Gases in chem. rxns ~ STOICHIOMETRY revisited!

- can use ideal gas eq ($pV = nRT$) to calculate:

n_{gas}, P_{gas}, V_{gas} } for gases used-up or produced in a chem rxn!

ex: Synthesis of methanol: CH_3OH

$$CO(g) + 2H_2(g) \longrightarrow CH_3OH(g)$$

Q: What vol. of $H_2(g)$ in liters @ 355K and a pressure of 738 mmHg is needed to make 35.7g CH_3OH ?

10/26/18

$$CO(g) + 2H_2(g) \longrightarrow CH_3OH(g)$$

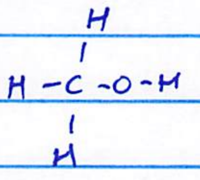
$$? \text{ mol } H_2 \xleftarrow{\text{coeff.}} ? \text{ mol } CH_3OH$$

$pV = nRT$

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

? mol H_2 → ideal gas eq ($V = nRT/p$) → ? L

35.7g CH_3OH → molar mass CH_3OH → ? mol CH_3OH



CH_3OH

$1 \times C = 12.01$

$4 \times H = 4 \times 1.008$

$1 \times O = 16.00$

$\underline{32.04 \text{ g/mol}}$

$$\frac{35.7\text{g } CH_3OH}{} \left| \frac{1 \text{ mol } CH_3OH}{32.04\text{g } CH_3OH} \right| \frac{2 \text{ mol } H_2}{1 \text{ mol } CH_3OH} =$$

2.2285 mol $H_2(g)$

$2.2285 \, mol \; H_2(g)$

@ 355K

@ 738mmHg ⇝ $p = 738 \, mmHg \times \frac{1 \, atm}{760 \, mmHg}$

V ? (liters)

$R = 0.08206 \, \frac{atm \cdot L}{mol \cdot K}$

$= 0.971 \, atm$

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

$$V = \frac{2.2285 \, \cancel{mol} \times 0.08206 \, \frac{\cancel{atm} \cdot L}{\cancel{mol} \cdot \cancel{K}} \times 355 \, \cancel{K}}{0.971 \, \cancel{atm}}$$

$= 66.9 \, L$ (3s.f.)

Kinetic Molecular Theory (KMT)

model of ideal gas

gas: 1) made of small particles
2) in constant, chaotic motion
3) with an averge KE $\propto$ Temp (K)
4) collide elastically (no E loss upon collision)

- can derive $pV = nRT$ from this!
- with math + physics, can predict things like...

ex:

$$\bar{v} = \sqrt{\frac{3RT}{\mathcal{M}}}$$

$\mathcal{M}$ = molar mass (kg/mol)

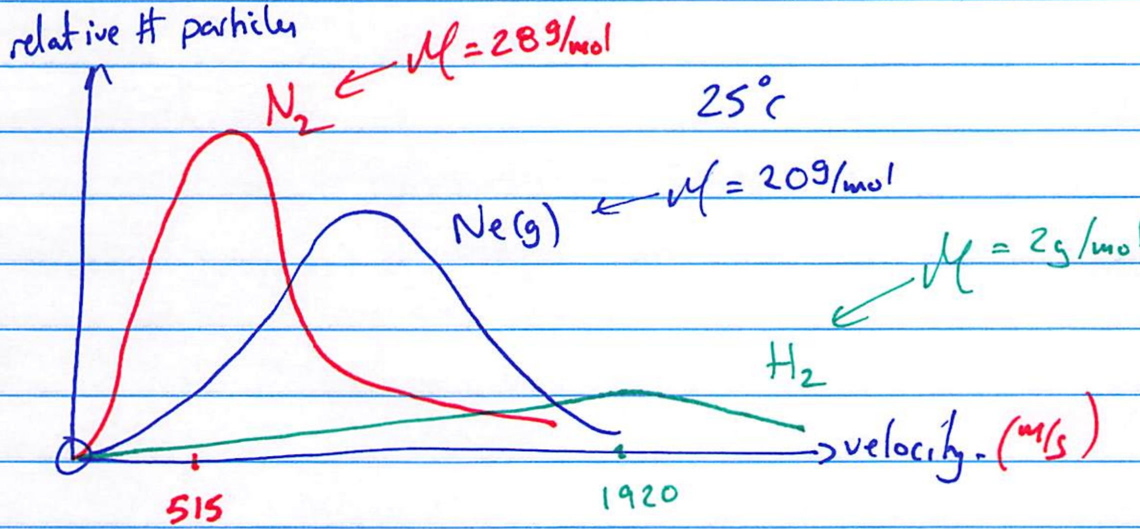
$R = 8.3145\ \text{J/mol·K}$

(note: $1\text{J} = 1\text{kg m}^2/\text{s}^2$)

can show: N_2 @ 298K has $\bar{v} = 515\ \text{m/s}$ (1152 mph)

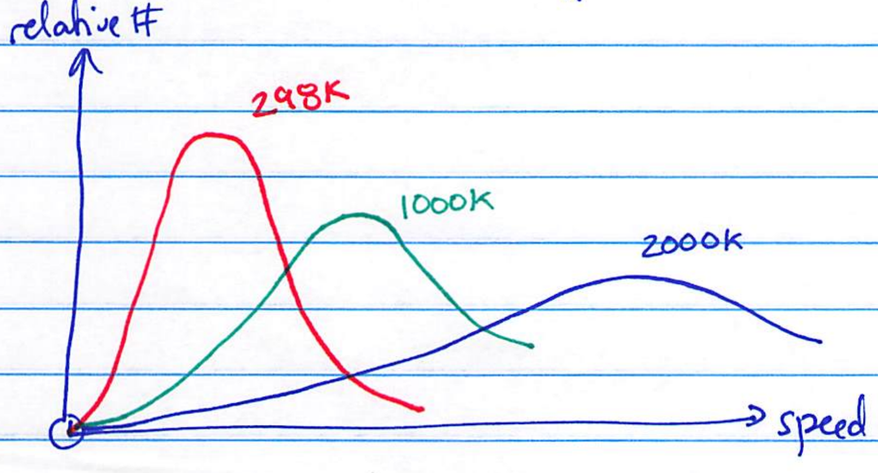
H_2 @ 298K has $\bar{v} = 1920\ \text{m/s}$ (4295 mph)

Maxwell - Boltzmann distribution



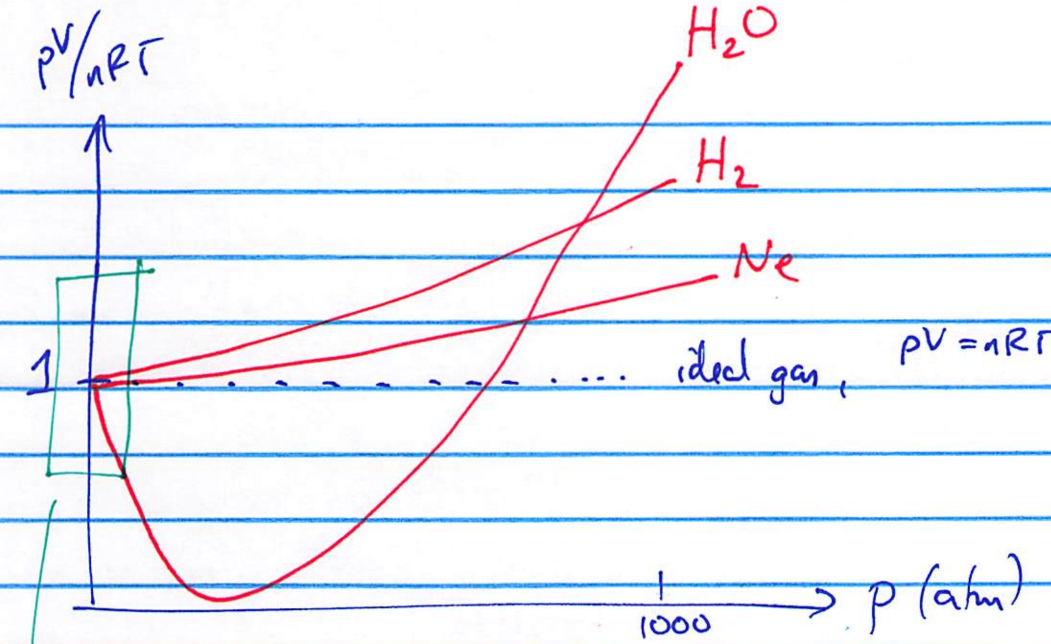
$SF_6(g)$

Can also see how T affects dsn:



Real Gases vs ideal.

ideal gas law: $\frac{pV}{nRT} = \frac{nRT}{nRT} \Rightarrow \frac{pV}{nRT} = 1$



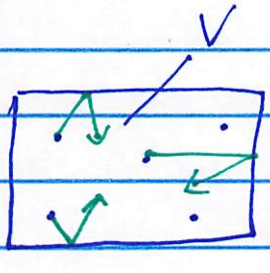
low p: ≈ ideal

high p

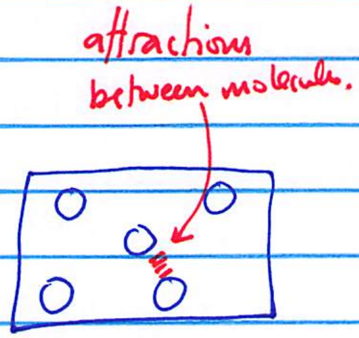
$pV \neq nRT$

Real gases

ideal gas:



real gas:



particles have no volume themselves!	particles <u>have</u> volume!
- move around in total vol, V	- move around in a reduced volume: $V - \text{vol. of gas molecules}$.
- no attraction between particles: p	- lower pressure, because molecules are attracting one-another.