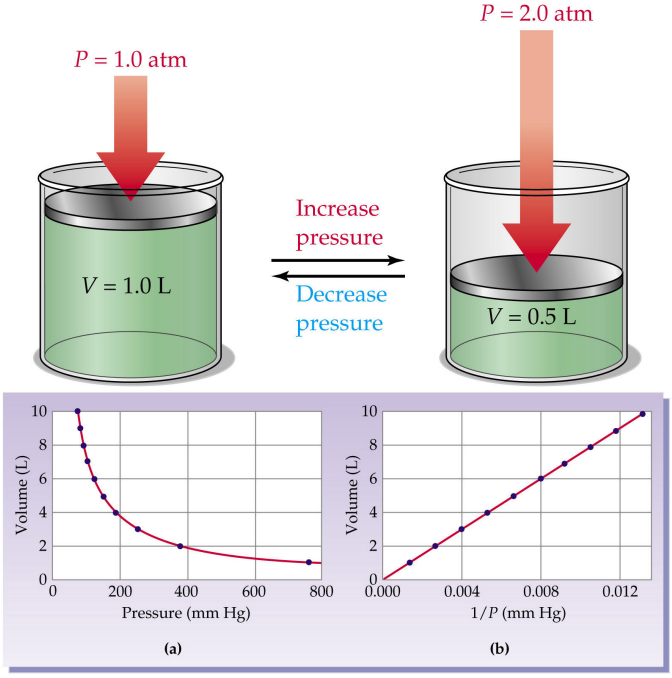
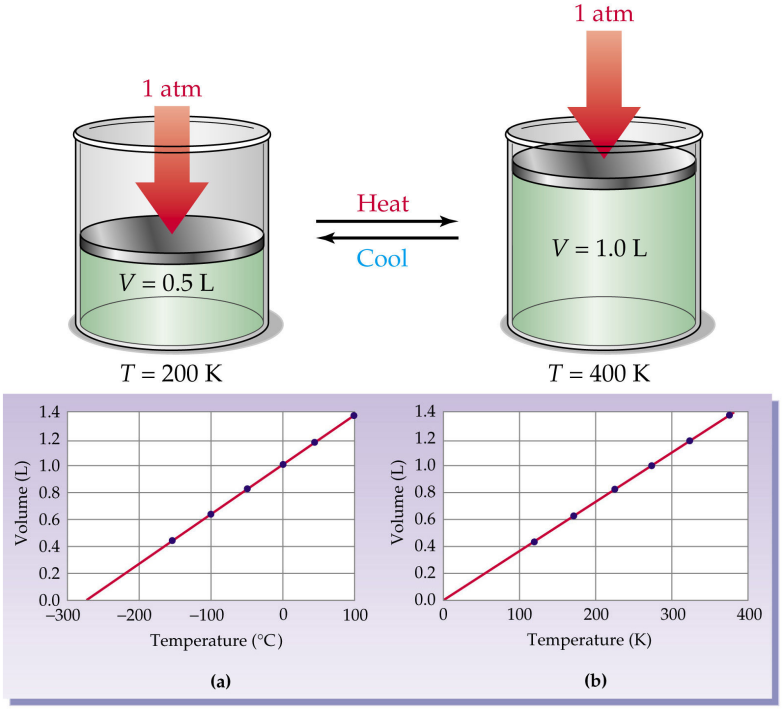
Gas Laws:
Relationship between Pressure (P), Volume (V), Temperature (T) and quantity; Moles (n)

Boyle's Law (PV = constant)



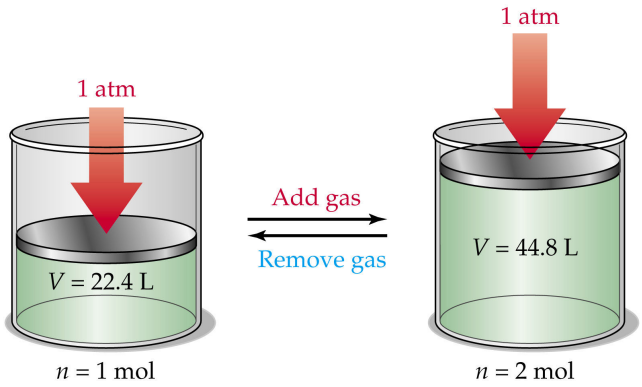

This is an inverse relationship: As volume decreases, pressure increases.

Charles' Law: (V/T = constant)



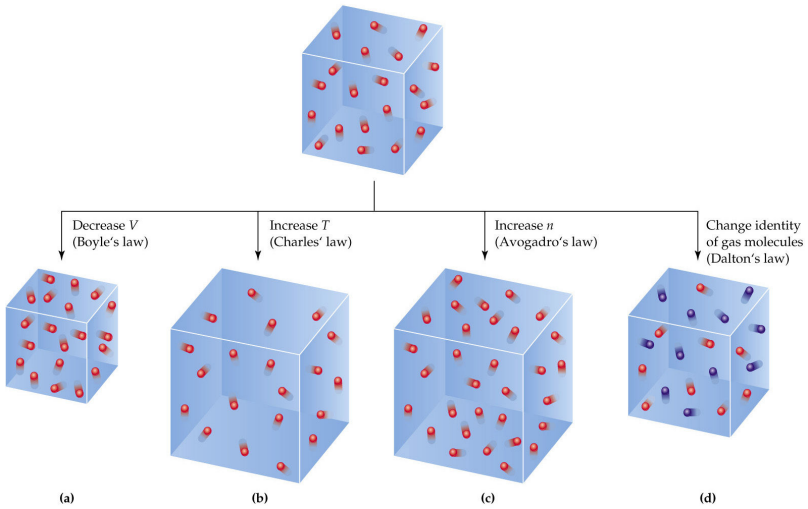

This is a direct relationship. As Temperature decreases, Volume decreases.

Avogadro's Law: (V/n = constant)




This is a direct relationship. As the number of moles decreases, the volume decreases

Summary:




Combined Gas Law:
PV/nT = constant (T in Kelvins)

$P_1V_1/n_1T_1 = P_2V_2/n_2T_2$

Ideal gas Law:
PV = nRT
R = .0821L atm/mol K

Gay-Lussac's/Avogadro's Law of Combining Volumes

Equal volumes of any gases at the same temperature and pressure contain the same number of moles of gas.

The coefficients of a balanced equation can be used to calculate relative volumes.

Standard Molar Volume: At standard temperature and pressure (STP = 1atm and 273.15K) 1 mole of any ideal gas has a volume of 22.4L
Variations on the ideal gas law equation:
PV = mRT/M (m = sample mass, M = molar mass of the gas)

d = MP/RT (d = density of the gas in g/L)

Examples:
1. Calculate:
a. The new pressure in a closed container if a 5.0L volume of gas at 2.5atm has its volume increased to 7.5L.

b. The new volume of gas (at constant T and P) if 2.0mol of He in a 3.0L container has another 3.0mol of He placed into the container.

Answers:
a. (5.0L)(2.5atm) = (7.5L)($P_2$)
$P_2$ = 1.7atm

b. 3.0L/2.0mol = $V_2$/5.0mol
$V_2$ = 7.5L

2. When a rigid hollow sphere containing 680 L of helium gas is heated from 300.K to 600.K, the pressure of the gas increases to 18atm. How many moles of helium does the sphere contain?

Answer:
n = PV/RT = (18atm)(680L)/(.0821)(600.K)
n = 248.48 = 250moles

3. A child has a lung capacity of 2.2 L. How many grams of air do her lungs hold at a pressure of 1.0 atm and a normal body temperature of 37$^{o}$C? Assume a "formula mass" of 29g/mol for air.

Answer:
m = MPV/RT = (29g/mol)(1.0atm)(2.2L)/(.0821Latm/molK)(310.15K) = 2.5g

4. A gas with a volume of 300.mL at 150.$^{o}$C is heated until its volume is 600.mL. What is the new temperature of the gas if the pressure is unaltered?

Answer:
300mL/423.15K = 600mL/$T_2$
$T_2$ = 846K = 573$^{o}$C

5. Calculate the number of liters occupied, at STP.
    a. 0.350 mol $O_2$
    b. 63.5g He

Answers:
a. 0.350mol (22.4L/mol) = 7.84L
b. (63.5g)(1mol/4.003g)(22.4L/1mol) = 355L

6. Determine the molar mass of a gas for which a 2.5g sample of that gas occupies a volume of 3.0L at STP.

Answer:
M =(2.5g)(.0821)(273.15K)/(3.0L)(1atm) =18.7g/mol
or
(2.5g)/(3.0L/22.4L/mol) = 18.7g/mol

7. Find the density of fluorine gas (g/L) at 700torr and 50°C.

Answer:
d = MP/RT
= (38.00g/mol)(700/760) / (.0821)(50+273.15) = 1.32g/L

8. For the equation
$Ag_2S_{(s)} + H_{2(g)} \rightarrow Ag_{(s)} + H_2S_{(g)}$
How many Liters of $H_2S$ can be produced from 15.0g of $Ag_2S$ and 1.00L of $H_{2(g)}$ if the reaction occurs at STP?

Answer:
$Ag_2S_{(s)} + H_{2(g)} \rightarrow 2Ag_{(s)} + H_2S_{(g)}$
mol $Ag_2S$ = 15.0g (1mol/247.8g) = .0605mol
mol $H_2$ = (1.00L)(1mol / 22.4L) = .0446mol
Hydrogen gas limits
.0446mol $H_2$ (1mol $H_2S$ / 1mol $H_2$) = .0446mol $H_2S$
V = .0446mol (22.4L/mol) = 1.0L
(Note that the last two steps aren't really necessary because of the 1:1 mole ratio between $H_2S$ and $H_2$.)