FIRST LAW – THERMODYNAMIC PROCESSES

For simplicity we are going to assume that our system consists of a perfect gas. Quantity will be n mols so

$$PV = nRT.$$

First law tells us that

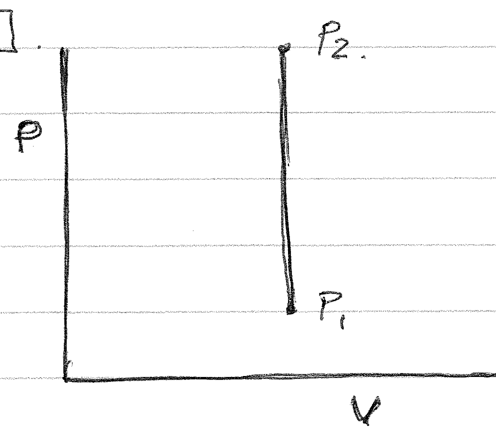
$$DQ = dU + DW$$

and U is a function of T only.

Monoatomic gas $U = \frac{3}{2} nRT$ (MA)

Diatomic gas $U = \frac{5}{2} nRT$ [near 300 K] (DA).

I: Constant Volume [ISOCHORE].



Here $DW = 0$.

so

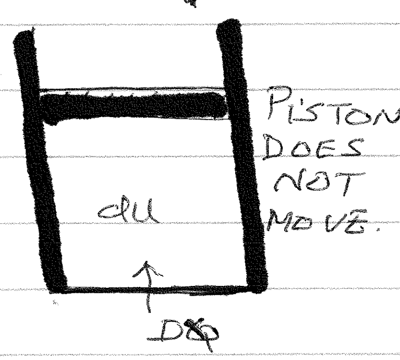
$$DQ = dU$$
$$= \frac{3}{2} nR\Delta T$$

Specific Heat

$$C_V = \left.\frac{DQ}{\Delta T}\right)_V = \frac{3}{2} nR.$$

C_V per mol is $\frac{3}{2} R$. (MA).

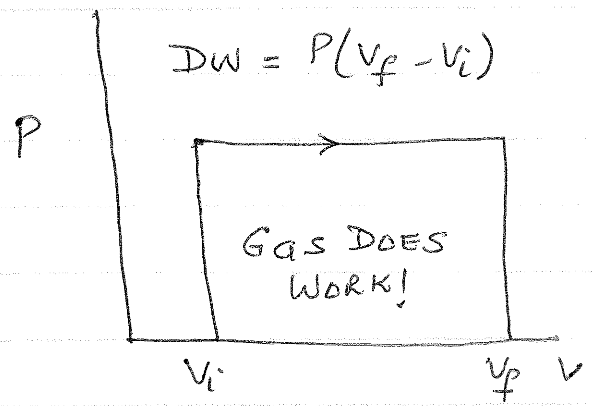
$\frac{5}{2} R$ (DA).

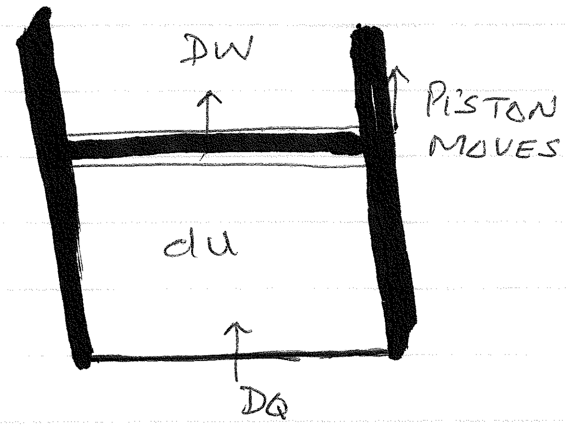


N.B. As V is Const. $\frac{P_2}{P_1} = \frac{T_2}{T_1}$.

II Constant Pressure [P = Const.].

$$DQ = dU + P\Delta V = \frac{3}{2} nR\Delta T + P\Delta V$$





$$PV = nRT$$

$$(P+\Delta P)(V+\Delta V) = nR\Delta T$$

$$P\Delta V + V\Delta P = nR\Delta T \qquad [\Delta P \Delta V \text{ negligible}].$$

$$\Delta P = 0, \quad P\Delta V = nR\Delta T$$

So $\quad DQ = \frac{3}{2} nR\Delta T + nR\Delta T \qquad (MA)$

specific heat

$$c_p = \left(\frac{DQ}{\Delta T}\right)_P = \frac{5}{2} nR.$$

c_p per mol $= (5/2)R \quad (MA) \qquad [c_p - c_v = R].$

$\qquad = (7/2)R \quad (DA).$

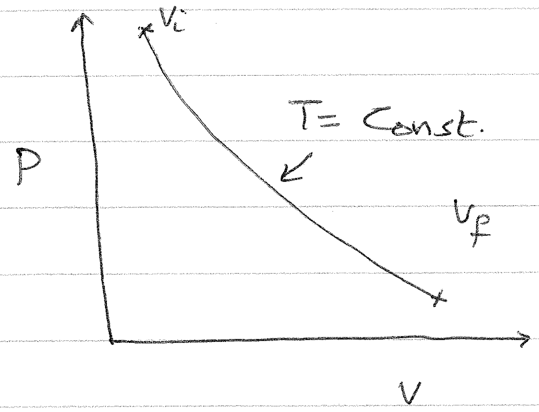
<u>NOTE</u>: c_p ALWAYS LARGER THAN c_v!

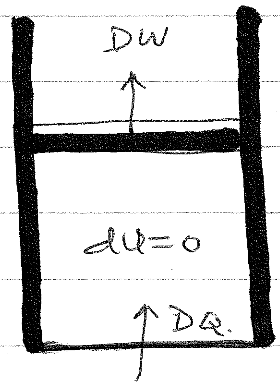
Define $\gamma = \frac{c_p}{c_v}$, always $\underline{\underline{> 1}}$

<u>III</u> <u>ISOTHERM</u>: TEMPERATURE IS CONST.

$$P \propto \frac{1}{V}.$$

$$du = 0$$

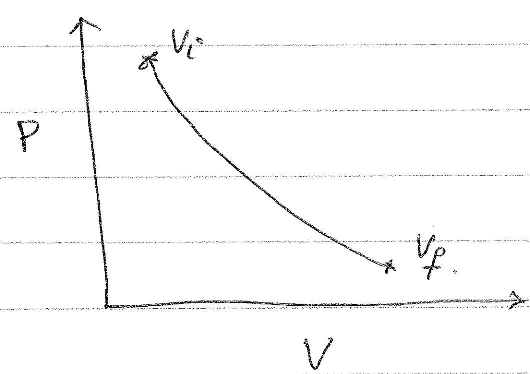


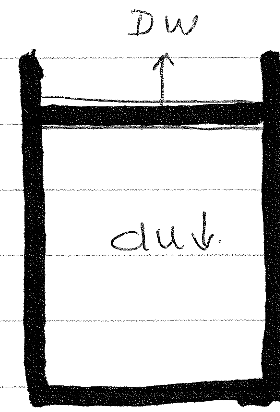


$P \propto \frac{1}{V}$ SO ISOTHERM MUST HAVE NEGATIVE SLOPE IN P vs V DIAGRAM.

$$DQ = nRT \ln (V_f / V_i)$$

IV ADIABATIC [DQ = 0].





IF GAS EXPANDS IT MUST COOL DOWN BECAUSE DW COMES FROM dU

$$0 = dU + P\Delta V$$

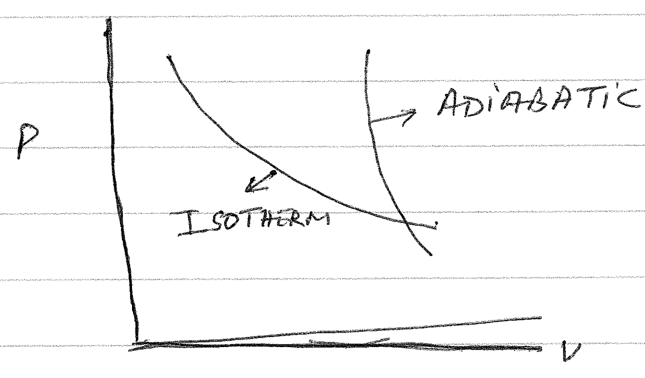
Implies:

$$PV^{\gamma} = \text{Const.} \qquad \gamma > 1$$

or

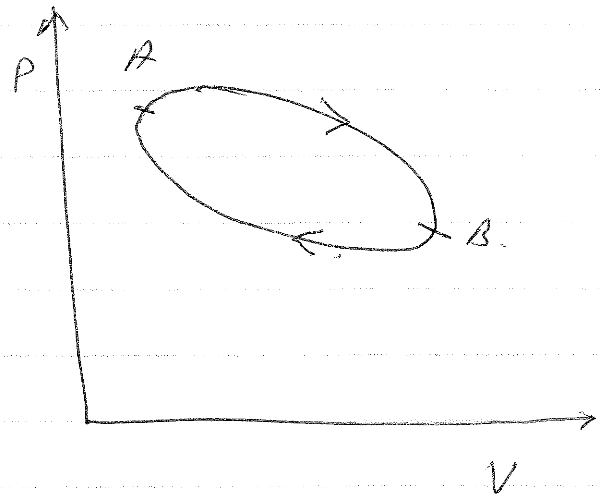
$$TV^{\gamma - 1} = \text{Const.}$$

n.B.



$\gamma > 1$
ADIABATIC must be STEEPER.

V Cyclic Process



Since dU is independent of path

$dU = 0$

for a closed loop

so

$DQ = DW.$

For the cycle shown

A → B Gas does work.

B → A You do work.

Gas does more work than you do so ~~the~~ you must <u>ADD</u> heat into the system to carry out this cycle.