AAQIL AHMED

JEE : THERMAL PROPERTES OF MATTER

1) A steel rod of length 1m is rigidly fixed between two immovable walls at 30°C. This temperature is raised to 80°C. Find the thermal stress developed in the rod [GIVEN, $\alpha = 1.2\times10^{-5} K^{-1}$, $Y = 2\times10^{11} N/m^2$]

ANSWER

$T_1 = 30$

$T_2 = 80$

$\Delta T = 50$

$$\sigma = Y\alpha\Delta T$$
$$= (2\times10^{11})(1.2\times10^{-5})(50)$$
$$\sigma = 1.2\times10^{8} N/m^2$$

2) A thin copper plate has a circular hole of of diameter 2cm at 20°C. The plate is heated to 120°C. Find the increase in diameter of the hole [$\alpha = 1.7\times10^{-5} K^{-1}$]

ANSWER

$d = 2cm$

$T_1 = 20°C$

$T_2 = 120°C$

$\Delta T = 100°K$

$$\Delta d = d\alpha\Delta T$$
$$= (2)(1.7\times10^{-5})(100)$$
$$= 3.4\times10^{-3} cm$$

3. Two blocks A and B of equal mass are made of different materials. Same amount of heat Q is supplied to both. Their temperature rises are in the ration $\Delta T_a : \Delta T_B = 3:2$. Find the ratio of their specific heats, $C_a : C_B$

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ANSWER

Since $Q = mc\Delta T$ & Q, m are same

$$C \propto \frac{1}{\Delta T}$$

$$\frac{C_A}{C_b} = \frac{\frac{1}{\Delta T_a}}{\frac{1}{\Delta T_b}} = \frac{\Delta T_b}{\Delta a}$$

$$\frac{C_a}{C_b} = \frac{2}{3}$$

$$\Rightarrow C_a : C_b = 2:3$$

Hazique Rizvi
2025-26

Thermal Properties of Matter

Q1. A bowl of hot soup cools from 98°C to 86°C in 2 minutes in a room at 22°C. Find the time taken to cool from 75°C to 69°C.

Ans: Using Newtons Law of cooling

$$\frac{T - T_S}{T_0 - T_S} = e^{-kt}$$

$$\frac{t_2}{t_1} = \frac{\ln\left(\frac{T_1 - T_S}{T_2 - T_S}\right)}{\ln\left(\frac{T_3 - T_S}{T_4 - T_S}\right)}$$

Room temperature : $T_S = 22$

First case: $\frac{98-22}{86-22} = \frac{76}{64}$

Second case: $\frac{75-22}{69-22} = \frac{53}{47}$

$$t_2 = 2 \times \frac{\ln(53/47)}{\ln(76/64)}$$

$\ln(53/47) \approx 0.12$, $\ln(76/64) \approx 0.17$

$$t_2 = 2 \times \frac{0.12}{0.17} = 1.4 \text{ min (approx)}$$

Q2. 100g of ice at 0°C is mixed with 200g of water at 50°C. Find final temperature. Given: $L_f = 80 cal/g$, $c = 1 g/g°C$

Ans: Heat needed to melt ice

$$Q = mL = 100 \times 80 = 8000 \text{ cal}$$

Heat available from hot water (if cooled to 0°C)

$$Q = 200 \times 1 \times 50 = 10000 \text{ cal}$$

Compare:

Available heat > required → all ice melts

Remaining heat:

$$10000 - 8000 = 2000\,\text{cal}$$

Temperature rise:

Total mass $= 300g$

$$2000 = 300 \times 1 \times T$$

$$T = \frac{2000}{300} = 6.67^\circ C$$

Q3. Two rods of equal length and area are connected in series. Thermal conductivities k_1 and k_2. Ends maintained at T_1 and T_2. Find temperature at junction.

Ans: Heat flow same in steady state:

$$\Rightarrow \frac{k_1 (T_1 - T_j)}{L} = \frac{k_2 (T_j - T_2)}{L}$$

$$\Rightarrow k_1 (T_1 - T_j) = k_2 (T_j - T_2)$$

$$k_1 T_1 - k_1 T_j = k_2 T_j - k_2 T_2$$

$$\Rightarrow k_1 T_1 + k_2 T_2 = (k_1 + k_2) T_j$$

$$T_j = \frac{k_1 T_1 + k_2 T_2}{k_1 + k_2}$$

JEE Questions

Thermal Properties of Heat And Matter

Q.1) 10 kg of ice at $-10°C$ is added to 100 kg of water to lower its temperature from $25°C$. Consider no heat exchange to surroundings. The decrement to the temperature of water is ____ °C.

(Specific heat of ice $= 2100\ J/Kg\ °C$, Specific heat of water $= 4200\ J/Kg\ °C$, Latent heat of fusion of ice $= 3.36 \times 10^5\ J/Kg$) [JEE main 2026]

Ans:-

100 kg H_2O $\rightarrow Q_{lost} = 100(4200)(25 - T_f)$

Heat gained by 10 kg ice:-

From $-10°C$ to $0°C$

$Q_1 = 10(2100)(10) = 2.1 \times 10^5 J$

From melting ice at $0°C$

$Q_2 = 10(3.36 \times 10^5) = 3.36 \times 10^6 J$

From $0°C$ to T_f:-

$Q_3 = 10(4200)T_f = 42000 T_f$

Now; $Q_{lost} = Q_1 + Q_2 + Q_3$

$\Rightarrow 420000(25 - T_f) = 2.1 \times 10^5 + 3.36 \times 10^6 + 42000 T_f$

$6.93 \times 10^6 = 462000 T_f$

$\therefore T_f = 15°C$

Therefore, Decrement in H_2O temperature:-

$\Rightarrow 25 - 15 \Rightarrow \underline{10°C}$

Q.2) A cylinder with fixed capacity of 67.2 (L) contains (He) gas at STP. The amt. of heat needed to raise the temperature of the gas by 20°C is :- $R = 8.31 \, J \, mol^{-1} K^{-1}$.
[JEE Main 2019]

Ans:- ⊛ n (no. of moles) $\Rightarrow \frac{67.2}{22.4} \Rightarrow$ 3 moles {at STP}

$$\Delta Q = n C_v \Delta T$$
$$\Delta Q \Rightarrow (3)\left(\frac{3}{2} \times R\right) \times (20)$$
$$\Delta Q \Rightarrow 60 \times \frac{3}{2} \times 0.0821$$
$$\Delta Q \Rightarrow 90 \times 0.0821 \Rightarrow \underline{\underline{748 J}}$$

Q.3) 200g of water is heated from 40°C to 60°C. Ignoring the slight expansion of water, the change in its internal energy (Specific heat of water = 4184 J/kg/K). [JEE Main 2016]

Ans:- ⊛ isochoric process, so;

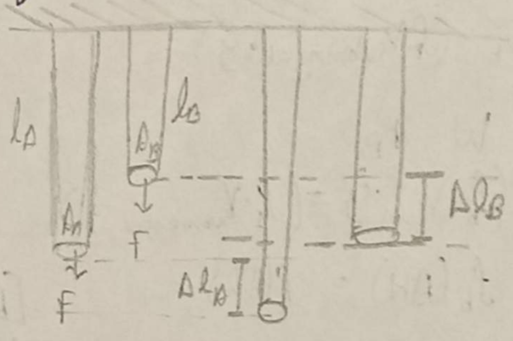
$$\Delta U = Q = m S \Delta T$$
$$\Delta T = 20°C$$
$$m = 0.2 \, kg$$
$$S = 4184 \, J/kg K$$
$$\Delta U = 4184 \times 20 \times 0.2$$
$$\Delta U = 4184 \times 4 \Rightarrow 16736 J \Rightarrow \underline{\underline{16.7 kJ}}$$

Thermal Properties Of Matter

Q.1. Two wires A and B made of different materials of length 6 cm and 5.4 cm, respectively and area of cross sections 3×10^{-5} m^2 and 4.5×10^{-5} m^2, respectively are stretched by the same magnitude under a given load. The ratio of the Young's modulus of A to that of B is x:3. The value of x is ______.

A. Young's Modulus = $\frac{Stress}{Strain}$

$= \frac{FL}{A\Delta L}$



$$\frac{Y_A}{Y_B} = \frac{\left(\frac{L_A}{A_A}\right)}{\left(\frac{L_B}{A_B}\right)} = \frac{L_A}{L_B} \times \frac{A_A}{A_B}$$

[∵ Both wires are stretched by same magnitude ($\Delta l_A = \Delta l_B$) under given load $F_A = F_B$]

$$\therefore \frac{Y_A}{Y_B} = \frac{\cancel{6}^{2}}{\cancel{5.4}_{1.8}\,0.6} \times \frac{\cancel{4.5}^{1.5}\times10^{-5}}{3\times10^{-5}}$$

$$= \frac{2}{\cancel{0.6}_{0.3}} \times \frac{\cancel{1.5}^{5}\times10^{-5}}{\cancel{0.3}\times10^{-5}} = \frac{5}{3} = \frac{x}{3}$$

$$\Longrightarrow \underline{x = 5}$$

Q.2. A small metallic sphere of diameter 2mm and density 10.5 g/cm³ is dropped in glycerine having viscosity 10 Poise and density 1.5 g/cm³ respectively. The terminal velocity is ______.

A. $V_t = \frac{2r^2(\rho-\sigma)g}{9\eta}$; $r = 0.1cm$, $\rho = 10.5g$ $\sigma = 1.5 g/cm^3$ $g = 10 m/s^2 = 1000 cm/s^2$ $\eta = 10$ Poise $= 10 \frac{g}{cm \cdot s}$

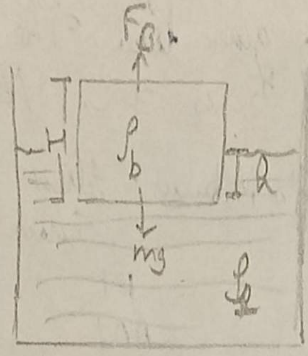
$$\therefore V_t = \frac{2\times(0.1)^2\times(10.5-1.5)\times1000}{9\times10} = \frac{2\times0.01\times9\times100\cancel{0}}{9\cancel{0}}$$

$= \underline{2 cm/s}$

Q.3. A cubical block of density $\rho_b = 600 kg/m^3$ float in a liquid of density $\rho_l = 900 kg/m3$. If the height of block is $H = 8 cm$, then height of submerged part is ______ cm.

A. $W = mg = (\rho_b \cdot V_{total}) \times g$

$F_B = (\rho_l V_{submerged} \cdot g)$



$W = F_B$

$(\rho_b \cdot V_{total} \cdot g) = (\rho_1 \cdot V_{submerged} \cdot g)$

$\rho_b (AH) = \rho_l (Ah)$

[A = Area of cross-section;
H = Height of block
h = Height submerged]

$\Rightarrow h = \frac{600}{900} \times 8$

$= \frac{16}{3} \approx \underline{5.33 cm}$

Thermal Properties of Matter

Q1. A railway track is made of iron segments, each 20m long. If the maximum temperature expected is 50°C and the tracks were laid at 20°C, what is the minimum gap that should be left between the segments to avoid buckling? (Given: $\alpha_{iron} = 1.2 \times 10^{-5}$ /°C)

Ans. The increase in length is given by $\Delta L = L_0 \alpha \Delta T$

$L_0 = 20m$

$\Delta T = 50 - 20$
$= 30°C$

$\Delta L = 20 \times (1.2 \times 10^{-5}) \times 30$

$\Delta L = 0.0072\ m$
$= 7.2mm$

Engineers must leave this specific gap so that when the metal expands in the summer heat, the rails don't push against each other and bend (buckle).

Q2. Calculate the final temperature when 100g of water at 80°C is mixed with 100g of water at 20°C

Ans Principle of Calorimetry, Heat Lost = Heat Gained.
Since both substances are the same (water), their specific heat S cancels out.

Let the temperature be T.
Heat lost by hot water, $Q_{loss} = ms(80 - T)$ —①
Heat gained by cold water, $Q_{gain} = ms(T - 20)$ —②
Equating ① & ②,

$100 \times S \times (80 - T) = 100 \times S \times (T - 20)$

$80 - T = T - 20$

$2T = 100$

$T = 50°C$

Q3. Two slabs of the same thickness but different materials with thermal conductivities K_1 and K_2 are joined in series. What is the equivalent thermal conductivity K_{eq} of the combination?

Ans. Thermal Resistance ($R = L/KA$).

When slabs are in series, their resistances add up like resistors in an electric circuit.

$R_{total} = R_1 + R_2$

Since thickness L and Area A are the same for both, the total length is $2L$.

$$\frac{2L}{K_{eq}A} = \frac{L}{K_1 A} + \frac{L}{K_2 A}$$

Cancelling L/A from both sides.

$$\frac{2}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2}$$

$\therefore K_{eq} : K_{eq} = \dfrac{2K_1 K_2}{K_1 + K_2}$

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Thermal Properties Of Matter

Q) A brass rod of Length of L fits exactly into a steel ring at temprature T. On heating both by ΔT, the rod just slips out.
Which is correct?

(a) $\alpha_{brass} = \alpha_{steel}$ (b) $\alpha_{brass} > \alpha_{steel}$ (c) $\alpha_{brass} < \alpha_{steel}$

(d) Depends on Radius

Sol.

At temprature T,
The brass rod fit exactly in steel ring
When heated by ΔT:
The brass rod's cross-section area decreases and thus length increases
The steel ring's diameter increases and hole becomes more large.
Given, the rod slips out so the expansion of steel ring is more.
Since, ring expands more faster than rod.

$\boxed{(c)\ \alpha_{brass} < \alpha_{steel}}$

~~Q) A Square alluminium plate has side 1m~~

Q) A Alluminium and steel rods have same lengths and cross-sections are joined to make total length of 120 cm at 30°C. The Cofficient of linear expansion of alluminium and steel are $24\times10^{-6}/°C$ & $1.2\times10^{-5}/°C$ respectively. The length of composite rod when temprature to 100°C, is ____ cm

(A) 120.20 (B) 120.06 (C) 120.15 (D) 120.03

Sol.

for alluminium rod & steel rod:

total length (aluminium + steel) = 120 cm at 30°C

Since length of both rods equal then, $L_{Al} = L_S = \frac{120}{2} = 60cm$

$\alpha = \frac{\Delta L}{L \cdot \Delta T}$ {linear expansion formula}

Alluminium rod	Steel rod
$\alpha_{Al} = \frac{\Delta L_{Al}}{L_{Al}\Delta T}$	$\alpha_{steel} = \frac{\Delta L_S}{L_S \Delta T}$
$\Delta L_{Al} = \alpha_{Al} L_{Al} \Delta T$	$\Delta L_S = \alpha_S L_S \Delta T$
$\Delta L_{Al} = (24\times10^{-6})\times(60)\times(100-30)$	$\Delta L_S = (1.2\times10^{-5})\times60\times(100-30)$
$\Delta L_{Al} = 0.1008cm$	$\Delta L_S = 0.0504\,cm$

Total expansion of combined rod $= \Delta L_{Al} + \Delta L_S = 0.1512$ cm

Total length of combined rod After expansion $= 120 + 0.1512 = 12.1512\,cm$

$\boxed{(C)\ 120.15}$

Q> 2 identical calorimeters contain equal masses of water at 30°C. One contains copper block and other alluminium block, each of same mass and both at 90°C. Which calorimeter will finally have high temperature?

{Given: specific heat of alluminium > specific heat of copper}

Sol.

we know,

Heat lost by metal = Heat gained by water + calorimeter

Concept: For same mass and same initial tempratures, the metal with larger specific heat releases more heat for same drop in temprature.

Given,

Heat Capacity C (Al) > Heat capacity (Cu)

$\boxed{\text{So, Al gives more heat than Cu}}$

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Thermal Properties of Matter

① When 300 J of heat given to an ideal gas with $C_p = \frac{7R}{2}$ its temperature raises from 20°C to 50°C keeping its volume constant. The mass of the gas is (approx.) ________ g.

Ans:-

$Q = n C_v \Delta T$

$\because C_p - C_v = R \Rightarrow C_v = C_p - R = \frac{7}{2}R - R = \frac{5}{2}R$

$\therefore 300 = n\left(\frac{5}{2} \times 8.314\right) \times 30$

$\Rightarrow n = \frac{300 \times 2}{5 \times 8.314 \times 30} = 0.481$ moles.

② A diatomic gas ($\gamma = 1.4$) does 100 J of work when it is expanded isobarically. Then the heat given to the gas 350 J.

Ans:-

$W = P\Delta V = nR\Delta T$

$\Delta U = nC_v\Delta T$, $Q = nC_p\Delta T$

$\therefore \gamma = \frac{C_p}{C_v}$; $C_p - C_v = R$; $\frac{Q}{W} = \frac{nC_p\Delta T}{nR\Delta T} = \frac{C_p}{R}$

$\Rightarrow \frac{Q}{W} = \frac{C_p}{C_p - C_v} \Rightarrow \frac{Q}{W} = \frac{\frac{C_p}{C_v}}{\frac{C_p - C_v}{C_v}} = \frac{\gamma}{\gamma - 1}$

$\therefore \frac{Q}{100} = \frac{1.4}{1.4 - 1}$

$\Rightarrow Q = 350 J$

(3) γ_A is the specific heat ratio of monoatomic gas A having 3 translational degree of freedom. γ_B is the specific heat ratio of polyatomic gas B having 3 translational, 3 rotational degree of freedom and 1 vibrational mode. If $\frac{\gamma_A}{\gamma_B} = \left(1+\frac{1}{n}\right)$, then the value of n is <u>3</u>.

Ans:-

$$f_A = 3; \quad \gamma_A = \frac{f_A+2}{f_A} = \frac{3+2}{3} = \frac{5}{3}$$

$$\therefore f_B = 3+3+2*1 = 8$$

$$\gamma_B = \frac{f_B+2}{f_B} = \frac{8+2}{8} = \frac{5}{4}$$

$$\frac{\gamma_A}{\gamma_B} = 1+\frac{1}{n} \Rightarrow \frac{\frac{5}{3}}{\frac{5}{4}} = \frac{4}{3} \Rightarrow \boxed{n = 3}$$

$$= 1+\frac{1}{n}$$

KOUSHIK.B

THERMAL PROPERTIES OF MATTER

Q. A solid sphere of radius r and mass m is suspended by a long wire of length L. The wire is heated by ΔT. If the coefficient of linear expansion of the wire is α, then the change in potential energy of the sphere is

(A) $mgL\alpha\Delta T$ (B) $mgL\alpha$ (C) $mg\alpha\Delta T$ (d) $mgL\Delta T$

Solution

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

The sphere attached to it rises by ΔL

$\Delta U = mg\Delta h = mg(\alpha L \Delta T)$

option (A) $mgL\alpha\Delta T$

Q. A rod of length L and coefficient of linear expansion α is clamped at both ends. The temperature of the rod is increased by ΔT. The stress developed in rod is

(A) $Y\alpha\Delta T$ (B) $Y\Delta T$ (C) $\frac{Y}{\alpha\Delta T}$ (D) $Y\alpha$

Solution

when ends are fixed, expansion is prevented

strain $= \alpha\Delta T$

stress $= Y \times$ strain

$\sigma = Y\alpha\Delta T$

option (A) $Y\alpha\Delta T$

Q Two rods of equal length and cross-sectional area are joined end to end. One rod has thermal conductivity K_1 and other K_2. The free ends are maintained at temperatures T_1 and T_2 The effective thermal conductivity of system is

(A) $\frac{K_1+K_2}{2}$ (B) $\frac{2K_1+K_2}{K_1+K_2}$ (C) $\frac{K_1K_2}{K_1+K_2}$ (D) $\sqrt{K_1K_2}$

Solutions

Two rods in series → effective conductivity

$$K_{ef} = \frac{2K_1K_2}{K_1+K_2}$$

Option (B) $\frac{2K_1K_2}{K_1+K_2}$

CamScanner

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2025-26

Thermal properties of Matter

Q.1 A diatomic gas with rigid molecules does 10J of work when expanded at constant pressure. What would be the heat energy absorbed by gas, in this process?

$\Delta Q = nC_pT$

$W = nRT = 10\,J$

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

$\Delta Q = n\left(\frac{7}{2}\right)R\Delta T$

$\Delta Q = \left(\frac{7}{2}\right)nR\Delta T = \left(\frac{7}{2}\right) \times 10$

$\Delta Q = 35\,J$

Q.2 70 calories of heat required to raise the temperature of 2 moles of an ideal gas at constant pressure from 30°c to 35°c. The amount of heat required to raise the temperature of the same gas through the same range at constant volume is.

$Q = nC_p dt$

$C_p = \frac{Q}{n dt} = \frac{70}{2 \times (35-30)}$

$C_p = \frac{70}{10}$

$C_p = 7$ cal / mol × K

$C_V = C_p - R$

$C_V = 5$ cal / mol × K

$Q = nC_V dt = 2 \times 5 \times 5$

$= 50$ cal

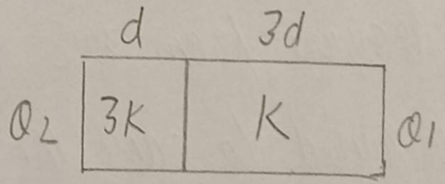
Q·3 Two materials having coefficient of thermal conductivity '3K' and 'K' and thickness and '3d' resp. are joined to form a slab as shown in the figure. The temperature of the outer surface is θ_2 and θ_1 resp ($\theta_2 > \theta_1$). The temp at the interface is?

Ans: $H_1 = H_2 Q_2$

$(3Ka(\theta_2 - \theta)/d) = (Ka(\theta - \theta_1))/3d$

$9(\theta_2 - \theta) = \theta - \theta_1$

$9\theta_2 + \theta_1 = \theta + 9\theta$



$\theta = (\theta_1/10) + (9\theta_2/10)$

2025-2026
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Thermal properties.

Q1. 0.1 kg of copper block at 100°C is placed in 0.2 kg water at 20°C. Specific heat capacity of copper = 400J
specific heat of water = 4200J

find final temperature.

Sol:

Heat lost by copper = Heat gained by water.

$$m_c c_c (T_c - T) = m_w c_w (T - T_w)$$

$$0.1(400)(100 - T) = 0.2(4200)(T - 20)$$

$$40(100 - T) = 840(T - 20)$$

$$4000 - 40T = 840T - 16800$$

$$20800 = 880T$$

$$\boxed{T = 23.6°C}$$

Q2. metal rod of length "L" heated from T_1 to T_2. coefficient of linear expansion is α: if increase in length is ΔL. find relation.

Sol:

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

$$\Delta T = T_2 - T_1$$

$$\boxed{\Delta L = L\alpha(T_2 - T_1)}$$

Q3. ice at $0°c$ of mass $100g$ dropped into $200g$ of water at $40°c$. find final temperature of system.

latent heat of ice = $80 cal/g$, Specific heat of water => $1 cal/(g°c)$

Sol:

$Q_{lost} = mc\Delta T = 200 \times (40 - T)$

ice $Q_1 = 100 \times 80 = 8000$ cal

$Q_2 = 100 \times 1 \times (T - 0) = 100T$

$Q_{gain} = 8000 + 100T$

$200(40 - T) = 8000 + 100T$

$8000 - 200T = 8000 + 100T$

$-300T = 0 \Rightarrow T = 0°C$

$200 \times 40 = 8000$ cal

$\boxed{\text{No temprise } 0°}$

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Q. The ratio of vapour densities of 2 gases at same temp is 4/25, then the ratio of RMS velocities will be:
[JEE Main 2025]

Sol: Given, vapour densities ratio of 2 gases : 4/25
The ratio of their r.m.s velocities:

$$\frac{V_{rms1}}{V_{rms2}} = \sqrt{\frac{M_2}{M_1}}$$

Substitute with molecular masses:

$$\sqrt{\frac{M_2}{M}} = \sqrt{\frac{25}{4}} = \underline{\underline{5/2}}$$

Q. Pressure of an ideal gas, contained in a closed vessel is increased by 0.4 % when heated by 1°C. Its initial temp must be: [JEE Main 2025]

Sol: For an ideal gas in a isochoric process: $P \propto T$

$$\frac{\Delta P}{P} = \frac{\Delta T}{T}$$

$\Delta P = 0.4$

$$\frac{0.4}{100} = \frac{1}{T}$$

$$\underline{\underline{T = 250\ K}}$$

Q. The resistance of a platinum wire at the ice point (0°C) & steam point (100°C) are 8Ω & 10Ω respectively. Find the resistance after inserting it in a hot bath of 400°C.
[JEE Main 2024]

$R_t = R_0(1 + \alpha\Delta t)$

$10 = 8(1 + \alpha \times 100) \Rightarrow 2 = 800\alpha \Rightarrow \alpha = 1/400$

Find resistance at 400°C:

$$R_{400} = 8\left(1 + \frac{1}{400} \times 400\right) = 8(1+1) = \underline{\underline{16\Omega}}$$

Q.) On Celsius scale the temperature of body increases by 40°c. The increase in farenheit scale is ____

(A) 68°F (B) 75°F

(C) 72°F (d) 70°F

Ans →

$1.8 \rightarrow 1^{\circ}c$

$x \rightarrow 40^{\circ}c$

$x = \frac{4\cancel{0} \times 18}{1\cancel{0}} = \boxed{72^{\circ}F}$

Q.) On a temperature scale 'x' the boiling point of water is 65° x and the freezing point is -15°x. Assuming that x scale is linear. The equivalent temperature corresponding to -95°x on the farenheit scale would be

(A) -122 F° (C) -48°F

(B) -148 F° (d) -63 F°

$$\frac{65-x}{65+15} = \frac{212-F}{180}$$

$$\boxed{F = -148 F^{\circ}}$$

Q.) A body cools in 7 min from 60°C to 40°C. The temperature of the surroundings is 10°C. The temperature of the body after the next 7 minutes will be :-

(A) 30°C

(B) 32°C

(C) 34°C

(d) 28°C

Ans →

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

$$K = \frac{20}{7 \times 60 \times 40}$$

$$\rightarrow \frac{40 - x}{7 \times 60} = K\left(\frac{40 + x}{2} - 10\right)$$

$$\boxed{x = 28°C}$$

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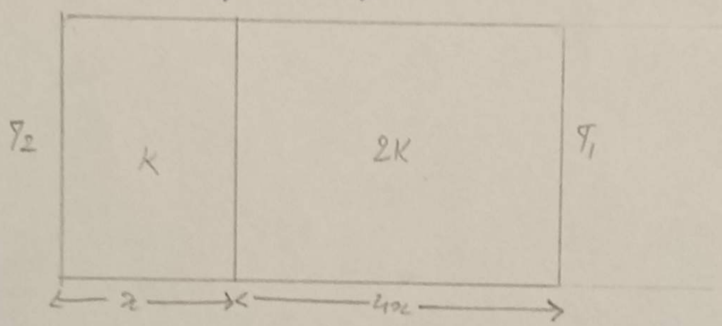
2025-26

Thermal Properties of Matter

Q The temperature of the two outer surfaces of a composite slab, consisting of two material having coefficients of thermal conductivity K and 2K and thickness x and 4x respectively are T_2 and T_1 ($T_2 > T_1$). The rate of heat transfer through the slab in a steady state is $[A(T_2 - T_1)K/x]f$; $f = ?$



$\Rightarrow$ First surface $Q_1 = KA(T_2 - T)t/x$

Second surface $Q_2 = 2KA(T - T_1)t/(4x)$

$Q_2 = Q_1 \Rightarrow 2\cancel{KA}(T - T_1)\cancel{t}/(4x) = \cancel{KA}(T_2 - T)\cancel{t}/x$

$= \quad 2(T_2 - T) = (T - T_1)$

$T = (2T_2 + T_1)/3$

$Q_1 = KA(T_2 - [(2T_2 + T_1)/3])t/x$

$H = Q_1/t = KA(T_2 - [(2T_2 + T_1)/3])\cancel{t}/x\cancel{t}$

$= KA(T_2 - (2T_2 + T_1)/3)/x$

$\left[A\frac{(T_2 - T_1)K}{x}\right]f = \frac{KA}{x}\left[\frac{T_2 - T_1}{3}\right]$ $\quad \therefore \boxed{f = \frac{1}{3}} \rightarrow$ Ans

Q In a process, temperature and volume of one mole of an ideal monoatomic gas are varied according to the relation $VT = K$, where K is a constant. In this process the temperature of the gas is increased by T. The amount of heat absorbed by gas is given by (R is gas constant).

$\Rightarrow$ $VT = K$

$V\left(\frac{PV}{R}\right) = K$

$PV^2 =$ constant.

For a polytropic process

$C = \left(\frac{R}{1} - 2\right) + C_v$

$\left(\frac{R}{1} - 2\right) + \frac{3R}{2} = \frac{R}{2}$

$\Delta Q = nCT$

$\boxed{\Delta Q = \frac{1}{2} R \Delta T} \longrightarrow$ Ans

Q. A diatomic gas with rigid molecules does 10J of work when expanded at constant pressure. What would be the heat energy absorbed by the gas, in this process?

$\Rightarrow$ heat absorbed by gas is :

$$\Delta q = n C_p T$$

Work done by the gas is :

$$W = nRT$$
$$= 10 J$$

$C_p = \left(\frac{7}{2}\right)R$ for diatomic gas

$$\Delta q = n \frac{7}{2} R \Delta T$$

$$= \frac{7}{2} n R \Delta T$$

$$= \frac{7}{2} \times 10$$

$$\boxed{\Delta q = \cancel{35} \ 35 J} \longrightarrow \text{Ans}$$

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Q1) A copper block of mass 2.5 kg is heated in a furnace to a temperature of 500°C and then placed on a large ice block. What is the maximum amount of ice that can melt? (Specific heat of copper = $0.39\ Jg^{-1}K^{-1}$, heat of fusion of water = $335\ Jg^{-1}$)

A) Given, $m_c = 2.5kg = 2500g$, $\Delta\theta = 500°C$, $S = 0.39\ Jg^{-1}K^{-1}$, $L = 335\ Jg^{-1}$

$Q = mC\Delta\theta$ (Maximum amount of heat copper block can lose)

$= 2500 \times 0.39 \times 500$

$= 487500\ J$

$Q = m_1 L$ (m_1 = Maximum amount of ice)

$m_1 = \frac{Q}{L} = \frac{487500}{335} = 1455.22g$

∴ Maximum amount of ice that can melt is 1.45 kg.

Q2) A steel tape 1 m long is correctly calibrated for a temperature of 27°C. The length of steel rod measured by a tape is found to be 63.0 cm on a hot day when 45°C. What is the actual length of steel rod that day? What is length of same steel rod when temperature is 27°C? Coefficient of linear expansion of steel $= 1.2 \times 10^{-5}\ K^{-1}$.

A) $T = 27°C$, $l = 1m = 100cm$

$T_1 = 45°C$, $l_1 = 63\ cm$

$\alpha = 1.2 \times 10^{-5}\ K^{-1}$

l_2 = actual length, l' = length of steel tape at 45°C

$l' = l + \alpha l(T_1 - T)$

$= 100 + 1.2 \times 10^{-5} \times 100(45 - 27)$

$= 100.0216\ cm$ //

$l_2 = \frac{100.0216}{100} \times 63 = 63.0136\ cm$ //

∴ Actual length of rod at 27°C = 100.0216 cm

at 45°C = 63.0136 cm

Q3) A hole is drilled in a copper sheet. The diameter of the hole is 4.24 cm at 27°C. What is the change in diameter when sheet is heated to 227°C? Coefficient of linear expansion of copper = $1.7 \times 10^{-5}\ K^{-1}$

A) $T_1 = 27°C$, $d_1 = 4.24\,cm$

$T_2 = 227°C$, $d_2 = ?$

$\alpha = 1.7 \times 10^{-5}\ K^{-1}$

β = Co-efficient of superficial expansion

$$\frac{\Delta A \text{ (Change in Area)}}{A \text{ (Area)}} = \beta \Delta T$$

$$\frac{\pi \frac{d_2^2}{4} - \pi \frac{d_1^2}{4}}{\pi \frac{d_1^2}{4}} = \beta \Delta T$$

$$\frac{d_2^2 - d_1^2}{d_1^2} = 2\alpha \Delta T \quad (\beta = 2\alpha)$$

$$\frac{d_2^2}{d_1^2} - 1 = 2\alpha (T_2 - T_1)$$

$d_2^2 = (2 \times 1.7 \times 10^{-5} (227 - 27) + 1) \times 4.24 = 18.1$

$d_2 = 4.2544\ cm$ //

$\Delta d = 4.2544 - 4.24 = 0.0144\ cm$ //

$\therefore$ diameter increases by 1.44×10^{-2} cm.

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