ElCoM

Electrical | Computer | Mechatronics

www.ELCOM-HU.com

إرادة .. ثقة .. تغيير

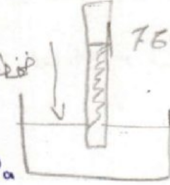
عزيز   ملخصات كيمياء عامة .

Chem107

Ch.5 / Gases

Samer HamZeh

5.3 The Gas Laws:

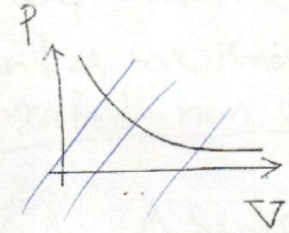


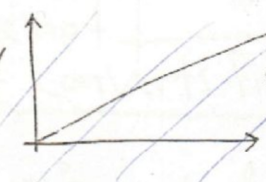
* **Boyle's Law:** درس العلاقة بين الضغط والحجم

pressur $\Rightarrow$ 1 atm = 760 mm Hg = 760 tour = 101325 Pa

$P \propto 1/V \xRightarrow{\text{atmospher}} P = \text{constant } 1/V \Rightarrow PV = \text{constant}$

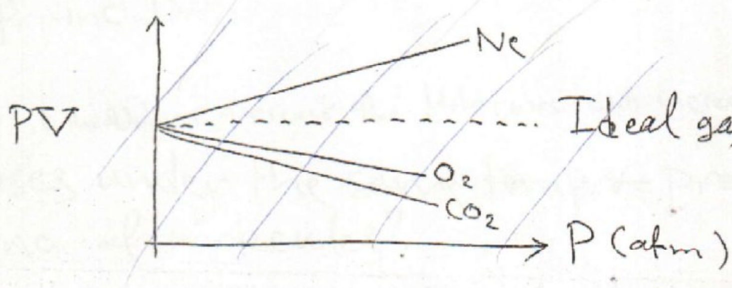
$\boxed{P_1V_1 = P_2V_2}$ at constant temp.





* Boyle's law holds precisely only at very low pressures. Measurements at higher pressures reveal that PV is not constant but varies as the pressure is varied.

- A gas that strictly obeys Boyle's law is called an ideal gas.



Ex. Consider a 1.53 (L) Sample of SO_2 - gas at $P = 5.6 \times 10^3$ Pa (L = Leter) the pressure is changed to 1.5×10^4 Pa, at constant temp. What will be the new volume of the gas? Q Calculate the change of Volume?

$P_1V_1 = P_2V_2 \Rightarrow (5.6 \times 10^3 \text{ Pa})(1.53 \text{ L}) = (1.5 \times 10^4 \text{ Pa}) V_2$

$\Rightarrow V_2 = 0.57 \text{ L}$ which is less than V_1 due to inc. ↑ in P.

($SO_{2(g)}$: Source of acid rain, found in exhaust of vechiles)

عندما يطلب the change Volume لا يكتب إشارة السالبة أو

the Volume is decreased by (   )

$t\,(^\circ C)$

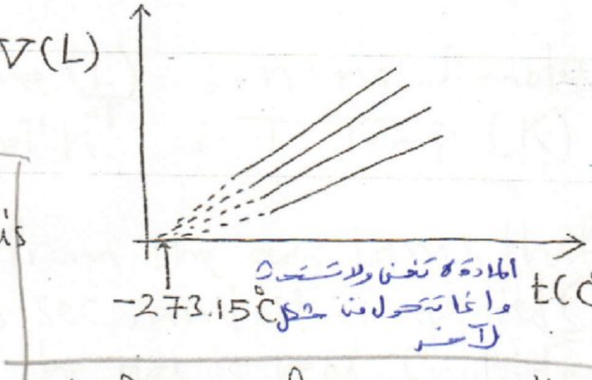
$T(K) = t(^\circ C) + 273$

* **Charles's Law**: (Charles's & Gay - Lussac's Law)

(Frensh-Balloon) $V \propto T$ with a constant pressure

$V = bT \Rightarrow \boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$

b: constant



−273.15°C (Zero Kelvin = absolute Zero)
Can not be reached because at this temp. Volume will be Zero and as we Know matter does not created non destroyed but converts from a form to another

Ex. A Sample of gas at 15°C & 1 atm has a volume of 2.58 L. What volume will this gas occupy at 38°C & 1 atm?

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{2.58\,L}{288\,\cancel{K}} = \frac{V_2}{311\,\cancel{K}} \Rightarrow V_2 = \underline{2.79\,L}$$

$V_2 > V_1$ because temp. inc. ↑.

* **Avogadro's Law**: if the Volume increase the Molecules will increase too

"Equal volume of gases under the same temp. & pressu contain the same no. of molecules".

$$V \propto n \Rightarrow V = bn \Rightarrow \boxed{\frac{V_1}{n_1} = \frac{V_2}{n_2}}$$ n: no. of moles.

Ex. Suppose a sample of 12.2 L contains 0.50 mole O_2 at P = 1 atm, t = 25°C. If all O_2 is converted into Ozone O_3 at the same temp & pressure. what would be the Volume of O_3?

$$3O_2 \longrightarrow 2O_3 \qquad 0.50\,\cancel{mole\ O_2} \times \frac{2\,mole\ O_3}{3\,\cancel{mole\ O_2}} = 0.33\ mole\ O_3$$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2} \Rightarrow \frac{12.2\,L}{0.50\,\cancel{mole}} = \frac{V_2}{0.33\,\cancel{mole}} \Rightarrow V_2 = 8.1\,L$$

1 atm = 760 mmHg = 760 torr = 101325 Pa

5.4 The Ideal Gas Equation:

$\Rightarrow$ $PV = nRT$

P: Pressure (atm) ; V: Volume (L) ; n: no. of moles
R: gas constant = 0.0821 L atm mol^{-1} K^{-1} ; T: Temp. (K)
= 8.314 J mol^{-1} K^{-1}

The previous eq. is derived from the gas Laws that are mentioned in the previous sec., and it is applied Only for the ideal gases. But if the gas is real (not ideal it can be applied under low pressure & high temp & low n

Ex. A sample of H_2-gas has a volume = 8.56 L & t = 0°C with P = 1.5 atm. Calculate no. of moles of H_2.

$$PV = nRT \Rightarrow n = \frac{PV}{RT} = \frac{1.5\,\cancel{atm} \times 8.56\,\cancel{L}}{0.0821\,\cancel{L\,atm}\,mol^{-1}\,\cancel{K^{-1}} \times 273\,\cancel{K}}$$

$n = 0.57$ moles H_2.

Ex. A sample of gas has P = 345 torr at t = −15 C & V = 3.48 L. If the conditions are changed so that t = 36 C° & P = 468 torr, what will be the change in volume?

$$PV = nRT \Rightarrow \frac{PV}{T} = nR = \text{constant}$$

$$\boxed{\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}} \Rightarrow \frac{(345\,\cancel{torr})(3.48\,L)}{(258\,\cancel{K})} = \frac{(468\,\cancel{torr})\,V_2}{(309\,\cancel{K})}$$

$V_2 = 3.07$ L $\Rightarrow \Delta V = V_f - V_i = 3.07 - 3.48 = -0.41$ L
Volume is decreased by 0.41 L.

The density & Molar mass of the ideal gas can be calculated also from the ideal gas law:

$$PV = nRT \Rightarrow PV = \frac{m}{M}RT \Rightarrow PM = \frac{m}{V}RT$$

$$\frac{m}{V} = d = \text{density} \Rightarrow PM = dRT$$

$d = \dfrac{PM}{RT} \Rightarrow$ M: Molar mass of the ideal gas (g/mol)
m: mass of the ideal gas (g)

d = density in unit of g/L

Also Molar mass: $M = \dfrac{dRT}{P} = \dfrac{g\,\cancel{L^{-1}}\,\cancel{L}\,\cancel{atm}\,mol^{-1}\,\cancel{K^{-1}}\,\cancel{K}}{\cancel{atm}} = g\,mol^{-1}$

ex an ideal gas at P = 730 torr
V = 350 mL, t = 25 C° has
a mass of 0.023 g
identify the gas
Molar mass = :
1) H_2O 2) O_2 3) N_2

$M = \dfrac{(m)RT}{PV}$ (gram) if density is unknown.

$M = \dfrac{dRT}{P}$ if density is known (!!)

5.5 Gas Stoichiometry:

One mole of any ideal gas at t = 0.0°C (273.15 K) & P = 1 atm will occupy (يأخذ) a volume = 22.4 L.

This volume is called molar volume = $\bar{V}$, and these conditio (0°C & 1 atm) is called Standard Temp. & Pressure (STP)

$(\bar{V})_{STP} = 22.4\ L/mole$. For the ideal gas.

Ex. A sample of N_2-gas has Volume = 1.75 L at STP. How many moles of N_2 are present?

$$1.75\,\cancel{L\text{-}N_2} \times \frac{1\,mole\ N_2}{22.4\,\cancel{L\,N_2}} = 7.81 \times 10^{-2}\ moles\ N_2$$

(Calculate no. of N_2-molecules ; Ans. = 4.7×10^{22} molecules N_2)

$$7.81 \times 10^{-2}\ moles\ N_2 \times \frac{6.023 \times 10^{23}}{1\,mole\ N_2} = 47.03 \times 10^{23}$$

تفكك

Ex. Calculate V_{CO_2} at STP produced from the decomposit of 152g $CaCO_3$ by the following rxn.: one ractant نفس

يجب أن تكون المعادلة موزونة

$$CaCO_{3(s)} \longrightarrow CaO_{(s)} + CO_{2(g)}$$

$$152g\ CaCO_3 \times \frac{1\ mole\ CaCO_3}{100.09g\ CaCO_3} \times \frac{1\ mole\ CO_2}{1\ mole\ CaCO_3} \times \frac{22.4L\ CO_2}{1\ mole\ CO_2} = 34.1\ L\ CO_2.$$

** $\boxed{\text{Ex.}}$ A sample of methane (CH_4) has $V = 2.80L$ at $t = 25°C$ & $P = 1.65$ atm, was mixed with O_2 that has $V = 35.0L$ at $t = 31$ & $P = 1.25$ atm. The mixture was ignited to form CO_2 & H_2O (composition) تفاعل الاحتراق. Calculate volume of CO_2 that is formed at $t = 125°C$ & $P = 2.50$ atm

ما بنحل بـ molar volume لأنها مش STP

لذلك بنحل بـ ideal gas low

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

$$PV = nRT \Rightarrow n_{CH_4} = \frac{PV}{RT} = \frac{1.65\,atm \times 2.80\,L}{0.0821\,L\,atm\,mol^{-1}K^{-1} \times 298\,K} = 0.189\ mole\ CH_4$$

(L.R.) limmeted reaction

$$n_{O_2} = \frac{1.25\,atm \times 35.0\,L}{0.0821\,L\,atm\,mol^{-1}K^{-1} \times 304\,K} = 1.75\ mole\ O_2$$

$$0.189\ mole\ CH_4 \times \frac{1\ mole\ CO_2}{1\ mole\ CH_4} = 0.189\ mole\ CO_2.$$

$$PV = nRT \Rightarrow V_{CO_2} = nRT/P = \frac{0.189\ mole \times 0.0821\ L\,atm\,mol^{-1}K^{-1} \times 398}{2.50\ atm}$$

$$V_{CO_2} = 2.47L$$

جزئي

5.6 Dalton's Law of Partial Pressures:

"For a mixture of gases in a container, the total pressure exerted is the sum of the pressures that each gas would exert if it were alone".

A B C

$$P_{tot.} = P_1 + P_2 + P_3 + \dots \qquad P_1: \text{Partial Pressure of gas 1}$$

$$= \frac{n_1RT}{V} + \frac{n_2RT}{V} + \frac{n_3RT}{V} + \dots = \frac{n_{tot.}RT}{V} = P_{tot.}$$

$P_{tot.}$ depends on the total no. of moles whatever the ideal gas

كمي (quantitative not نوعي qualitative property) (depends on amount not nature identity)

~~This leads to two important properties about the ideal:~~

~~(1) The volume for particles of the ideal gas must not be importa~~

~~(2) The forces among the particles must not be important too.~~

Ex. 46.0 L He at $t = 25°C$ & $P = 1.0$ atm & 12.0 L O_2 at 25°C & 1 atm were كانوا داخلين كل واحد وحطيناهم مع بعض pumped into a container with $V = 5.0$ L. Calculate the partial pressure of each gas in the container, at $t = 25°C$ / Ptotal ?

نستخدم هذا القانون عشان لا يتغير الغاز

$$\left(\frac{P_1 V_1}{T_1}\right)_{He} = \left(\frac{P_2 V_2}{\cancel{T_2}}\right)_{He} \Rightarrow \frac{1 \times 46}{\cancel{298K}} = \frac{P_2 \times 5}{\cancel{298K}} \Rightarrow P_2 = P_{He} = 9.2 \text{ at.}$$

$$\left(\frac{P_1 V_1}{T_1}\right)_{O_2} = \left(\frac{P_2 V_2}{T_2}\right)_{O_2} \Rightarrow \frac{1 \times 12}{\cancel{298}} = \frac{P_2 \times 5}{\cancel{298}} \Rightarrow P_2 = P_{O_2} = 2.4 \text{ atm}$$

$$P_{tot.} = 2.4 + 9.2 = 11.6 \text{ atm}$$

OR: $PV = nRT \Rightarrow n_{He} = P_1V_1/RT_1 = (1 \times 46)/(0.0821 \times 298) = 1.9$

$P_2V_2 = n_{He}RT_2 \Rightarrow P_{He} = n_{He}RT_2/V_2 = (1.9 \times 0.0821 \times 298)/5 = 9.2$

$n_{O_2} = P_1V_1/RT_1 = (1 \times 12)/(0.0821 \times 298) = 0.49$ mole O_2

$P_{O_2} = n_{O_2}RT_2/V_2 = (0.49 \times 0.0821 \times 298)/5 = 2.4$ atm

* **Mole fraction: X_i**

The ratio of no. of moles of a given component in a mixture the no. of moles of the mixture.

$$\boxed{X_1 = \frac{n_1}{n_{tot.}} = \frac{n_1}{n_1 + n_2 + \dots}} \text{ —— } 3$$

Unitless

$$\chi_1 = \frac{n_1}{n_1+n_2+\cdots} = \frac{P_1(V/RT)}{P_1(V/RT)+P_2(V/RT)} = \frac{P_1}{P_1+P_2+\cdots}$$

$$\boxed{\chi_1 = \frac{n_1}{n_{tot.}} = \frac{P_1}{P_{tot.}}} \qquad \chi \text{ is unitless}$$

$$\begin{cases} \chi_1+\chi_2+\chi_3 = 1 \\ 0 \le \chi_1 \le 1 \\ 0 \le \chi_2 \le 1 \\ 0 \le \chi_3 \le 1 \end{cases}$$

Ex. The mole fraction of N_2 in air is 0.7808. Calculate the partial pressure of N_2 at sea level. (1 atm)

الضغط الجوي ويساوي ويمثل P_{tot}
عند سطح البحر

$$\chi_{N_2} = 0.7808 = \frac{P_{N_2}}{P_{tot.}} = \frac{P_{N_2}}{P_{atm}} = \frac{P_{N_2}}{1.0\,atm} \quad (\text{sea level } P = 1.0\,at$$

$$\Rightarrow P_{N_2} = 0.7808\ atm = 593\ torr.$$

$\underset{limit}{Mg} + \underset{exis}{HCl} \longrightarrow MgCl_2 + H_2$

* Collection of gas over water:

In some experiments, gases are collected over water & du to water has vapor pressure, the pressure over water will b

$$\underset{\text{in the container}}{\boxed{P_{tot.}}} = P_{H_2O} + P_{gas.} \qquad (\underline{\text{not}} \text{ the gas only over water})$$

Ex. A sample of $KClO_3$ was heated in a test tube and decomposed according to the following chemical equation:

$$\underset{??\,g}{2KClO_{3(s)}} \longrightarrow 2KCl_{(s)} + 3O_{2(g)}$$

The O_2 was collected over water at $t = 22°C$ & $P_{tot.} = 754$ torr.
$V_{O_2} = 0.650L$ & P_{H_2O} (Vapor pressure of water) = 21.0 torr at $t = 22°C$
الضغط البخاري
Calculate required mass of $KClO_3$.

ideal gas بنحل ع
stp عند ظروف

$P_{tot.} = 754 \text{ torr} = P_{H_2O} + P_{O_2}$

$P_{O_2} = 754 - P_{H_2O} = 754 - 21 = 733 \text{ torr}$

$$PV = nRT \Rightarrow n_{O_2} = PV/RT = \frac{(733/760)\text{atm} \times 0.650 \text{ L}}{0.0821 \text{ L atm mol}^{-1} \text{K}^{-1} \times 295 \text{ K}}$$

$n_{O_2} = 2.59 \times 10^{-2} \text{ mole } O_2$

$$2.59 \times 10^{-2} \text{ mole } O_2 \times \frac{2 \text{ mole } KClO_3}{3 \text{ mole } O_2} \times \frac{122.6 \text{ g } KClO_3}{1 \text{ mole } KClO_3} = \underline{2.12 \text{ g } KClO_3}$$

Diffusion كل ما زاد MM تقل
molar mass بيعتمد على

5.7: The Kinetic Molecular Theory of Gases:

انتشار - Diffusion: Term used to describe the mixing of gases.
تسرب - Effusion: Term used to describe the process by which a gas under a pressure escapes from container to another through small opening.

Thomas Graham found experimentally that the rate of diff. of gas is inversely proportional to the square root of the mass of its particles.

Effusion

$$\frac{\text{Rate of diff. of gas 1}}{\text{Rate of diff. of gas 2}} = \frac{\sqrt{M_2}}{\sqrt{M_1}}$$ (Graham's Law of eff)

M_1 & M_2: Molar mass of gases 1 & 2.

Ex. Calculate the ratio of diff. of H_2 to UF_6

$$\frac{\text{Rate diff. } H_2}{\text{Rate diff } UF_6} = \frac{\sqrt{352.02}}{\sqrt{2.016}} = 13.2$$ which means rate of diff. of H is 13.2 times of UF_6

which on of the following statment of A
if you have 1 mole B & 2 mole A

limiting B

A) A is L.R & B exces
B) A is exeses and B L.R

Which one of the following has highest rate of diffusion/Effu
a) O_2 b) N_2 c) H_2
d) Ar e) CO_2 (Molar mass اقل)

Which one of the following arigment is correct in order of the dec of rate of diffusion/Effusion

Calculat ration of diffution of A to B يعني $\boxed{\frac{A}{B}}$

Which one of the following statement is corrict with respect to rate of diff of H_2 to UF_6?
a) rate of eff of H_2 is 13 tims of UF_6

If rate of diff/Eff of gas H_2 18 times gas X Identify X
a) CO_2
b) N_2
c) O_2
d) Ar
e) Ne

X ...

$\frac{\text{rate } H_2}{\text{rate } X} = 18 = \frac{\sqrt{M_X}}{\sqrt{2}}$

$M_X =$

$\frac{H_2}{X} = \frac{\sqrt{M_X}}{\sqrt{2}} = 18$

18