Heat and Thermodynamics

Question1

A body cools from a temperature of $60^{\circ}\mathrm{C}$ to $50^{\circ}\mathrm{C}$ in 10 minutes and $50^{\circ}\mathrm{C}$ to $40^{\circ}\mathrm{C}$ in 15 minutes. The time taken in minutes for the body to cool from $40^{\circ}\mathrm{C}$ to $30^{\circ}\mathrm{C}$ is

TG EAPCET 2025 (Online) 2nd May Evening Shift

Options:

A.

30

B.

20

C.

25

D.

40

Answer: A

Solution:

According to Newton's law of cooling.

$$\frac{T_1-T_2}{t}=K\left(\frac{T_1+T_2}{2}-T_0\right)$$

For the first case

$$\frac{60-50}{10} = K\left(\frac{60+50}{2} - T_0\right)$$
$$1 = K(55 - T_0) \qquad \ldots(i)$$

For the second case

$$\frac{50-40}{15} = K\left(\frac{50+40}{2} - T_0\right)$$
$$\Rightarrow \frac{10}{15} = K(45 - T_0)$$
$$\frac{2}{3} = K(45 - T_0) \qquad \ldots(ii)$$

Dividing Eqs. (i) by Eq. (ii), we get

$$\frac{1}{2/3} = \frac{55-T_0}{45-T_0}$$
$$\frac{3}{2} = \frac{55-T_0}{45-T_0}$$
$$\Rightarrow T_0 = 25^\circ\mathrm{C}$$

$\therefore$ From Eq. (i), $1 = K(55-25)$,

$\Rightarrow K = \frac{1}{30}$

If t be the time taken to cool from $40^\circ\mathrm{C}$ to $30^\circ\mathrm{C}$, then

$$\frac{40-30}{t} = K\left(\frac{40+30}{2} - T_0\right)$$
$$\frac{10}{t} = \left(\frac{1}{30}\right)(35-25)$$
$$\Rightarrow t = 30 \text{ minutes}$$

Question2

When the temperature of a gas in a closed vessel is increased by $2.4^\circ\mathrm{C}$, its pressure increases by 0.5%. The initial temperature of the gas is

TG EAPCET 2025 (Online) 2nd May Evening Shift

Options:

A.

$120^\circ\mathrm{C}$

B.

$240^\circ\mathrm{C}$

C.

$480^{\circ}\mathrm{C}$

D.

$207^{\circ}\mathrm{C}$

Answer: D

Solution:

According to Gay-Lussac's law,

$$
\begin{aligned}
& \frac{P_1}{T_1}=\frac{P_2}{T_2} \\
\Rightarrow \quad & \frac{P_1}{T_1}=\frac{P_1+0.5\% \text{ of } P_1}{T_1+2.4} \\
\Rightarrow \quad & \frac{P_1}{T_1}=\frac{1.005 P_1}{T_1+2.4} \Rightarrow T_1+2.4=1.005 T_1 \\
\Rightarrow \quad & 0.005 T_1=2.4 \\
\Rightarrow \quad & T_1=\frac{2.4}{0.005}=\frac{2400}{5} \\
& =480 \mathrm{~K}=480-273^{\circ}\mathrm{C} \\
& =207^{\circ}\mathrm{C}
\end{aligned}
$$

Question3

A gas is suddenly compressed such that its absolute temperature is doubled. If the ratio of the specific heat capacities of the gas is 1.5 , then the percentage decrease in the volume of the gas is

TG EAPCET 2025 (Online) 2nd May Evening Shift

Options:

A.

30

B.

50

C.

25

D.

75

Answer: D

Solution:

For adiabatic process,

$$T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$
$$T_1V_1^{1.5-1} = (2T_1)V_2^{(1.5-1)}$$
$$V_1^{0.5} = 2V_2^{0.5}$$
$$\Rightarrow \quad V_1 = 4V_2 \Rightarrow V_2 = \frac{V_1}{4}$$

$\therefore$ Percentage decrease in the volume

$$= \frac{V_1 - V_2}{V_1} \times 100$$
$$= \frac{V_1 - \frac{V_1}{4}}{V_1} \times 100 = 75\%$$

Question4

If the heat required to increase the rms speed of 4 moles of a diatomic gas from v to $\sqrt{3}v$ is 83.1 kJ , then the initial temperature of the gas is

(universal gas constant $= 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$ **)**

TG EAPCET 2025 (Online) 2nd May Evening Shift

Options:

A.

$377^{\circ}\mathrm{C}$

B.

$327^{\circ}\mathrm{C}$

C.

227°C

D.

277°C

Answer: C

Solution:

Step 1: How rms speed relates to temperature

The root mean square (rms) speed of a gas, V_{rms}, increases as the square root of its temperature (T). So, $V_{\text{rms}} \propto \sqrt{T}$.

Step 2: Setting up the ratio

Since $V_{\text{rms}}^2 \propto T$, we can write:

$$\left[\frac{(V_{\text{rms}})_1}{(V_{\text{rms}})_2}\right]^2 = \frac{T_1}{T_2}$$

Step 3: Substituting given values

The rms speed increases from v to $\sqrt{3}v$. So:

$$\left(\frac{v}{\sqrt{3}v}\right)^2 = \frac{T_1}{T_2}$$

This simplifies to $\frac{1}{3} = \frac{T_1}{T_2}$, so $T_2 = 3T_1$.

Step 4: Calculating heat required

The heat (Q) needed to raise the temperature is:

$$Q = nC_V\Delta T$$

For 4 moles of a diatomic gas, $C_V = \frac{5}{2}R$, so:

$$Q = 4 \times \frac{5}{2}R(T_2 - T_1)$$

We know $T_2 = 3T_1$, so $\Delta T = 3T_1 - T_1 = 2T_1$.

Step 5: Plugging in the numbers

We are given $Q = 83.1\ \text{kJ} = 83,100\ \text{J}$ and $R = 8.31\ \text{J mol}^{-1}\text{K}^{-1}$.

$$83,100 = 4 \times \frac{5}{2} \times 8.31 \times 2T_1$$

$4 \times \frac{5}{2} \times 2 = 20$, so:

$83,100 = 20 \times 8.31 \times T_1$

$20 \times 8.31 = 166.2$, so:$83,100 = 166.2 \times T_1$

$T_1 = \frac{83,100}{166.2} = 500 \text{ K}$

Step 6: Converting to Celsius

T_1 in Celsius = $500 - 273 = 227^{\circ}\text{C}$

Question5

The length of a metal rod is 20 cm and its area of cross-section is 4 cm^2. If one end of the rod is kept at a temperature of 100°C and the other end is kept in ice at 0°C, then the mass of the ice melted in 7 minutes is (Thermal conductivity of the metal $= 90\text{Wm}^{-1}\text{ K}^{-1}$ and latent heat of fusion of ice $= 336 \times 10^3\text{Jkg}^{-1}$)

TG EAPCET 2025 (Online) 2nd May Morning Shift

Options:

A.

90 g

B.

67.5 g

C.

22.5 g

D.

45 g

Answer: C

Solution:

The heat transferred through the rod is

$Q = \frac{kA\Delta T}{l} t$

$$Q = \frac{90 \text{ W/mk} \times 4 \times 10^{-4} \text{ m}^2 \times (100^\circ\text{C} - 0^\circ\text{C})}{0.2 \text{ m}} \times 420 \text{ s}$$

$$Q = \frac{90 \times 4 \times 10^{-4} \times 100}{0.2} \times 420 \text{ J}$$

$$Q = \frac{36000 \times 10^{-4}}{0.2} \times 420 \text{ J}$$

$$Q = \frac{3.6}{0.2} \times 420 \text{ J}$$

$$Q = 18 \times 420 \text{ J} = 7560 \text{ J}$$

The heat required to melt a mass m of ice is given by $Q = mL_f$

$$m = \frac{Q}{L_f}$$

$$m = \frac{7560 \text{ J}}{336 \times 10^3 \text{ J/kg}}$$

$$m = \frac{7560}{336000} \text{ kg}$$

$$m = 0.0225 \text{ kg}$$

$$m = 22.5 \text{ g}$$

The mass of ice melted is 22.5 g

Question6

The heat required to convert 8 g of ice at a temperature of -20°C to steam at 100°C is [specific heat capacity of ice $= 2100 \text{Jkg}^{-1} \text{ K}^{-1}$, specific heat capacity of water $= 4200 \text{ J kg}^{-1} \text{ K}^{-1}$, latent heat of fusion of ice $= 336 \times 10^3 \text{ J kg}^{-1}$ and latent heat of steam $= 2.268 \times 10^6 \text{Jkg}^{-1}$]

TG EAPCET 2025 (Online) 2nd May Morning Shift

Options:

A.

5400 cal

B.

5840 cal

C.

5760 cal

D.

5120 cal

Answer: B

Solution:

Heat of raise temperature of ice from $-20^{\circ}\mathrm{C}$ to $0^{\circ}\mathrm{C}$.

$$\begin{aligned} Q_1 &= m \cdot C_{\text{ice}} \cdot \Delta T \\ &= 0.008 \times 2100 \times 20 = 336\ \mathrm{J} \end{aligned}$$

Heat to melt ice at $0^{\circ}\mathrm{C}$ to water

$$Q_2 = m \times L_f = 0.008 \times 336000 = 2,688\ \mathrm{J}$$

Heat to raise temperature of water from $0^{\circ}\mathrm{C}$ to $100^{\circ}\mathrm{C}$

$$\begin{aligned} Q_3 &= m \times C_{\text{water}} \times \Delta T \\ &= 0.008 \times 4200 \times 100 = 3360\ \mathrm{J} \end{aligned}$$

Heat to convert water at $100^{\circ}\mathrm{C}$ to steam

$$\begin{aligned} Q_4 &= M \cdot L_v = 0.008 \times 2.268 \times 10^6 \\ &= 18144\ \mathrm{J} \end{aligned}$$

Total heat required

$$\begin{aligned} Q_{\text{Total}} &= Q_1 + Q_2 + Q_3 + Q_4 \\ &= 336 + 2688 + 3360 + 18144 \\ &= 24,528\ \mathrm{J}(\text{ or } 24.5\ \mathrm{kJ}) \end{aligned}$$

1 calorie $= 4.18\ \mathrm{J}$

Total heat in joules

$$Q = \frac{24528}{4.2} \approx 5840 \mathrm{cal}$$

Question7

Two moles of a gas at a temperature of $327^{\circ}\mathrm{C}$ expands adiabatically such that its volume increases by 700%. If the ratio of the specific heat capacities of the gas is $\frac{4}{3}$, then the work done by the gas is (Universal gas constant $= 8.3\ \mathrm{J\ mol^{-1}\ K^{-1}}$)

Options:

A.

14.94 kJ

B.

29.88 kJ

C.

44.82 kJ

D.

59.76 kJ

Answer: A

Solution:

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

$$T_2 = T_1\left[\frac{V_1}{V_2}\right]^{\gamma-1} = 600\left[\frac{V}{8V}\right]^{\frac{4}{3}-1}$$

$$T_2 = 600 \times \frac{1}{2} = 300\ \mathrm{K}$$

$$W = \frac{nRT_1}{\gamma-1}\left[1-\left(\frac{V_1}{V_2}\right)^{\gamma-1}\right]$$

$$= \frac{2 \times 8.3 \times 600}{\frac{4}{3}-1}\left[1-\left(\frac{1}{8}\right)^{\frac{4}{3}-1}\right]$$

$$= \frac{3 \times 2 \times 8.3 \times 600}{1}\left[1-\frac{1}{2}\right]$$

$$= \frac{3 \times 2 \times 8.3 \times 600}{2} = 14940\ \mathrm{J}$$

$$= 14.94\ \mathrm{kJ}$$

Question8

The molar specific heat of a monoatomic gas at constant pressure is

(Universal gas constant $= 8.3 \text{ J mol}^{-1} \text{ K}^{-1}$ **)**

TG EAPCET 2025 (Online) 2nd May Morning Shift

Options:

A.

$24.9 \text{ J mol}^{-1} \text{ K}^{-1}$

B.

$20.75 \text{ J mol}^{-1} \text{ K}^{-1}$

C.

$41.5 \text{ J mol}^{-1} \text{ K}^{-1}$

D.

$16.6 \text{ J mol}^{-1} \text{ K}^{-1}$

Answer: B

Solution:

Step 1: Recall relations

For an ideal gas,

$C_p - C_v = R$

For a **monoatomic** gas,

$C_v = \frac{3}{2}R$

So,

$C_p = C_v + R = \frac{3}{2}R + R = \frac{5}{2}R$

Step 2: Substitute the gas constant

Given:

$R = 8.3 \text{ J mol}^{-1} \text{ K}^{-1}$

Hence,

$C_p = \frac{5}{2} \times 8.3 = 2.5 \times 8.3 = 20.75 \text{ J mol}^{-1} \text{ K}^{-1}$

✅ **Final Answer:**

$\boxed{20.75 \text{ J mol}^{-1} \text{ K}^{-1}}$

Correct option: B

Question9

A pendulum clock loses 10.8 s a day when the temperature is 38°C and gains 108 s a day when the temperature is 18°C. The coefficient of linear expansion of the metal of the pendulum clock is

TG EAPCET 2024 (Online) 11th May Morning Shift

Options:

A. $7 \times 10^{-5\circ}\text{C}^{-1}$

B. $1.25 \times 10^{-5\circ}\text{C}^{-1}$

C. $5 \times 10^{-5\circ}\text{C}^{-1}$

D. $2.5 \times 10^{-5\circ}\text{C}^{-1}$

Answer: D

Solution:

Temperature at which the clock loses time, $T = 38^\circ\text{C}$

Temperature at which the clock gains

time, $T_2 = 18^\circ\text{C}$

$\Delta T = T_1 - T_2$

$\quad = (38 - 18)^\circ\text{C} = 20^\circ\text{C}$

Time lost per day, $\Delta t_1 = -10.8 \text{ s}$

Time gained per day, $\Delta t_2 = 10.8 \text{ s}$

The total change in time per day,

$\Delta t = \Delta t_1 - \Delta t_2 = -10.8 - 10.8 = -21.6 \text{ s}$

Time period of a pendulum,

$$T = 2\pi\sqrt{\frac{L}{g}}$$

The change in length ΔL due to a temperature change ΔT is given by

$$\Delta L = L\alpha\Delta T$$

where, $\alpha =$ coefficient of linear expansion

So, $\frac{\Delta L}{L} = \alpha\Delta T$

The fractional change in the time period is approximately half the fractional change in length.

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta L}{L} = \frac{1}{2}\alpha\Delta T$$

$$\frac{\Delta t_{\text{day}}}{T_{\text{day}}} = \frac{-21.6}{86400}$$

Putting value in Eq. (ii) from Eq. (i) and Eq. (iii), we get

$$\frac{-21.6}{86400} = \frac{1}{2} \times \alpha \times 20$$

$$\alpha = -2.5 \times 10^{-5}{}^{\circ}\mathrm{C}^{-1}$$

Negative sign indicated the clock runs slower at higher temperature.

Question10

A liquid cools from a temperature of 368 K to 358 K in 22 min . In the same room, the same liquid takes 12.5 min to cool from 358 K to 353 K . The room temperature is

TG EAPCET 2024 (Online) 11th May Morning Shift

Options:

A. $27.5^{\circ}\mathrm{C}$

B. 27.5 K

C. $30.5^{\circ}\mathrm{C}$

D. 30.5 K

Answer: A

Solution:

Newton's law of cooling says that,

$\frac{\theta_1-\theta_2}{t} \propto\left(\frac{\theta_1+\theta_2}{2}-\theta_0\right)$

$\frac{\theta_1-\theta_2}{t}=k\left(\frac{\theta_1+\theta_2}{2}-\theta_0\right)$

where, $\theta_1=$ Initial temperature, $\theta_2=$ Final temperature,

$\theta_0=$ Room temperature, $t=$ time and $k=$ constant that depends on the characteristics of the liquid and the environment.

For first cooling period

$\frac{368-358}{22}=k\left(\frac{368+358}{2}-\theta_0\right)$

$\frac{10}{22}=k\left(363-\theta_0\right) \Rightarrow k=\frac{10}{22\left(363-\theta_0\right)} \ldots$ (i)

For second cooling period

$\frac{358-353}{12.5}=k\left(\frac{358+353}{2}-\theta_0\right)$

$\frac{5}{12.5}=k\left(355.5-\theta_0\right) \Rightarrow k=\frac{5}{12.5\left(355.5-\theta_0\right)}$

On comparing Eq. (i) with Eq. (ii), we get

$$\frac{10}{22\left(363-\theta_0\right)}=\frac{5}{12.5\left(355.5-\theta_0\right)}$$

$25\left(355.5-\theta_0\right)=22\left(363-\theta_0\right)$

$$901.5=3 \theta_0 \Rightarrow \theta_0=300.5 \mathrm{~K}$$

$$\Rightarrow \quad \theta_0=300.5-273$$

$$\theta_0=27.5^{\circ} \mathrm{C}$$

Question11

For a gas in a thermodynamic process, the relation between internal energy U, the pressure p and the volume V is $U=3+15 p V$. The ratio of the specific heat capacities of the gas at constant volume and constant pressure is

TG EAPCET 2024 (Online) 11th May Morning Shift

Options:

A. $\frac{5}{3}$

B. $\frac{3}{5}$

C. $\frac{4}{3}$

D. $\frac{3}{4}$

Answer: B

Solution:

Given, $U = 3 + 1.5\text{pV}$

At constant volume, the change in internal energy is given by the change in temperature

$dU = C_V dT \Rightarrow \frac{dU}{dT} = C_V$

We know that, $pV = nRT$

So, $U = 3 + 1.5nRT$

Putting value in Eq. (ii), we get

$C_V = \frac{d}{dT}(3 + 1.5nRT)$

$C_V = 1.5nR$

For C_p, we use the relation

$C_p = C_V + nR$

$C_p = 1.5nR + nR = 2.5nR$

The ratio of the specific heat capacities of the gas at constant volume and constant pressure is

$\frac{C_V}{C_p} = \frac{1.5nR}{2.5nR}$

$\frac{C_V}{C_p} = \frac{15}{25}$

$\frac{C_V}{C_p} = \frac{3}{5}$

Question12

At a pressure p and temperature $127^{\circ}\mathrm{C}$, a vessel contains 21 g of a gas. A small hole is made into the vessel, so that the gas in it leaks out. At a pressure of $\frac{2p}{3}$ and a temperature of $t^{\circ}\mathrm{C}$, the mass of the gas leaked out is 5 g . Then, $t=$

TG EAPCET 2024 (Online) 11th May Morning Shift

Options:

A. $273^{\circ}\mathrm{C}$

B. $77^{\circ}\mathrm{C}$

C. $350^{\circ}\mathrm{C}$

D. $87^{\circ}\mathrm{C}$

Answer: B

Solution:

We know that,

$pV=nRT$

Given, Initial pressure, temperature and mass of a gas are p, $127^{\circ}\mathrm{C}$ and 21 g respectively.

$T_1=127^{\circ}\mathrm{C}=400\ \mathrm{K}$

Let M be the molar mass of the gas, then

$pV=\left(\frac{21}{m}\right)\times R\times 400$

After the gas leakes out,

New pressure $=\frac{2p}{3}$, New temperature

$=T_2$

Mass of gas remaining $=(21-5)\mathrm{g}=16\ \mathrm{g}$

Now using ideal gas equation,

$\frac{2pV}{3}=\left(\frac{16}{m}\right)\times R\times T_2$

On solving Eq. (i) and Eq. (ii), we get

$\frac{21}{m} \times R \times 400 = \frac{16}{m} \times R \times T_2 \times \frac{3}{2}$

$\frac{21 \times 400 \times 2}{16 \times 3} = T_2$

$T_2 = 350 \text{ K}$

$T_2 = 350 - 273$

$T_2 = 77^{\circ}\text{C}$

Question13

Steam of mass 60 g at a temperature 100°C is mixed with water of mass 360 g at a temperature 40°C. The ratio of the masses of steam and water in equilibrium is (Latent heat of steam is 540calg^{-1} and specific heat capacity of water is $1 \text{calg}^{-1}{}^{\circ}\text{C}^{-1}$)

TG EAPCET 2024 (Online) 10th May Evening Shift

Options:

A. 1 : 20

B. 1 : 10

C. 1 : 5

D. 1 : 3

Answer: A

Solution:

To determine the ratio of the masses of steam and water in equilibrium, we begin with the given data:

Mass of steam, $m_1 = 60 \text{ g}$

Temperature of steam, $\theta_1 = 100^{\circ}\text{C}$

Mass of water, $m_2 = 360 \text{ g}$

Temperature of water, $\theta_2 = 40^{\circ}\text{C}$

Latent heat of steam, $L = 540 \text{ cal/g}$

Specific heat of water = 1 cal/g°C

According to the principle of calorimetry, the heat lost by steam equals the heat gained by water:

Heat gain by water:

Using the formula $Q = ms\Delta T$, where m is the mass, s is the specific heat, and ΔT is the change in temperature:

$Q = 360 \times 1 \times (100 - 40) = 21600 \, \text{cal}$

Heat lost by steam:

First, consider the latent heat: $Q = mL = 60 \times 540 = 32400 \, \text{cal}$

Calculate the mass of steam x that would release 21600 calories of energy:

$$1 \text{ g of steam} = 540 \, \text{cal}$$
$$x \text{ g of steam} = 21600 \, \text{cal}$$
$$x = \frac{21600}{540} = 40 \, \text{g}$$

Thus, 40 grams of steam converted to water, releasing 21600 calories of energy.

Calculate the total mass of water after the steam condenses:

Total amount of water = initial water + condensed steam:

$360 \, \text{g} + 40 \, \text{g} = 400 \, \text{g}$

Calculate the remaining steam:

Steam left = initial steam - condensed steam:

$60 \, \text{g} - 40 \, \text{g} = 20 \, \text{g}$

Determine the ratio of steam to water:

Ratio of steam to water:

$\frac{20}{400} = \frac{1}{20} = 1 : 20$

Thus, the ratio of the masses of steam to water in equilibrium is $1 : 20$.

Question14

The temperature difference between the ends of two cylindrical rods A and B of the same material is $2 : 3$. In steady state the ratio of the rates of flow of heat through the rods A and B is $5 : 9$. If the radii of the rods A and B are in the ratio $1 : 2$, then the ratio of lengths of the rods A and B is

TG EAPCET 2024 (Online) 10th May Evening Shift

Options:

A. 2 : 7

B. 3 : 7

C. 2 : 5

D. 3 : 10

Answer: D

Solution:

Given, ratio of flow of heat (ratio) $= \frac{5}{9}$

Ratio of radii of cylinder A and $B = \frac{1}{2}$ We know that rate flow of heat is given as

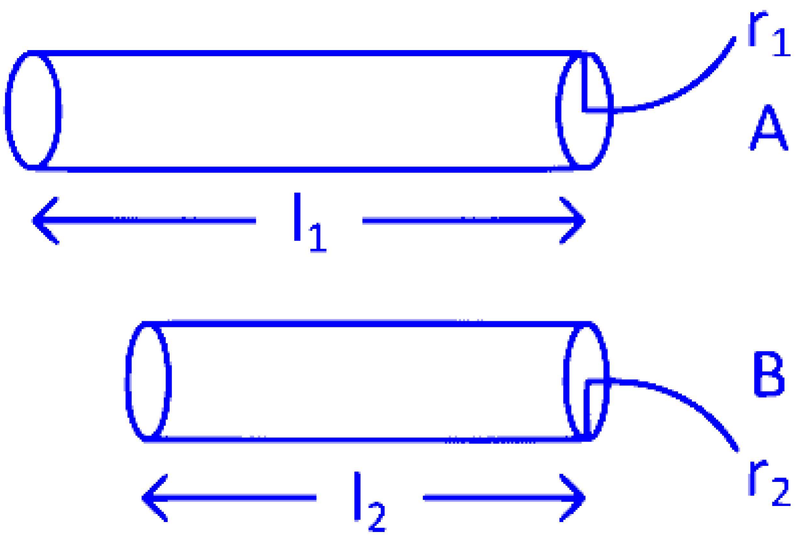
$\frac{dQ}{dt} = -kA\frac{d\theta}{l_1}$

[$l =$ length of conductor]

[$k =$ conductivity constant]

[$d\theta =$ temperature difference]

$\left(\frac{dQ}{dt}\right)_A = -kd\theta\frac{A_1}{1}$



$$\frac{\left(\frac{dQ}{dt}\right)_A}{\left(\frac{dQ}{dt}\right)_B} = \frac{A_1}{l_1} \times \frac{l_2}{A_2} \times \frac{\Delta\theta_1}{\Delta\theta_2} [k, \text{ is constant }]$$

$$= \frac{\pi r_1^2}{l_1} \times \frac{l_2}{\pi r_2^2} \times \frac{\Delta\theta_1}{\Delta\theta_2}$$

$$\frac{5}{9} = \left(\frac{r_1}{r_2}\right)^2 \times \frac{l_2}{l_1} \times \frac{2}{3}$$

$$\frac{5}{9} = \frac{1}{4} \times \frac{2}{3} \times \frac{l_2}{l_1}$$

$$\frac{l_1}{l_2} = \frac{3}{10}$$

$$l_1 : l_2 = 3 : 10$$

Question15

When Q_1 amount of heat supplied to a monoatomic gas, the work done by the gas is W. When Q_2 amount of heat is supplied to a diatomic gas, the work done by the gas is $2W$. Then, $Q_1 : Q_2$.

TG EAPCET 2024 (Online) 10th May Evening Shift

Options:

A. 2 : 3

B. 3 : 5

C. 5 : 7

D. 5 : 14

Answer: D

Solution:

According to the first law of thermodynamics:

$dQ = dU + dW$

where dQ is the heat supplied, dU is the change in internal energy, and dW is the work done by the system.

For a Monoatomic Gas:

The heat supplied Q_1 can be expressed as:

$Q_1 = nC_VdT + W$

Here, the change in internal energy dU is given by:

$dU = nC_VdT = n\left(\frac{3}{2}\right)RdT$

Substituting this into the equation for Q_1:

$Q_1 = \frac{3}{2}nRdT + W$

Since $nRdT = W$ (since $PV = nRT$, therefore work done $W = PV$):

$Q_1 = \frac{3}{2}W + W$

Thus:

$Q_1 = \frac{5W}{2}$

For a Diatomic Gas:

The heat supplied Q_2 is:

$Q_2 = n\left(\frac{5}{2}\right)RdT + 2W$

Substituting for $nRdT = 2W$:

$Q_2 = \frac{5}{2} \times 2W + 2W$

This simplifies to:

$Q_2 = 7W$

Ratio of Q_1 to Q_2:

To find the ratio $Q_1 : Q_2$:

$\frac{Q_1}{Q_2} = \frac{\frac{5W}{2}}{7W} = \frac{5}{14}$

Thus, the ratio $Q_1 : Q_2$ is:

5 : 14

Question16

The temperature at which the rms speed of oxygen molecules is 75% or rms speed of nitrogen molecules at a temperature of $287^\circ\mathrm{C}$

TG EAPCET 2024 (Online) 10th May Evening Shift

Options:

A. $87^\circ C$

B. $127^\circ C$

C. $227^\circ C$

D. $360^\circ C$

Answer: A

Solution:

To solve this problem, we need to find the temperature at which the root mean square (rms) speed of oxygen molecules is 75% of the rms speed of nitrogen molecules at a given temperature of $287^\circ C$.

Given:

The rms speed of oxygen is 75% of the rms speed of nitrogen.

Temperature of nitrogen (T_{nitrogen}) = $287^\circ C$.

First, convert this nitrogen temperature from Celsius to Kelvin:

$T_{\text{nitrogen}} = 287 + 273 = 560\,\text{K}$

Formula for rms speed:

The rms speed (v_{rms}) is given by:

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

Where:

R is the gas constant,

T is the temperature in Kelvin,

M is the molar mass of the gas.

For oxygen ($M_{\text{oxygen}} = 32\,\text{g/mol}$) and nitrogen ($M_{\text{nitrogen}} = 28\,\text{g/mol}$), we establish the following relationship by squaring both sides and canceling R:

$$\sqrt{\frac{3RT_{\text{oxygen}}}{32}} = \frac{3}{4}\sqrt{\frac{3RT_{\text{nitrogen}}}{28}}$$

Simplifying:

Square both sides to eliminate the square roots:

$$\frac{3T_{\text{oxygen}}}{32} = \frac{9}{16} \times \frac{3T_{\text{nitrogen}}}{28}$$

Cancel out the constants and solve for T_{oxygen}:

$T_{\text{oxygen}} = \frac{9}{16} \times \frac{560 \times 32}{28}$

Calculate T_{oxygen} :

$T_{\text{oxygen}} = 360\,\text{K}$

Convert back to Celsius:

$T_{\text{oxygen}} = 360 - 273 = 87^{\circ}\text{C}$

Thus, the temperature at which the rms speed of oxygen achieves 75% of the rms speed of nitrogen molecules at 287°C is 87°C.

Question17

A big liquid drop splits into n similar small drops under isothermal conditions, then in the process

TG EAPCET 2024 (Online) 10th May Morning Shift

Options:

A. volume decreases

B. total surfaces area decrease

C. energy is absorbed

D. energy is liberated

Answer: C

Solution:

When a large liquid drop splits into n similar smaller drops under isothermal conditions, the following process occurs:

Volume Consistency: The total volume remains the same before and after the split. This is due to the conservation of mass principle, where the sum of the volumes of all the small drops equals the initial volume of the large drop.

Surface Area Increase: The surface area increases. The surface area A of a sphere is given by $A = 4\pi r^2$, where r is the radius. If a large drop with radius R has a volume V given by $V = \frac{4}{3}\pi R^3$, splitting into n smaller drops each with radius r retains the total volume as:

$n \times \left(\frac{4}{3}\pi r^3\right) = \frac{4}{3}\pi R^3$

Solving this gives:

$nr^3 = R^3 \Rightarrow r = R\left(\frac{1}{n}\right)^{\frac{1}{3}}$

Each small drop has a surface area $4\pi r^2$, so the total surface area for n small drops is:

$$n \times 4\pi r^2 = n \times 4\pi\left(R\left(\frac{1}{n}\right)^{\frac{1}{3}}\right)^2 = 4\pi R^2 \times n^{\frac{1}{3}}$$

Since $n^{\frac{1}{3}} > 1$ for $n > 1$, the total surface area indeed increases when a large drop splits into smaller drops.

Energy Changes: The increase in surface area results in an increase in surface energy. According to thermodynamic principles, forming a new surface requires energy due to surface tension. Therefore, energy must be absorbed to create the additional surfaces of the new drops.

Consequently:

Option A: Incorrect, since the total volume remains constant.

Option B: Incorrect, since the total surface area increases.

Option C: Correct, energy is absorbed to increase the total surface area.

Option D: Incorrect, energy is not liberated; it is absorbed.

Thus, the correct answer is **Option C: energy is absorbed**.

Question18

37 g of ice at $0^{\circ}\mathrm{C}$ temperature is mixed with 74 g of water at $70^{\circ}\mathrm{C}$ temperature. The resultant temperature is (specific heat capacity of water $= 1\mathrm{cal g}^{-1o}\mathrm{C}^{-1}$ and latent heat of fusion of ice $= 80\mathrm{cal g}^{-1}$)

TG EAPCET 2024 (Online) 10th May Morning Shift

Options:

A. $45^{\circ}\mathrm{C}$

B. $70^{\circ}\mathrm{C}$

C. $20^{\circ}\mathrm{C}$

D. $35^{\circ}\mathrm{C}$

Answer: C

Solution:

water mass $m_1 = 74$ g

$\theta_1 = 70^\circ C$

Ice mass, $m_2 = 37$ g

$\theta_2 = 0^\circ C$

Ice latent heat of fusion, $L = 80 \mathrm{cal/g}$

Specific heat capacity of water

$s = 1 \mathrm{cal/g/^\circ C}$

Now using principle of calorimetry

Heat lost by water is equal to heat gain by ice. Let θ be the common temperature.

$$m_1 s(\theta_1 - \theta) = m_2 L + m_2 s(\theta - \theta_2)$$

$$74 \times 1 \times [70 - \theta] = 37[80 + 1(\theta - 0)]$$

$$2[70 - \theta] = [80 + \theta]$$

$$140 - 2\theta = 80 + \theta$$

$$140 - 80 = 3\theta \Rightarrow 60 = 3\theta$$

$$\theta = 20^\circ C$$

Question19

The thickness of a uniform rectangular metal plate is 5 mm and the area of each surface is $5 \mathrm{~cm}^5$. In steady state, the temperature difference between the two surfaces of the plate is $14^\circ C$. If the heat flowing through the plate in one second from one surface to the other surface is 42 J , then the thermal conductivity of the metal is

TG EAPCET 2024 (Online) 10th May Morning Shift

Options:

A. $90 \mathrm{Wm}^{-1} \mathrm{~K}^{-1}$

B. $30 \mathrm{Wm}^{-1} \mathrm{~K}^{-1}$

C. $45 \mathrm{Wm}^{-1} \mathrm{~K}^{-1}$

D. $60 \mathrm{Wm}^{-1} \mathrm{~K}^{-1}$

Answer: B

Solution:

Given,

Metal plate thickness,

$dx = 5 \text{ mm} = 5 \times 10^{-3} \text{ m}$

Area of plate, $A = 5 \text{ cm}^2 = 5 \times 10^{-4} \text{ m}^2$

Temperature difference,

$dT = 14^{\circ}\text{C} = 14 \text{ K}$

Rate of thermal flow $= 42 \text{ J}$

We know that equation for rate of thermal flow is

$$\frac{dQ}{dt} = -KA\frac{dT}{dx}$$

$$\frac{dQ}{dT} = -42 \text{ J} \quad [\text{ heat flows out }]$$

$$-42 = \frac{-K \times 5 \times 10^{-4} \times 14}{5 \times 10^{-3}}$$

$$42 = 1.4K$$

$$K = 30 \text{ W/m/K}$$

Question20

The ratio of the specific heat capacities of a gas is 1.5 . When the gas undergoes adiabatic process, its volume is doubled and pressure becomes p_1. When the gas undergoes isothermal process, its volume is doubled and pressure becomes p_2. If $p_1 = p_2$, the ratio of the initial pressures of the gas when it undergoes adiabatic and isothermal processes is

TG EAPCET 2024 (Online) 10th May Morning Shift

Options:

A. $\sqrt{3} : \sqrt{2}$

B. 1 : 1

C. $\sqrt{3}:1$

D. $\sqrt{2}:1$

Answer: D

Solution:

Given, ratio of $\frac{C_p}{C_V}$ or $\gamma = 1.5$

For adiabatic process,

Let initial pressure p_a, Final pressure $= p_1$ Initial volume $= V$, Final volume $= 2V$

Using adiabatic equation

$$pV^{\gamma} = \text{ constant}$$

$$\underset{\text{(Initial)}}{p_a V_1^{\gamma}} = \underset{\text{(Final)}}{p_1 V_2^{\gamma}} \quad = p_1\left[\frac{2V}{V}\right]^{\gamma},$$

$$\Rightarrow \quad p_a$$

For isothermal process, final pressure $= p_2$ Using isothermal equation

$$pV = \text{ constant} \qquad p_{\text{iso}} = p_2\left[\frac{2V}{V}\right]$$

$$\underset{\text{(Initial)}}{p_{\text{iso}} V_1} = \underset{\text{(Final)}}{p_2 V_2} \qquad \Rightarrow \quad p_2 = \frac{p_{\text{iso}}}{2}$$

According to question,

$$p_1 = p_2$$

$$\frac{p_a}{[2]^{1.5}} = \frac{p_{\text{iso}}}{2}$$

$$\frac{p_a}{p_{\text{iso}}} = \frac{2\sqrt{2}}{2} \quad \left[\text{as } a^{1.5} = a \cdot \sqrt{a}\right]$$

$$p_a : p_{\text{iso}} = \sqrt{2}:1$$

Question21

A vessel contains hydrogen and nitrogen gases in the ratio $2:3$ by mass. If the temperature of the mixture of the gases is $30^{\circ}\mathrm{C}$, then the ratio of the average kinetic energies per molecule of hydrogen and nitrogen gases is (Molecular mass of hydrogen $=2$ and molecular mass of nitrogen $=28$)

TG EAPCET 2024 (Online) 10th May Morning Shift

Options:

A. $3:7$

B. $2:3$

C. $1:1$

D. $1:14$

Answer: C

Solution:

The average translational kinetic energy (per molecule) of any ideal gas (diatomic or monoatomic or polyatomic) is always $\frac{3}{2} k_B T$.

It depends only on temperature and is independent of nature of gas.

Hence, the ratio of two gases is $1:1$.

Question22

When 54 g of ice at $-20^{\circ}\mathrm{C}$ is mixed with 25 g of steam at $100^{\circ}\mathrm{C}$, then the final mixture at thermal equilibrium contains

TG EAPCET 2024 (Online) 9th May Evening Shift

Options:

A. 20 g water at $100^{\circ}\mathrm{C}$

B. 73 g water at $100^{\circ}\mathrm{C}$ and 6 g steam at $100^{\circ}\mathrm{C}$

C. 8 g steam at $100^{\circ}\mathrm{C}$ and 12 g water at $0^{\circ}\mathrm{C}$

D. 20 g water at 50°C

Answer: B

Solution:

Given, mass of ice at $-20^{\circ}C$,

$m_{ice} = 54$ g

Mass of steam at $100^{\circ}C$, $m_{meam} = 25$ g

Specific heat capacity of ice,

$s_{iee} = 0.5 cal/g^{\circ}C$

Heat required to bring ice at $0^{\circ}C$

$= m_{ce} \; s_{cle} \; \Delta T$

$q_1 = 54 \times 0.5 \times (20) = 540 cal$

Heat required to melt ice at $0^{\circ}C$

$= m_{ice} \times L_{ice}$

$q_2 = 54 \times 80 = 4320 cal$

Condense steam at $100^{\circ}C$ to water at $100^{\circ}C$.

$q_3 = m_{steam} \times L_{steam} = 25 \times 540$

$= 13500 cal$

To cold water from $100^{\circ}C$ to $0^{\circ}C$,

$q_4 = m_{water} \times s_{water} \times \Delta T$

$= 25 \times 1 \times 100 = 2500 cal$

$\therefore$ Total heat gained by ice,

$Q_{gain} = q_1 + q_2 = 4860 cal$

Heat lost by steam, $Q_{lott} = q_3 = 13500 cal$ Heat gained by ice to melt will be provided by steam i.e, $\frac{4860}{540} = 9$ g

Thus, only 9 g steam is needed to completely melt the ice,

Hence, $(54 + 9)$g of water will be present along with $(25 - 9)$g of steam at $100^{\circ}C$.

Lets calculate the temperature of mixture.

Remaining heat of steam;

$Q = 16 \times 540$

$= 8640 \text{cal}$

Heat required to raise the tempature of 63 g upto T° will be

$$Q = m s_{\text{water}} \times (\Delta T)$$

$$8640 = 63 \times 1(\Delta T)$$

$$\Rightarrow \quad \Delta T > 100^{\circ}\mathrm{C}$$

Hence, not all steam will be converted into water. The steam required to raise 63 g water upto $100^{\circ}\mathrm{C}$ will be,

$m = \frac{6300}{540} = 11.66 \text{ g}$

$\therefore$ Total steam used $= 11.66 + 9$

≈ 20 g

Hence 20 g of steam will be used to bring 54 g of ice at $-20^{\circ}\mathrm{C}$ upto $100^{\circ}\mathrm{C}$ water.

Total water $= 54 + 20 \approx 74$ g

and steam $= 5$ g

Which is close to option (b).

Question23

A solid sphere at a temperature T K is cut in to two hemisphere. The ratio of energies radiated by one hemisphere to the whole sphere per second is

TG EAPCET 2024 (Online) 9th May Evening Shift

Options:

A. 1 : 1

B. 1 : 2

C. 3 : 4

D. 1 : 4

Answer: C

Solution:

Total surface area of solid sphere

$A_1 = 4\pi r^2$

Total surface area of solid hemisphere,

$A_2 = 3\pi r^2$

As, we know that, $E \propto A$

$\therefore \quad \frac{E_2}{E_1} = \frac{A_2}{A_1} = \frac{3}{4}$

Question24

If dQ, dU and dW are heat energy absorbed, change in internal energy and external work done respectively by a diatomic gas at constant pressure, then $dW : dU : dQ$ is

TG EAPCET 2024 (Online) 9th May Evening Shift

Options:

A. $5:3:2$

B. $7:5:2$

C. $4:3:1$

D. $2:5:7$

Answer: D

Solution:

For diatomic gas, $C_p = \frac{7}{2} R$

$$C_v = \frac{5}{2} R$$

$\therefore \quad dU = nC_v dT$

$$dQ = nC_p dT$$

$$dW = p \times dV$$

$$= nRdT$$

$$\therefore dW : dU : dQ = nRdT : n\frac{5}{2}RdT : n\frac{7}{2}RdT$$

$$= 1 : \frac{5}{2} : \frac{7}{2}$$

$$= 2 : 5 : 7$$

Question25

If the temperature of a gas increased from $27^{\circ}\mathrm{C}$ to $159^{\circ}\mathrm{C}$, the increase in the rms speed of the gas molecules is

TG EAPCET 2024 (Online) 9th May Evening Shift

Options:

A. 142%

B. 71%

C. 80%

D. 20%

Answer: D

Solution:

We know that, $v_{\mathrm{rms}} = \sqrt{\frac{3RT}{M}}$

According to question, $v_1 = \sqrt{\frac{3R(300)}{M}}$

$v_2 = \sqrt{\frac{3R(432)}{M}}$

Thus, $\frac{v_2 - v_1}{v_1} = \frac{\sqrt{432} - \sqrt{300}}{\sqrt{300}} = \frac{3.46}{17.32}$

$$\% \text{ increase } = \frac{v_2 - v_1}{v_1} \times 100\%$$

$$= \frac{3.46}{17.32} \times 100\%$$

$$= 19.99\%$$

$$\approx 20\%$$

Question26

The temperature on a fahrenheit temperature scale that is twice the temperature on a celsius temperature scale is

TG EAPCET 2024 (Online) 9th May Morning Shift

Options:

A. $160^{\circ}\mathrm{F}$

B. $240^{\circ}\mathrm{F}$

C. $320^{\circ}\mathrm{F}$

D. $480^{\circ}\mathrm{F}$

Answer: C

Solution:

The relationship between the two scales,

$F = \frac{9}{5}C + 32 \quad \ldots \text{(i)}$

If the temperature is twice the celsius temperature, we can write

$F = 2C \quad \ldots \text{(ii)}$

Now, $\frac{9}{5} \times C + 32 = 2C$

$$\frac{9}{5} \times C + 32 = \frac{10}{5}C$$

$$32 = \frac{10}{5}C - \frac{9}{5}C \Rightarrow 32 = \frac{1}{5}C$$

$C = 160 \quad \ldots \text{(iii)}$

Fahrenheit temperature,

$$F = \frac{9}{5} \times 160 + 32$$

$$F = 288 + 32$$

$$\Rightarrow \quad F = 320$$

Therefore, the temperature on the fahrenheit scale that is twice the temperature of 160°C on the celsius scale is 320°F.

Question27

The temperatures of equal masses of three different liquids A, B and C are $15^{\circ}\mathrm{C}$, $24^{\circ}\mathrm{C}$ and $30^{\circ}\mathrm{C}$, respectively. The resultant temperature when liquids A and B are mixed is $20^{\circ}\mathrm{C}$ and when liquids B and C are mixed is $26^{\circ}\mathrm{C}$. Then, the ratio of specific heat capacities of the liquids A, B and C is

TG EAPCET 2024 (Online) 9th May Morning Shift

Options:

A. 5 : 8 : 10

B. 8 : 10 : 5

C. 5 : 10 : 8

D. 8 : 5 : 10

Answer: B

Solution:

For liquid A and B mixed to reach a final temperature of $20^{\circ}\mathrm{C}$, the equation based on the heat exchanged is

$m \times C_B \times (24 - 20) = m \times C_A \times (20 - 15)$

Simplifying, we get

$4m \times C_B = 5m \times C_A$

$$\frac{C_B}{C_A} = \frac{5}{4}$$

For liquid B and C mixed to reach a final temperature of 26°C,

$m \times C_C \times (30 - 26) = m \times C_B \times (26 - 24)$

we get,

$4m \times C_C = 2m \times C_B$

$$\frac{C_C}{C_B} = \frac{1}{2} \Rightarrow \frac{C_B}{C_A} \times \frac{C_C}{C_B} = \frac{5}{4} \times \frac{1}{2} = \frac{5}{8}$$

Therefore,

$C_A : C_B : C_C = 1 : \frac{5}{4} : \frac{5}{8}$

$C_A : C_B : C_C = 8 : 10 : 5$

Question28

The efficiency of a reversible heat engine working between two temperatures is 50%. The coefficient of performance of a refrigerator working between the same two temperatures but in reverse direction is

TG EAPCET 2024 (Online) 9th May Morning Shift

Options:

A. 1

B. 2

C. 3

D. 4

Answer: A

Solution:

The efficiency of a reversible heat engine is given by the ratio of work output to heat input, which can be also be expressed in terms of the temperatures of the hot (T_H) and cold (T_C) reservoirs,

$\eta = 1 - \frac{T_C}{T_H}$

Given, efficiency is $\mathbf{50\%}$

$0.5 = 1 - \frac{T_C}{T_H}$

Solving for $\frac{T_C}{T_H}$, we get

$\frac{T_C}{T_H} = 0.5$

Coefficient of performance (COP),

$\mathrm{COP} = \frac{Q_C}{W} = \frac{T_C}{T_B - T_C}$

For a reversible process, the (COP) can also be related to the temperatures of the hot and cold reservoirs,

$$\mathrm{COP} = \frac{0.5 \times T_H}{T_H - 0.5 \times T_H}$$

$$= \frac{0.5}{1 - 0.5} = \frac{0.5}{0.5} = 1$$

Therefore, the coefficient of performance of the refrigerator working between the same two temperature but reverse direction is 1.

Question29

The total internal energy of 4 moles of a diatomic gas at a temperature of $27^{\circ}\mathrm{C}$ is (gas constant $= 831\ \mathrm{Jmol}^{-1}\ \mathrm{K}^{-1}$)

TG EAPCET 2024 (Online) 9th May Morning Shift

Options:

A. 13.47 kJ

B. 4.98 kJ

C. 24.93 kJ

D. 14.96 kJ

Answer: C

Solution:

Given, $n = 4$ moles

Temperature,

$T = 27^{\circ}\mathrm{C} = 27 + 273 = 300\ \mathrm{K}$

We know that,

$U = \frac{5}{2} \times n \times R \times T \quad \ldots \text{(i)}$

Putting above values in Eq. (i),

$U = \frac{5}{2} \times 4 \times 8.314 \times 300 \text{ K}$

$\therefore$ Universal gas constant,

$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$

$U = 5 \times 2 \times 8.31 \times 300$

$= 10 \times 8.31 \times 300$

$= 3000 \times 8.31$

$U = 24930 \text{ J} = 24.930 \text{ J}$

Thus, $U = 24.93 \text{ kJ}$

Question30

Two rod of same area of cross-section have lengths L and $2L$ and coefficients of linear expansions 2α and a respectively. If they are welded to form a composite rod of length $3L$ then the coefficient of linear expansion of the composite rod is

TS EAMCET 2023 (Online) 12th May Evening Shift

Options:

A. $\frac{3\alpha}{2}$

B. 3αx

C. $\frac{3\alpha}{4}$

D. $\frac{4\alpha}{3}$

Answer: D

Solution:

Initial Setup :

First rod: length L, coefficient of expansion 2α

Second rod: length $2L$, coefficient of expansion α

Composite Rod:

Total initial length = $L + 2L = 3L$

Expansion Calculation:

Expansion of the First Rod:

$\Delta L_1 = L(2\alpha)\Delta T$

Expansion of the Second Rod:

$\Delta L_2 = 2L(\alpha)\Delta T$

Total Expansion:

Combine the expansions:

$\Delta L_{\text{total}} = 2L\alpha\Delta T + 2L\alpha\Delta T = 4L\alpha\Delta T$

Final Step:

Given that the total increase in length of the composite rod is the sum of the individual expansions, equate the change to find the overall coefficient of linear expansion, α_{total} :

$4L\alpha\Delta T = 3L\alpha_{\text{total}} \Delta T$

Solving for α_{total} :

$\alpha_{\text{total}} = \frac{4}{3}\alpha$

Thus, the coefficient of linear expansion of the composite rod is $\frac{4}{3}\alpha$.

Question31

For a given mass of a gas at constant temperature, the volume and the pressure are V and p respectively. Then the slope of the graph drawn between $\log_e V$ on X-axis and $\log_e p$ on Y-axis is

TS EAMCET 2023 (Online) 12th May Evening Shift

Options:

A. 1

B. -1

C. zero

D. infinity

Answer: B

Solution:

For a gas with a constant temperature, we examine the relationship between the volume (V) and pressure (p). Specifically, we are interested in the slope of a graph where $\log_e V$ is plotted on the X-axis, and $\log_e p$ is plotted on the Y-axis.

Given the ideal gas equation:

$pV = nRT$

Taking the natural logarithm of both sides, we have:

$\log_e(pV) = \log_e(nRT)$

This expands to:

$\log_e p + \log_e V = \log_e(nRT)$

Since nRT is a constant (as both the amount of gas and the temperature are constant), we can rearrange the equation as follows:

$\log_e p = -\log_e V + \log_e(nRT)$

This equation is in the form of a straight line, where:

$Y = mx + c$

By comparing:

$\log_e p = (-1)\log_e V + \log_e(nRT)$

We identify that the slope (m) is -1.

Therefore, the slope of the graph where $\log_e V$ is on the X-axis and $\log_e p$ is on the Y-axis is -1.

Question32

An ideal gas at 127°C is compressed suddenly to $8/27$of its initial volume. If $\gamma = 5/3$ for an ideal gas, then rise in its temperature is

Options:

A. 450 K

B. 500 K

C. 225 K

D. 405 K

Answer: B

Solution:

Given:

Initial temperature of the ideal gas, $T_0 = 127^{\circ}\mathrm{C} = 400\,\mathrm{K}$

Initial volume, V_0

Final volume, $V_1 = \frac{8}{27} V_0$

Heat capacity ratio, $\gamma = \frac{5}{3}$

The process described is adiabatic, meaning no heat is exchanged with the surroundings. For an adiabatic process involving an ideal gas, the relation $TV^{\gamma-1} = \text{constant}$ holds.

Initial State:

$T_0 V_0^{\gamma-1} = T_0 V_0^{5/3-1} \quad \text{(equation i)}$

Final State:

$T_1 V_1^{\gamma-1} = T_1 \left(\frac{8}{27} V_0\right)^{5/3-1} \quad \text{(equation ii)}$

By dividing equation (i) by equation (ii), we have:

$\frac{T_0}{T_1} = \frac{V_1^{\gamma-1}}{V_0^{\gamma-1}} = \left(\frac{8}{27}\right)^{5/3-1} = \left(\frac{8}{27}\right)^{2/3}$

This simplifies to:

$\frac{T_0}{T_1} = \frac{4}{9}$

Solving for T_1:

$T_1 = \frac{400 \times 9}{4} = 900\,\mathrm{K}$

The rise in temperature is then calculated as:

$T_1 - T_0 = 900\,\mathrm{K} - 400\,\mathrm{K} = 500\,\mathrm{K}$

Question33

An insulating cylinder contains 4 moles of an ideal diatomic gas. When a heat Q is supplied to it, 2 moles of the gas molecules dissociate. If the temperature of the gas remains constant, then the value of Q is ($R =$ universal gas constant)

TS EAMCET 2023 (Online) 12th May Evening Shift

Options:

A. $2RT$

B. RT

C. $3RT$

D. $4RT$

Answer: B

Solution:

Given an insulating cylinder containing 4 moles of an ideal diatomic gas, when heat Q is supplied, 2 moles of the gas molecules dissociate. The temperature of the gas remains constant. We need to find the value of Q.

Initially, the gas has 4 moles of an ideal diatomic gas. When supplied with heat, 2 moles dissociate into monoatomic gas, effectively converting 2 moles of diatomic gas into 4 moles of monoatomic gas.

Degrees of Freedom

Diatomic gas: $f = 5$

Monoatomic gas: $f = 3$

Internal Energy Calculation

The internal energy E for gas is given by:

$E = n \times \frac{f}{2} \times RT$

Where n is the number of moles, f is the degree of freedom, R is the universal gas constant, and T is the temperature.

Initial Internal Energy E_i

For 4 moles of diatomic gas:

$E_i = 4 \times \frac{5}{2} \times RT = 10RT$

Final Internal Energy E_f

After dissociation, we have:

2 moles of diatomic gas:

$2 \times \frac{5}{2} \times RT = 5RT$

4 moles of monoatomic gas:

$4 \times \frac{3}{2} \times RT = 6RT$

Total final internal energy:

$E_f = 5RT + 6RT = 11RT$

Change in Internal Energy

The change in internal energy is:

$\Delta E = E_f - E_i = 11RT - 10RT = RT$

Thus, the value of Q required to maintain constant temperature during the dissociation process is RT.

Question34

Two objects made of the same material have masses m and $2m$ and are at temperatures $2T$ and T respectively. When heat Q is supplied to the object of mass $2m$, its temperature raises to $2T$. If the same heat is supplied to the object of mass m, its temperature raises to

TS EAMCET 2023 (Online) 12th May Morning Shift

Options:

A. $2T$

B. $\frac{3T}{2}$

C. $4T$

D. $3T$

Answer: C

Solution:

Let's analyze the problem step by step.

For the object with mass $2m$:

Initial temperature: T

Final temperature: $2T$

Temperature change: $\Delta T = 2T - T = T$

The amount of heat required is given by:

$Q = \text{mass} \times c \times \Delta T = 2m \cdot c \cdot T$

So, we have:

$Q = 2mcT$

For the object with mass m:

Initial temperature: $2T$

Let the final temperature be T_f

Temperature change: $\Delta T = T_f - 2T$

The same heat Q is supplied, so:

$Q = m \cdot c \cdot (T_f - 2T)$

Since both expressions for Q are equal, set them equal to each other:

$2mcT = mc(T_f - 2T)$

Cancel the common factors m and c (assuming they are non-zero):

$2T = T_f - 2T$

Now, solve for T_f:

$$\begin{aligned} T_f &= 2T + 2T \\ &= 4T \end{aligned}$$

Thus, when the same heat is supplied to the object of mass m, its temperature raises to $4T$.

The correct answer is Option C: $4T$.

Question35

On a new temperature scale, the melting point of ice is $20^{\circ}\mathrm{X}$ and the boiling point of water is $110^{\circ}\mathrm{X}$. A temperature of $40^{\circ}\mathrm{C}$ would be indicated on this new temperature scale as

TS EAMCET 2023 (Online) 12th May Morning Shift

Options:

A. $60^{\circ}\mathrm{X}$

B. $56^{\circ} X$

C. $70^{\circ}\mathrm{X}$

D. $54^{\circ}\mathrm{X}$

Answer: B

Solution:

To convert temperatures between the Celsius scale and the new X scale, we can assume a linear relationship. Here's how to determine the conversion:

Recognize the given points:

Melting point of ice: $0^{\circ}\mathrm{C}=20^{\circ}\mathrm{X}$

Boiling point of water: $100^{\circ}\mathrm{C}=110^{\circ}\mathrm{X}$

Express the relationship in the form:

$X=a+b \cdot C,$

where a is the offset and b is the scale factor.

Substitute the known temperatures:

For $0^{\circ}\mathrm{C}$:

$20=a+b \cdot 0 \quad \Rightarrow \quad a=20.$

For $100^{\circ}\mathrm{C}$:

$110=20+b \cdot 100.$

Solve for b:

$110-20=100 b \quad \Rightarrow \quad 90=100 b \quad \Rightarrow \quad b=\frac{90}{100}=0.9.$

Write the complete conversion formula:

$X=20+0.9 \cdot C.$

Convert $40^{\circ}\mathrm{C}$ to the new X scale:

$X = 20 + 0.9 \times 40 = 20 + 36 = 56.$

Therefore, on the new scale, 40°C is indicated as 56°X. This corresponds to Option B.

Question36

The percentage of heat supplied to a diatomic ideal gas that is converted into work in an isobaric process is

TS EAMCET 2023 (Online) 12th May Morning Shift

Options:

A. 62.7

B. 71.4

C. 28.6

D. 34.6

Answer: C

Solution:

In an isobaric process, the pressure of the system remains constant. For such a process, the heat supplied to a diatomic ideal gas can be expressed as:

$\Delta Q = nC_p \Delta T$

Where:

n represents the number of moles of the ideal gas.

C_p is the specific heat at constant pressure.

ΔT is the change in temperature.

The work done during an isobaric process is calculated using:

$\Delta W = p\Delta V$

Substituting the ideal gas law $pV = nRT$ into the work done expression, we get:

$\Delta W = p(V_2 - V_1) = nR(T_2 - T_1) = nR\Delta T$

The ratio of the work done ΔW to the heat supplied ΔQ is:

$\frac{\Delta W}{\Delta Q} = \frac{nR\Delta T}{nC_p \Delta T} = \frac{R}{C_p}$

For a diatomic gas, the specific heat at constant pressure is:

$C_p = \frac{7}{2}R$

Substituting this into the ratio, we find:

$\frac{W}{Q} = \frac{R}{\frac{7}{2}R} = \frac{2}{7}$

Therefore, the percentage of the heat supplied that is converted into work is:

$= \frac{2}{7} \times 100 \approx 28.6\%$

Question37

Ratio of translational degrees of freedom to rotational degrees of freedom of a polyatomic linear gas molecule is

TS EAMCET 2023 (Online) 12th May Morning Shift

Options:

A. 1 : 1

B. 1 : 2

C. 2 : 3

D. 3 : 2

Answer: D

Solution:

For any gas molecule, the translational degrees of freedom are determined by its ability to move in three-dimensional space. This means:

Translational degrees of freedom = 3 (movement along the x, y, and z axes).

For rotational degrees of freedom:

In a linear molecule (like a polyatomic linear gas molecule), rotation about the axis of the molecule doesn't contribute significantly because the moment of inertia about that axis is negligible.

Thus, only the rotations about the two axes perpendicular to the molecular axis matter.

So, rotational degrees of freedom = 2.

Now, the ratio of translational to rotational degrees of freedom is:

$$\frac{3 \text{ (translational)}}{2 \text{ (rotational)}} = 3 : 2.$$

Hence, the correct answer is:

Option D: 3 : 2
