

previous year questions

Ques. of different and different by numerics) no. 10  
and here is a brief answer 2020 question no. 10

Ques. (a) write down the fundamental assumptions

of kinetic theory of gases. (no. 10)

(b) Show that,  $p = \frac{1}{3} P_0^2$ , where symbols have  
their usual meaning. (no. 10)

Explain their usual meaning's. (no. 10)

(c) Write a short note of intermolecular forces. (no. 10)

Ques. (a) What are the corrections involved in kinetic  
theory of gases that lead to the equations of  
state? (no. 10)

for real gas, at steady state. (no. 10)

for a real gas.

(b) Argon with density  $100 \text{ kg/m}^3$  under a pressure  
of  $10 \text{ mps}$  is in a vessel. Consider  
argon under each pressure to be at

1000 K. Find its temperature. (no. 10)

Given  $R = 8.314 \text{ J/mol K}$ . (no. 10)

POCO to avoid losses of heat. (no. 10)

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Digitized by you. (no. 10)

## Qn. 1. ~~Explain the concept of entropy~~

- (a) How can the enthalpy points  $P_{\text{sat}}$ ,  $T_{\text{sat}}$  and  $P_{\text{vap}}$  be fixed by the van der waals constants  $a$  and  $b$ .
- (b) Using transport phenomena of gases, obtain an expression for thermal conductivity of it.
- (c) (a) Define thermodynamics of systems. (d)
- (b) State the zeroth law of thermodynamics
- (c) Write the comparison between Le Chatelier's principle and Carnot's principle of irreversibility.
- (d) State and prove the first law of thermodynamics.
- (e) What is adiabatic process? Derive the equation of work done during an adiabatic process.
- (f) Define reversible and irreversible process. Write down the conditions of reversibility for any heat engine.

(a) What is thermodynamics equilibrium.

Ans. (a) State the Kelvin-Planck as well as Clausius version of the second law of thermodynamics.

(b) Show that the Kelvin-Planck and Clausius statements of second law of thermodynamics are equivalent

(c) What is refrigerator? Write down the working mechanism of a refrigerator.

Ans. (a) State and prove Carnot's theorem.

(b) Define entropy. Illustrate the Carnot's cycle in entropy-temperature (ST) diagram.

(c) Calculate the entropy of one mole of an ideal gas,  $V$ .

✓ (a) Define compound & find their relation.

(b) What do you mean by equilibrium state? Deduce the relation  $PV' = \text{constant}$ .

(c) What is a reformation energy of half mole?

more about how to write answer for this state

2019

freshwater area

✓ (c) Show from kinetic theory that gases that instead of the energy of translation of one molecule of a perfect gas is  $\frac{3}{2}kT$ .

forming of Stanfelli's postures

(d) Explain the principle of equipartition of energy.

to show this to require some space that the  
2 (e) Define mean free path. Show that the  
**POCO** shown POCO free path is inversely proportional

to the molecules per cm<sup>3</sup>. compute the diameters  
of the molecules.

3. (b) Using the first law of thermodynamics  
show that  $CP - CV = \left[ P + \left( \frac{\partial V}{\partial T} \right)_P \right] \left( \frac{\partial V}{\partial T} \right)_P$  use this  
result to show that  $CP - CV = R$  for an ideal gas.

(ii)  $CP - CV = R \left( 1 + \frac{2A}{3V} \right)$  for a van der waals gas.

Note that  $P + \left( \frac{\partial V}{\partial T} \right)_P = T \left( \frac{\partial P}{\partial T} \right)_V$

(c) Two grams of oxygen are heated at constant

atmospheric pressure from 270 to 127 °C. How  
much heat is transferred to the oxygen?

Internal energy of the oxygen is measured  
as 6.8 J/g. Do for subsequent processes.

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(d) An ideal gas is originally confined to a volume  $V_1$  in an insulated container of volume  $V_1 + V_2$ , with the remainder of the container is evacuated. The partition is then removed and the gas expands to fill the entire container. If the initial temperature of the gas is  $T_1$ , what was the final temperature  $T_2$ ?

(e) A Carnot's refrigerator extracts 35.0 KJ as heat during each cycle, operating with a coefficient of performance of 4.00. What is the energy per cycle transferred as heat to the room and the work done by the cycle to drive it?

(f) Consider a steam engine that operates between a maximum steam temperature of  $500^\circ\text{C}$  and an ambient temperature of  $20^\circ\text{C}$ . Find the

efficiency of info management will bring us to

~~QUESTION - B~~  $\rightarrow$  returns most first off potential function  
Q) What are the thermodynamic potentials?

(b) State and explain third law of thermodynamics  
by considering zeroth law state (3) - 3

(c) Deduce the four relation of Maxwell.

to 5000 ft. & 5000 ft. of 1200 ft. at left end (4) of

(c) deduced the relation present for one mole of an ideal gas. Now, at standard (s)

(d) Show that  $\left(\frac{\partial P}{\partial V}\right)_T + \left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial T}{\partial P}\right)_V = 0$  if and only if  $P = PV^{\alpha}$

2. (a) what do you mean by transport properties of gas, obtain an expression for thermal

conductivity of the gas.

(v) Write a short note of Andreev's curve.

(e) Write a short note on the relationship between the mean and median of a frequency distribution.

**BOCO** Artic compressed  
SHOT ON POCO MERRILL volume. If the air was initially  
at its original volume.

at  $27^\circ\text{C}$  and the atmospheric pressure often calculate the final temperature and pressure

from the barometric altitude from (ii)

G. (a) state and prove increase of entropy.

(b) Prove that  $\Delta S = \int \frac{V}{T} dT$  for reversible expansion.

4. (a) Show that the isothermal work done of

expansion of an ideal gas is  $W = nRT \ln \frac{V_2}{V_1}$ .

(b) calculate the work done upon expansion

of one mole of gas thermally from volume

$V_1$  to  $V_2$  when the equation states

$$(P + \frac{a}{V^2}) (V - b) = RT$$

itself not necessarily true.

Exp off to  $P(V, T)$ .

Ans:  $\Delta S = nR \ln \frac{V_2}{V_1}$

Work off to other form of entropy.

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# Heat and Thermodynamics

Preparation of Notes by [unclear] 1st chapter

2021

- ① write down the essential features of the kinetic theory of ideal gases.
- ② What do you mean by transport properties of gas? Obtain an expression for thermal conductivity of the gas.
- ③ Write a short note on Andrews curve.
- ④ Write down the fundamental assumption of kinetic theory of gases.
- ⑤ Show that,  $P = \frac{1}{3} p_{\text{ext}}$ , where the symbols have their usual meanings.
- ⑥ Write a short note on intermolecular forces.

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2019

Q) What are the differences between real gas and ideal gas.

A) Explain the laws of thermodynamics. How

(a) Explanation of temperature is obtained from the concept of temperature law.

(b) Show from the kinetic theory of gases that the mean kinetic energy of translation of one molecule of a perfect gas is  $\frac{3}{2} kT$ .

(c) Explain the principle of equipartition of energy.

2. (a) What are the corrections in the kinetic theory of gases that led to the equation of state for a real gas.

(b) Define mean free path. Is it inversely proportional to the macroscopic collision cross section.

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(c) The mean free path of the molecules of a gas is  $2 \times 10^{-3}$  cm when there are  $1.25 \times 10^{10}$  molecules per  $\text{cm}^3$ , compute the diameters of the molecules.

Ans for probt 2018

- ① Can we use any liquid as a thermodynamic substance? Ans Substances having definite properties are called thermodynamic substances.
- ② What do you mean by sensitive thermometer?
- ③ Describe construction and working of a

### 3. fundamental assumptions of kinetic theory of gases.

(a) ~~Kinetic theory of gases~~ ~~is based on following assumptions~~

(b) Write short note on equipartition of energy.

(c) Derive an expression for work done in

**POCO** ~~expansion~~

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Work done =  $\frac{1}{2} k T_1 V_1 - \frac{1}{2} k T_2 V_2$   
Hence find Vanderwaals constants  $a$  and  $b$

## Chapter - 2

2018

- (1) State and explain first law of thermodynamics
- (2) Define  $c_p$  and  $c_v$  and explain why  $c_p > c_v$  where symbols have their usual meaning.
- (3) Derive the Mayer's relation  $c_p - c_v = R$  where symbols have their usual meaning.
- Q. (a) Define control system, wall and surroundings  
(b) Explain the reason why isothermal process and conductors and extremely slow process.
- (c) Derive an expression for work done in expansion of gas.
- 2019
- (1) State and explain first law of thermodynamics
- (2) Deduce the relation  $T P^{(1-y)/y} = \text{constant}$  where  $y$  has its usual meaning
- POCO**  
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3. (a) What are differences between reversible and irreversible process

(b) Using the first law of thermodynamics show that  $CP - CV = \left[ P + \left( \frac{\partial V}{\partial T} \right)_P \right] \left( \frac{\partial T}{\partial V} \right)_P$  using result show

$$\textcircled{1} \quad CP - CV = R$$

$$\textcircled{2} \quad CP - CV = R \left( 1 + \frac{\partial V}{R_T V} \right) \text{ for van der waals gas.}$$

\textcircled{3} (a) Define thermodynamics system

(b) State the zeroth law of thermodynamics

(c) Write the comparison between heat and work

(d) State and prove the first law of thermodynamics

4. (a) What is adiabatic process? Derive the equation of work done during an adiabatic process
- (b) Define reversible - irreversible process.
- (c) Write down the conditions of reversibility for any heat engine
- (d) What is thermodynamic equilibrium?

Previous year question solution

## Heat and thermodynamics

2020

1. (A) Basic assumption of the kinetic theory of gases:

1. A confined gas of a material consists of an extremely large number of identical molecules.

2. The gas molecules can be treated as an ideal particle like it has mass but its structure

and size can be ignored as compared with the

intermolecular separation in a dilute

gas and the dimensions of the container

3. Molecules are continuously moving at random with velocities colliding with each other

and with the walls of the container and the

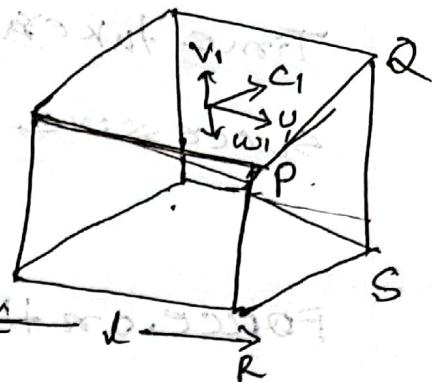
POCO SHOT ON POCO PROBEY NEWTON'S LAW OF MOTION

SHOT ON POCO PROBEY NEWTON'S LAW OF MOTION

- (A) The pressure exerted by a gas due to the continuous movement of the molecules with the walls of the container.
- (B) Between the successive collisions the molecules move in straight line uniform velocities.
- (C) The distribution of velocities among the molecules do not change with time.
- (D) When molecules collide with each other no energy is gained or lost.
- (E) The kinetic energy of gases increase with increased temperature.
- (F) The molecules are in continuous random motion.
- (G) There are no forces of attraction or repulsion between the molecules.

(b) Let us consider an ideal gas inside a cube of side  $a$ . Let

( $c_1, c_2, \dots, c_n$ ) be the velocity of its  $n$  molecule of mass  $m$ .



Let  $(u_1, v_1, w_1), (u_2, v_2, w_2), \dots, (u_n, v_n, w_n)$  be the rectangular components  $c_1, c_2, c_3$  respectively. Then  $c_1^2 = u_1^2 + v_1^2 + w_1^2$  and so on.

Now momentum of the first molecules along  $x$ -axis  $= m u_1$

After collision with face PQRS, it come back with same velocity. So, momentum along  $x$ -axis after collision  $\approx -m u_1$

now the change in momentum of the molecule

$$= -m u_1 - (m u_1)$$

$$= -2 m u_1$$

The momentum imparted to the face PQRS is

$$= 2 m u_1$$

8. Time taken by the molecule between two successive collisions  $\approx \frac{2L}{v_1}$

$$\text{to travel distance } L$$

Force on the surface PQRS due to 1<sup>st</sup> molecule

$$F_1 = \frac{dp}{dt} = \frac{2mv_1}{L}$$

Similarly force due to the 2<sup>nd</sup> molecule

$$F_2 = \frac{2mv_2^2}{L}$$

Total force along x-axis,

$$F_x = F_1 + F_2 + \dots + F_n$$

$$F_x = \frac{m}{L^2} (v_1^2 + v_2^2 + \dots + v_n^2)$$

Pressure exerted along x-axis

$$P_x = \frac{F_x}{L^2} = \frac{m}{L^3} (v_1^2 + v_2^2 + \dots + v_n^2)$$

Similarly pressure exerted along y-axis

$$P_{yy} = \frac{m}{L^3} (v_1^2 + v_2^2 + \dots + v_n^2)$$

of balanced reaction

and pressure exerted along z-axis

$$P_z = \frac{m}{k_B} (w_1^2 + w_2^2 + w_n^2)$$

The gas is uniform throughout out the tube

therefore,  $P_x = P_y = P_z = P$

Then, Average pressure

$$P = \frac{P_x + P_y + P_z}{3}$$

not suitable to express other pressures

$$\Rightarrow P = \frac{m}{3k_B} [(u_1^2 + u_2^2 + u_n^2) + (v_1^2 + v_2^2 + v_n^2) + (w_1^2 + w_2^2 + w_n^2)]$$

not suitable to express other pressures

$$= \frac{m}{3k_B} [(u_1^2 + v_1^2 + w_1^2) + (u_2^2 + v_2^2 + w_2^2) + \dots + (u_n^2 + v_n^2 + w_n^2)]$$

not suitable to express other pressures

$$= \frac{m}{3k_B} (c_1^2 + c_2^2 + c_3^2 + \dots + c_n^2)$$

not suitable to express other pressures

$$= \frac{m}{3k_B} (c_1^2 + c_2^2 + \dots + c_n^2) \quad \text{denote } C$$

not suitable to express other pressures

we know that

$$POCO \quad \text{SHOT ON POCO M2 PRO, velocity } c = \sqrt{\frac{c_1^2 + c_2^2 + \dots + c_n^2}{n}}$$

Now from eqn(1)

$$P = \frac{m}{3V} c^2$$

nm = m total mass

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

Shift off  $P = \frac{1}{3} PC^2$

(c) write short note on intermolecular force.

$$q = 39 \rightarrow q = 4$$

An intermolecular force is the force that mediates interaction between molecules, including the electromagnetic forces of attraction or repulsion which act between atoms and other types of neighbouring particles e.g. atoms or ions. Intermolecular forces - the forces which hold molecules together. For example, the covalent bond involving sharing electron pairs between atoms is much stronger than the force present between neighboring molecules. Both sets of forces responsible parts of force fields frequently used in.

2. (a) The van der waals equation can be derived by making some modification of the assumption on the kinetic theory of gases.

Firstly, In kinetic theory, the size of the gas molecules was ignored. Hence the available volume occupied by a gas molecule within a container was ~~out~~ of the volume of the container. Actually, the molecules are small but they have some finite size. At low pressure their size of ~~of~~ gas molecules, hence the volume occupied by them may be ignored. At high pressure, the volume occupied by them can't be ignored, hence the available volume will be decreased.

Volume correction: Let there are  $n$  molecules of volume,  $V$ . If  $v$  be the volume of each molecule then the

POCOs within a enclosure

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occupied by each molecule of gas (with

$$\text{d}V = \frac{4}{3}\pi r^3 \text{ since pressure } P = \frac{F}{A}$$

$$s = \frac{4}{3}\pi (r + \frac{2\sigma}{3})^3 \text{ with surface modifications}$$

$$\text{d}V = \frac{4}{3}\pi r^3 \delta V$$

so  $\delta V = 28x$  (from difference of volumes)

so the volume available to first molecule is

$$v = \frac{4}{3}\pi r^3 + \frac{4}{3}\pi (r + \delta V)^3 - \frac{4}{3}\pi (r + 2\delta V)^3$$

$$= \frac{4}{3}\pi r^3 + 3\delta V + 3\delta V^2 + \dots$$

$$= v + \frac{4}{3}\pi r^3 + 3\delta V + \dots$$

similarly for second molecule

Average space (or volume) available to each

molecule will be  $v + \frac{4}{3}\pi r^3 + 3\delta V + \dots + (v + (n-1)\delta V)$

so  $v = \frac{1}{N} [v + \frac{4}{3}\pi r^3 + 3\delta V + \dots + (v + (n-1)\delta V)]$

$$= v - \frac{\delta V}{N} \cdot \frac{n(n-1)}{2}$$

$$= v - \frac{\delta V}{N} \cdot \frac{n(n-1)}{2}$$

$$= v - \frac{\delta V}{N} \cdot \frac{n(n-1)}{2}$$

POCO SHOT ON POCO M2 PRO  $\frac{ns}{2} + \frac{s}{2}$

$$= v - \frac{n(8\pi)}{2} \quad [S_{12} \text{ is neglected}]$$

$$= v - 4n\alpha$$

If there are  $n$  mole of gas,

$$N = nNA$$

Average space available to each molecule will be  
[from state to most probable]  $v = 4n\alpha$

$$v - 4n\alpha N = v - nb \quad [\text{where } b = 4n\alpha]$$

thus, the equation of state of the gas will be,  
[where subscript eff is applied to atoms not molecules]

$$\therefore P(v-nb) = nRT$$

For one mole of the gas,

$$P(v-b) = RT$$

pressure correction: the pressure correction

$$= (P + \frac{b}{v})$$

$$P(v-b) = RT$$

After volume correction the equation of state

$$\text{will be, } P = \frac{RT}{v-b} = \frac{RT}{v - \frac{b}{v} + \frac{b}{v}} = \frac{RT}{\frac{v^2 - bv + b^2}{v^2}} = \frac{RTv^2}{v^2 - bv + b^2}$$

$$(P) = \frac{RT}{v-b} = \frac{RT}{v - \frac{b}{v} + \frac{b}{v} (\frac{Tb}{v} + \frac{b}{v})} = \frac{RTv^2}{v^2 - bv + b^2}$$

**POCO**  $P = \frac{RT}{v-b} \rightarrow \frac{P}{v^2}$  [when reduction of pressure is considered]  
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$$\left(P + \frac{a}{V^2}\right)(V - b) = RT \quad (n)$$

For n moles of gas,

$$\left(P + \frac{a}{V^2}\right)(V - nb) = nRT \quad (ii)$$

~~Now~~  $\left(P + \frac{a}{V^2}\right)(V - nb) = nRT$  This equation is called the van der waal's equation of state for real gas.

2. (c) For 1 mole of the gas, the van der waal's equation is,

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT \quad (i)$$

$$\Rightarrow \left(\frac{PV^2 + a}{V^2}\right)(V - b) = RT$$

$$\Rightarrow (PV^2 + a)(V - b) = RTV^2$$

$$\Rightarrow PV^2 - PV^2b + av - ab = RTV^2$$

$$\Rightarrow V^3 - V^2b - \frac{RT}{P} V^2 + \frac{a}{P} V - \frac{ab}{P} = 0$$

$$\Rightarrow V^3 - \left(b + \frac{RT}{P}\right)V^2 + \frac{a}{P}V - \frac{ab}{P} = 0 \quad (iii)$$

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At the critical temperature, all the roots become equal for a particular value of pressure, i.e.

Now representing critical volume by  $v_c$ ,

we should have,

$$v = v_c$$

$$\Rightarrow (v - v_c)^3 = 0$$

$$\Rightarrow v^3 - 3v^2 v_c + 3v v_c^2 - v_c^3 = 0 \quad (\text{iii})$$

At the critical point  $P \rightarrow P_c$  or  $T \rightarrow T_c$  the equation (w) becomes,

equation (w) becomes,

$$v^3 - \left(b + \frac{RT_c}{P_c}\right)v^2 + \frac{a}{P_c} v - \frac{ab}{P_c} = 0 \quad (\text{iv})$$

At critical point the equations (ii) and (iv) must be identical.

$$2v_c^2 = b + \frac{RT_c}{P_c} \quad (\text{v})$$

$$\text{and } 3v_c^2 = \frac{a}{P_c} \quad (\text{vi})$$

$$\text{and also } v_c^3 = \frac{ab}{P_c} \quad (\text{vii})$$

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By (vii) we get,

round & from addition of eqn (i) & (ii) we get  
 $\frac{1}{3}V_c = b$

$$V_c = 3b \quad \text{(iii)}$$

putting the value of  $V_c$  in eqn (i) we

get,

$$3(3b)^2 = \frac{a}{P_c} \quad \text{from above eqn}$$

$$\Rightarrow P_c = \frac{a}{27b^2} \quad \text{(iv)}$$

putting the value of  $P_c$  and  $V_c$  in eqn (v)

$$3 \times (3b) = b + \frac{RT_c}{P_c} \quad \text{Excess (w) molecules}$$

$$(v) \Rightarrow T_c = \frac{P_c}{R} (3b - b) \cdot \frac{1}{27} + \frac{1}{3} \left( \frac{RT_b}{P_b} + 1 \right) - \theta$$

$$\text{from (v) } b = \frac{a}{27b^2 R} \times 3b \quad \text{left from left side of eqn}$$

$$= \frac{8a}{27bR}$$

(v)  $\Rightarrow T_c = \frac{8a}{27bR}$   
thus, the critical temperature.

$$(vi) \Rightarrow T_c = \frac{8a}{27bR}$$

the critical pressure,  $P_c = \frac{a}{27b^2}$

POCO <sup>POCO</sup> the critical volume,  $V_c = 3b$   
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2 (d) BOOK - BRILAL 82 page (Ans) aligned

3. (a) BRILAL book page - 102

(b) BRILAL book page - 109

(c) BRILAL book page - 112

(d) BRILAL book page - 110

(e) BRILAL book page - 110

(f) BRILAL book page - 118 - 122

4. (a) BRILAL book page

(b) BRILAL book page

(c) reversible process (A process in which the

process can be reversed to return the system to its initial state.

The original conditions from the final state

without producing any changes in the

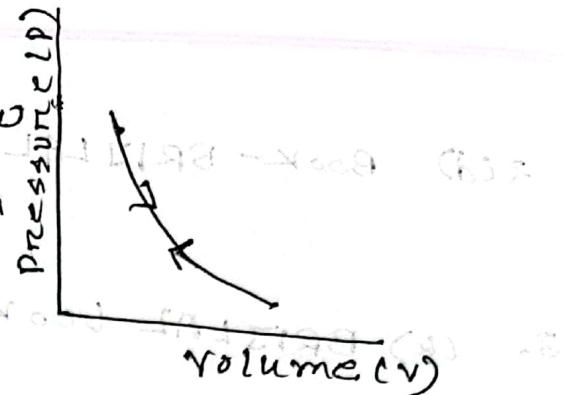
thermodynamic properties of the universe

Two processes reversed effect ①

of the process

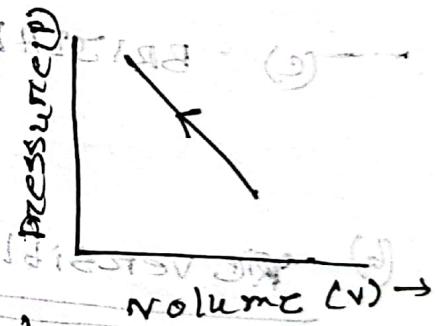
POCO  
SHOT ON POCO M2 PRO - BRILAL - 182 PAGE

Example: current flow through a conductor with resistance.



### Irreversible process:

An irreversible process is a process in which both the system and surrounding do not return to their original condition once the process is initiated.



### Example: transfer of heat

A heat transfer from a hot object to a cold tube object, with no fibers, is an example of a reversible process.

Condition of reversible process: function

when salt to water - > > > > > > >

(1) ~~first~~ The process is carried out

infinitely slowly.

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2. At any stage, the equilibrium is not disturbed

3. It takes infinite time for completion.

4. Work obtained in this process is maximum.

5. It is an ideal process.

(a) PdF (second law of thermodynamics)

(b) PdF (second law of thermodynamics)

(c) PdF (second law of thermodynamics)

(d) PdF (second law of thermodynamics)

(e) PdF (second law of thermodynamics)

6. (a) BRILAL - page - 140

(b) BRILAL - page - 134 vi important

forces to act on forces of attraction

(c) PdF

7. (a) BRILAL book (page) - 115

(b) BRILAL book (page) - 118-119

(c) BRILAL book page - 113

Math formulae revised 2019 up to 12th semester till 2020

1. (c) BRILAL Book (page) → 13  
of class 12th

(d). Principle of equipartition of energy:

The equipartition theorem relates the temperature of system with its average energies. The original idea of equipartition was that, in thermal equilibrium, energy is shared equally among all of its various forms, for example

the average kinetic energy per degree of freedom in the translational motion of a molecule

should equal that of its rotational motions.

At temperature  $T$ , the average energy of any quadratic degree of freedom is  $1/2 kT$ .

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For a system of  $N$  molecules, each with  $f$  degrees of freedom:

$$v_b A = v_B$$

$$v_b A + v_b = 0.2$$

$$U_{\text{thermal}} = N_f \frac{1}{2} kT$$

(With respect to Boltzmann distribution)

2. (b) BRIJ LAL Page  $\rightarrow$  83

$$\frac{\partial U}{\partial T} + \frac{\partial U}{\partial V} \left( \frac{\partial V}{\partial T} \right) + T \frac{\partial V}{\partial T} \left( \frac{\partial U}{\partial V} \right) = 0.2$$

3. If  $V$  and  $T$  are chosen as the independent variables,

$$\frac{\partial U}{\partial T} + \frac{\partial U}{\partial V} \left( \frac{\partial V}{\partial T} \right) = -\frac{0.2}{T}$$

Differentiating equation (i),

$$\frac{\partial U}{\partial T} \left[ T \left( \frac{\partial V}{\partial T} \right)^2 + 1 \right] + \frac{\partial U}{\partial V} \left( \frac{\partial V}{\partial T} \right)^2 = dT + \left( \frac{\partial U}{\partial V} \right)_T dV$$

If an amount of heat  $Q$  is supplied to a thermodynamic system, say an ideal gas and if the volume increases by  $dV$  at a constant pressure  $P$ , then according to the first law of thermodynamics

$$dU = \left( \frac{\partial U}{\partial T} \right)_V dT + \left( \frac{\partial U}{\partial V} \right)_T dV$$

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at diffing  $S_Q = dU + S_W$  relation for first step is met

$$S_W = P \cdot dV$$

which want to express

$$S_Q = dU + P \cdot dV$$

Substituting the value of  $dU$  from eqn (ii)

$$S_Q = \left(\frac{\partial U}{\partial T}\right)_V dT + \left(\frac{\partial U}{\partial V}\right)_T dV + P dV \quad (ii)$$

Dividing both sides by  $dT$  and taking  $V = C_V$

$$\frac{dQ}{dT} = \left(\frac{\partial U}{\partial T}\right)_V + \left(\frac{\partial U}{\partial V}\right)_T \frac{dV}{dT} + \frac{P dV}{dT}$$

$$\left(\frac{dQ}{dT}\right)_V = \left(\frac{\partial U}{\partial T}\right)_V + \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right] \frac{dV}{dT}$$

result of behaviour of gas for constant volume

If the gas is heated at constant volume

then  $\frac{dV}{dT} = 0$  so  $\left(\frac{dQ}{dT}\right)_V = C_V$

and to get  $\frac{dV}{dT} = 0$  let  $P = k$  then result is 9

$$\frac{dV}{dT} = 0$$

$$\left(\frac{dQ}{dT}\right)_V = \left(\frac{\partial U}{\partial T}\right)_V = C_V$$

POCO the gas is heated at constant pressure

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$$\text{from equation (iv)} \quad q\left(\frac{\partial U}{\partial T}\right)_V + q\left(\frac{\partial U}{\partial V}\right)_T + q\left(\frac{\partial U}{\partial P}\right)_T = \Delta H - q$$

$$C_P = \left(\frac{\partial U}{\partial T}\right)_P + \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right] \cdot \left(\frac{\partial V}{\partial T}\right)_P$$

$$C_V = C_V + \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right] \left(\frac{\partial V}{\partial T}\right)_P$$

$$q = q\left(\frac{\partial U}{\partial T}\right)_V q = \Delta H - q$$

$$C_P - C_V = \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right] \left(\frac{\partial V}{\partial T}\right)_P$$

From Joule's experiment, for an ideal gas on opening the stopcock, no work was done and no heat transfer took place. so  $\Delta Q = 0 = \Delta U + 0$ . Therefore  $\Delta U = 0$ . Even though the volume changed while the temperature is constant there is no change in the internal energy.

$$\left(\frac{\partial U}{\partial V}\right)_T = 0$$

$$\left(\frac{\partial U}{\partial V}\right)_T = \frac{RT}{T+q}$$

From the ideal gas equation

$$PV = RT$$

$$P \left(\frac{\partial V}{\partial T}\right)_P = R$$

$$(R-q)q/T$$

$$C_P - C_V = P \left( \frac{\partial V}{\partial T} \right)_P + \left( \frac{\partial V}{\partial T} \right) T \left( \frac{\partial S}{\partial V} \right)_T$$

$$\left( \frac{\partial V}{\partial T} \right)_T = 0 \quad \left( \frac{\partial S}{\partial V} \right)_T + P = 0$$

$$\left( \frac{\partial S}{\partial V} \right)_T + \left( \frac{\partial S}{\partial V} \right)_P + \alpha = 0$$

$$C_P - C_V = P \left( \frac{\partial V}{\partial T} \right)_P = R$$

$$\boxed{C_P - C_V = R \left[ 1 + \left( \frac{\partial S}{\partial V} \right)_T + \alpha \right] = R(1+\alpha)}$$

Ques 20 (a) (Ans 6 marks)

4. (a) Taking  $PV = RT$  from first law of thermodynamics

and substituting in  $C_P - C_V = R$

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

$$0 + u_b = 0 = \alpha \text{ or } \alpha = u_b$$

Similar  $\left( \frac{RT}{V} \right)^{1/\gamma} = \text{constant}$

But  $R$  is constant

$$RTV^{1/\gamma} = \text{constant}$$

$\Rightarrow$  Pressure  $\propto T V^{1/\gamma-1} = \text{constant}$

ALSO

$$P \left( \frac{RT}{P} \right)^{1/\gamma} = \text{constant}$$

$$\frac{R^{\gamma} T^{\gamma}}{P^{\gamma-1}} = \text{constant}$$

$$\frac{P^{\gamma-1}}{T^{\gamma}} = \text{constant}$$

$$T P^{(1-\gamma)/\gamma} = \text{constant}$$

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7. (a) BRIJ LAL page - 219

(b) BRIJ LAL Page - 208

$$\frac{P}{T} = \text{constant} = 0.5 \text{ bar}$$

2021

10 (a) 1.  $\Delta H = \text{constant}$  with adiabatic condition

2 (b) BRIJ LAL page  $\frac{P}{T} = 0.5 \text{ bar}$

$w_b = w_h$

1 (a) 4 (b) isothermal process,

because  $P \propto \frac{1}{V}$  (constant for  $n, T, R$ )  
for  $n \text{ mol}$  gas,

$$PV = nRT \quad \text{so result will be}$$

$$\text{or, } P = \frac{nRT}{V}$$

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

work done for volume changes from  $V_1$  to  $V_2$

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

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

$$W = nRT \ln \left[ \frac{V_2}{V_1} \right]$$

$$W = nRT \ln \left( \frac{V_2}{V_1} \right) \quad \left. \begin{aligned} x &= V_2 - V_1 \\ x &= V_2 - V_1 \\ x &= V_2 - V_1 \end{aligned} \right\} \quad \left. \begin{aligned} x &= V_2 - V_1 \\ x &= V_2 - V_1 \\ x &= V_2 - V_1 \end{aligned} \right\} = W$$

$W = nRT \ln \left( \frac{V_2}{V_1} \right)$  isothermal process  $T \neq 0 \Rightarrow dW = dQ$

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$$W = Q = \pi R T \ln\left(\frac{V_2}{V_1}\right)$$

$$\text{Solut} \quad n = \frac{V_2}{V_1} \times \text{RT}$$

4.(c) In adiabatic process

$$d\varphi = \omega = du + dw$$

$$du = -dw$$

$$dw = -du$$

If the first internal energy is  $u_1$  and second is  $u_2$  then we have,  $v_0$

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$$du = u_2 - u_1 = -dw$$

$v_2 < v_1$  (most segments) Newton not stable

$$du \stackrel{?}{=} -(-dw) = dw$$

$$U_2 - U_1 = \frac{V_b T_{\text{eff}}}{A} = \frac{V_b T_{\text{eff}}}{A} = V_b$$

$$\therefore U_2 \succ U_1$$

$$W = \int_{v_1}^{v_2} \frac{k}{v^y} dv = k \int_{v_1}^{v_2} v^{-y} dv = k \left[ \frac{v^{-y+1}}{-y+1} \right]_{v_1}^{v_2}$$

$$\approx K \left[ \frac{v^{1-y}}{1-y} \right]_{v_1}^{v_2} \approx \frac{K}{1-y} [v_2^{1-y} - v_1^{1-y}]$$

MATH

$$= \frac{1}{1-\gamma} [k v_2^{1-\gamma} - k v_1^{1-\gamma}]$$

$$= \frac{1}{1-\gamma} [P_2 v_2^\gamma v_2^{1-\gamma} - P_1 v_1^\gamma v_1^{1-\gamma}]$$

$$= \frac{1}{1-\gamma} [P_2 v_2 - P_1 v_1]$$

$$= \frac{1}{1-\gamma} [R T_2 - R T_1] \quad [ \because Pv = RT ]$$

$$W = \frac{R}{\gamma-1} [T_1 - T_2]$$

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