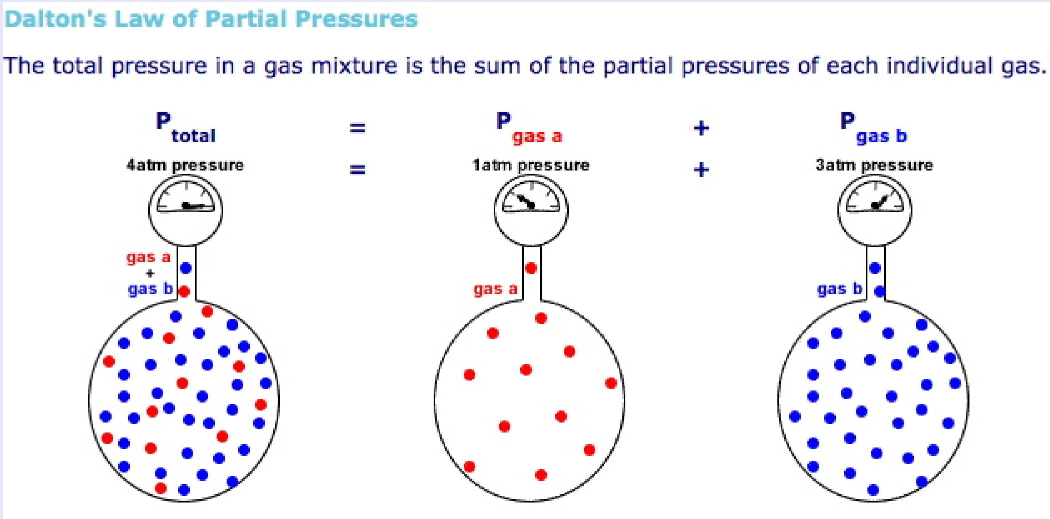
# Equilibrium Constant, $K_p$

## using partial pressures




May 5-8:41 PM

## Writing Equilibrium Constants:

$A_{(aq)} + 2B_{(l)} + 3C_{(g)} \rightarrow 4D_{(s)} + 5\,F_{(aq)}$

$$K_c = \frac{[F]^5}{[A]^1[C]^3}$$ (g) and (aq)

$$K_p = \frac{1}{[P_C]^3}$$ gas only

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

$$K_p = \frac{(P_{SO_3})^2}{(P_{SO_2})^2 \times P_{O_2}}$$

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

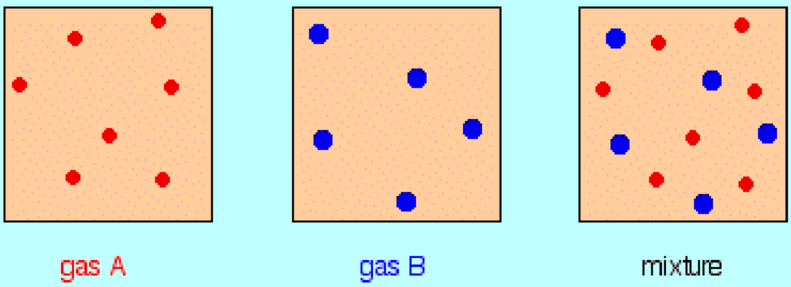
$$K_p = \frac{(P_{NH_3})^2}{P_{N_2} \times (P_{H_2})^3}$$

# Use partial pressures to determine $K_p$

## Dalton's Law of Partial Pressures

the partial pressure of one of the gases in a mixture is
the pressure which it would exert if it alone occupied the whole container.

$$\text{Total pressure } P = P_A + P_B + P_C + \ldots$$




Pressure is due to the collisions on the walls

How do we calculate partial pressure?

mole fraction of the gas

$$x_A = \frac{\text{number of moles of gas A}}{\text{total number of moles of gas}}$$

At 200 atm, a mixture is made of

20 mol $N_2$, 60 mol $H_2$, and 20 mol $NH_3$

$P_A$ = mole fraction of A x total pressure

$P_A = x_A \times P$

| gas | mole fraction | partial pressure |
|---|---|---|
| nitrogen | 20/100 = 0.2 | 0.2 x 200 = 40 atm |
| hydrogen | 60/100 = 0.6 | 0.6 x 200 = 120 atm |
| ammonia | 20/100 = 0.2 | 0.2 x 200 = 40 atm |

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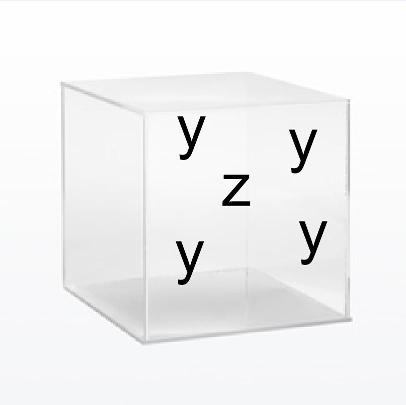
# $K_p$ and Partial Pressure

reaction vessel - cube




2 L

2 atm

273 $^0$C

contains 4 y and 1 z (gas)

partial pressures of z and y

mole fraction= $\frac{\text{mol z}}{\text{total mol}}$

z: $\frac{1}{5}$ $P_z$= 0.2 x 2 atm = 0.4 atm

y: $\frac{4}{5}$ $P_y$= 0.8 x 2 atm = 1.6 atm

Dalton's Law of Partial Pressures

we can calulate P from the number of moles from

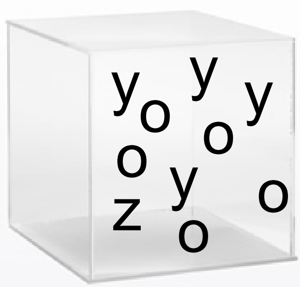
PV=nRT

partial pressure (P) — partial mols (n)

$$P_z = \frac{n_z RT}{V} = \frac{n_z(0.0821)(273K)}{2L}$$

Examples:

**add 5 o particles**



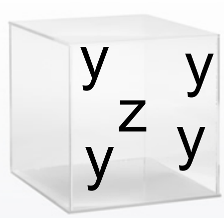

same container
2 L
273 $^0$C
contains 4 y, 1 z, **5 o**

$$P = \frac{nRT}{V}$$

Pressure?

$P_z$ = 0.4 atm
$P_y$ = 1.6 atm
+ $P_o$ = 2 atm
total = 4 atm

**Half the volume:**




**1 L**
273 $^0$C
contains 4 y and 1 z

same

$$P_z = \frac{n_z RT}{V}$$

half

pressure? 4 atm
$P_z$ = 0.8 atm
$P_y$ = 3.2 atm

$P_x V = P_x V$