P. Chem I Lecture Notes 1/23/23

1st Law = $\Delta U = q + w$ (P, V) is a state function

- ΔU: (internal) energy (energy of system)
- q: Thermal energy
- w: work

ΔU only depends on the initial and final conditions (not path)

$$\Delta U = U_f - U_i = \int_{U_i}^{U_f} dU$$

Constant V

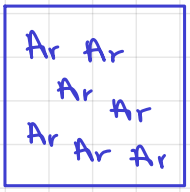
$$w = -P_{ext}\, dV = 0$$

$$\boxed{\Delta U = q_v}$$

define $C_v = \frac{q}{\Delta T}$ how much energy needs to be put into system to raise it by 1 degree. $= \left(\frac{\Delta U}{\Delta T}\right)_V = C_V$ larger C_v, more capacity to store energy

ideal gas - monatomic Ar

* remember: ideal gas means particles do not "see" each other. They do not interfere with each other.



can move in (x, y, z), store energy in each

3 degrees of freedom = 3 translational motions

$U = 3 \cdot \frac{1}{2} k_B T$ (per particle)

$= \frac{3}{2} RT$ (per mole) ($k_B \cdot N_a = R$)

$$\frac{C_v}{\partial T} = \frac{3}{2} R \frac{T}{dT} = \boxed{\overline{C_v} = \frac{3}{2} R}$$

differentiate with respect to T

---

ideal gas - diatomic H_2

↓ still not interacting

3 translational d.o.f → $3 \frac{1}{2} RT$ per mole

2 rotational d.o.f → $2 \frac{1}{2} RT$ per mole

1 vibrational d.o.f → complicated but roughly 0 (can be 2)

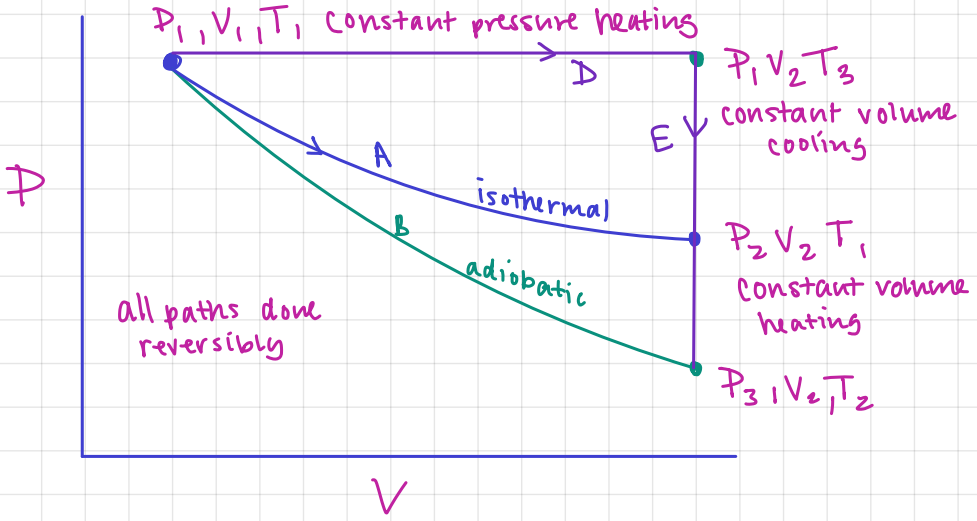
(both potential and kinetic; can't store energy)

(can be 7/2 if access to vibrations)

$C_v = \frac{5}{2} R$ or can be $\frac{7}{2} R$

* for HW, assume 5/2 ignore 7/2

Figure 19.5 from book



Path A $w = -P_{ext}\,dV \overset{\text{rev}}{=} -P\,dV = -\int_{V_1}^{V_2} P\,dV = -\int_{V_1}^{V_2} \frac{nRT}{V}\,dV = -nRT_1 \int_{V_1}^{V_2} \frac{dV}{V} = -nRT_1 \ln\left(\frac{V_2}{V_1}\right)$

$U = \frac{3}{2} nRT_1$

$q + w = \Delta U = 0 \Rightarrow q = -w = nRT_1 \ln\left(\frac{V_2}{V_1}\right)$

Path B adiabatic $q = 0$ (vacuum or styrafoam on system)
↳ so it doesn't absorb heat from surrounding

$w = \Delta U = \frac{3}{2} nR(T_2 - T_1)$

Path C: $w = 0$ ↳ when $P_{ext} = 0$ or $\Delta V = 0$ $\quad q = \Delta U = \frac{3}{2} nR(T_1 - T_2)$

} important: initial, final

Path B & C rely on either w or q being 0