GAS LAWS

CHEM

Boyle's

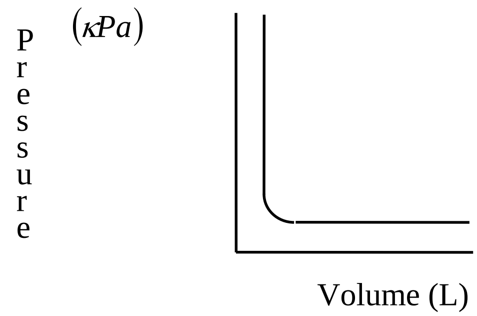
$$p \propto \frac{1}{V}$$

$$p = \frac{k}{V}$$

$$k = PV$$

$$\boxed{P_1V_1 = P_2V_2}$$

indirect variation
temperature constant



Charles'

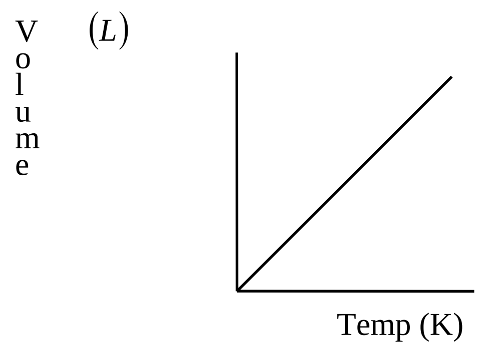
$$V \propto T$$

$$V = kT$$

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

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

direct variation
pressure constant



Gay Lussac's

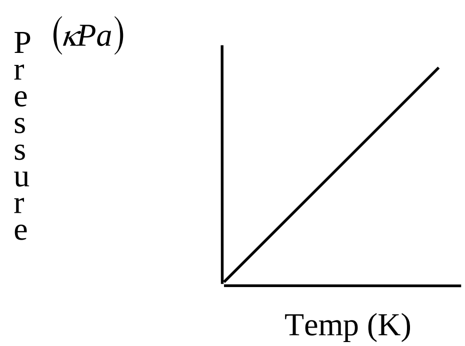
$$P \propto T$$

$$P = kT$$

$$k = \frac{P}{T}$$

$$\boxed{\frac{P_1}{T_1} = \frac{P_2}{T_2}}$$

direct variation
volume constant



Dalton's partial pressure

$$\boxed{P = \bar{p}\text{gas} + \bar{p}H_2O_{(g)}}$$

$P =$ total pressure

$\bar{p} =$ partial pressure

Combined Gas Law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

change in variables
P,V,T

reaction NOT at STP

Ideal Gas Law

$$PV = nRT$$

P = pressure
V = volume
n = moles
T = temperature (K)
R = constant

S T P
(Standard Temperature Pressure)
$273\ K$ $0°\ C$ $1\ atm$ $760\ mm\ Hg$ $101\ \kappa Pa$

S A T P
(Standard Ambiant Temperature Pressure)
$298\ K$ $25°\ C$ $101\ \kappa Pa$

* Temperature must always be in Kelvin

$$T = 273\ K + °\ C$$

1. change $25°\ C$ to Kelvin

   $T = 273\ K + 25°\ C$

   $T = 298\ K$

2. change $-25°\ C$ to Kelvin

   $T = 273K + (-25°C)$
   $T = 248K$

Molar volume of gas at STP is $\frac{22.4\ L}{mole}$

Kinetic Energy $E\kappa = \frac{1}{2}mv^2$

Pressure $= \frac{\text{force}}{\text{area}}$

1. 〉 temperature 〉 kinetic energy

2. 〉 temperature 〉 molar volume

3. 〉 temperature 〉 pressure

   i.e., driving a car the temperature of tires increase, therefore pressure increases

4. 〉 temperature (ave $E\kappa$) 〉 average velocity of molecules

   (still will be some slow and fast moving molecules)

5. 〉 molecules 〉 pressure

6. 〉 moles 〉 volume

7. 〉 pressure 〈 volume

   i.e., pressure doubled --- volume decreased 1/2

8. Gas moves in air, therefore easy to compress

9. Volume available in gas much greater than in solid or liquid since the gas will expand to fill the space available.

10. Atmospheric pressure <u>decreases</u> with increasing altitude.

QUESTIONS

1. Problem: A sudden depressurization on a Canadian Airlines flight causes the air volume to increase from 152 cm^3 to 158 cm^3. If the pressure was standard before the oxygen masks were deployed, what was the drop in pressure within the cabin? (Assume there was no change in temperature.)

   Solution:

   $V_1 = 152\ cm^3$

   $V_2 = 158\ cm^3$

   $P_1 = 101\ \kappa Pa$

   $P_2 = ?$

   $P_1V_1 = P_2V_2$

   $(101\kappa Pa)(152cm^3) = P_2(158cm^3)$

   $\boxed{P_2 = 97.2\ \kappa Pa}$

2. Problem: Before its early demise, the Dairy Queen hot air balloon flew the skies of Calgary. If the volume of gas in the balloon was initially 12.0 L when a sudden decrease in temp. from $25.0°$ C to $10.0°$ C occurred, what was the volume after the change in temp.?

   Solution:

   $V_1 = 12.0\ L$ $T_1 = 25.0°\,C = 298\ K$

   $V_2 = ?$ $T_2 = 10.0°\,C = 283\ K$

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

   $$\frac{12.0\ L}{298\ K} = \frac{V_2}{283\ K}$$

   $\boxed{V_2 = 11.4\ L}$

3. Problem: A tank of propane has a pressure of $150.0\ \kappa Pa$ at $19.0^\circ C$. If this tank can withstand a pressure of $200.0\ \kappa Pa$, will it explode if the temperature rises to $100.0^\circ C$?

Solution:

$P_1 = 150.0\ \kappa Pa$

$P_2 = ?$

$T_1 = 19.0^\circ C + 273\ K = 292\ K$

$T_2 = 100.0^\circ C + 273\ K = 373.0\ K$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{150.0\ \kappa Pa}{292\ K} = \frac{P_2}{373.0\ K}$$

$$\boxed{P_2 = 192\ \kappa Pa \qquad \text{No!}}$$

4. Problem: A weather balloon contains $532\ mL$ of gas at $650\ mm\ Hg$ when $16.0\ km$ above the earth's surface where the temperature is $-25.0^\circ C$. what would the pressure be on the earth's surface if the temperature is $298\ K$ and the volume is $546\ mL$?

$P_1 = 650mmHg$

$T_1 = -25.0°C = 248K$

$V_1 = 532mL$

$P_2 = ?$

$T_2 = 298\ K$

$V_2 = 546\ mL$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{(650mm)(532mL)}{248K} = \frac{(P_2)(546mL)}{298K}$$

$$\boxed{V_2 = 761\ mm\ Hg}:$$

5. Problem: A $2.7\ L$ sample of chlorine gas has a pressure of $1.21\ atm$ at $59°\,C$. What mass of chlorine gas is present?
$\left(\text{Given } R = \frac{0.082 atm \bullet L}{mole \bullet K}\right)$

Solution:

$V = 2.7\ L$

$P = 1.21\ atm$

$T = 59°\,C = 332\ K$

$R = \frac{0.082\ atm \bullet L}{mole \bullet K}$

$n = ?$

$PV = nRT$

$(1.21 atm)(2.7L) = n\left(\frac{0.082 atm \bullet L}{mole \bullet K}\right)(332K)$

$n = 0.12 moles$

$0.12\ moles \times \frac{70.9\ g}{1\ mole} = \boxed{8.5\ g}$

6. Problem: How many moles are present in $3.65 \times 10^5\, mL$ of $CH_{4(g)}$ at STP?

Solution:

$3.65 \times 10^5\ mL \times \frac{1\ L}{1000\ mL} \times \frac{1\ mole}{22.4\ L} = \boxed{16.3\ moles}$

7. Problem: Find the kinetic energy of 2.0 moles of fluorine moving at a rate of $5.0\ \frac{m}{s}$.

Solution:

$n = 2.0 moles$

$v = 5.0 \frac{m}{s}$

$m = 2.0 moles \times \frac{38.00 g}{1 mole} = 76 g = 7.6 \times 10^{-2} kg$

$E\kappa = ½ mv^2$

$= ½ (7.6 \times 10^{-2} kg)\left(5.0 \frac{m}{s}\right)^2$

$\boxed{E\kappa = 0.95\ J}$

8. Problem: A force of 20 N acts on an area of $1.5 \times 10^{-3} m^2$ at a temperature of $25.0° C$. If the temperature changes to $-5.00° C$, what will the new pressure be?

Solution:

$$P_1 = \frac{\text{Force}}{\text{Area}}$$

$$P_1 = \frac{20N}{1.5 \times 10^{-3} m^2}$$

$$P_1 = 1.3 \times 10^3 Pa \left(\frac{N}{m^2} = Pa\right)$$

$$P_1 = 1.3 \kappa Pa$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{1.3\kappa Pa}{298K} = \frac{P_2}{268K}$$

$$\boxed{P_2 = 1.2\ \kappa Pa}$$

$P_2 = ?$

$T_1 = 25.0° C = 298\ K$

$T_2 = -5.00° C = 268\ K$

9. Problem: A sample of chlorine gas is collected over water. If there are 37 g of chlorine gas and 58 g of $H_2O_{(g)}$, find the partial pressure of each gas if the total pressure is 690 mm Hg.

Solution:

Find moles:

$Cl_{2(g)}$ $$37g \times \frac{1 mole}{2(35.45g)} = 0.5219 mol$$

$H_2O_{(g)}$ $$58g \times \frac{1 mole}{18.02g} = 3.2186 mol$$

$Total\ moles = 3.7405\ mol$

Partial Pressure $Cl_{2(g)}$

$$\frac{0.5219 mol}{3.7405 mol} \times 690 mmHg = 96 mmHg$$

Partial pressure $H_2O_{(g)}$

$$\frac{3.2186 mol}{3.7405 mol} \times 690 mmHg = 5.9 \times 10^2 mmHg$$