→ BASIC CONCEPTS :-

THERMODYNAMICS :

It is the science of energy transfer and its effects on properties of system.

Basic aim of thermodynamic study is to convert heat (disorganise from of energy) into work (organised form of energy) in an efficient manner.

SYSTEM :

It is a region in space upon which the study is focused or concentrated.

SURROUNDINGS :

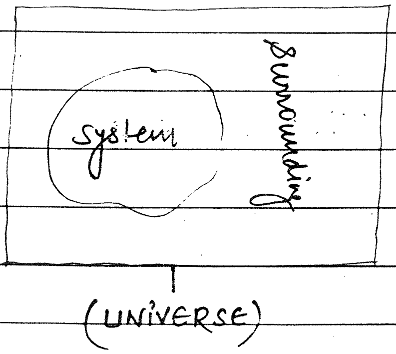
Anything external to the system is known as surroundings.

BOUNDARY :

The separation between system and surrounding is known as boundary.

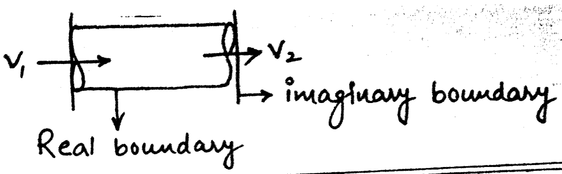
The boundary can be rigid or flexible, real or imaginary

UNIVERSE = system + surroundings



(UNIVERSE)

→ Universe is an isolated system.



TYPES OF SYSTEM :

SYSTEM	MASS TRANSFER	ENERGY TRANSFER	EXAMPLE
Closed	×	✓	Piston cylinder without valves
Open	✓	✓	Turbine, pump, compressor
Isolated	×	×	Universe, Hot coffe in a well insulated flask

MICROSCOPIC & MACROSCOPIC APPROACH OF THERMODYNAMICS :-

In microscopic approach the behaviour of individual molecule is taken into consideration and this approach is also known as statistical thermodynamics. This approach is useful at low density (higher altitudes) because low density means low mass.

In macroscopic approach the behaviour of individual molecule is not taken into consideration but the average behaviour of molecule is taken into consideration. This approach is also known as classical thermodynamics.

PURE SUBSTANCE :

A substance is said to be a pure substance if it is i) homogenious in chemical composition ii) homogeneous in chemical aggregation (bonding)

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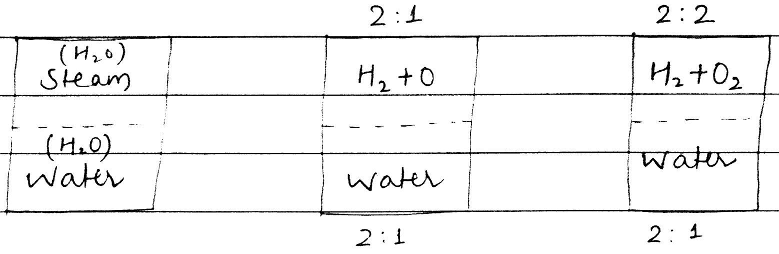

1 ✓	1 ✓	1 ×
2 ✓	2 ×	2 ×

→ PROPERTY OF A SYSTEM :-

Properties are any measurable characteristics of a system. eg :- P, T, V etc.

Properties are of two types -

1.) Intensive or intrinsic
2.) Extensive or extrinsic

Intensive properties are independent of size or mass of system. eg: P, T, ρ, μ, K etc.

Extensive properties are dependent on size or mass of system eg :- V, All forms of energy etc.

(**) Ratio of two extensive properties is an intensive property.

All specific properties are intensive properties.
eg: specific volume (v), specific internal energy (u), specific enthalpy (h), specific entropy (s)

→ STATE OF A SYSTEM :

Conditions of a system is called as state of a system. The state of a system is specified by means of its properties. As long as state is fixed, the properties are also fixed and hence properties are state functions.

PROCESS : Change of state is known as a process.

→ Important Points wrt. property :-

1.) Properties are always point functions.
2.) Properties are independt of past history.
3.) Properties are exact differentials.

→ THERMODYNAMIC EQUILIBRIUM :-

A system is said to be in thermodynamic equilibrium if it is in
i) thermal equilibrium (equality of temperature)
ii) Mechanical equilibrium (equality of forces/pressures)
iii) chemical equilibrium (equality of chemical potential)

→ REVERSIBLE & IRREVERSIBLE PROCESS :-

A process is said to be reversible process if when reversed in direction follows the same path as that of the forward path without leaving any effect on system and surrounding.

Reversible process is the most efficient process.

A process which is not a reversible process is an irreversible process. friction is one of the reasons which makes the process irreversible.

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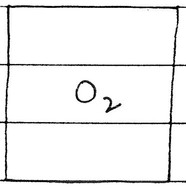
QUASI-STATIC PROCESS :-

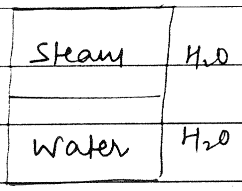
A process which is carried out in a very slow manner with small potential is known as quasi-static process. Frictionless quasi-static process is a reversible process.

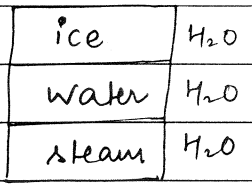
THERMODYNAMIC CYCLE :-

A system is said to have undergone a cycle if the initial and final points are same. The change in property for a cycle is always zero because properties are point functions and for a cycle initial and final points are same.

GIBBS PHASE RULE :-







$P=1$	$P=2$	$P=3$
$C=1$	$C=1$	$C=1$
$1+F = C+2 \Rightarrow \boxed{F=2}$;	$2+F = C+2 \Rightarrow \boxed{1}$	$\boxed{F=0}$

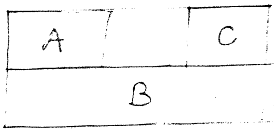
According to Gibbs phase rule $\boxed{P+F = C+2}$
where,

P = No. of phases
F = Min^m no. of intensive variable required
C = No. of components

ZEROTH LAW OF THERMODYNAMICS (CONCEPT OF TEMPERATURE) :-

When a body A is in thermal equilibrium with body B and body B is in thermal equilibrium with body C , a then A and C are in thermal equilibrium.

In zeroth law of thermodynamics, one body is taken as thermometer



Thermometric principle :-

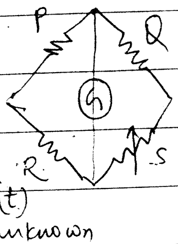
In this principal, the property which changes with temp. is found first and then the temperature is found. The property which helps in finding the temp. is known as thermometric property.

VARIOUS THERMOMETERS :-

1.) Resistance Thermometer (Thermistor) :

These thermometers are based upon wheatstone Bridge principle and in this themometer, resistance plays the role of thermometric property.

$$R = R_0(1+\alpha t+\beta t^2)$$



for balanced W.B.

$$\frac{P}{Q} = \frac{R}{S}$$

2.) THERMOCOUPLE :

Thermocouples are based upon Seebeck Effect. When two dissimilar metals are joined to form two junctions and if these two junctions are maintained at different temperatures, emf or voltage is generated and this voltage is proportional to temp. diff b/w two junctions, and hence in thermocouple emf plays the role of thermometric property.

3) CONSTANT VOLUME GAS THERMOMETER :

In constant gas volume thermometer pressure plays the role of thermometric property.

4.) CONSTANT PRESSURE GAS THERMOMETER :

Volume plays the role of thermometric property.

→ TEMPERATURE SCALES :

Temperature scales are arbitary. The ice point (freezing point) and steam point (boiling point) temperature are taken as 0 and 100 on celcius scale

$$\boxed{K = {}^\circ C + 273.15}$$

→ METHOD OF TEMPERATURE MEASUREMENT before 1954 :-

This method is based upon two reference temp. that is ice point (0°c) and steam point (100°c).

$t = ap + b$

$t_s = ap_s + b$
$t_i = ap_i + b$

$100 = ap_s + b$ — (3)
$0 = ap_i + b$ — (4)

$>$ by solving for (a) & (b)

$\Rightarrow a = \frac{100}{P_s - P_i}$

& $b = \frac{-100 \cdot p_i}{P_s - P_i}$

$\therefore t = \frac{100}{P_s - P_i} p - \frac{100 \, p_i}{P_s - P_i}$

$$\Rightarrow \boxed{t = \frac{100}{(P_s - P_i)} (p - p_i)} \quad \text{— (A)}$$

By finding the property 'p', the corresponding temp. 't' can be found.

→ Method of finding temp. after 1954 :

It is based on a single fixed temp. ie tripple point of water. The tripple point of water is assigned a value of $\cdot 01^\circ C$. (273·16 K).

for ideal gas $PV = mRT$

if $V =$ constant

$P \propto T$

$= CT$

$\therefore C = \frac{P}{T}$

At tripple point $C = \frac{P_{tp}}{T_{tp}}$

$$\therefore \quad P = \frac{P_{tp} \cdot T}{T_{tp}}$$

$$\Rightarrow \quad T = \frac{P}{P_{tp}} \cdot T_{tp}$$

$$\Rightarrow \quad T = 273.16 \left(\frac{P}{P_{tp}}\right)$$

(**) Ideal gas thermometer is independent of material of construction.

P:1 The reading t_A & t_B of two thermometer A & B agree at 0°C and 100°C and are related by eqn $t_A = l + m t_B + n t_B^2$ b/w these temp. where l, m, n are constants. When both are immersed in oil, A reads 51 and B reads 50 determine the reading on A when B reads 25°C.

as $\quad t_A = l + m t_B + n t_B^2 \quad$ —(1)

at 0°C $\Rightarrow$ $t_A = 0 = t_B$

& at 100°C $\Rightarrow$ $t_A = 100 = t_B$

using $\quad l = 0$

$(t_A = t_B = 100) \Rightarrow \quad 100 = m(100) + n(100)^2$

$\Rightarrow \quad 1 = m + 100n \quad$ —(2)

Now at, $t_B = 50$ & $t_A = 51$

$\Rightarrow \quad 51 = 50m + 2500n \quad$ —(3)

Solving (2) & (3) $\Rightarrow$ $m = 1.04$

$n = -4 \times 10^{-4}$

$\therefore\ t_A = 0 + 1.04\,t_B + (-4\times10^{-4}\,t_B^2)$

$\Rightarrow\ t_A = 1.04(25) + \{-4\times10^{-4}\times(25)^2\}$

$\Rightarrow\ t_A = 25.75^\circ C$

4) Though the end points temp. are same, this does not mean that the intermediate temp. are also same.

2 → Assertion (A): If an alchohal and mercury thermometer read exactly at 0°C and 100°C then these two thermometer's will give exactly the same reading at 50°C

Reason (R): Temp scales are arbitary.

A is wrong and R is right so. Ans $\boxed{d}$

:3 → Which of the following are intensive properties –

i) KE
ii) Thermal conductivity
iii) Pressure
iv) Volume

a) 1 & ii [✓ b) ii & iii] c) ii, iii, iv d) 1, 3, 4

-4 → Match List 1 with List II

List I	List II		
1) Mercury in Glass	Pressure	A)	1 — C ✓
2) Thermocouple	Resistance	B)	2 → D ✓
3) Thermistor	Volume or length	C)	3 — B ✓
4) Const. V gas thermometer	emf	D)	4 — A ✓

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P-5 → In a new temp. scale, °P the boiling and freezing point of water are 100°P and 300°P respectively. find the reading corresponding to 0°P on celcius scale.

Let the relation b/w both scales is linear.

$$°P = a°C + b$$

$$\therefore \quad 300 = a(0) + b \quad \Rightarrow \quad b = 300$$

$$\& \quad 100 = 100a + 300 \quad \Rightarrow \quad a = -2$$

$$\therefore \quad °P = -2°C + 300$$

so at °P = 0

$$\Rightarrow \quad 0 = -2°C + 300 \quad \Rightarrow \boxed{°C = 150°C}$$

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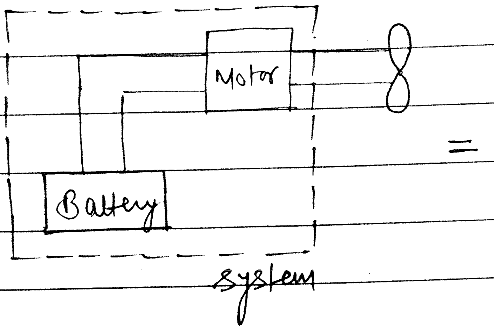
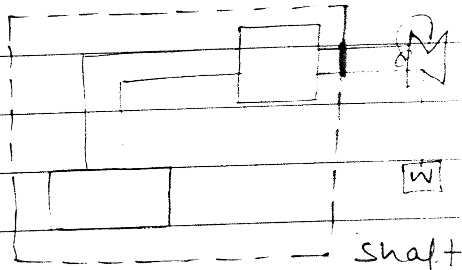
→ ENERGY INTRECTIONS (WORK & HEAT) :-

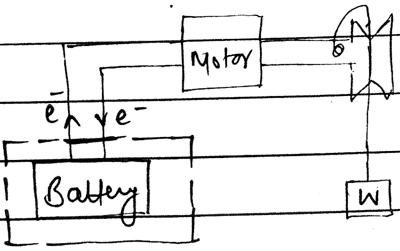
•) THERMODYNAMIC WORK :

Work is said to be done by the system if the sole effect on things external to the system can be equated to raising of weights (Weights may not be raised but the effect can be equated to raising of weights).

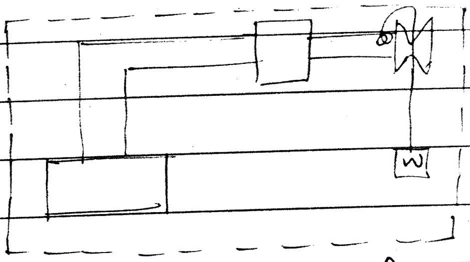




shaft work



electrical work



NO work transfer

Work transfer occurs only when it crosses the boundary if it does not cross the boundary there is no work transfer and hence work transfer is a boundary phenomenon.

CONVENTION OF WORK TRANSFER :

Work done by the system is taken as +ve and work done on the system is taken as −ve

Whenever weights are raised → work done by system

Whenever weights are lowered → work done on system

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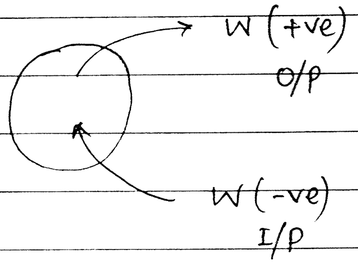
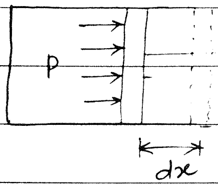


When boundary is expanding, work will be +ve.
when boundary is contracting, work will be -ve.

GENERALISED EQ^N FOR CLOSED SYSTEM WORK TRANSFER :
(NON FLOW WORK)



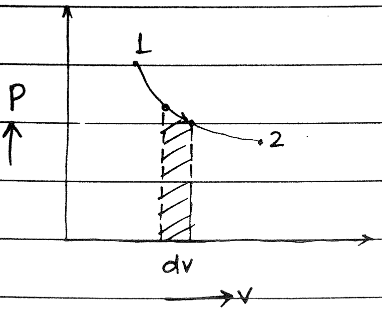
work done = force × distance

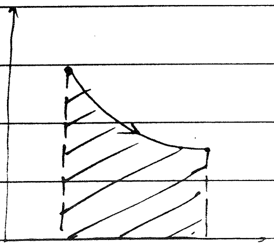
$dW = F \times dx$

$dW = pA\,dx$

$dW = p\,dV$

& $\boxed{W = \int p\,dV}$ Non flow or closed system work





Area = Pdv
Work = Pdv

(**) Area under the P-V curve when projected on volume axis gives non flow or closed system work.

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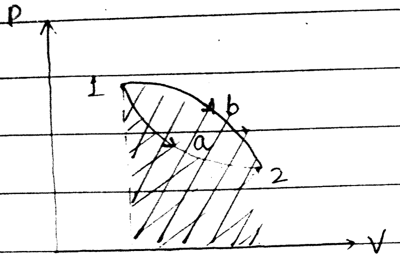


$W_a \neq W_b$

$\therefore\ \delta W$ or $đW$

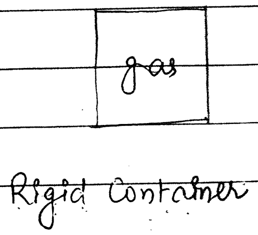
**) Though for paths A & B, end points are same, the work transfer is not same because areas are different for different paths and therefore work transfer depends upon the path. Hence the work transfer is a path function and it is not a property and it is inexact differential ($đW$ or δW).

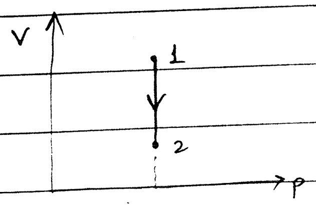
CONDITIONS FOR APPLYING THE EQ^N $W = \int P dV$

i) The system must be a closed system
ii) Work should cross the boundary.
** iii) The process must be a reversible process.

•) NON-FLOW OR CLOSED SYSTEM WORK FOR VARIOUS PROCESSES :-

i.) CONSTANT VOLUME or ISOCHORIC or ISOMETRIC PROCESS -





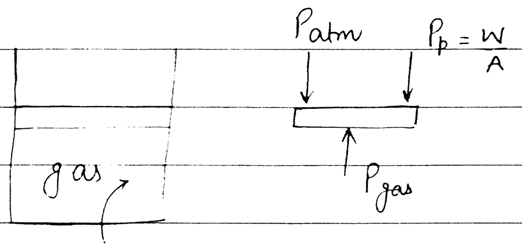
$W = \int P dV$

as $V =$ constant

$dV = 0$

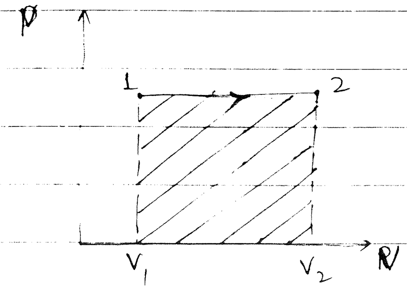
$\therefore\ W = 0$

ii.) CONSTANT PRESSURE OR ISOBARIC OR ISOPIESTIC PROCESS :-



$$P_{atm} + \frac{W}{A} = P_{gas}$$

so P_{gas} is constant.



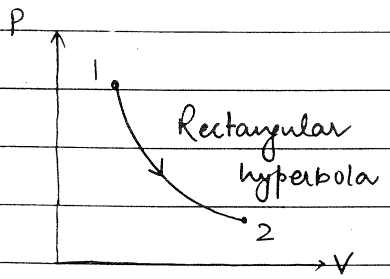
$$W = P(V_2 - V_1)$$

or

$$W = \int_{V_1}^{V_2} P\,dv$$

$$\Rightarrow \boxed{W = P(V_2 - V_1)}$$

iii.) CONSTANT TEMPERATURE OR ISOTHERMAL PROCESS :-



$$PV = mRT$$

$$PV = C$$

$$P_1V_1 = P_2V_2 = C$$

$$\therefore\ W = \int_1^2 P\,dv$$

$$\Rightarrow W = \int_1^2 C\,\frac{dv}{v}$$

$$\Rightarrow W = C\,\ln\left(\frac{V_2}{V_1}\right)$$

$$\Rightarrow \boxed{W = mRT\,\ln\left(\frac{V_2}{V_1}\right)}$$

or

$$W = P_1V_1\,\ln\left(\frac{V_2}{V_1}\right)$$

for an ideal gas, isothermal process is a rectangular hyperbola on P-V diagram.

iv.) ADIABATIC PROCESS :-

A process is said to be an adaibatic process if there is no heat transfer from the system or to the system. for an adaibatic process-

$$\boxed{PV^{\gamma} = C}$$

here,

γ = Adaibatic index and greater than 1:

so, work done $= \int_{V_1}^{V_2} P\,dV$ $\qquad PV^{\gamma} = C$

$\qquad\qquad P = CV^{-\gamma}$

$$= \int_{V_1}^{V_2} CV^{-\gamma}\,dV \qquad P_1 = CV_1^{-\gamma}$$

$\qquad\qquad P_2 = CV_2^{-\gamma}$

$$= C\left[\frac{V^{-\gamma+1}}{-\gamma+1}\right]_{V_1}^{V_2}$$

$$= \frac{C}{-\gamma+1}\left[V_2^{-\gamma+1} - V_1^{-\gamma+1}\right]$$

$$= \frac{C}{-\gamma+1}\left[V_2^{-\gamma}V_2 - V_1^{-\gamma}V_1\right]$$

$$= \frac{1}{-\gamma+1}\left[CV_2^{-\gamma}V_2 - CV_1^{-\gamma}V_1\right]$$

$$= \frac{1}{-\gamma+1}\left[P_2V_2 - P_1V_1\right]$$

$$\Rightarrow \quad W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

It is a closed system adaibatic work.

v.) POLYTROPIC PROCESS :-

A process is said to be a polytropic process when $PV^n = c$, in general n lies b/w 1 & γ. In polytropic process, there is both heat and work transfer but in adaibatic process, there is only work transfer. here, n is known as polytropic index.

$$W = \frac{P_1V_1 - P_2V_2}{n-1}$$

(**) $PV^K = C$

i) for $P=C$ $\Rightarrow K = 0$

$\Rightarrow PV^0 = C$

$\Rightarrow P = C$

ii) for $V=C$ $\Rightarrow P^{1/K}V = C^{1/K}$ $(K=\infty)$

$\Rightarrow P^{1/\infty}V = C$

$\Rightarrow V = C$

	K
P = C	0
T = C	1
Polytropic	n
Adaibatic	γ
V=c	∞

iii) for $T=C$ $\Rightarrow PV^1 = C$

$K = 1$

iv) for adaibatic $K = \gamma$

v) for polytropic $K = n$

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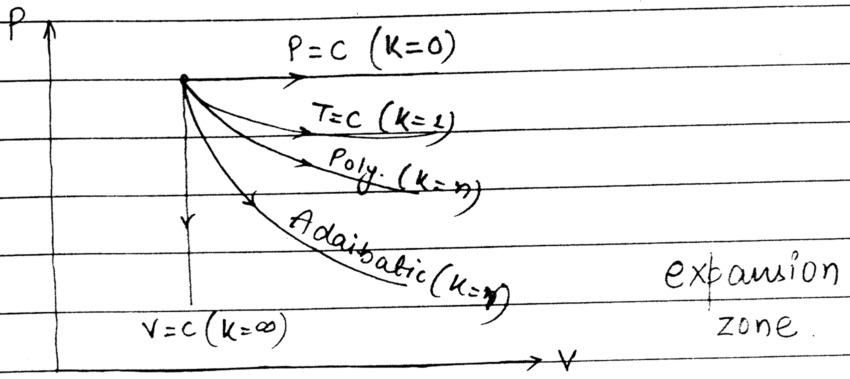
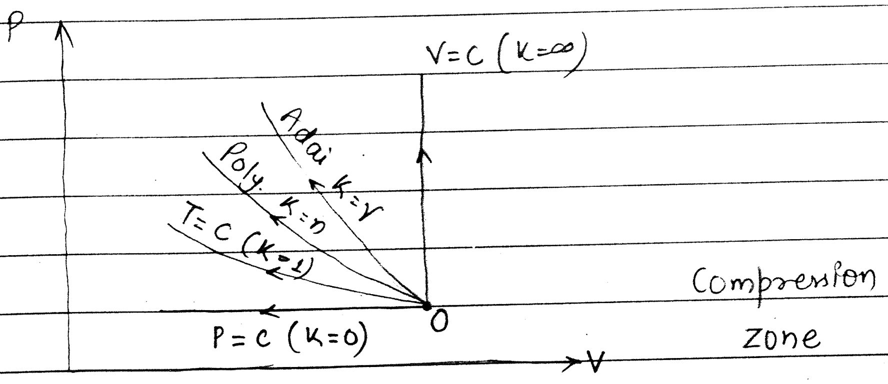
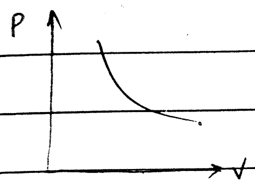
→ Representation of various processes on P-V diagram :-





→ SLOPE OF ISOTHERMAL CURVE ON P-V Diagram –



$$PV = C$$

$$P\,dV + V\,dP = C$$

$$\Rightarrow P\,dV = -V\,dP$$

$$\Rightarrow \frac{dP}{dV} = -\frac{P}{V}$$

$\therefore$ slope of isothermal curve on P-V diagram $= \frac{-P}{V}$

→ SLOPE OF ADIABATIC CURVES ON P-V Diagram :

$$PV^{\gamma} = C$$

$$\Rightarrow P\gamma V^{\gamma-1}dV + dP\,V^{\gamma} = 0$$

$$\Rightarrow \frac{P\gamma V^{\gamma}}{V}\,dV = -dP\,V^{\gamma}$$

$$\Rightarrow \frac{dP}{dV} = \frac{-\gamma P}{V}$$

⇒ slope of adaibatic curve on P-V diagram = $\frac{-\gamma P}{V}$

⇒ Adaibatic slope = $\gamma(-P/V)$

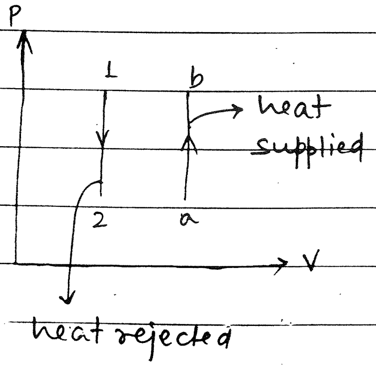
⇒ Adaibatic slope = γ (Isothermal slope)

⇒ $\frac{\text{Adaibatic slope}}{\text{Isothermal slope}} = \gamma$ (as $\gamma > 1$)

⇒ Adaibatic slope > isothermal slope

→ IDEAL GAS EQUATIONS FOR VARIOUS PROCESSES :

1.) CONSTANT volume PROCESS :

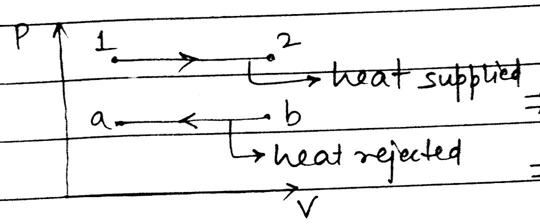


$$PV = mRT$$

$$\Rightarrow P \propto T$$

$$\Rightarrow \frac{P_2}{P_1} = \frac{T_2}{T_1}$$

2.) CONSTANT PRESSURE PROCESS :-



$$PV = mRT$$

$$\Rightarrow \quad V \propto T$$

$$\Rightarrow \quad \frac{V_2}{V_1} = \frac{T_2}{T_1}$$

3.) ISOTHERMAL PROCESS :-

$$PV = mRT$$

$$PV = C$$

$$P_1V_1 = P_2V_2$$

4.) ADIABATIC PROCESS :-

$$PV = mRT$$

$$PV^{\gamma} = C$$

$$\Rightarrow \quad P_1V_1^{\gamma} = P_2V_2^{\gamma}$$

$$\Rightarrow \quad \frac{V_1}{V_2} = \left(\frac{P_2}{P_1}\right)^{1/\gamma} \quad \text{---(1)}$$

$$\& \quad \frac{T}{V} \cdot V^{\gamma} = C$$

$$\Rightarrow \quad T\,V^{\gamma-1} = C$$

$$\Rightarrow \quad T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$

$$\Rightarrow \quad \frac{V_1}{V_2} = \left(\frac{T_2}{T_1}\right)^{1/\gamma-1} \quad \text{---(2)}$$

from (1), (2)

$$\left(\frac{P_2}{P_1}\right)^{1/\gamma} = \left(\frac{T_2}{T_1}\right)^{1/\gamma-1}$$

$$\Rightarrow \quad \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} \quad \text{---(3)}$$

So, $$\boxed{\begin{aligned} P_1V_1^{\gamma} &= P_2V_2^{\gamma} \\ T_1V_1^{\gamma-1} &= T_2V_2^{\gamma-1} \\ \frac{T_2}{T_1} &= \left(\frac{P_2}{P_1}\right)^{\gamma-1/\gamma} \end{aligned}}$$ → valid for an ideal gas undergoing adaibatic process.

5> POLYTROPIC PROCESS :

$$PV^n = C$$

& $$\boxed{\begin{aligned} P_1V_1^{n} &= P_2V_2^{n} \\ T_1V_1^{n-1} &= T_2V_2^{n-1} \\ \frac{T_2}{T_1} &= \left(\frac{P_2}{P_1}\right)^{n-1/n} \end{aligned}}$$

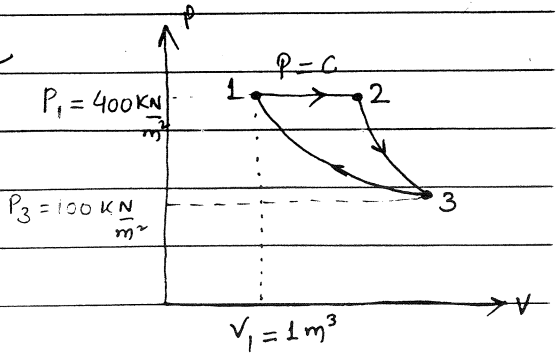
P:1 A system undergoes 3 processes as shown in fig.

1-2 isobaric process ,

2-3 polytropic process $(m = 1.4)$

3-1 isothermal process in which $PV = C$.

find i) V_2 ii) Net work transfer



i) 3-1 ⇒ $T = C$

$\Rightarrow PV = C$

$\Rightarrow P_3V_3 = P_1V_1$

$\Rightarrow V_3 = \frac{P_1V_1}{P_3} = \frac{400 \times 1}{100}$

$\Rightarrow V_3 = 4 \, m^3$

And, 2-3 ⇒ $PV^{1.4} = C$ ⇒ $P_2V_2^{1.4} = P_3V_3^{1.4}$

$\Rightarrow \frac{V_2}{V_3} = \left(\frac{P_3}{P_2}\right)^{1/1.4}$

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$\Rightarrow \quad \frac{V_2}{V_3} = (4)^{1/1.4}$

$\Rightarrow \quad V_2 = \underline{1.486\ m^3}$ Ans.

ii) Net work done $= W_{12} + W_{23} + W_{31}$

$\therefore \quad W_{12} = P_1(V_2 - V_1) = 400(1.486-1)$

$= 194.4$ KJ

$W_{23} = \frac{P_2V_2 - P_3V_3}{n-1} = \frac{400\times1.486 - 100\times4}{1.4-1}$

$= 486$ KJ

$W_{31} = P_3V_3 \ln\left(\frac{V_1}{V_3}\right) = 100\times4\times\ln(1/4)$

$= -554.5$ KJ

So, Net work $= 194.4 + 486 - 554.5$

$\Rightarrow \quad W_{net} = \underline{125.8\ KJ}$ Ans.

***) ① ~~All~~ Net work in a cycle is equal to area of closed region.

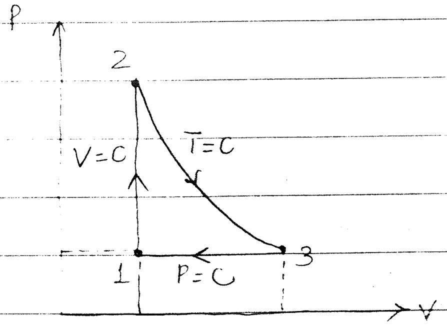
② All clockwise cycles on P-V diagram are power producing or work producing cycles.

③ All anticlockwise cycle on P-V diagram are power absorbing or work absorbing cycle.

P:2 ('2003) An ideal gas is heated at constant volume until its temp. is 3 times the original temp. It is then expanded isothermally till its reaches its original pr. The gas is then cooled at constant pr. till it is restored to the original state. Determine

i) the net work done per kg of gas

Take the initial temp. as 315oK and express your answer in terms of gas constant R



for process 1-2

$\Rightarrow W_{12} = 0$

for (2-3) process

$\Rightarrow W_{23} = P_2 V_2 \ln\left(\frac{V_3}{V_2}\right)$

$W_{23} = mRT_2 \ln(V_3/V_2)$ —(1)

for (3-1) process

$\Rightarrow W_{31} = P_1(V_1 - V_3)$ —(2)

NOW, $T_1 = 350\ K$

$T_2 = 3 \times T_1$

$T_2 = 1050\ K$ —(3)

$T_3 = 1050\ K$ —(4)

& $P_2V_2 = P_3V_3 \Rightarrow \frac{V_3}{V_2} = \frac{P_2}{P_3} = \frac{P_2}{P_1} = \frac{T_2}{T_1}$

$\Rightarrow \frac{V_3}{V_2} = 3$ —(5)

NOW, $W_{23} = RT_2 \ln(V_3/V_2) = 1153.5\ R$ —(6)

& $W_{31} = P_1(V_1 - V_3) = P_1V_1\left(1 - \frac{V_3}{V_1}\right)$

$= R(350)\left(1 - \frac{V_3}{V_2}\right)$

$= R\ 350\ (1-3) = -700\ R$

$\therefore W_{net} = 1153.5\ R - 700\ R$

$\boxed{W_{net} = 453.5\ R}$ Ans

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*)

:3 An insulated vertical cylinder contains 0.1 kg of argon gas with the help of a frictionless non conducting piston as shown in fig., the mass of the piston is 5 kg and it initially rests on the bottom of the cylinder The cylinder is connected to a nitrogen tank at 100 bar to a pipe line fitted in a valve. The valve is opened and N_2 slowly enters into the cylinder and during this process the piston is lifted to a height of 10 cm at N_2 gas. Initial temp. and pressure of Argon are 300 K and 1 bar respectively. final temp. of argon is 320 K. for argon gas take R = 0.208 KJ/kgK and γ = 1.67

find : work done by argon

: work done by nitrogen gas.

us: i) As the argon cylinder is insulated and piston is non conducting, there is no heat transfer from Argon or to Argon, therefore it undergoes adaibatic process.

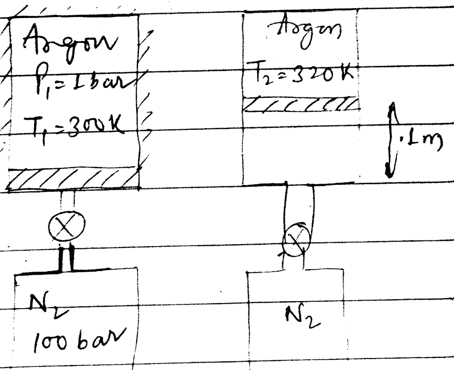
$$W_{argon} = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

$$W_{argon} = \frac{mRT_1 - mRT_2}{\gamma - 1}$$

$$= \frac{mR(T_1 - T_2)}{\gamma - 1}$$

$$\Rightarrow W_{argon} = \frac{0.1 \times 0.208 (300 - 320)}{1.67 - 1}$$

$$\Rightarrow W_{argon} = -0.6208 \text{ KJ}$$ — Ans.



ii)

$$W_{N_2} = W_{argon} + W_{piston}$$

$$W_{N_2} = 0.6208 + (mgh)$$

$$\boxed{kg \times \frac{m}{sec^2} \cdot m} \quad N \cdot m - J$$

$$W_{N_2} = 0.6208 + \frac{5 \times 9.81 \times .1}{1000}$$

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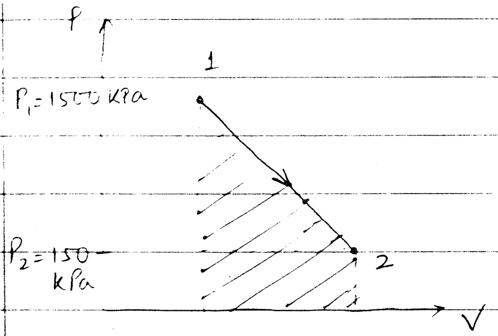
⇒ $W_{N_2} = \underline{0.6275\ KJ}$ Ans

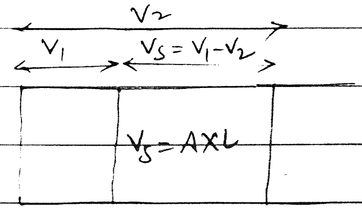
***

P:4 An engine cylinder has a piston of area 0.12 m^2 and contains a gas at a pr. of 1500 KPa. The gas expands according to a process which is represented by a straigh line on P-V diagram, the final pr. is 150 kPa. calculate the work done by the gas if the stroke length is 0.3 m.



$V_s = V_2 - V_1 = AXL$

$V_s = .036\ m^3$



W = area under P-V curve

$\Rightarrow W = \frac{1}{2}(1500 + 150)(V_2 - V_1)$

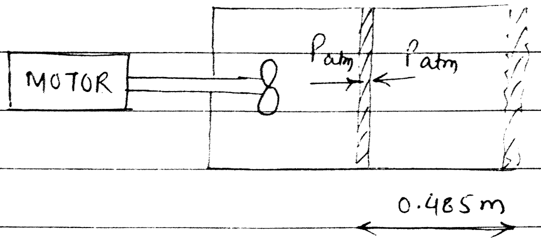
$\Rightarrow W = \frac{1}{2} \times 1650 \times .036$

$\Rightarrow W = 29.7$ kJ

****

P:5 A fluid contained in a horizontal cylinder fitted with a ~~flu~~ frictionlessly ~~pr~~ leak proof piston is continuously agitated by means of a stirrer passing through the cylinder cover The cylinder dia. is 0.4 m, during the stirring process lasting 10 minutes the piston slowly moves out a distance of 0.485 m against the atm. pressure. The net work done by the fluid is 2 KJ. The speed of the motor driving stirrer is 840 rpm. Determine the power of motor and torque in the shaft.

Whenever weights are lowered, work is done on the system (-ve work)
eg: Paddling work or Stirring work



for gas:

$$W_{net} = W_{stirring} + W_{piston} \quad \text{---(1)}$$

$$W_{piston} = P_{atm.} (\Delta V)$$

$$\Rightarrow W_{piston} = 101.325 \times \left(\frac{\pi}{4} d^2 \times 0.485 \right)$$

$$\Rightarrow W_{piston} = 6.175 \text{ kJ.}$$

from (1) $\Rightarrow$ $2 = W_{stiring} + 6.175$

$$\Rightarrow W_{stiring} = -4.175 \text{ kJ.}$$

Now for motor $W_{motor} = 4.175 \text{ kJ}$

$$W_{motor} = 4175 \text{ J}$$

$$\& \quad P_{motor} = \frac{W_{motor}}{t}$$

$$P_m = \frac{4175}{10 \times 60}$$

$$P_m = 6.95 \text{ Watt}$$

$$\because \quad P_m = \frac{2\pi NT}{60}$$

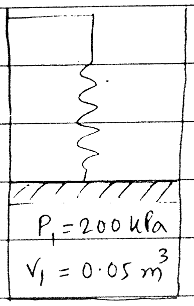
$$\Rightarrow \boxed{T = 0.08 \text{ Nm}}$$

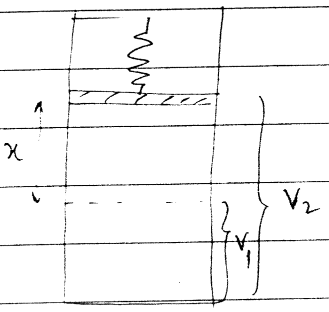
***
P: 6. A piston cylinder device contain 0.05 m^3 of a gas initially at 200 kPa. At this state a linear spring which has a spring constant of 150 kN/m is just touching the piston but exerting no force on it. Now heat is transferred

to gas causing the piston to rise and to compress the spring until the volume inside the cylinder doubles. If the X-sec. area of piston 0.25 m². find

i) final pr. inside the cylinder

ii) work done by the gas.





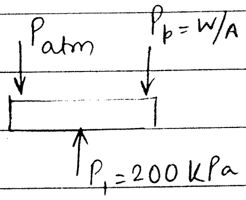
$V_2 - V_1 = \Delta V$

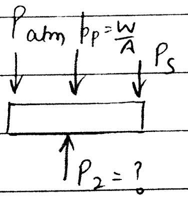
$V_2 - V_1 = A(x)$

$\Rightarrow V_1 = A(x)$

$\Rightarrow x = V_1/A$

$\Rightarrow x = 0.2$ m





$P_s = \frac{kx}{A} = \frac{150 \times \cdot 2}{\cdot 25}$

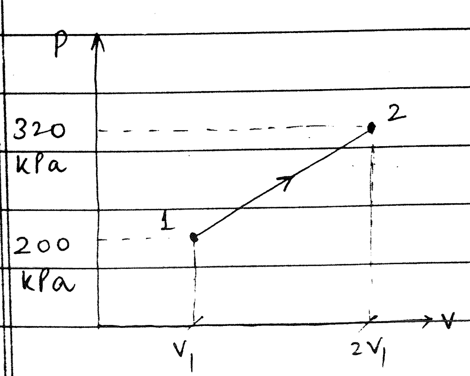
$= 120$ KPa

$P_{atm} + P_p = 200$ —(1)

$P_{atm} + P_p + P_s = P_2$ —(2) $\Rightarrow 200 + P_s = P_2$

$\Rightarrow 200 + 120 = P_2$

$\Rightarrow \underline{P_2 = 320 \text{ kPa}}$ Ans



$P_2 = 200 + P_s$

$P_2 = 200 + \frac{kx}{A}$

$P_2 = 200 + \frac{k}{A} \times \frac{\Delta V}{A}$

$\therefore P \propto V$

Work done $= \frac{1}{2}(200 + 320)(V_1)$

$\Rightarrow W = \frac{1}{2} \times 520 \times 0.05$

$\Rightarrow W = \underline{13 \text{ kJ}}$ Ans.

HEAT :-

The energy interactions due to temperature difference is known as heat transfer.

$Q \propto \Delta T$

$Q \propto m$

so, $Q \propto m\Delta T$

$\Rightarrow \boxed{Q = mC\Delta T}$

here

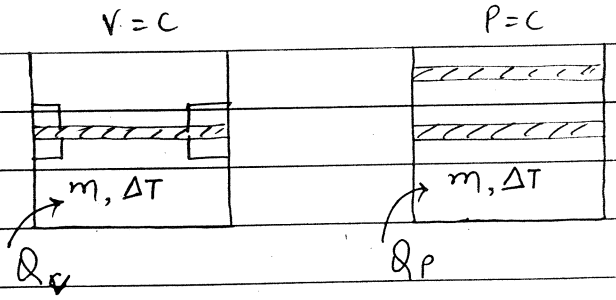
C = specific heat

if $m = 1$ kg then $\boxed{Q = C}$

$\Delta T = 1^\circ C$

$Q = C$ → 1 kg, $\Delta 1^\circ C$

SPECIFIC HEAT : It is the amount of heat required to raise the temp. of unit mass substance to the unit degree temp. difference



$Q_P > Q_V$

$\Rightarrow C_P > C_V$

$Q_v \rightarrow U$

$\rightarrow (W=0)$

$Q_P \rightarrow U$

$\rightarrow W$

Specific heat at const. pr. (C_P) is always greater than specific heat at const. volume (C_V) because C_P includes internal energy (U) and external work (W) where C_V includes only internal energy (U).