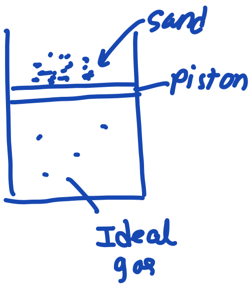
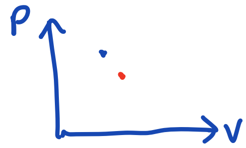



Gas has P & V, represented by a point in graph




State of gas at macroscopic level

↓

P & V tells whole story of gas

No need for T

T can be derived from $PV = nRT$ ← EOS

To change state, Cannot change quickly, remove lot of sand, piston will fly off → No equilibrium.

↘ different $\rho$, P

All points on diagram represent an equilibrium

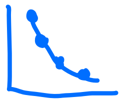
Slow enough to follow : Remove 1 grain, ↑V ⇒ ↓P (small)

(Quasi static) reversible

↓

Never deviate from eq.

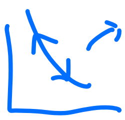
↓



↓

Gas follows a path (always near eq.)

reversible : Put/remove grain



Go up or down.

At Every point in PV. Gas has internal Energy U.

↖ State Variable.

↳ Only at desired points

No need to know prior history

$U = \frac{3}{2}NkT = \frac{3}{2}nRT = \frac{3}{2}PV$

U is uniquely determined by PV

U is $\frac{1}{2}mv^2$ for each molecule

Add all up get Total Energy.

Change IE : $\Delta U = U_2 - U_1$

$= \Delta Q - P\Delta V$

$= \Delta Q - \Delta W$

$\underline{\underline{U}} = \frac{3}{2}\underline{\underline{NkT}} = \frac{3}{2}\underline{\underline{nRT}} = \frac{3}{2}PV$

$E_k$ of molecule

Energy Internal depends only on T (or PV product)

U

Asking how to change U ≃ How to raise T

① Put on hot plate (heat up gas) → Cannot See (microscopic)

molecular

$\Delta Q$

Molecule hot plate ↑$E_k$ → transf. to Gas

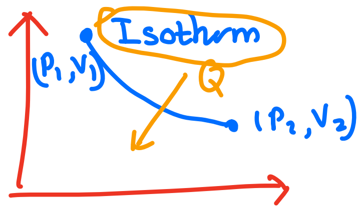
Archaic Caloric fluid. (Add heat to gas)

$-\Delta W$ : Wd on gas : Push down on piston $\Delta V = -ve$
$\Rightarrow -P\Delta V = +ve$
$\Rightarrow \uparrow U$

Take grain of sand: Piston move up, gas Work against surr.
pays from U.

↑ Can see (Macroscopic)

1st Law : $\Delta U = \Delta Q - P\Delta V$




$$W = \int_{V_1}^{V_2} P(V)\, dV$$

$$= nRT \int_{V_1}^{V_2} \frac{dV}{V}$$

$$= nRT \ln\left|\frac{V_2}{V_1}\right|$$

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

$U_2 - U_1 = 0$

$\Delta U = 0$ (Const. T on Isotherm)

U depends on T

$\Rightarrow \boxed{\Delta Q = \Delta W}$

WD by gas = heat input by gas

Isothermal

Take piston place it on plate at temp. $T_1$ (stuck at temp. $T_1$)

Remove grain of sand (Expand)

Expansion would cause it to cool down.
But it does not as We are pumping heat from hot plate $T_1$ constantly.

Deadbeat
When pumping quickly cools down can.
If slow enough, T remains constant.

$\Rightarrow \delta W$ (WD against atmosphere) is paid by $\Delta Q$ from plate.

Universe cools down → Expansion.

At constant T $\Rightarrow \Delta U = 0$

$\Rightarrow$ U lost by doing work is equal to U gained as Q from hot plate.

U is a function of T.

# Specific heat