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.

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

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

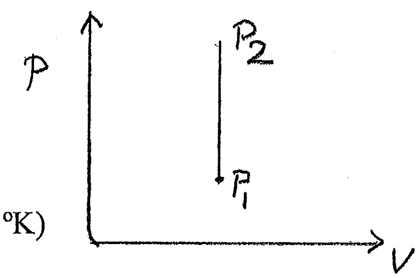
I: Constant Volume $[ISOCHORE]$

Here DW = 0

So

$$DQ = dU$$

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

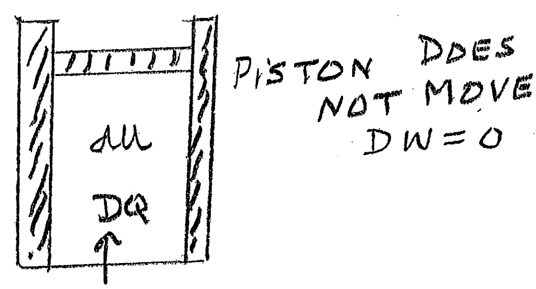


Specific Heat (Quantity of heat required to change temperature by 1°K)

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

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

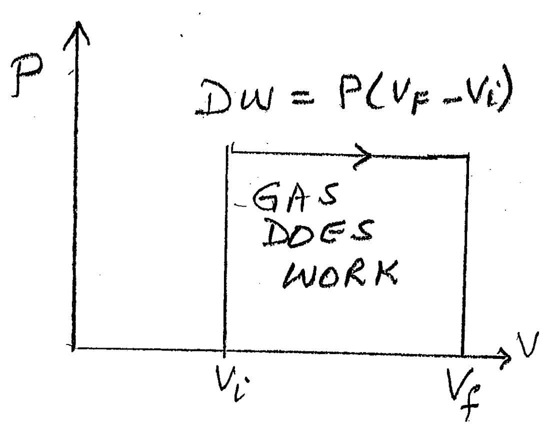
$\frac{5}{2}R \quad$ (DA)

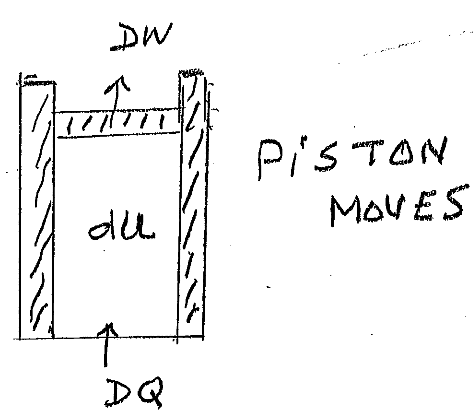


N.B. As V is const. $\frac{P_2}{P_1} = \frac{T_2}{T_1}$

II: Constant Pressure $[P = Const.]$

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





$PV = nRT$

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

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

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

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 $= \left(\frac{5}{2}\right) R$ $\qquad$ (MA) $\qquad$ $[C_P - C_V = R]$

$= \left(\frac{7}{2}\right) R$ $\qquad$ (DA)

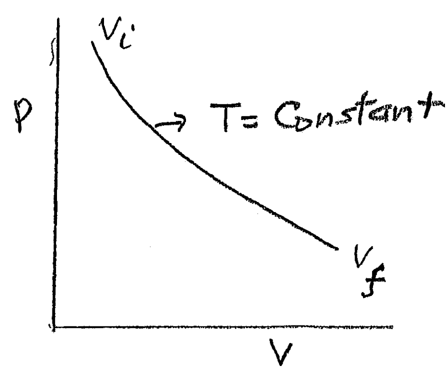
<u>NOTE:</u> C_p ALWAYS LARGER THAN C_V!

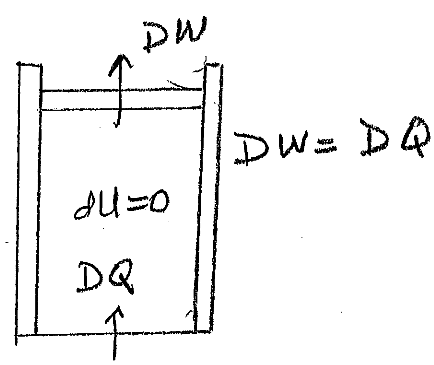
Define $\quad \gamma = \frac{C_p}{C_v}$, $\quad$ always <u>≥1</u>

III: <u>ISOTHERM.</u> Temperature is const.

$P \alpha \frac{1}{V}$

$dU = 0$

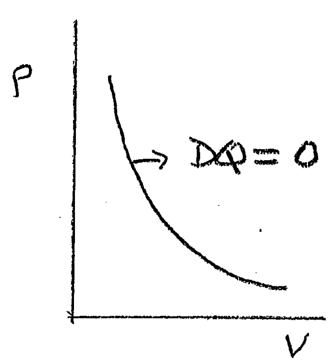


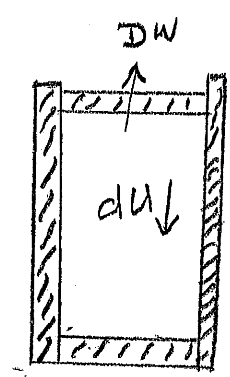


$P \alpha \frac{1}{V}$ $\qquad$ SO ISOTHERM MUST HAVE NEGATIVE SLOPE IN Pvs V DIAGRAM.

$$DQ = \frac{3}{2} nRT \ln(V_f / V_i)$$

IV: <u>ADIABATIC</u> $\qquad [DQ = 0.]$





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

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

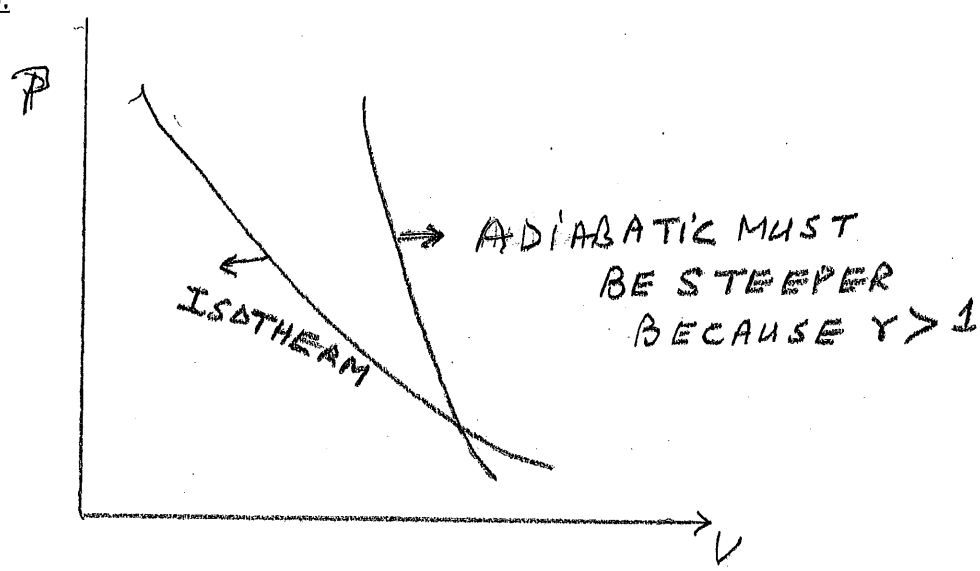
Implies:

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

or

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

N.B.



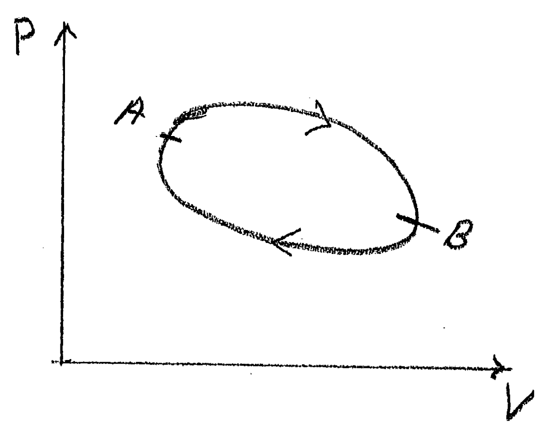
V: Cyclic Process

Since dU is independent of path

$$dU = 0$$

for a closed loop so

$$DQ = DW$$



For the cycle shown

$A \rightarrow B$ Gas does work.

$B \rightarrow A$ You do work.

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