PETIT SEMINAIRE HIGHER SECONDARY SCHOOL – PUDUCHERRY

UNIT – 3 THERMAL PHYSICS

STD: X SELF – EVALUATION

I. Choose the best answer:

1. The value of universal gas constant - **(D) 8.31 J mol^{-1} K^{-1}**
2. If a substance is heated or cooled, the change in mass of that substance is - **(C) Zero**
3. If a substance is heated or cooled, the linear expansion occurs along the axis of - **(C) both (a) and (b)**
4. Temperature is the average ---- of the molecules of a substance - **(C) difference in T.E and P.E**
5. In the given diagram, the possible direction of heat energy transformation is **(A) A←B, A←C, B←C**

II. Fill in the blanks:

1. The value of Avogadro number is **6.023 x 10^{23} mol^{-1}**
2. The temperature and heat are **Scalar** quantities.
3. One calorie is the amount of heat energy required to raise the temperature **1 gram** 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. State whether the following statements are true or false, if false explain why?

1. For a given heat in liquid, the apparent expansion is more than that of real expansion. - **False**

   Correct statement: 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

   Correct statement: According to Charles's law, at constant pressure, the temperature is directly proportional to volume.

IV. Match the following:

S.No	Column 1	Column 2
1	Linear expansion	Change in length
2	Superficial expansion	Change in area
3	Cubical expansion	Change in volume
4	Heat transformation	Hot body to cold body
5	Boltzmann constant	1.381×10^{-23} JK^{-1}

V. Assertion & Reasoning:

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.

   C. Assertion is true but the reason is false.
2. **Assertion:** Gas is highly compressible than solid and liquid.

   Reason: Interatomic or intermolecular distance in the gas is comparably high.

   A. Both the assertion and the reason are true and the reason is the correct explanation of the assertion.

VI. Answer in briefly:

1. Define one calorie?

   One calorie is defined as the amount of heat energy required to raise the temperature of 1 gram of water through 1°C.
2. Distinguish between linear, arial and cubical expansion?

S.No	Linear expansion	Areal expansion	Cubical expansion
1	When a body is heated or cooled, the length of the body changes due to change in its temperature. Then the expansion is said to be linear or longitudinal	If there is an increase in the area of a solid object due to heating, then the expansion is called superficial or areal expansion.	If there is an increase in the volume of a solid body due to heating, then the expansion is called cubical or volumetric expansion

	expansion.		
2	$\frac{\Delta L}{L_o} = \alpha_L \Delta T$	$\frac{\Delta A}{A_o} = \alpha_A \Delta T$	$\frac{\Delta V}{V_o} = \alpha_V \Delta T$

3. What is co – efficient of cubical expansion?

   The ratio of increase in volume of the body per degree rise in temperature to its unit volume is called as coefficient of cubical expansion. This is also measures in K^{-1}.

4. State Boyle's law?

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

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

   In other words, for an invariable mass of a perfect gas, at constant temperature, the product of its pressure and volume is a constant. PV = constant.

5. State the law of volume?

   According to this law, when the pressure of a gas is kept constant, the volume of a gas is directly proportional to the temperature of the gas.

   $$V \alpha T$$

6. Distinguish between ideal gas and real gas?

S.No	Real gas	Ideal gas (or) perfect gas
1	Molecule or atom of gases interact with each other with definite amount of inter atomic or molecular force of attraction	Molecules or atoms of gases do not interact with each other.
2	At very high temperature or low pressure real gas behaves ideal gas	At high temperature or low pressure they will be termed as perfect gas.
3	There is no inter atomic or intermolecular force of attraction.	The inter atomic or intermolecular forces of

		attraction are weak
4	Real gas has volume	Ideal gas does not have volume

7. What is co – efficient of real expansion?

   It is defined as the ratio of the true rise in the volume of the liquid per degree rise in temperature to its unit volume. The SI unit of coefficient of real expansion is K^{-1}.

8. What is co – efficient of apparent expansion?

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

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. (Co – efficient of superficial expansion is 0.0021 / K)

   Given:

   T_i = 90K; A = 10 m^2; ΔA = 11 – 10 = 1 m^2; co-efficient of superficial expansion = 0.0021/K; T_f =?

   $$\frac{\Delta A}{A} = \alpha \, \Delta T$$

   $$\frac{1}{10} = 0.0021\,(T_2 - 90)$$

   $$T_2 = \frac{1}{10 \times 0.0021} + 90$$

   T_2 = 47.6 + 90

   Final temperature, T_2 = 137.6 K

2. Calculate the co – efficient of cubical expansion of a zinc bar. Whose volume is increased 0.25 m^3 from 0.3 m^3 due to the change in its temperature of 50 K.

   Volume of the zinc bar V = 0.3 m^3

   Change in volume ΔV = 0.25 m^3

   Change in temperature ΔT = 50 K

$\alpha_v = ?$

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

$$\alpha_v = \frac{0.25}{0.3 \times 50} = \frac{0.25}{15} = 0.0166\ K^{-1}$$

Co – efficient of cubical expansion = $0.0166\ K^{-1}$

VIII. Answer in detail:

1. Derive the ideal gas equation?

The ideal gas equation is an equation, which relates all the properties of an ideal gas. An ideal gas obeys Boyle's law and Charles' law and Avogadro's law. According to Boyle's law,

$$PV = constant \qquad (3.1)$$

According to Charles's law,

$$V/T = constant \qquad (3.2)$$

According to Avogadro's law,

$$V/n = constant \qquad (3.3)$$

After combining equations (3.1), (3.2) and (3.3), you can get the following equation.

$$PV/nT = constant \qquad (3.4)$$

The above relation is called the combined law of gases. If you consider a gas, which contains μ moles of the gas, the number of atoms contained will be equal to μ times the Avogadro number, N_A.

$$i.e. \quad n = \mu N_A. \qquad (3.5)$$

Using equation (3.5), equation (3.4) can be written as

$$PV/\mu N_A T = constant$$

The value of the constant in the above equation is taken to be k_B, which is called as **Boltzmann constant ($1.38 \times 10^{-23} JK^{-1}$)**. Hence, we have the following equation:

$$PV/\mu N_A T = k_B$$

$$PV = \mu N_A k_B T$$

Here, $\mu N_A k_B = R$, which is termed as universal gas constant whose value is $8.31\ J\ mol^{-1} K^{-1}$.

$$PV = RT \qquad (3.6)$$

Ideal gas equation is also called as *equation of state* because it gives the relation between the state variables and it is used to describe the state of any gas.

2. Explain the experiment of measuring the real and apparent expansion of a liquid with a neat diagram?

To start with, the liquid whose real and apparent expansion is to be determined is poured in a container up to a level. Mark this level as L_1. Now, heat the container and the liquid using a burner as shown in the Figure 3.5.

Initially, the container receives the thermal energy and it expands. As a result, the volume of the liquid appears to have reduced. Mark this reduced level of liquid as L_2.

On further heating, the thermal energy supplied to the liquid through the container results in the expansion of the liquid. Hence, the level of liquid rises to L_3. Now, the difference between the levels L_1 and L_3 is called as **apparent expansion,** and the difference between the levels L_2 and L_3 is called **real expansion**. The real expansion is always more than that of apparent expansion.

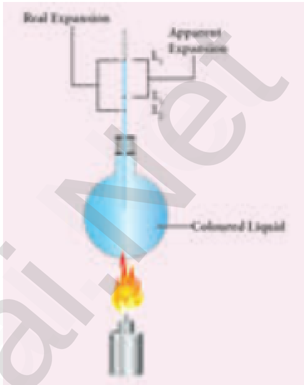

Figure 3.5 Real and apparent expansion of liquid

Real expansion = $L_3 - L_2$

Apparent expansion = $L_3 - L_1$

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?

- Ice transfer more chillness to our hands than water.
- Due to thermal conduction in between ice and environment
- The latent heat of vaporization for ice is more than water at 0°C
- Ice has a very significant heat of fusion. The number of calories required to melt each gram.
- Water has only its 1 calorie per gram per °C specific heat.