Real gases ... have volume + attractions!

van der Waals eq: $\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT$

a, b - different for each gas!

- look up in text!

$H_2O(g)$ $a = 5.46 \frac{L^2 \cdot atm}{mol^2}$, $b = 0.0305 \frac{L}{mol}$

Q: What's p (ideal) for 14.0 g $H_2O(g)$ @ 130. °C (t) and 0.500 L ?

Q: What's p (vdw) ...

ideal: $pV = nRT$, $R = 0.08206 \frac{atm \cdot L}{mol \cdot K}$

$$p = \frac{nRT}{V} = \frac{0.777\,mol \times 0.08206 \frac{atm \cdot L}{mol \cdot K} \times 403\,K}{0.500\,L} = 51.4\,atm$$

$$n = \#mol = 14.0\,g\,H_2O \times \frac{1\,mol\,H_2O}{18.02\,g\,H_2O} = 0.777\,mol\,H_2O$$

$T = t/°C + 273.15 = 130. + 273.15 = 403\,K$

(0dp) (2dp.) (0 d.p.)

vdw: $\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT \rightarrow p + \frac{an^2}{V^2} = \frac{nRT}{V - nb}$

$(V - nb)$ $(V - nb)$ $-\frac{an^2}{V^2}$ $-\frac{an^2}{V^2}$

$$\rightarrow p = \frac{nRT}{V - nb} - \frac{an^2}{V^2}$$

$$p = \frac{nRT}{V-nb} - \frac{an^2}{V^2}$$

$n = 0.777\,mol$

$T = 403\,K$

$V = 0.500\,L$

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

$a = 5.46\ \frac{L^2 \cdot atm}{mol^2}$

$b = 0.0305\ L/mol$

$$p = \frac{0.777\,mol \times 0.08206\ \frac{atm \cdot L}{mol \cdot K} \times 403\,K}{0.500\,L - 0.777\,mol \times 0.0305\,L/mol} - \frac{5.46\ \frac{L^2 \cdot atm}{mol^2} \times (0.777\,mol)^2}{(0.500\,L)^2}$$

$= 53.95\,atm - 13.19\,atm = 40.8\,atm$ (vdW)

XPT: 41.5 atm

compare: 51.4 atm (ideal)

Ch 7 – Thermochemistry

2 kinds of E → KE (movement), Kinetic E, $\frac{1}{2}mv^2$
→ PE (position), potential E

PE: chemical energy (one form)
- position of atoms.

SI unit of energy: Joule (J)
1 calorie = 4.184 J

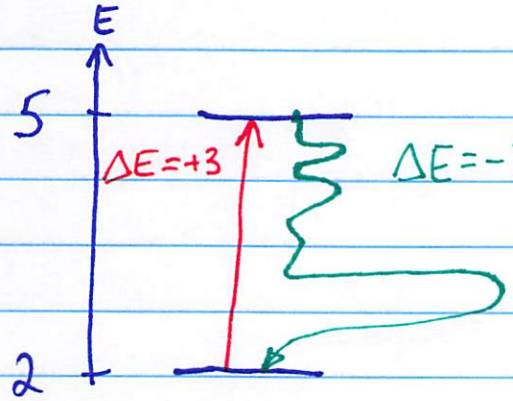
1st law of thermodynamics: total E of universe = constant
(energy cannot be created nor destroyed)

E: state function
- only depends on current state, not history.

ΔE = change in energy
- only depends on init + final states, not path!

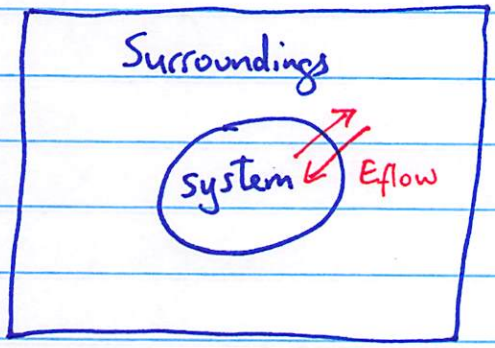
Δ = Differences
Changes

$E_{final} - E_{initial}$



UNIV:

UNIV = SYS + SURR



$\Delta E_{SYS} = -\Delta E_{SURR}$ (1st law)

ex: $\Delta E_{SYS} = +5\,J$ (gains 5 J)
$\Delta E_{SURR} = -5\,J$ (loses 5 J)
} $\Delta E_{UNIV} = \emptyset$

2 ways of Energy flow:
(1) HEAT (temp difference).
(2) WORK (force difference)

Measuring heat

$\therefore$ heat $\propto \Delta T$

$q \propto \Delta T$ (if +ve, energy enters/gained
if -ve, energy leaves/lost)

$q = C \cdot \Delta T$

- q: heat
- C: heat capacity (extensive) .... heat required to raise temp by 1°C or 1K.
- ΔT: change in temp: $\Delta T = T_f - T_i$

Specific heat capacity, C_s (intensive)

- heat required to raise 1g of a substance by 1°C or 1K.

$$q = m \cdot C_s \cdot \Delta t$$

C

Ag: $C_s = 0.235\ J/g \cdot °C$

Calculate q_{Ag} if a 17.3g sample changes temp from 25.1°C to 137.8°C.

$$q = m \cdot C_s \cdot \Delta t = 17.3\,g \times 0.235\ \frac{J}{g \cdot °C} \times 112.7\,°C$$

$$\Delta t = t_F - t_I = 137.8°C - 25.1°C = +112.7°C$$

$$= +458\ J$$