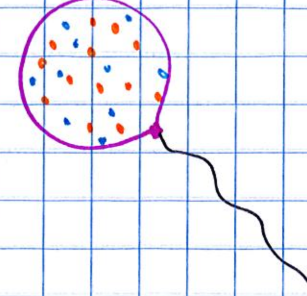
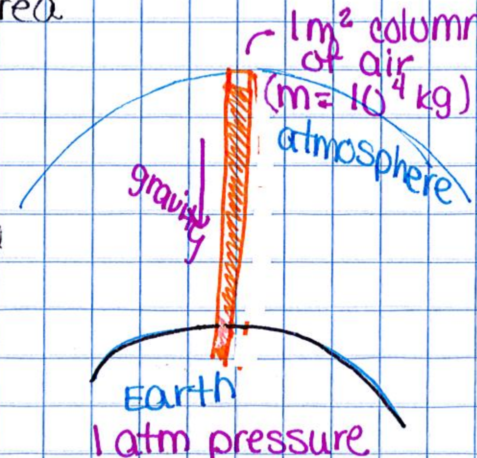
Ch 10 - Gases

1. Characteristics of Gases
    - expand to fill their containers
    - high compressible
    - extremely low densities
    - always homogeneous mixtures



2. Pressure
    - amount of force applied to an area

$$P = \frac{F}{A}$$



- atmospheric pressure - weight of the air per unit area

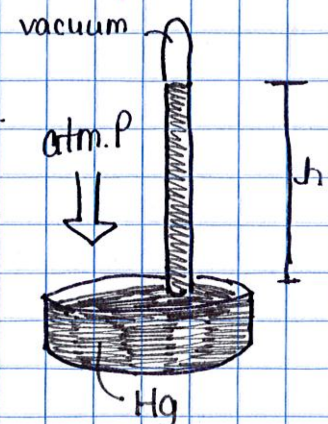
- units of pressure

    - Pascals $1\,Pa = 1\,N/m^2$

    - Bar $1\,bar = 10^5\,Pa = 100\,kPa$

    - mm Hg (torr) - diff. in height of 2 connected columns of Hg

    - atmosphere $1.00\,atm = 760\,torr$)



- Standard Pressure
    - normal atmospheric pressure @ sea level

    = 1.00 atm
    = 760 torr (760 mm Hg)
    = 101.325 kPa

Ex (1) In countries that use the metric system, like Canada, atmospheric pressure in weather reports is given in units of kPa.

(A) Convert 99.3 kPa to mmHg.

(B) Convert mmHg to in. Hg, the U.S. system.

(C) Convert 99.3 kPa to atm.

760 mm Hg = 101.325 kPa

(A) $99.3 \text{ kPa} \left(\frac{760 \text{ mmHg}}{101.325 \text{ kPa}}\right) = 744.8 \text{ mmHg}$

(B) $744.8 \text{ mmHg} \left(\frac{1 \text{ cm Hg}}{10 \text{ mmHg}}\right)\left(\frac{1 \text{ in Hg}}{2.54 \text{ cmHg}}\right) = 29.32 \text{ in Hg}$

1 in = 2.54 cm

1 cm = 10 mm

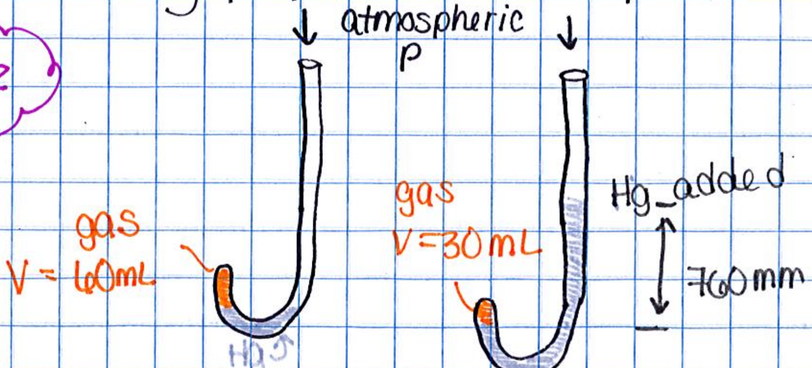
(C) $99.3 \text{ kPa} \left(\frac{1.00 \text{ atm}}{101.325 \text{ kPa}}\right) = .98 \text{ atm}$

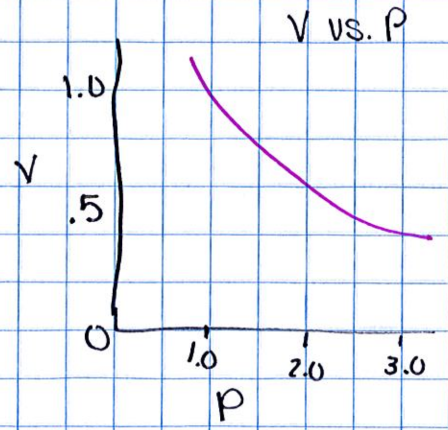
1 atm = 101.325 kPa

3. Boyle's Law $V \propto \frac{1}{P}$

The volume of a fixed quanity of gas at constant temperature is inversely proportional to its pressure.

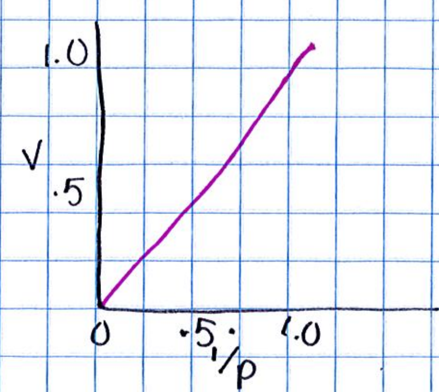
$P_1V_1 = P_2V_2$





$PV = K$

$V = K\left(\frac{1}{P}\right)$



Ex (2) Boyle's Law $P_1V_1 = P_2V_2$

Sulfur dioxide (SO_2), a gas that plays a role in the formation of acid rain, is found in the exhaust of vehicles & power plants. Consider a 1.53L sample of gaseous SO_2 at a pressure of 5.6×10^3 Pa. If the pressure changed to 1.5×10^4 Pa at constant temperature, what will be the new volume of the gas?

P_1 5.6×10^3 Pa
V_1 1.53L
P_2 1.5×10^4 Pa
V_2 ?

$(5.6 \times 10^3 \text{ Pa})(1.53L) = (1.5 \times 10^4 \text{ Pa}) V_2$

$.571 \text{ L} = V_2$

(3) Fluorine gas exerts a pressure of 900 torr. When the pressure increases to 1.50 atm, the volume is 250mL. What was the original volume?

P_1 900 torr $\left(\frac{1 \text{ atm}}{760 \text{ torr}}\right) = 1.18$ atm
V_1 ?
P_2 1.50 atm
V_2 250 mL

$(1.18 \text{ atm})(V_1) = (1.50)(250 \text{mL})$
$(1.18 \text{ atm})(V_1) = 375 \text{ atm}\cdot\text{mL}$
$V_1 = 317.8 \text{ mL}$

(4) Ozone gas occupies 1.20 L at 720 torr pressure. What volume will it occupy at 1.00 atm pressure?
= 760 torr

P_1 720 torr
V_1 1.20 L
P_2 760 torr
V_2

$$\frac{(720 \text{ torr})(1.20 \text{L})}{760 \text{ torr}} = \frac{(760 \text{ torr})(V_2)}{760 \text{ torr}}$$

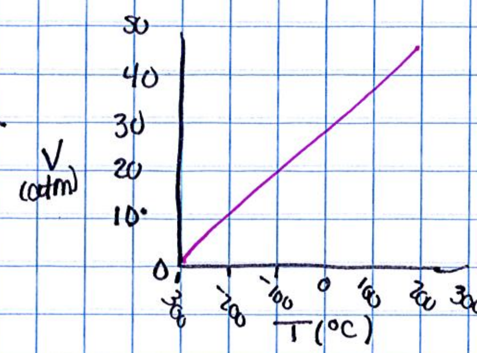
$V_2 = 1.14 \text{ L}$

4. Charles's Law $V \propto T$

The volume of a fixed amount of gas at constant pressure is directly proportional to its absolute temperature (in Kelvin)

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

$$\frac{V}{T} = K$$



Ex (5) Charles's Law $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

A sample of neon gas at 50°C and a volume of 2.50L is cooled to 25°C. What is the new volume?

$V_1 = 2.50L$
$T_1 = 50°C$
$V_2 = ?$
$T_2 = 25°C$

$$\frac{(2.50\,L)}{50°C} = \frac{V_2}{25°C}$$

$$\boxed{1.25L = V_2}$$

Ex (6) A sample of argon gas is cooled and its volume changed from 380mL to 250mL. If the final temperature was -55°C, what was the original temperature?

$V_1 - 380\,mL$
$T_1 - ?$
$V_2 - 250\,mL$
$T_2 - -55°C =$ ~~388~~ K 218

$$\frac{380}{t_1} = \frac{250}{\text{~~388~~ } 218}$$

$\boxed{t_1 = \text{~~289~~ } k}$

~~435~~ k

331 k = 58.36 °C

5. Avogadro's Law $V \propto n$

The volume of a gas at constant temperature and pressure is directly proportional to the number of moles of gas.

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

$V = kn$

Ex (7) Avogadro's Law $\frac{V_1}{n_1} = \frac{V_2}{n_2}$

100.g of N_2 gas occupies a volume of 33.6L. Adding another 50.0g of N_2 gas, changes the volume to what?

$n_1 = 100.g\left(\frac{1\,mol}{28\,g}\right) = 3.57\,mol$

$V_1 = 33.6L$

$n_2 = (100.g + 50.0g)(1\,mol/28g) = 5.36\,mol$

$V_2 = ?$

$$\frac{33.6L}{3.57\,mol} = \frac{V_2}{5.36\,mol}$$

50.4L = V_2

Ex (8) Starting with a 10.2L balloon filled with 40.0g of helium, the helium slowly leaks out of the balloon to a volume of 4.8L. What mass of helium is left in the balloon?

$n_1 = 10\,mol$

$V_1 = 10.2L$

$n_2 = 4.71\,mol$

$V_2 = 4.8L$

$$40.0g \times \frac{1\,mol}{4.00g} = 10\,mol\,He$$

$$\frac{10.2L}{10\,mol} = \frac{4.8L}{n_2} \quad n_2 = 4.71\,mol$$

$$4.71\,mol\,He \times \frac{4.00g}{1\,mol} = \boxed{18.82g}$$