REAL GASES

- The empirical gas laws (including the ideal gas equation) do not always apply.
  - The gas laws don't apply in situations where the assumptions made by kinetic theory are not valid.
    - When would it be FALSE that the space between gas molecules is much larger than the molecules themselves?
      - at high pressure, molecules would be much closer together!
    - When would it be FALSE that attractive and repulsive forces would be negligible?
      - at high pressure, attractions and repulsions should be stronger!
      - at low temperature, attractions and repulsions have a more significant affect on the paths of molecules

-The gas laws are highly inaccurate near the point where a gas changes to liquid!

- In general, the lower the pressure and the higher the temperature, the more IDEAL a gas behaves.

van der Waals equation

- an attempt to modify PV = nRT to account for several facts.
  - gas molecules actually have SIZE (they take up space)
  - attractive and repulsive forces

$$PV = nRT$$ Ideal gas equation

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$$ van der Waals equation

$\frac{n^2 a}{V^2}$: attempts to account for attractive / repulsive forces

nb: attempts to account for molecular size

* "a" and "b" are experimentally determined parameters that are different for each gas.

p211

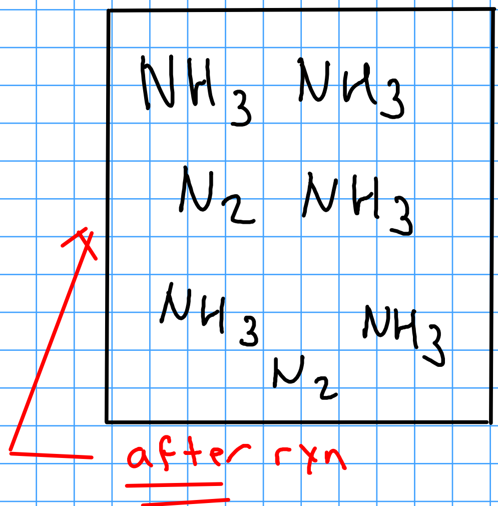
He: $a = 0.0346$, $b = 0.0238$ tiny, no special attractive forces

H_2O: $a = 5.537$, $b = 0.03049$ small, but polar and H-bonding

CH_3CH_2OH: $a = 12.56$ $b = 0.08710$ larger, and polar / H-bonding

Practice problems from the textbook:

#3.13 p 114



a) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

b) Hydrogen is limiting, because there's none left after the reaction is done. Some nitrogen still remains!

c) Six. We have two nitrogen molecules remaining, and because of the stoichiometry, each nitrogen molecule requires three hydrogen molecules to react.

#3.19 p115

b) Find moles K^+ in 2.5 mol K_2SO_4:

$$2.5 \text{ mol } K_2SO_4 \times \frac{1 \text{ mol } K^+ \text{ ions}}{1 \text{ mol } K_2SO_4} \times \frac{6.022 \times 10^{23}\ K^+ \text{ ions}}{1 \text{ mol } K^+ \text{ ions}} = \ldots$$

Find the problem with this solution and fix it!

This should be a "2"!

K_2SO_4 : K^+ K^+ SO_4^{2-}

#3.79, p 118

$$WO_3 + 3H_2 \longrightarrow W + 3H_2O$$

How much W can be obtained from 4.81 kg of hydrogen gas and excess tungsten(IV) oxide?

$10^3\ g = kg$ $2.016\ g\ H_2 = 1\ mol\ H_2$ $3\ mol\ H_2 = 1\ mol\ W$

$$4.81\ kg\ H_2 \times \frac{10^3\ g}{kg} \times \frac{1\ mol\ H_2}{2.016\ g\ H_2} \times \frac{1\ mol\ W}{3\ mol\ H_2} \times \frac{183.84\ g\ W}{1\ mol\ W} = 146208.73\ g\ W$$

$$= \boxed{1.46 \times 10^5\ g\ W}$$

$183.84\ g\ W = 1\ mol\ W$

* "excess": This means that you have more than enough tungsten(IV) oxide to completely react away all the hydrogen. Since hydrogen is the limiting reactant, we calculate the answer based on the hydrogen.

#3.105

$$CaO + 3C \rightarrow CaC_2 + CO$$

Given 2.60 kg of each reactant (CaO and C), how many grams of calcium carbide can be produced?

CaO: 56.08 g/mol C: 12.01 g/mol CaC_2: 64.10 g/mol

① $$2600\ g\ CaO \times \frac{mol\ CaO}{56.08\ g\ CaO} \times \frac{1\ mol\ CaC_2}{1\ mol\ CaO} \times \frac{64.10\ g\ CaC_2}{mol\ CaC_2} = \boxed{2971.8\ g\ CaC_2}$$

② $$2600\ g\ C \times \frac{mol\ C}{12.01\ g\ C} \times \frac{1\ mol\ CaC_2}{3\ mol\ C} \times \frac{64.10\ g\ CaC_2}{mol\ CaC_2} = 4625.6\ g\ CaC_2$$

CaO is limiting, so **2970 g CaC_2 produced**

41.32, p 167

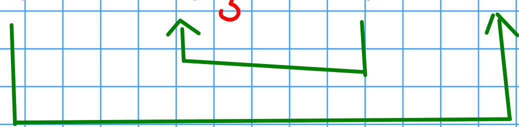
a) $AgNO_3 + NaI \longrightarrow AgI_{(s)} + NaNO_3$ molecular

$Ag^+ \quad NO_3^- \qquad Na^+ \quad I^-$

$Ag^+ + I^- \longrightarrow AgI_{(s)}$ net ionic

b) $Ba(NO_3)_2 + K_2SO_4 \longrightarrow BaSO_{4(s)} + 2KNO_3$

$Ba^{2+} \quad NO_3^- \quad K^+ \quad SO_4^{2-}$



$Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_{4(s)}$

c) $Mg(NO_3)_2 + K_2SO_4 \rightarrow$ ~~$MgSO_4 + 2KNO_3$~~ NO REACTION

Mg^{2+} NO_3^- K^+ SO_4^{2-}

d) $3CaCl_2 + 2Al(NO_3)_3 \rightarrow$ ~~$2AlCl_3 + 3Ca(NO_3)_2$~~ NO REACTION

Ca^{2+} Cl^- Al^{3+} NO_3^-

$HCl + NaOH \rightarrow H_2O + NaCl$

H^+ Cl^- Na^+ OH^-

Formation of water molecule (NOT the formation of a solid) drives this reaction. Observation: heat

Other molecules may form. We discussed hydrogen sulfide and carbonic acid previously.