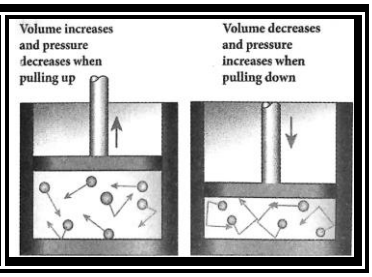
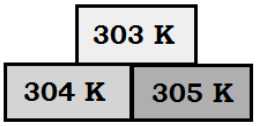
UNIT - 3
THERMAL PHYSICS



I. Choose the correct answer

1. The value of universal gas constant
   a) 3.81 J mol^{-1} K^{-1} b) 8.03 J mol^{-1} K^{-1} c)1.38 J mol^{-1} K^{-1} **d) 8.31 J mol^{-1} K^{-1}**
2. If a substance is heated or cooled, the change in mass of that substance is **[PTA – 1]**
   a) positive b) negative **c) zero** d) none of the above
3. If a substance is heated or cooled, the linear expansion occurs along the axis of
   a) X or –X b) Y or –Y c) both (a) and (b) **d) (a) or (b)**
4. Temperature is the average _____of the molecules of a substance.
   a) difference in K.E and P.E b) sum of P.E and K.E
   c) difference in T.E and P.E d) difference in K.E and T.E
5. In the Given diagram, the possible direction of heat energy transformation is



   a) A←B, A←C, B ← C b) A → B, A → $C, B \rightarrow C$
   c) A → $B, A \leftarrow C, B \rightarrow C$ d) A← $B, A \rightarrow C, B \leftarrow C$

II. Fill in the blanks

1. The value of Avogadro's number **$6.023\times 10^{23}/mole$.** **[SEP – 2020]**
2. The temperature and heat are **scalar** quantities. **[PTA – 2]**
3. One calorie is the amount of heat energy required to raise the temperature of **1 g** of water through **1°C**.
4. According to Boyle's law, the shape of the graph between pressure and reciprocal of volume is **straight line.**

III. True or False. If false correct it.

1. For a given heat in liquid, the apparent expansion is more than that of real expansion. **[False]**
   For a given heat in liquid, the apparent expansion is **less than that of real expansion.*
2. Thermal energy always flows from a system at higher temperature to a system at lower temperature. **[True]**
3. According to Charles's law, at constant pressure, the temperature is inversely proportional to volume. **[False]** **[PTA – 2]**
   According to Charles's law, at constant pressure, temperature of gas is **directly proportional to volume.*

IV. Match the items in Column-I to the items in Column-II

Column I	Column II	Answer
1. Linear expansion	(a) change in volume	1-d) change in length
2. Superficial expansion	(b) hot body to cold body	2-e) change in area
3. Cubical expansion	(c) 1.381×10^{-23}JK^{-1}	3-a) change in volume
4. Heat transformation	(d) change in length	4-b) hot body to cold body
5. Boltzmann constant	(e) change in area	5-c) 1.381×10^{-23} JK^{-1}

V. Assertion & Reason type questions

Mark the correct choice as

(a) If both the assertion and the reason are true and the reason is the correct explanation of assertion.
(b) If both the assertion and the reason are true, but the reason is not the correct explanation of the assertion.
(c) Assertion is true, but the reason is false.
(d) Assertion is false, but the reason is true.

1. **Assertion :** There is no effects on other end when one end of the rod is only heated.
   Reason : Heat always flows from a region of lower temperature to higher temperature of the rod.
   Ans. ***Both Assertion and Reason are false.***

2. **Assertion :** Gas is highly compressible than solid and liquid. **[PTA – 2]**
   Reason : Interatomic or intermolecular distance in the gas is comparably high.
   Ans. (a) ***Both the assertion and the reason are true and the reason is the correct explanation of assertion.***

VI. Answer in briefly

1. **Define one calorie.** **[AUG – 2022, MDL – 19]**

   One calories is the amount of heat energy required to rise the temperature of 1 gram of water through 1°C.

2. **Distinguish between linear, areal (or) superficial expansion.**

Linear Expansion	Areal / Superficial Expansion
1) When a body is heated or cooled, the length of the body changes.	1) When a body is heated or cooled, the area of the body changes.
2) Coefficient of linear expansion, $\alpha_L = \frac{\Delta L}{L_o \Delta T}$	2) Coefficient of Areal expansion, $\alpha_A = \frac{\Delta A}{A_o \Delta T}$

3. **What is co-efficient of cubical expansion?** **[PTA – 6]**

   It is the ratio of increase in volume of the body per degree rise in temperature to its unit volume.

$$\alpha_v = \frac{\Delta V}{V_o \Delta T}$$

   Its SI unit is K^{-1}.

4. **State Boyle's law.** **[MDL – 19, MAY - 2022]**

   When temperature is kept constant, the volume of a gas is inversely proportional to its pressure.

$$P \propto \frac{1}{V} \quad \text{(i.e.) } PV = \text{constant.}$$

5. **State the law of volume. (or) State Charles's law.**

   When pressure is kept constant, the volume of a gas is directly proportional to its temperature.

$$V \propto T \text{ (or) } \frac{V}{T} = \text{constant}$$

6. Distinguish between ideal gas and real gas.

Ideal gas	Real gas
1. Atoms/molecules do not interact with each other. 2. It has low intermolecular/interatomic force of attraction.	1. Atoms/molecules interact with each other. 2. It has definite intermolecular/ interatomic force of attraction.

7. What is co-efficient of real expansion? **[SEP – 2020]**

It is the ratio of the true rise in the volume of the liquid per degree rise in temperature to its unit volume. Its SI unit is K^{-1}.

8. What is co-efficient of apparent expansion?

It is the ratio of the apparent rise in the volume of the liquid per degree rise in temperature to its unit volume. Its SI unit is K^{-1}.

VIII. Answer in detail

1. Derive the ideal gas equation.

According to Boyle's law $PV = \text{Constant}$ ……(1)

According to Charles's law $\frac{V}{T} = \text{Constant}$ ……(2)

According to Avogadro's law $\frac{V}{n} = \text{Constant}$ ……(3)

Combine (1), (2) & (3) $\mathbf{\frac{PV}{nT} = Constant}$ ……(4)

This is called a combined law of gases.

Gas contains μ moles. $\therefore \mathbf{n = \mu N_A}$ ……(5)

(5) in (4), $\frac{PV}{\mu N_A T} = \text{Constant}$

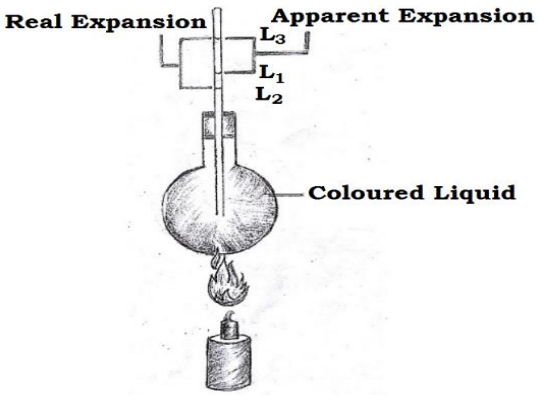
$$\frac{PV}{\mu N_A T} = k_B \quad (k_B = \text{Boltzmann constant} = 1.38 \times 10^{-23} JK^{-1})$$

$$PV = \mu N_A k_B T$$

Considering $\mu N_A k_B = R = 8.31\ J\ mol^{-1}K^{-1}$ R is Universal gas constant.

Thus ideal gas equation (or) equation of state is **PV = RT**.

2. Explain the experiment of measuring the real and apparent expansion of a liquid with a neat diagram. **[MDL – 19]**



Real expansion = $L_3 - L_2$

Apparent expansion = $L_3 - L_1$

- Liquid is poured in a container upto a level L_1. Heat it using a burner.
- Initially container expands. Hence, volume of liquid is reduced. Mark this level as L_2.
- On further heating, the liquid expands and the level of liquid rises to L_3.
- Difference between L_1 and L_3 is called apparent expansion.
- Difference between L_2 and L_3 is called real expansion.
- Real expansion is always more than apparent expansion.

VII. Numerical problems

1. Find the final temperature of a copper rod, whose area of cross section changes from 10 m^2 to 11 m^2 due to heating. The copper rod is initially kept at 90 K. (Coefficient of superficial expansion is 0.0021/ K^{-1})

Given : $A_o = 10\ m^2$, $A = 11 m^2$, $\Delta A = 11 - 10 = 1\ m^2$

$T_o = 90$ K, $T = ?$ $\Delta T = T - T_o = T - 90$

$\alpha_A = 0.0021\ K^{-1}$

Solution : $\frac{\Delta A}{A_o} = \alpha_A \Delta T \Rightarrow \Delta T = \frac{\Delta A}{A_o \alpha_A} = \frac{1}{10 \times 0.0021}$

$$T - 90 = \frac{1}{0.021} = 47.61$$

$$T = 47.61 + 90 = 137.6\ K$$

∴ Final temperature is 137.6 K

2. Calculate the coefficient of cubical expansion of a zinc bar, whose volume is increased from 0.25 m^3 to 0.3 m^3 due to the change in its temperature of 50 K.

Given : $V = 0.3\ m^3$ $V_o = 0.25\ m^3$ $\Delta T = 50$ K

Solution : $\alpha_v = \frac{\Delta V}{V_o \Delta T} = \frac{V - V_o}{V_o \Delta T}$

$$\alpha_v = \frac{0.3 - 0.25}{0.25 \times 50} = \frac{0.05}{12.5} = 0.004\ K^{-1}$$

∴ The coefficient of cubical expansion is $0.004\ K^{-1}$.

IX. HOT Question

1. If you keep ice at 0°C and water at 0°C in either of your hands, in which hand you will feel more chillness? Why?

We feel more chillness in the hand in which ***ice*** is placed at 0℃

Reason: *When water and ice are kept in our hand at* 0℃*, ice requires additional latent heat energy to melt down. ∴ Ice absorbs more heat energy when compared to water.*