not take on negative values.

The conversion between ^{o}C and degrees K is:

$$K = {}^{o}C + 273.15$$

When performing calculations with absolute temperatures, on must use the ***Kelvin scale***.

Convert 25.0 ^{o}C to Kelvin:

$$\begin{array}{r} 25.0\ ^{o}\text{C} \\ +\ 273.15 \\ \hline =\ 298.2\ \text{K} \end{array}$$

Convert 323 K to ^{o}C:

$$\begin{array}{r} 323\ \text{K} \\ -\ 273.15 \\ \hline =\ 50.\ ^{o}\text{C} \end{array}$$

Watch your sig. figs.!!!!

Standard Temperature and Pressure:

Often it is the case that scientists need a reference point at which they can compare gas systems.

This reference point refers to a *standard temperature* and *pressure* (***STP***)

$$\text{STP} = 1\text{ atm} \quad \& \quad 0\ ^{o}\text{C}$$

760 torr
760 mm Hg

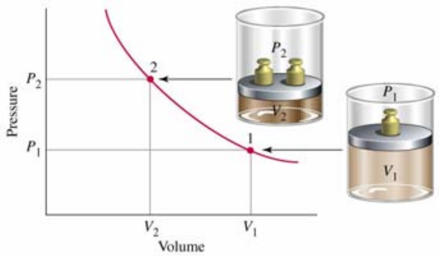
273.15 K

Boyle's Law: *Pressure vs. Volume*

$$V \propto \frac{1}{P}$$

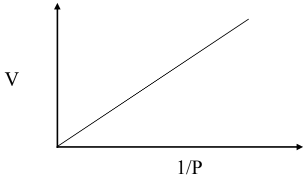
or

$$V \times P = \text{Constant}$$



A plot of V vs. $\frac{1}{P}$ yields a straight line

$$y = mx + b$$



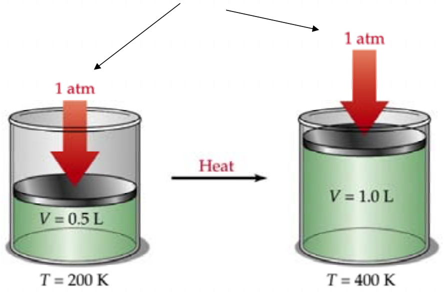
Charles's Law: *Volume vs. Temperature (absolute)*

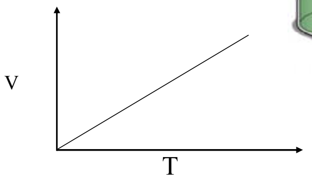
$$V \propto T$$

or

$$\frac{V}{T} = \text{Constant}$$

at constant pressure





A plot of T vs. V yields a straight line

$$y = mx + b$$

Boyle's Law: *Pressure vs. Volume*

$$V \propto \frac{1}{P}$$

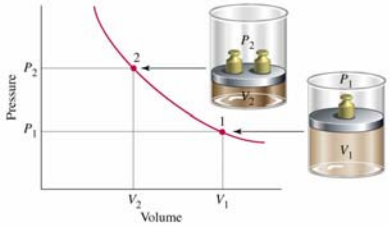
or

$$V \times P = \text{Constant}$$

as pressure increases, volume decreases!

$$V_1 \times P_1 = V_2 \times P_2$$

$$V_2 = \frac{V_1 \times P_1}{P_2}$$



$$\text{if } P_2 = 2 \times P_1$$

$$V_2 = \frac{V_1 \times P_1}{2P_1} = \frac{1}{2} V_1$$

double the pressure, halve the volume

Calculate the new volume of a 352 mL sample of helium at a 25.0 ^{o}C after the temperature is changed to 50.0 ^{o}C.

$$\frac{V_{(1)}}{T_{(1)}} = \frac{V_{(2)}}{T_{(2)}} \qquad V_{(2)} = \frac{V_{(1)} \times T_{(2)}}{T_{(1)}}$$

*The temperature doubles so the volume doubles, **Right?***

Wrong! One must use the Kelvin scale!

$$V_{(2)} = \frac{352 \text{ mL} \times (50.0 + 273.15)\cancel{K}}{(25.0 + 273.15)\cancel{K}} = 382 \text{ mL}$$

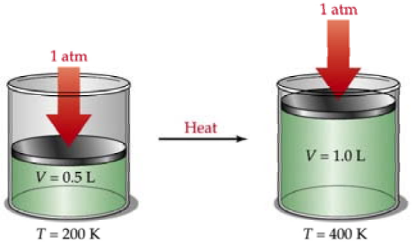
Charles's Law: ***Volume vs. Temperature (absolute)***

$$V \propto T$$

or

as temperature increases, volume increases!

$$\frac{V}{T} = \text{Constant}$$



$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad V_2 = \frac{V_1}{T_1} \times T_2$$

if $T_2 = 2 \times T_1$

$$V_2 = \frac{V_1}{T_1} \times 2T_1 = 2 \times V_1$$

Double the ***Kelvin*** temperature, double the volume!

What temperature (in °C) would change the volume of 35.2 mL of helium at 25.0 °C to 575 μL?

$$\frac{V_1}{T_1} = \frac{\cancel{V}_2}{T_2}$$

$$T_2 = \frac{575\ \cancel{\mu L} \times (25.0 + 273.15)\text{K}}{35.2\ \cancel{mL} \times \frac{\cancel{L}}{10^3\ \cancel{mL}} \times \frac{10^6\ \cancel{\mu L}}{1\cancel{L}}} - 273.15$$

$$= -268\ ^{o}\text{C}$$