Chapter 3
Thermal Physics

I. Choose the correct Answer.

Question 1.
The value of universal gas constant:
(a) 3.81 mol^{-1} K^{-1}
(b) 8.03 mol^{-1} K^{-1}
(c) 1.38 mol^{-1} K^{-1}
(d) 8.31 mol^{-1} K^{-1}
Answer:
(d) 8.31 mol^{-1} K^{-1}

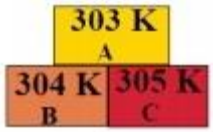
Question 2.
If a substance is heated or cooled, the change in mass of that substance is:
(a) positive
(b) negative
(c) zero
(d) none of the above
Answer:
(b) negative

Question 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) either (a) or (b).
Answer:
(c) both (a) and (b)
Hint: When a substance is heated its expansion is positive i,e, can be taken along either +X or +Y direction. But when substance is cooled it's either length or area or volume decreases i.e. with respect expansion, it is opposite direction i.e. either -X or -Y direction respectively.

Question 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

Answer:
(b) sum of P.E and K.E

Question 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 → C
(c) A → B, A ← C, B → C
(d) A ← B, A → C, B ← C
Answer:
(a) A ← B, A ← C, B ← C

II. Fill in the blanks.

1. The value of Avogadro number …….
2. The temperature and heat are ……. quantities.
3. One calorie is the amount of heat energy required to raise the temperature of ……. of water through
4. According to Boyle's law, the shape of the graph between pressure and reciprocal of volume is …….

Answer:

1. 6.023×10^{23}
2. Inter convertible
3. 1 gram, 1°C
4. A 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.
2. Thermal energy always flows from a system at higher temperature to a system at lower temperature.
3. According to Charles's law, at constant pressure, the temperature is inversely proportional to volume.

Answer:

1. True

2. True
3. False – According to Charles law, at constant pressure, the volume is directly proportional to temperature.

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

Column I		Column II	
A	Linear expansion	*(p)*	change in volume
B	Superficial expansion	*(q)*	hot body to cold body
C	Cubical expansion	*(r)*	$1.381 \times 10^{-23}\ JK^{-1}$
D	Heat transformation	*(s)*	change in length
E	Boltzmann constant	*(t)*	change in area

Answer:
A. (s)
B. (t)
C. (p)
D. (q)
E. (r)

V. Assertion and Reason type Questions.

(a) Both the assertion and the reason are true and the reason is the correct explanation of the assertion.
(b) Both the assertion and the reason are true but the reason is not the correct explanation of the assertion.
(c) The assertion is true but the reason is false.
(d) The 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.

2. Assertion: Gas is highly compressible than solid and liquid
Reason: Interatomic or intermolecular distance in the gas is comparably high.
Answer:
1. (b)
2. (a)

VI. Answer in briefly.

Question 1.
Define one calorie.
Answer:

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

Question 2.
Distinguish between linear and superficial areal expansion.
Answer:

Linear Expansion	Areal and Superficial Expansion
In this expansion, length of a body increases.	In.this expansion, area of a body increases.
Coefficient of linear expansion is different for different materials.	Coefficient of areal expansion is different for different materials.
$\frac{\Delta L}{L_o} = \alpha_L \Delta T$	$\frac{\Delta A}{A_o} = \alpha_A \Delta T$

Question 3.
What is the coefficient of cubical expansion?
Answer:
The ratio of increase in the volume of the body per degree rise in temperature to its unit volume is called a coefficient of cubical expansion.

Question 4.
State Boyle's law
Answer:
When the temperature of a gas is kept constant, the volume of a fixed mass of gas is inversely proportional to its pressure.
$P \propto 1 / V$

Question 5.
State-the law of volume.
Answer:
When the pressure of a gas is kept constant, the volume of a gas is directly proportional to the temperature of the gas.
i.e., $V \propto T$.
(or)
$\frac{V}{T}$ = constant.

Question 6.
Distinguish between ideal gas and real gas.
Answer:

Ideal gas	Real gas
In this gas, molecules or atoms of a gas interact with each other with some interatomic force.	In this gas, atoms or molecules of a gas do not interact with each other.
They obey Boyle's law, Charles law and Avogadro's law.	They do not obey Boyle's law, Charles law and Avogadro's law.

Question 7.
What is co-efficient of real expansion?
Answer:
Coefficient of real expansion 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 the K^{-1}.

Question 8.
What is the coefficient of apparent expansion?
Answer:
Coefficient of apparent expansion 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 the coefficient of apparent expansion is K^{-1}.

VII. Numerical problems.

Question 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).
Answer:
Change in area $\Delta A = 11 - 10 = 1\ m^2$
Initial temperature $T_1 = 90$ K
Let Final temperature be T_2K\

$A_0 = 10\ m^2$

Coefficient of superficial expansion is

$\alpha_A = 0.0021 / k$

$\frac{\Delta A}{A_0} = \alpha_A \Delta T$

$\frac{1}{10} = 0.0021\ \Delta T$

$\therefore \Delta T = 0.0021 \times 10$

$= 0.021$

$T_2 - T_1 = 0.021$

$T_2 - 90 = 0.021$

$\therefore$ Final temperature $T_2 = 90.021$ K

Question 2.
Calculate the coefficient 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.
Answer:
Initial volume $V_0 = 0.25\ m^3$
Final volume $= 0.30\ m^3$
Change in volume $\Delta V = 0.3 - 0.25 = 0.05\ m^3$
Temperature $\Delta T = 50K$
Coefficient of cubical expansion is

$$\alpha_V = \frac{\Delta V}{V_0 \Delta T}$$

$$= \frac{0.05}{0.25 \times 50}$$

$$= \frac{1}{5 \times 50} = \frac{1}{250}$$

$$= \frac{1000 \times 10^{-3}}{250} = 4 \times 10^{-3}$$

$\therefore$ Coefficient of Cubical expansion
$\alpha_v = 0.004\ /K$

VIII. Answer in detail.

Question 1.
Derive the ideal gas equation.
Answer:
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's law and Avogadro's law.
According to Boyle's law, PV = constant ……. (1)
According to Charles's law,
VT = constant …… (2)
According to Avogadro's law,
VT = constant …….. (3)
After combining equations (1), (2) and (3), you equation. can get the following
VnT = constant ……. (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_0.
i.e., $n = \mu N_A$

Using equation (5), in equation (4) can be written as

$\frac{PV}{\mu N_A T}$ = constant

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

$\frac{PV}{\mu N_A T} = K_B$

$PV = \mu N_A K_B T$

$\mu N_A K_B = R$

which is termed as universal gas constant whose value is 8.31 J mol^{-1} K^{-1}.

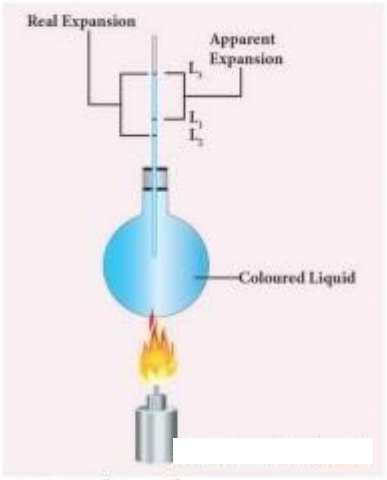
$PV = RT$

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.

Question 2.

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

Answer:



Real and apparent expansion of liquid

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. 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.

Real expansion = $L_3 - L_2$
Apparent expansion = $L_3 - L_1$

IX. HOT Question

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?
Answer:
The hand consisting of ice at 0°C would feel more chillness because, ice undergoes melting. More amount of energy (chillness) is transferred to hand. In addition ice has latent heat of fusion.