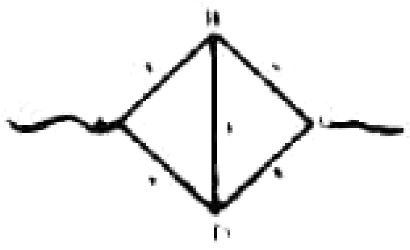
1.

Three rods of material x and two rods of material y are connected as shown in figure



$R_y = \frac{\ell}{KA} = 2R$

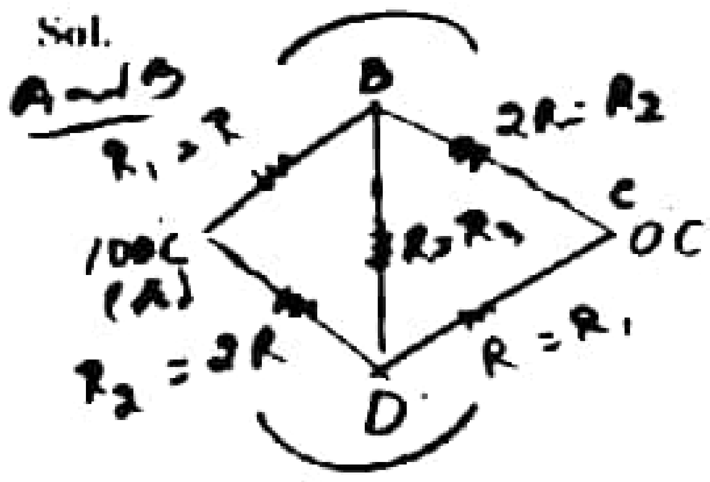
$R_x = \frac{\ell}{2KA} = R$

All the rods are of identical length and cross-sectional area. The end A is maintained at 100°C and the junction C at 0°C. It is given that resistance of rod of material x is R. Further, $K_x = 2K_y$. Match the entries of Column I and II

Column I	Column II
(A) Temperature of junction B → R	(P) 3R/5
(B) Temperature of junction D → S	(Q) 7R/5
(C) Thermal resistance between B and D → P	(R) 400/7 °C
(D) Thermal resistance between A and C → Q	(S) 300/7 °C

~~(A)~~ (A) → (R), (B) → (S), (C) → (P), (D) → (Q)
(B) (A) → (S), (B) → (R), (C) → (Q), (D) → (P)
(C) (A) → (Q), (B) → (R), (C) → (S), (D) → (P)
(D) (A) → (P), (B) → (R), (C) → (S), (D) → (Q)

Sol.



A→B

$R_1 = R$

$2R = R_2$

$R_3 = R$

100C (A)

0C

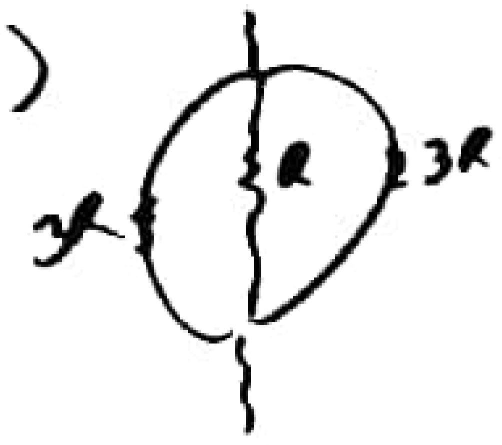
$R_2 = 2R$

$R = R_1$

$\frac{1}{2} = \frac{R_1}{R_2}$ $T_B > T_D$

$\frac{R_2}{R_1} = \frac{2}{1}$

c)



$R_{eq} = \frac{3R}{5}$

D) R_{AC}

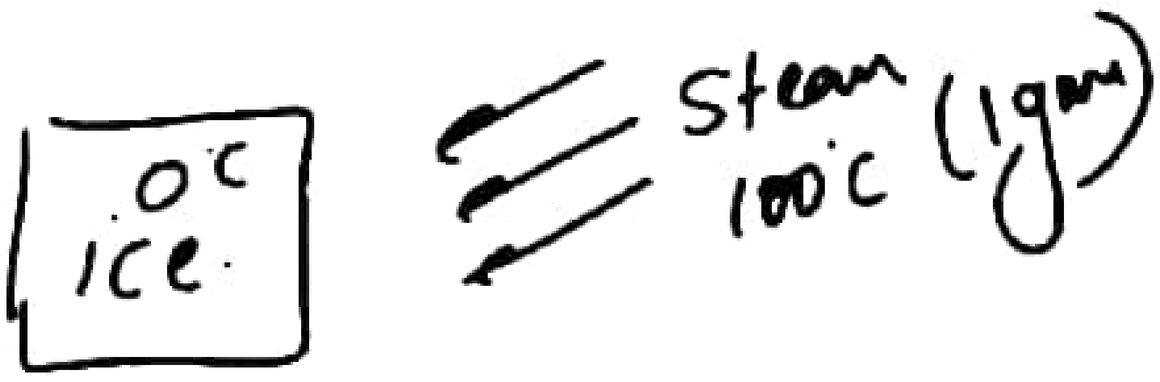
$= \frac{R_1R_3 + R_2R_3 + 2RR_2}{R_1 + R_2 + 2R_3}$

$= \frac{R^2 + 2R^2 + 4R^2}{R + 2R + 2R} = \frac{7R}{5}$

2.

1 g of a steam at 100°C melt how much ice at 0°C? (Latent heat of ice = 80 cal/gm and latent heat of steam = 540 cal/gm) -

(A) 1 gm (B) 2 gm (C) 4 gm ~~(D)~~ 8 gm



Steam

① 100C steam → 100C W

$\Delta Q_1 = mL$
$= 1 \times 540 = 540\,cal$

② 100C water → 0C water

$\Delta Q_2 = ms\Delta T$
$= 1 \times 1 \times 100 = 100\,cal$

$\Delta Q_{given} = 640\,cal. = m' L_f$

$640 = m' \times 80$

$\boxed{m' = 8gm}$

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3.

Two spheres A and B have diameters in the ratio 1 : 2, densities in the ratio 2 : 1 and specific heats in the ratio 1 : 3; find the ratio of their thermal capacities -

(A) 1 : 6 (B) 1 : 12 (C) 1 : 3 (D) 1 : 4

Sol^n

$$\frac{d_1}{d_2} = \frac{r_1}{r_2} = \frac{1}{2}$$

$$\frac{\rho_1}{\rho_2} = \frac{2}{1}$$

$$\frac{s_1}{s_2} = \frac{1}{3}$$

$$H = m \times s = \rho \times \frac{4}{3}\pi r^3 \times s$$

$$\frac{H_1}{H_2} = \frac{\rho_1}{\rho_2} \times \left(\frac{r_1}{r_2}\right)^3 \times \frac{s_1}{s_2}$$

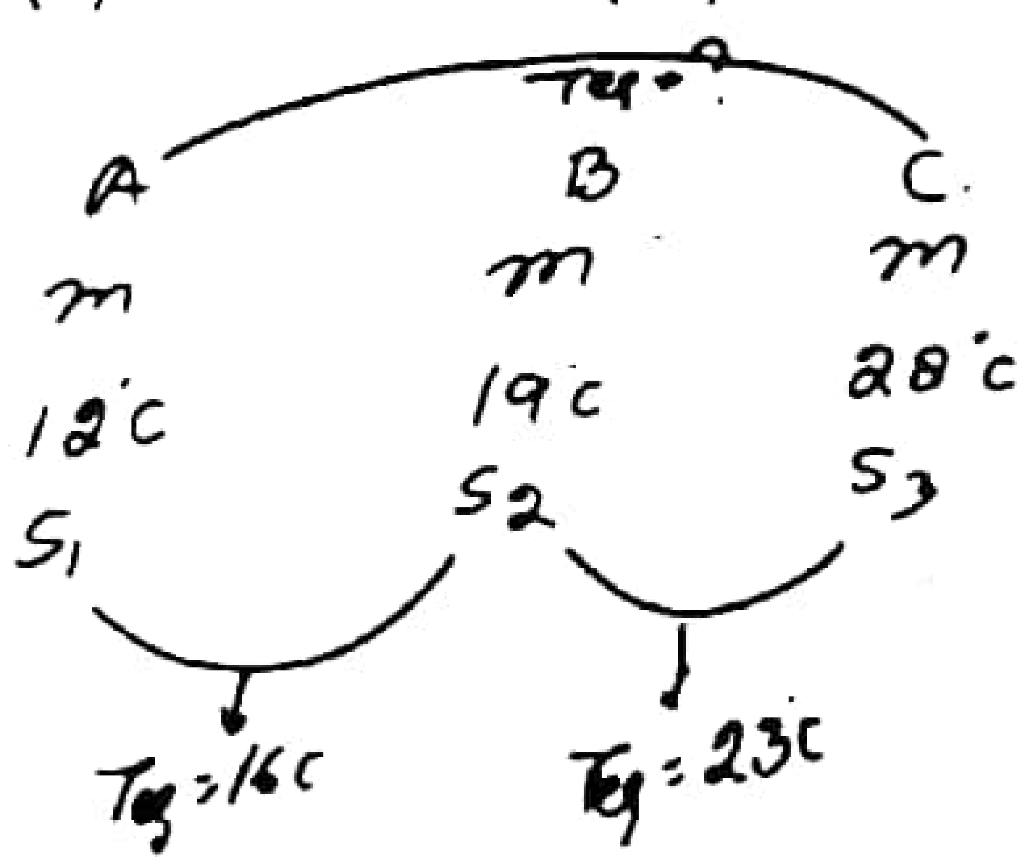
$$= \frac{2}{1} \times \left(\frac{1}{2}\right)^3 \times \frac{1}{3}$$

$$= \frac{1}{12}$$

4.

The temperature of equal masses of three different liquids A,B and C are 12°C, 19°C and 28°C respectively . The temperature when A and B are mixed is 16°C, when B and C are mixed is 23°C; what is the temperature when A and C are mixed ?

(A) 31°C (B) 20.26°C (C) 19.5°C (D) 28°C



① A and B

$$16 = \frac{12 m s_1 + 19 m s_2}{m s_1 + m s_2}$$

$$4 s_1 = 3 s_2 \quad \text{—(1)}$$

② B and C

$$23 = \frac{19 m s_2 + 28 m s_3}{m s_2 + m s_3}$$

$$4 s_2 = 5 s_3 \quad \text{—(2)}$$

③ A and C

$$T_{eq} = \frac{12 m s_1 + 28 m s_3}{m s_1 + m s_3}$$

$$T_{eq} = \frac{12 \times \frac{3 s_2}{4} + 28 \times \frac{4 s_2}{5}}{\frac{3 s_2}{4} + \frac{4 s_2}{5}}$$

$$T_{eq} = 20.26\,°C$$

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5.

10 gm of ice at $0^\circ C$ is kept in a calorimeter of water equivalent 10 gm. How much heat should be supplied to the apparatus to evaporate the water thus formed ?

(A) 6200 cal (B) 7200 cal (C) 13600 cal (D) 8200 cal

Sol^n

$\Rightarrow$ cal $\rightarrow$ $m_a = 10\,gm$, $S_{eq} = 1 \frac{cal}{gm^\circ C}$

Heat = Cal (0C → 100C) + ice(0C) → 0C W + 0C W → 100C W + 100C W → 100C (G)

$= 10\times1\times100 + 10\times80 + 10\times1\times100 + 10\times540$

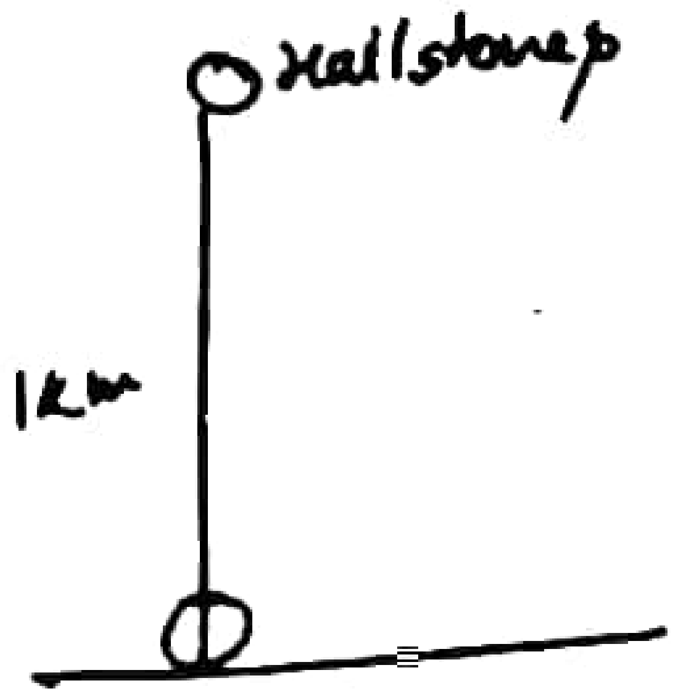
Heat $= 8200$ cal

6.

Hailstone at 0ºC falls from a height of 1 km on an insulating surface converting whole of its kinetic energy into heat. What part of it will melt ? (Given : $g = 10\ m/s^2$. $L_f = 3.3\times10^5 J/KG$)

(A) $\frac{1}{33}$ (B) $\frac{1}{8}$ (C) $\frac{1}{33}\times10^{-4}$ (D) All of it will melt

Sol.



$U = K = m'L$

$mgh = m'L$

$(m) \times 10 \frac{m}{s^2} \times 1000\,m = m' \times 3.3\times10^5 \times \frac{J}{kg}$

$m\times10^4 \times \frac{m^2}{s^2} = m' \times 3.3\times10^5 \times \frac{m^2}{s^2}$

fraction melted $= \frac{m'}{m} = \frac{1}{33}$ ✓

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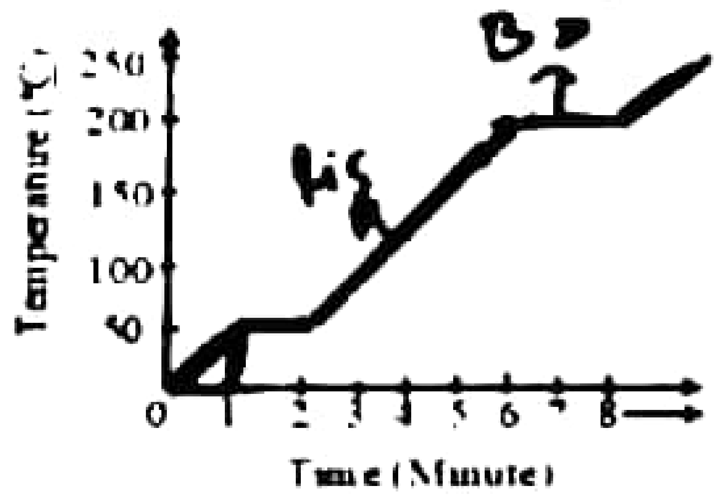
7.

A student takes 50gm wax (specific heat = 0.6 kcal/kg°C) and heats it till it boils. The graph between temperature and time is as follows. Heat supplied to the wax per minute and boiling point are respectively



(A) 500 cal, 50°C (B) 1000 cal, 100°C

(C) 1500 cal, 200°C (D) 3000 cal, 200°C

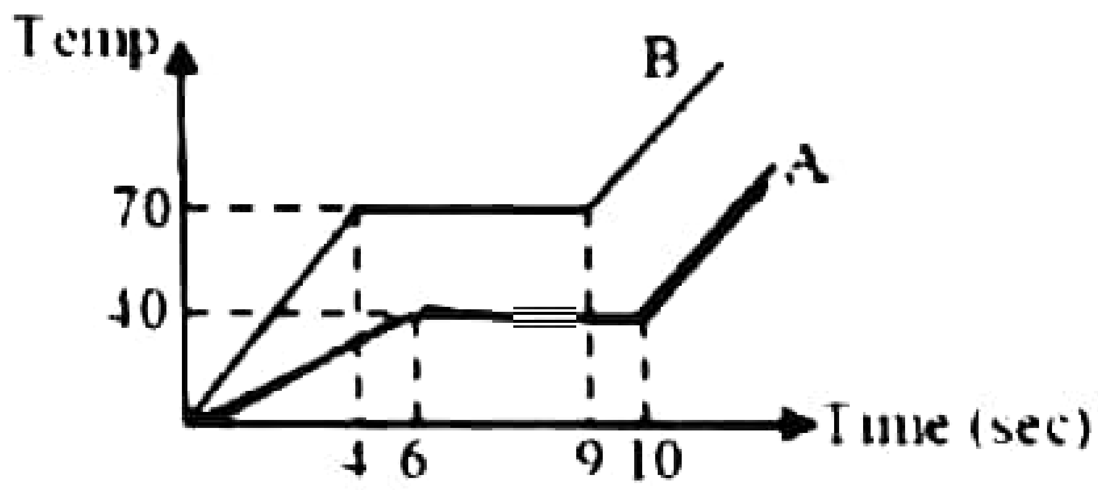
Heat supplied / min $= \frac{ms\Delta T}{\Delta t}$

$= \frac{50\,gm \times 0.6\,\frac{cal}{gm\,°C} \times 50°C}{1\,min}$

$= 1500\,\frac{cal}{min}$

8.

Two solid bodies of equal masses are heated at the same rate under identical condition. The change is temperature is shown graphically as a function of time. The ratio of specific heat in solid form should be (S_A/S_B):



(A) 4/3 (B) 21/8 (C) 15/8 (D) 3/4

A B

m m

$\left(\frac{\Delta Q}{\Delta t}\right)_A = \left(\frac{\Delta Q}{\Delta t}\right)_B$

$m s_A \left(\frac{\Delta T}{\Delta t}\right)_A = m s_B \left(\frac{\Delta T}{\Delta t}\right)_B$

$S_A \times \frac{40}{6} = S_B \times \frac{70}{4}$

$\frac{S_A}{S_B} = \frac{21}{8}$

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9.

Among the following four cylindrical rods, in which rod the rate of conduction of heat will be maximum, if the temperature difference between their ends is same ?

(A) Length 2 m, radius 1 cm

(B) 4m , 2 cm

(C) 2 m, 2cm

(D) 2m, 4 cm

$$\frac{\Delta\theta}{\Delta t} = \frac{\Delta\theta}{R}$$

R = least Rate of Heat supplied = Max.

$$R = \frac{l}{KA} = \frac{l}{K\pi r^2}$$

$$R_A = \frac{2}{K\pi\times 1}$$

$$R_B = \frac{4}{K\times\pi\times 4}$$

$$R_C = \frac{2}{K\pi\times 4}$$

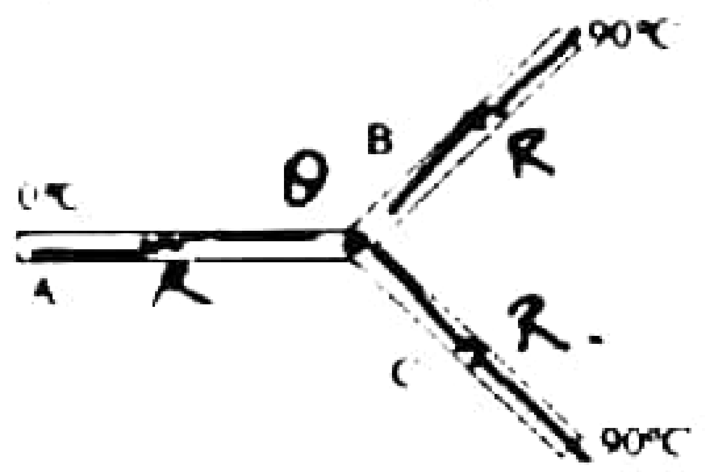
$$R_D = \frac{2}{K\pi 16}$$

R_D = Min.

for R_D Rate = Max

10.

Three rods made of the same material and having the same cross section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0°C and 90°C respectively. The temperature of the junction of the three rods will be -



(A) 45°C (B) 60°C (C) 30°C (D) 20°C

$$\theta_i = \frac{\Sigma \theta/R}{\Sigma 1/R}$$

$$\theta_i = \frac{0 + \frac{90}{R} + \frac{90}{R}}{\frac{3}{R}} = 60^\circ C$$

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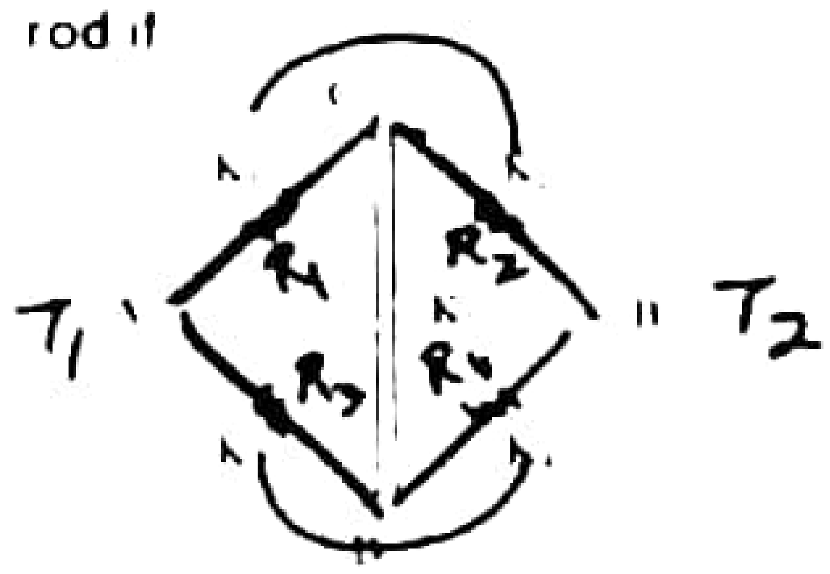
11.

Five rods of same dimensions are arranged as shown in the figure. They have thermal conductivities K_1, K_2, K_3, K_4 and K_5. When points A and B are maintained at different temperatures. No heat flows through the central rod if



(A) $K_1 = K_4$ and $K_2 = K_3$ (B) $K_1 K_4 = K_2 K_3$

(C) $K_1 K_2 = K_3 K_4$ (D) $\frac{K}{K_1} \frac{K}{K}$

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

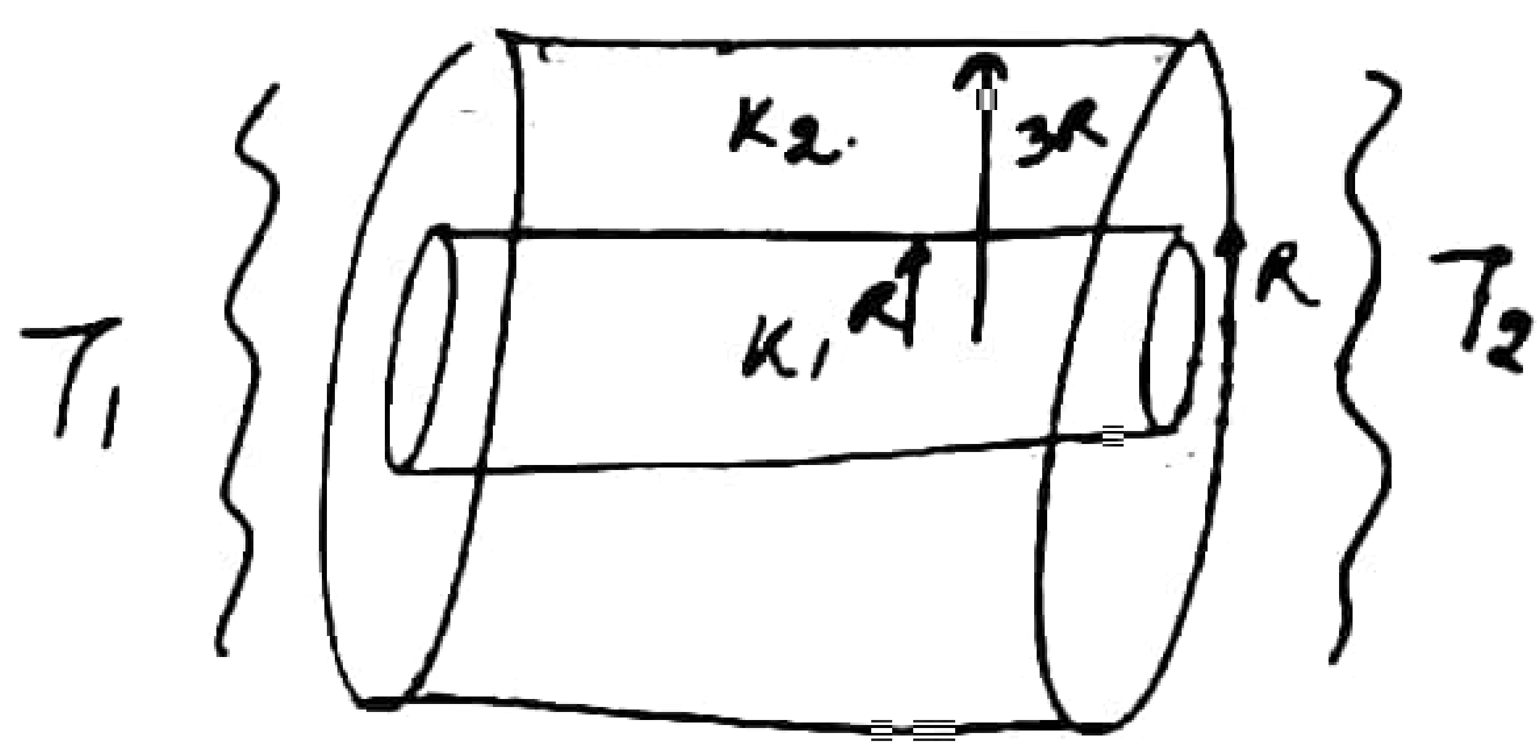
$$\frac{k_2}{k_1} = \frac{k_4}{k_3}$$

$$k_2 k_3 = k_1 k_4$$

12.

A cylinder of radius R made of material of thermal conductivity K_1 is surrounded by a cylindrical shell of inner radius R and outer radius 3R made of a material of thermal conductivity K_2. The two ends of the combined system are maintained at two different temperature. What is the effective thermal conductivity of the system ?

(A) $K_1 + K_2$ (B) $\frac{K_1 + 8K_2}{9}$ (C) $\frac{K_1 K_2}{K_1 + K_2}$ (D) $\frac{8K_1 + K_2}{9}$



$$K_{eq} = \frac{\Sigma KA}{\Sigma A}$$

$$K_{eq} = \frac{K_1 \times \cancel{\pi} R^2 + K_2 \times (\cancel{\pi} 9R^2 - \pi R^2)}{\cancel{\pi} 9 R^2}$$

$$K_{eq} = \frac{K_1 + 8K_2}{9}$$

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13.

Ice starts forming in a lake with water at 0°C when the atmospheric temperature is –10°C. If the time taken for the first 1cm of ice to be formed is 7 hours, then the time taken for the thickness of ice to change from 1cm to 2 cm is –

(A) 7 hours (B) 14 hours (C) 21 hours (D) 3.5 hours

Sol^n

$$t \propto (x_2^2 - x_1^2)$$

$$7 \propto [1^2 - 0^2]$$

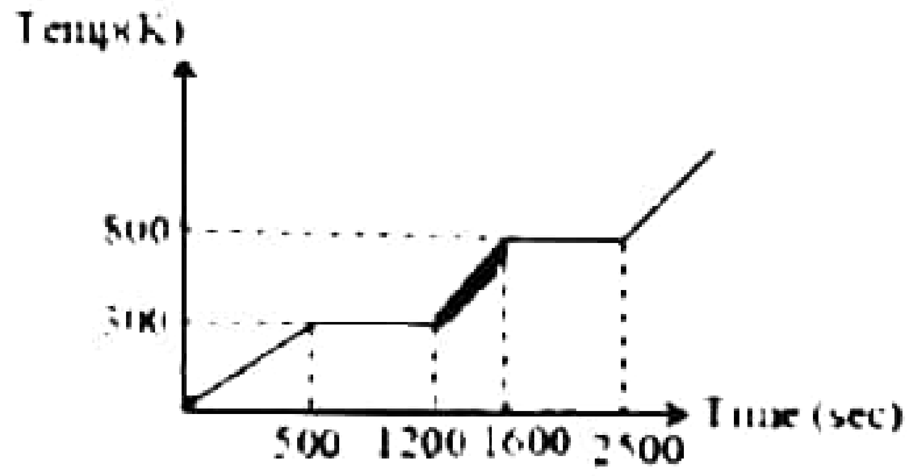
$$t \propto (2^2 - 1^2)$$

$$\frac{7}{t} = \frac{1}{3}$$

$$\boxed{t = 21 hr}$$

14.

Temperature variation with time is plotted for an object as shown in figure. The mass of the object is 200 g. Heat is supplied to the object at constant rate of 1 KW. Specific heat of object in liquid phase is -



(A) 3000 J/kg K (B) 1000 J/kg-K

(C) 4000 J/kg-K (D) 2000 J/kg-K

Sol^n:

$$\frac{\Delta Q}{\Delta t} = \frac{ms\Delta T}{\Delta t}$$

$$1000 \frac{J}{s} = 0.2kg \times S \times \frac{500}{400} \frac{°C}{s}$$

$$S = \frac{1000 \times 4}{1}$$

$$\boxed{S = 4000 \frac{J}{kg K}}$$

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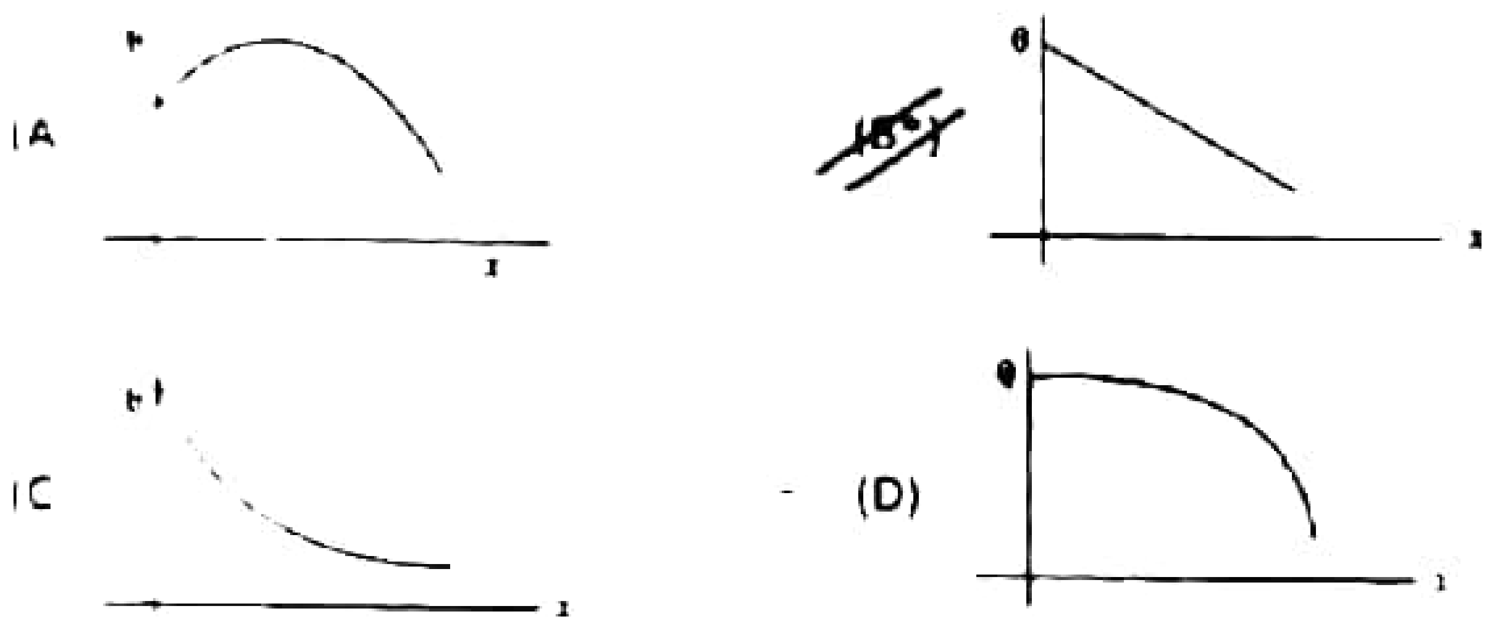
15.

A long metallic bar is carrying heat from one of its ends to the other end under steady state. The variation of temperature θ along the length x of the bar from its hot end is best described by which of the following figures?

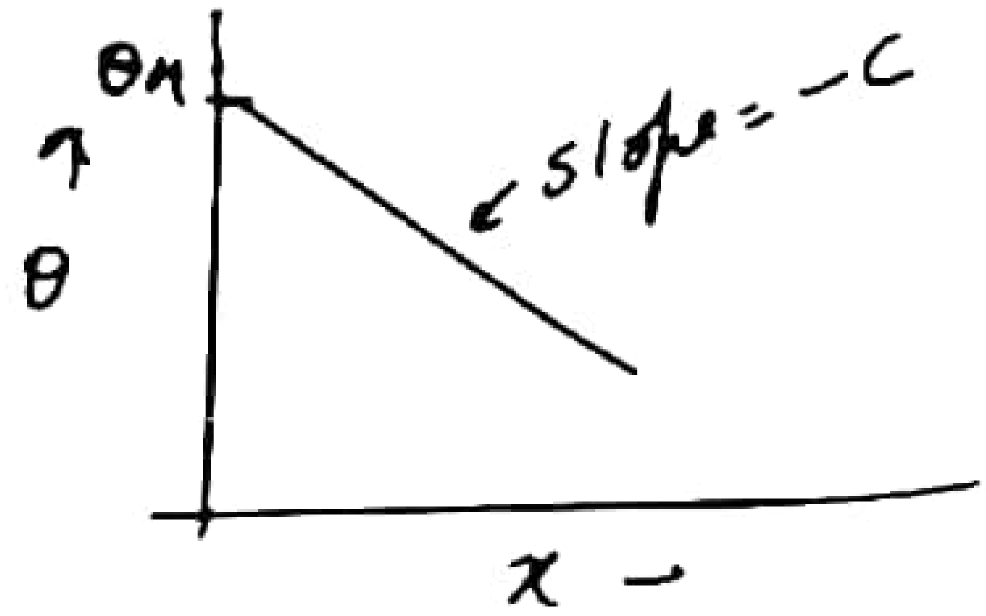


$$\frac{\Delta Q}{\Delta t} = \text{Const} = \frac{KA(\theta_H - \theta)}{x}$$

$$\frac{\theta_H - \theta}{x} = C$$

$$\theta_H - \theta = Cx$$

$$\boxed{\theta = -Cx + \theta_H}$$



16.

Statements 1: Specific heat of a substance during change of state is infinite. Correct

Statements 2: During change of state $\Delta Q = mL$, specific heat does not come in. Correct

(1*) Both Statements (1) and (2) are true ✓
(2) Statement (1) is true but statement (2) is false.
(3) Statement (1) is false but statement (2) is true
(4) Both Statements (1) and (2) are False

$$\Delta Q = ms\Delta T$$

$$s = \frac{\Delta Q}{m\Delta T}$$

$$\Delta T = 0 \quad s = \infty.$$

$$\Delta Q = mL$$

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17.

An anisotropic material has coefficient of linear expansion α, 2α and 3α along the three co-ordinate axis. Coefficient of cubical expansion of material will be equal to –

(A) 2α (B) $\sqrt[3]{6}\,\alpha$ (C) 6α (D) None of these

$$\gamma = \alpha_1 + \alpha_2 + \alpha_3$$

$$\gamma = 6\alpha$$

18.

When a metal rod is heated it expands because–

(A) The size of its atom increases

(B) The distance among its atom increases

(C) Atmospheric air rushes into it

(D) The actual cause is still unknown

19.

A uniform metal rod is used as a bar pendulum. If the room temperature rises by 10°C, and the coefficient of linear expansion of the metal of the rod is 2×10^{-6} per °C, the period of the pendulum will have percentage increase of –

(A) -2×10^{-3} (B) -1×10^{-3} (C) 2×10^{-3} (D) 1×10^{-3}

$$\% \frac{\Delta T}{T} = \frac{1}{2}\alpha \Delta\theta \times 100$$

$$= \frac{1}{2} \times 2 \times 10^{-6} \times 10 \times 100$$

$$= 1 \times 10^{-3}\%$$

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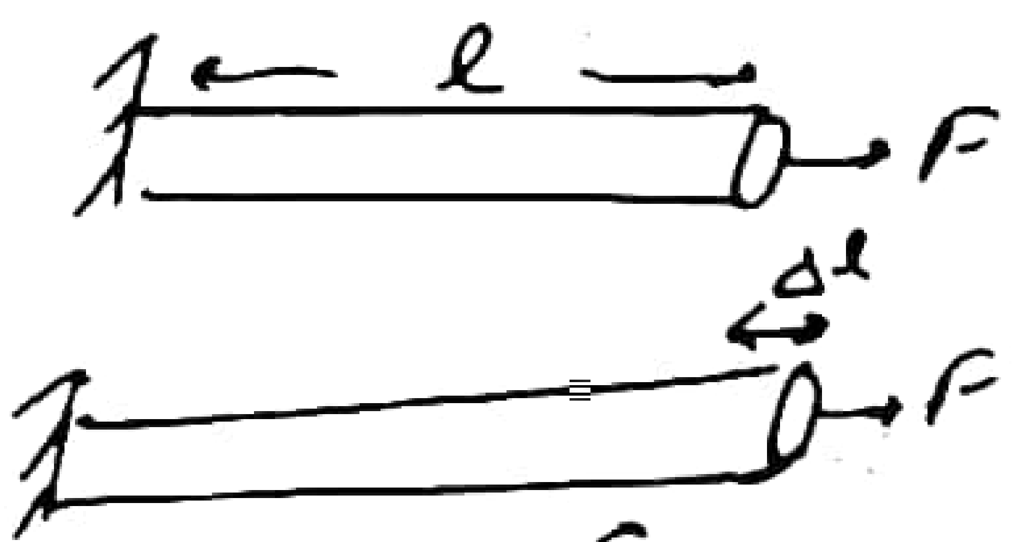
20.

A steel rod of length 25 cm has a cross–sectional area of 0.8 cm^2. The force required to stretch this rod by the same amount as the expansion produced by heating it through 10ºC is coefficient of linear expansion of steel is 10^{-5} ºC^{-1}. Young's modulus of steel is 2×10^{10} N/m^2.

(A) 40 N (B) 80 N (C) 120 N (D) 160 N



$$F = YA\frac{\Delta l}{l}$$

$$\boxed{F = YA\alpha\Delta\theta}$$

$$F = 2\times10^{10} \times 0.8\times10^{-4} \times 10^{-5} \times 10$$

$$F = \underline{160 N}$$

$$Y = \frac{F}{A \cdot \frac{\Delta l}{l}}$$

21.

The coefficient of volume expansion of glycerine is 49×10^{-5} °C^{-1}. What is the fractional change in its density for a 30°C rise in temperature.

(A) 3×10^{-2} (B) 2×10^{-2} (C) 1.47×10^{-2} (D) 1.47×10^{-4}

$$d_2 = d_1(1 - \gamma\Delta T)$$

$$\text{fractional change } \left|\frac{\Delta d}{d}\right| = |-\gamma\Delta T| = \gamma\Delta T$$

$$= 49\times10^{-5} \times 30$$

$$= \underline{1.47\times10^{-2}}$$

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22.

A glass flask is filled up to a mark with 50 cc of mercury at 18°C. If the flask and contents are heated to 38ºC, how much mercury will be above the mark ? (α for glass is 9×10^{-6}/°C and coefficient of real expansion of mercury is 180×10^{-6}/°C) –

(A) 0.85 cc (B) 0.46 cc (C) 0.153 cc (D) 0.05 cc

$V_0 = 50\,cm^3$

$T_1 = 18°C$

$T_2 = 38°C$

$\gamma_{app} = \gamma_r - 3\alpha_g$

$= 180\times10^{-6} - 3\times9\times10^{-6}$

$= 153\times10^{-6}/°C$

$\Delta V_{app} = V_0\, \gamma_{app}\, \Delta T$

$= 50\,cc \times 153\times10^{-6}/°C \times 20\,°C$

$\Delta V_{app} = 0.153\,cc$

23.

The coefficient of linear expansion of steel and brass are 11×10^{-6}/°C and 19×10^{-6}/°C respectively. If their difference in lengths at all temperatures has to be kept constant at 30 cm, their lengths at 0°C should be –

(A) 71.25 cm and 41.25 cm

(B) 82 cm and 52 cm

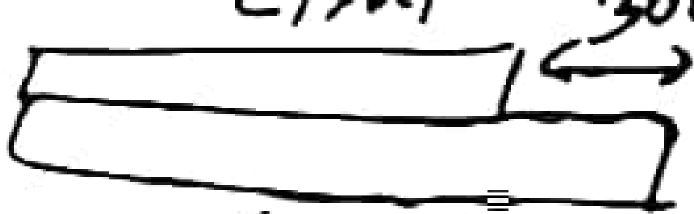
(C) 92 cm and 62 cm

(D) 62.25 cm and 32.25 cm

$\alpha_s = 11\times10^{-6}/°C$

$\alpha_b = 19\times10^{-6}/°C$

L_1, α_1 30 cm



L_2, α_2

$L_2 - L_1 = 30\,cm$

$L_1\alpha_1 = L_2\alpha_2$

$L_1 \times 19\times10^{-6} = L_2 \times 11\times10^{-6}$

$L_2 = \frac{19 L_1}{11}$

$\frac{19 L_1}{11} - L_1 = 30$

$L_1 = 41.25\,cm$ $L_2 = 71.25\,cm$

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24.

The volume of a solid decreases by 0.6% when it is cooled through 50°C. Its coefficient of linear expansion is –

(A) 4×10^{-6} /K (B) 5×10^{-5} /K (C) 6×10^{-4} /K (D) 4×10^{-5} /K

$$\frac{\Delta V}{V} \times 100 = 0.6$$

$$\frac{\Delta V}{V} = \frac{0.6}{100} = \gamma \Delta T$$

$$\frac{6 \times 10^{-3}}{50} = \gamma = 3\alpha$$

$$\alpha = \frac{\cancel{2} \times 10^{-3}}{\cancel{50}\ 25}$$

$$= 4 \times 10^{-5}/K$$

25.

A beaker is filled with water at 4°C. at one time the temperature is increased by few degrees above 4°C and at another time it is decreased by a few degrees below 4°C. One shall observe that-

(A) The level remains constant in each case

(B) In first case water flows while in second case its level comes down

(C) In second case water overflows while in first case it comes down

(D) Water overflows in both the cases

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26.

Two rods one of aluminium and the other made of steel, having initial length l_1 and l_2 are connected together to form a single rod of length $l_1 + l_2$. The coefficients of linear expansion for aluminimum and steel are α_a and α_s respectively. If the length of each rod increases by the same amount when their temperature are raised by t°C, then find the ratio $l_1/(l_1 + l_2)$ –

(A) α_s / α_a (B) α_a/α_s (C) $\alpha_s /(\alpha_a + \alpha_s)$ (D) $\alpha_a /(\alpha_a + \alpha_s)$

$$\Delta l_{al} = \Delta l_s$$

$$l_1 \alpha_a \cancel{t} = l_2 \alpha_s \cancel{t}$$

$$\boxed{l_1 \alpha_a = l_2 \alpha_s}$$

$$\frac{l_1}{l_1 + l_2} = \frac{\cancel{l_2}\,\alpha_s/\alpha_a}{\frac{\cancel{l_2}\alpha_s}{\alpha_a} + \cancel{l_2}} = \frac{\alpha_s}{\alpha_s + \alpha_a}$$

27.

A pendulum clock has an iron pendulum 1m long ($\alpha_{iron} = 10^{-5}/^\circ C$). If the temperature rises by 10ºC, the clock–

(A) Will lose 8 seconds per day

(B) Will lose 4.32 seconds per day

(C) Will gain 8 seconds per day

(D) Will gain 4.32 seconds per day

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

loss in time of clock $= \frac{1}{2}\alpha \Delta\theta \times 86400$

$= \frac{1}{2} \times 10^{-5} \times 10 \times 86400$

$= 4.32$ sec/day

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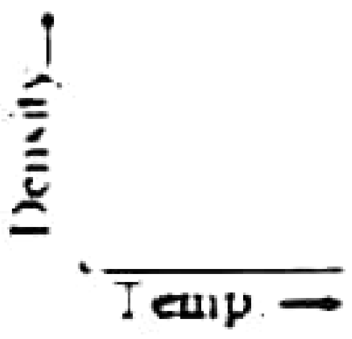
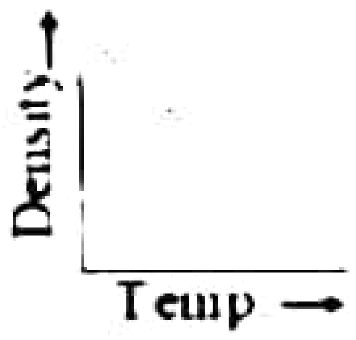
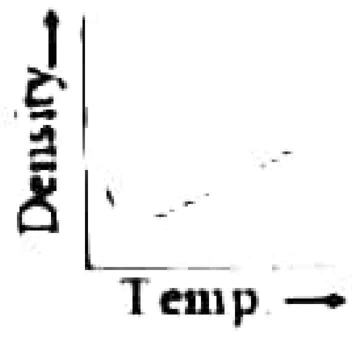
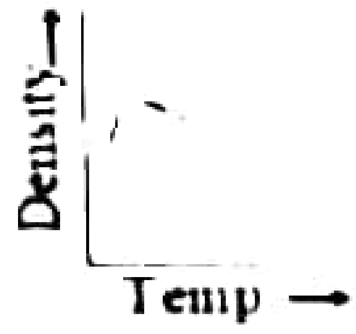
28.

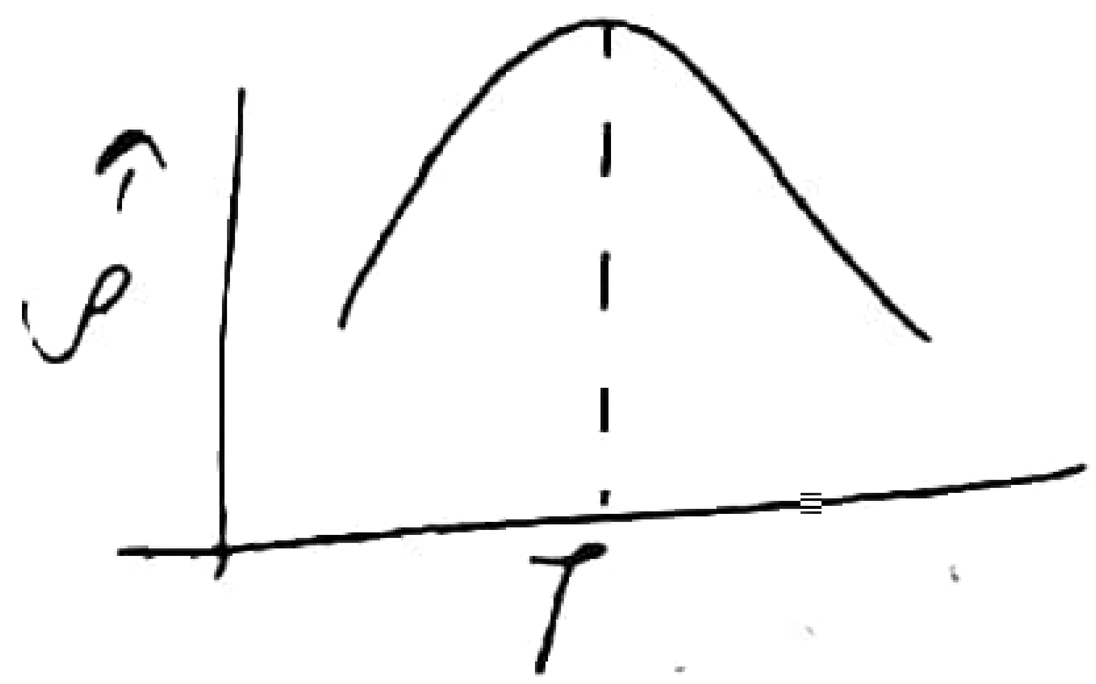
Which of the following curve represent variation of density of water with temperature best –

(A) 

(B) 

(C) 

~~(D)~~ 



29.

An ideal gas expanding such that PT^2 = constant. the coefficient of volume expansion of the gas is–

(A) $\frac{1}{T}$ (B) $\frac{2}{T}$ ~~(C)~~ $\frac{3}{T}$ (D) $\frac{4}{T}$

$$PT^2 = \text{Cont}$$

$$\gamma = \frac{1}{V}\frac{dV}{dT}$$

$$\frac{nRT}{V}T^2 = \text{Cont}$$

$$V \propto T^3$$

$$V = CT^3$$

$$\frac{dV}{dT} = 3CT^2$$

$$\gamma = \frac{1}{\cancel{C}T^3} \times 3\cancel{C}T^2$$

$$\gamma = \frac{3}{T}$$

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30.

The maximum energy in the thermal radiation from a hot source occurs at a wavelength of 11×10^{-5} cm. According to Wein's law, the temperature of the source (on Kelvin scale) will be n times the temperature of another source (on Kelvin scale) for which the wavelength at maximum energy is 5.5×10^{-5} cm. The value n is -

(A) 2 (B) 4 (C) $\frac{1}{2}$ (D) 1

$\lambda_1 = 11 \times 10^{-5}$ cm

$T_1 = n T_2$

$\lambda_2 = 5.5 \times 10^{-5}$ cm

$\lambda_1 T_1 = \lambda_2 T_2$

$11 \times 10^{-5} \times n T_2 = 5.5 \times 10^{-5} \times T_2$

$n = \frac{1}{2}$

31.

Energy is being emitted from the surface of a black body at 127°C temperature at the rate of 1.0×10^6 J/sec–m². Temperature of the black body at which the rate of energy emission is 16.0×10^6 J/sec–m² will be -

(A) 254°C (B) 508°C (C) 527°C (D) 727°C

$\frac{\Delta Q}{\Delta t \times A} = \sigma T^4$

$10^6 = \sigma (400)^4$ —(1)

$16 \times 10^6 = \sigma T^4$ —(2)

$\frac{1}{16} = \left(\frac{400}{T}\right)^4$

$\frac{1}{2} = \frac{400}{T}$

$\boxed{T = 800\,K}$

-273

$T = 527^\circ C$

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32.

A cup of tea cools from 80°C to 60° C in one minute. The ambient temperature is 30°C. In cooling from 60 ºC to 50°C it will take -

(A) 30 seconds (B) 60 seconds

(C) 90 seconds ~~(D)~~ 50 seconds

Sol^n $\theta_1 = 80\,C \xrightarrow[\Delta t = 1\,min]{} 60\,C = \theta_2$

$\theta_0 = 30\,C$

$\frac{\Delta\theta}{\Delta t} = -k(\theta - \theta_0)$

$\frac{-20}{1\,min} = -k\cdot(70-30)$

$\boxed{K = \frac{1}{2}/min}$

$\theta_1 = 60\,c$ to $\theta_2 = 50\,c$

$\Delta t = ?$

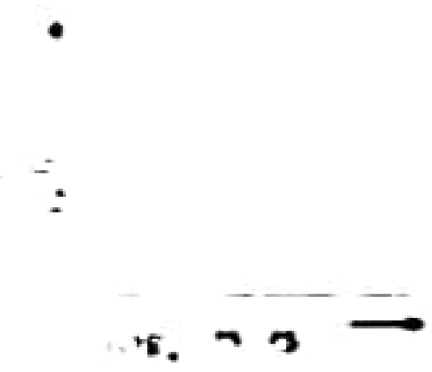
$\frac{-10}{\Delta t} = -\frac{1}{2}\times(55-30)$

$\boxed{\Delta t \simeq 48\,sec}$

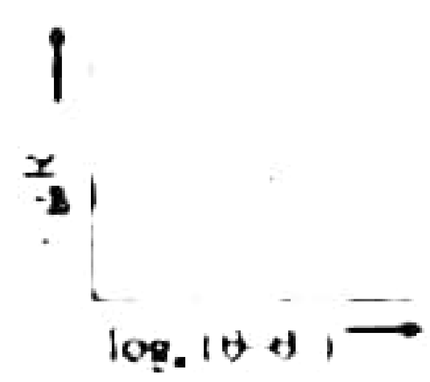
33.

The correct curve between $\log_e R$ and $\log_e(\theta - \theta_0)$ is

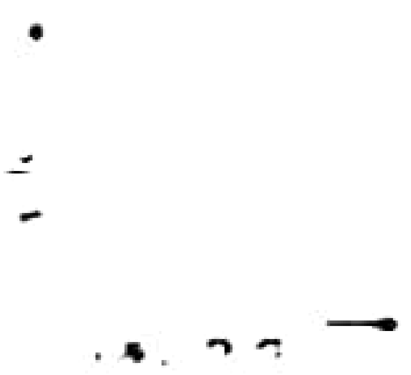
~~(A)~~



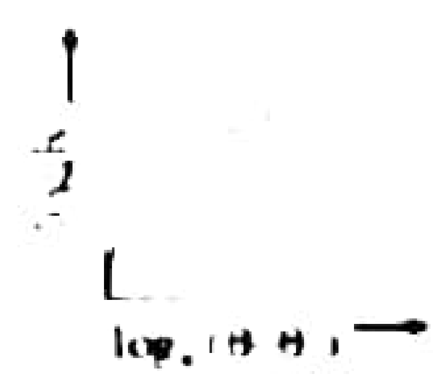
(B)



(C)



(D)



$R = k(\theta - \theta_0)$

$\boxed{\log R = \log(\theta - \theta_0) + \log k}$

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34.

If for wavelength λ, e_λ and a_λ are the emissive and absorptive powers of a body respectively and E_λ is the emissive power of a perfectly black body. Then according to Kirchhoff's law –

(A) $a_\lambda = E_\lambda/a_\lambda$ ~~(B)~~ $a_\lambda = e_\lambda/E_\lambda$ (C) $e_\lambda = a_\lambda/E_\lambda$ (D) $a_\lambda = E_\lambda/e_\lambda$

$$\frac{E_\lambda}{a_\lambda} = \frac{E_B}{a_B = 1}$$

$$\frac{e_\lambda}{a_\lambda} = E_\lambda$$

$$a_\lambda = \frac{e_\lambda}{E_\lambda}$$

35.

Two sphere made of same substance have radii 1m and 4m, and temperatures 4000°K and 2000°K respectively. The ratio of power radiated by two spheres is –

(A) 1/2 (B) 1/4 (C) 4 ~~(D)~~ 1

$$\frac{\Delta Q}{\Delta t} = e\sigma \times 4\pi r^2 \cdot T^4$$

$$\frac{P_1}{P_2} = \left(\frac{r_1}{r_2}\right)^2 \times \left(\frac{T_1}{T_2}\right)^4$$

$$= \left(\frac{1}{4}\right)^2 \times \left(\frac{2}{1}\right)^4 = \frac{16}{16} = 1$$

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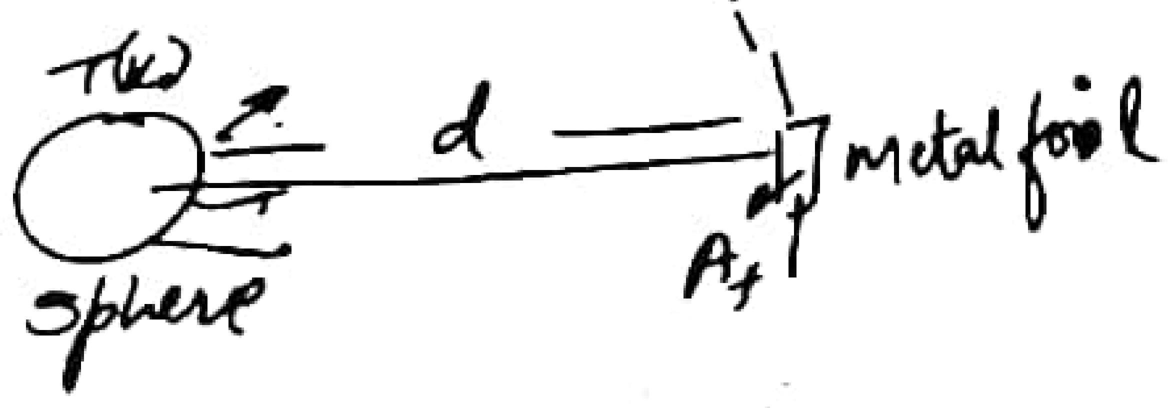
36.

A black metal foil is warmed by radiation from a small sphere at temperature T and at a distance d. It is found that the power received by the foil is 'P'. If both the temperature and the distance are doubled, the power received by the foil will be–

(A) 16P (B) 4P (C) 2P (D) P



$$\frac{\Delta Q}{\Delta t} = e\sigma A \cdot T^4$$

$$I = \left(\frac{\Delta Q}{\Delta t}\right) / \text{Area} = \frac{e\sigma A \times T^4}{4\pi d^2}$$

$$\text{Power Recieved} = \frac{e\sigma A_s T^4}{4\pi d^2} A_f$$

$$P \propto \frac{T^4}{d^2}$$

$$P' \propto \frac{(T')^4}{d'^2}$$

$$\frac{P}{P'} = \left(\frac{T}{T'}\right)^4 \times \left(\frac{d'}{d}\right)^2$$

$$\frac{P}{P'} = \left(\frac{1}{2}\right)^4 \times \left(\frac{2}{1}\right)^2 = \frac{1}{4}$$

$$\boxed{P' = 4P}$$

37.

The temperature of a body falls from 40ºC to 36ºC in 5 minutes when placed in a surrounding of constant temperature 16ºC. Then what is the cooling constant (per minute) –

(A) $-\frac{2}{55}$ (B) $-\frac{1}{15}$ (C) $\frac{\log_e(5/6)}{5}$ (D) $\frac{\log_e(6/5)}{5}$

$$\frac{d\theta}{dt} = -k(\theta - \theta_0)$$

$$\boxed{\log \frac{\theta_2 - \theta_0}{\theta_1 - \theta_0} = -kt}$$

$$\log \frac{36-16}{40-16} = -k \times 5\,\text{min}$$

$$k = -\frac{1}{5} \log \frac{20}{24}$$

$$\boxed{k = -\frac{1}{5} \log_e 5/6}$$

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38.

A body with an initial temperature θ_i is allowed to cool in a surrounding which is at a constant temperature of $\theta_0 (\theta_0 < \theta_i)$. Assume that Newton's law of cooling is obeyed. Let k = constant. The temperature of the body after time t is best expressed by

(A) $(\theta_i - \theta_0)e^{-kt}$ (B) $(\theta_i - \theta_0)\ln(kt)$

(C) $\theta_0 + (\theta_i - \theta_0)e^{-kt}$ (D) $\theta_i e^{-kt} - \theta_0$

$$\log \frac{\theta_2 - \theta_0}{\theta_1 - \theta_0} = -kt$$

$$\theta_2 - \theta_0 = (\theta_1 - \theta_0)e^{-kt}$$

$$\boxed{\theta_2 = \theta_0 + (\theta_1 - \theta_0)e^{-kt}}$$

39.

Two metallic spheres S_1 and S_2 are made of the same material and have got identical surface finish. The mass of S_1 of thrice that of S_2. Both the spheres are heated to the same high temperature and placed in the same room having lower temperature but are thermally insulated from each other. The ratio of the initial rate of cooling of S_1 to that of S_2 is-

(A) [illegible] (B) $\frac{1}{\sqrt{3}}$ (C) $\frac{\sqrt{3}}{1}$ (D) $\left(\frac{1}{3}\right)^{\frac{1}{3}}$

Sol^n Material same

e = same

$m_1 = 3m_2$

T = same

T_0 = same

$$-\frac{d\theta}{dt} = \frac{e\sigma A}{ms}(T^4 - T_0^4)$$

$$\frac{4}{3}\pi r_1^3 = 3\,\frac{4}{3}\pi r_2^3$$

$$\boxed{r_1 = 3^{1/3}\cdot r_2}$$

$$\frac{R_1}{R_2} = \left(\frac{r_1}{r_2}\right)^2 \times \left(\frac{m_2}{m_1}\right)$$

$$= 3^{2/3} \times \frac{1}{3}$$

$$= \left(\frac{1}{3}\right)^{1/3}$$

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40.

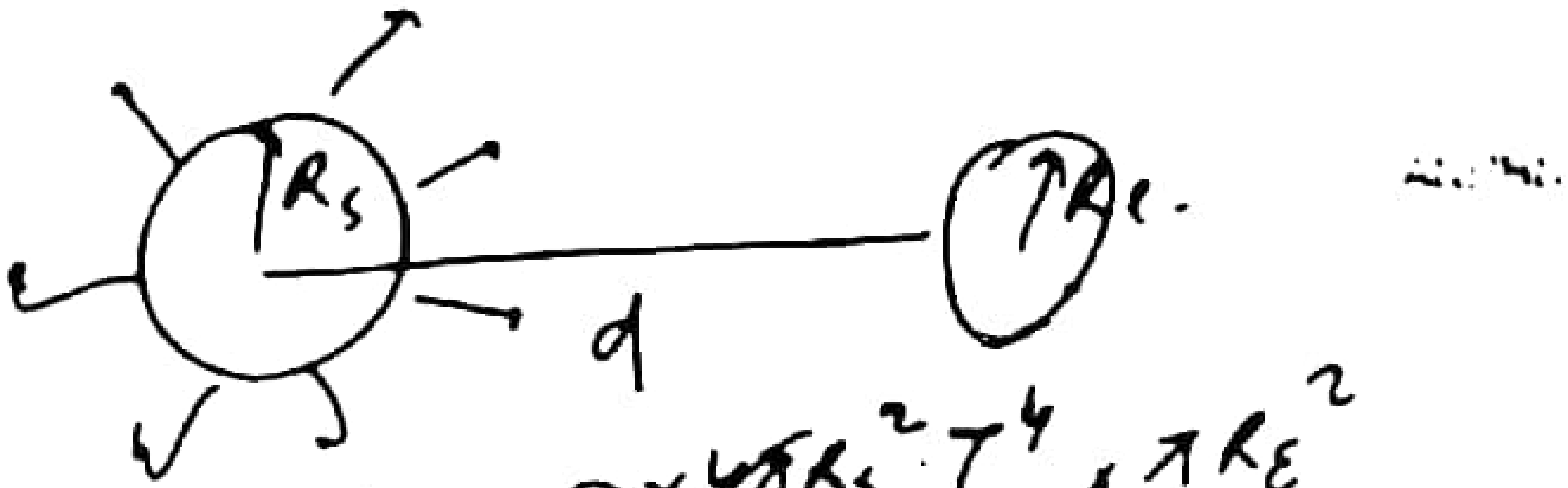
R, and R are the radius of sun, distance between sun and earth and radius of earth respectively If temperature of sun is T Then amount of radiation incident on earth is –

(A) $\frac{R}{d}$ σT

(B) $\frac{R}{d}$ σT $(2\pi R_e)$

(C) $\frac{R}{d}$ σT (πR_e)

(D) $\frac{R}{R}$ σT (πd)



$$S = \frac{\sigma \times 4\pi R_s^2 T^4}{4\pi d^2} \times \pi R_E^2$$

$$S = \sigma \left(\frac{R_s}{d}\right)^2 (\pi R_E^2) T^4$$

41.

Heat radiations travel in vacuum with a velocity equal to -

(A) 3×10^8 m/sec (B) 3×10^{10} m/sec

(C) 1120 ft/sec (D) 3×10^6 m/sec

42.

Emissive power of any surface (e), Absorptive power (a), Reflecting power (r) and transmission power (t) are related as –

(A) a + e + t = 1 (B) a + r + t = 1

(C) r + e + t = 1 (D) r + e + a = 1

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43.

Radius of a sphere is R, density is d and specific heat is s, It is heated and then allowed to cool. Its rate of decrease of temperature will be proportional to –

(A) Rds (B) 1/Rds (C) $1/R^2ds$ (D) R^2ds

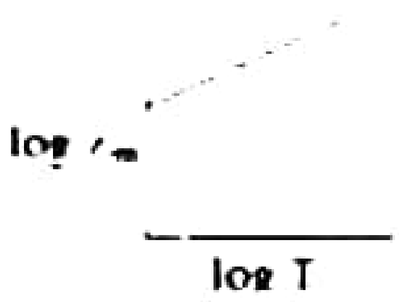
$$-\frac{d\theta}{dt} = \frac{e\sigma A}{ms}\left(T^4 - T_0^4\right)$$

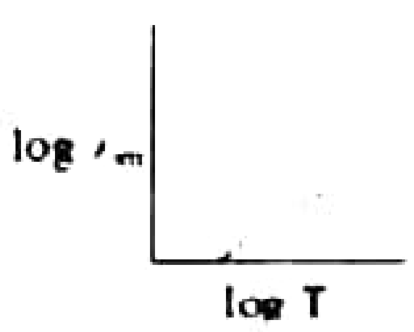
$$= \frac{e\sigma 4\pi R^2}{d \times \frac{4}{3}\pi R^3 s}\left(T^4 - T_0^4\right)$$

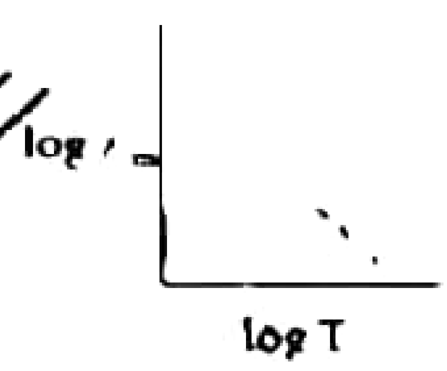
$$\propto \frac{1}{dRs}$$

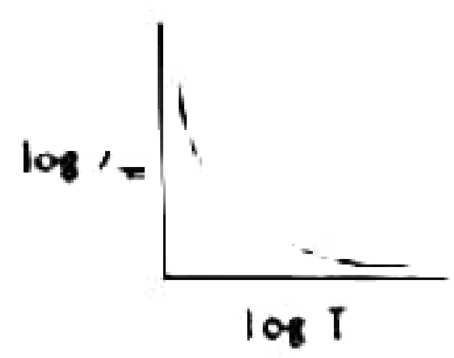
44.

Wein's displacement law is shown by the following relation $\lambda_m T = b$ then the curve drawn between log T and log λ_m will be –

(A) 

(B) 

(C) 

(D) 

$$\lambda_m T = b$$

$$\log \lambda_m + \log T = \log b$$

$$y = -x + c$$

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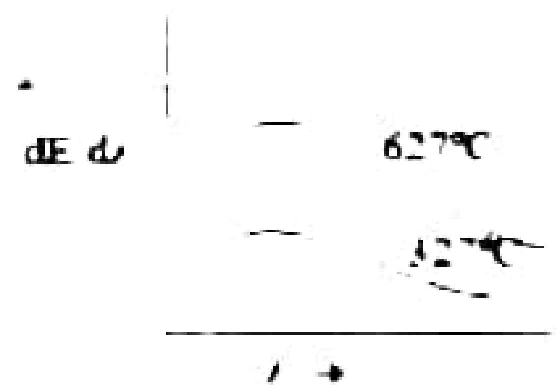
45.

The spectra of a black body at temperatures 327°C and 627°C are shown in the Fig. If A_1 and A_2 be the areas under the two curves respectively, the value of A_2/A_1 is -



(A) $\frac{81}{16}$ (B) $\frac{9}{4}$ (C) $\frac{27}{8}$ (D) $\frac{16}{81}$

Sol.

$A = \int y\,dx$

$= \int \frac{dE}{dx}\,dx$

Area of Graph $= E = \frac{\Delta Q}{\Delta t A} = \sigma T^4$

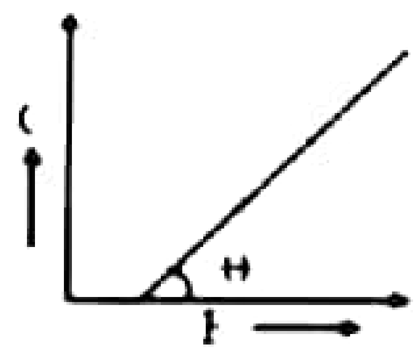
$\frac{A_1}{A_2} = \left[\frac{T_1}{T_2}\right]^4$

$= \left(\frac{600}{900}\right)^4$

$\frac{A_1}{A_2} = \frac{16}{81}$ $\quad \frac{A_2}{A_1} = \frac{81}{16}$.

46.

The graph shown in the figure is a plot of the temperature of a body in °C and °F. The value of sin θ –



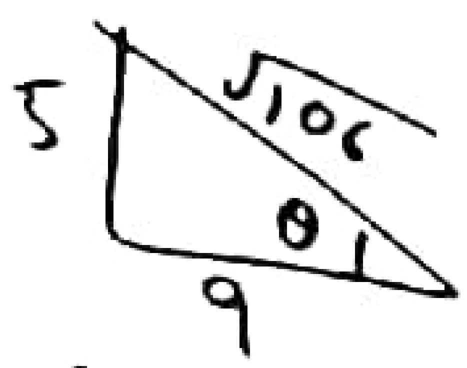
(A) $\frac{5}{9}$ (B) $\frac{5}{\sqrt{86}}$ (C) $\frac{5}{\sqrt{106}}$ (D) $\frac{9}{\sqrt{86}}$

$\frac{T_C}{100} = \frac{T_F - 32}{180}$

$T_C = \left(\frac{5}{9}\right)T_F - \frac{32\times 5}{9}$

$y = (m)x - c$

$\tan\theta = \frac{5}{9}$



$\sin\theta = \frac{5}{\sqrt{106}}$.

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47.

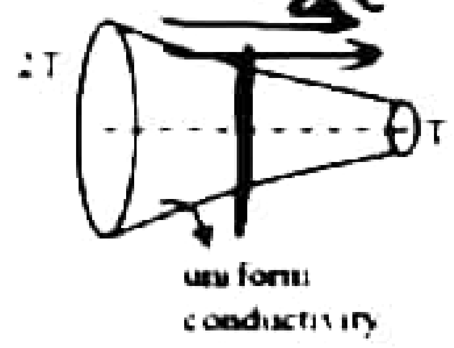
In the given conical distorted shape of rod heat is being conducted under steady state. The two ends are maintained at different temperature. Now choose the correct alternative – $\frac{\Delta Q}{\Delta t}$ = const

$\frac{\Delta Q}{\Delta t} = KA\frac{\Delta \theta}{\Delta x}$

$A\frac{\Delta \theta}{\Delta x}$ = Const

$\frac{\Delta \theta}{\Delta x} \propto \frac{1}{A}$

Temp Gradient $\propto \frac{1}{A}$



(A) The rate of heat flow will not be constant through the rod ✗

(B) The magnitude of temperature gradient increase from left to right ✓

(C) The temperature at mid-point will be $\frac{3T}{2}$ ✗

(D) The temperature at mid-point will be less than $\frac{3T}{2}$ ✗

48.

Statement-1: When a liquid with coefficient of cubical expansion γ is heated in a vessel of coefficient of linear expansion $\gamma/3$, the level of liquid in the vessel remains unchanged. Correct

Statement-2 $\gamma_a = \gamma_r - \gamma_g = \gamma - 3\left(\frac{\gamma}{3}\right) = 0$ Correct

(1) Both Statements (1) and (2) are true ✓
(2) Statement (1) is true but statement (2) is false.
(3) Statement (1) is false but statement (2) is true
(4) Both Statements (1) and (2) are False

$\gamma_l = \gamma \qquad \alpha_s = \frac{\gamma}{3}$

$\gamma_{app} = \gamma_l - 3\alpha_s$

$= \gamma - 3\times\frac{\gamma}{3} = \underline{\underline{0}}$

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49.

The coefficient of volume expansion of glycerin is $49 \times 10^{-5}\ {}^\circ C^{-1}$. What is the fractional change in its density for a 30°C rise in temperature?

(A) 3×10^{-2} (B) 2×10^{-2} (C*) 1.47×10^{-2} (D) 1.47×10^{-4}

$$\gamma = 49 \times 10^{-5} / {}^\circ C$$

$$\rho = \rho_0 (1 - \gamma \Delta T)$$

$$\text{Fractional change} = \frac{\rho_0 - \rho}{\rho_0} = \gamma \Delta T$$

$$= 49 \times 10^{-5} \times 30$$

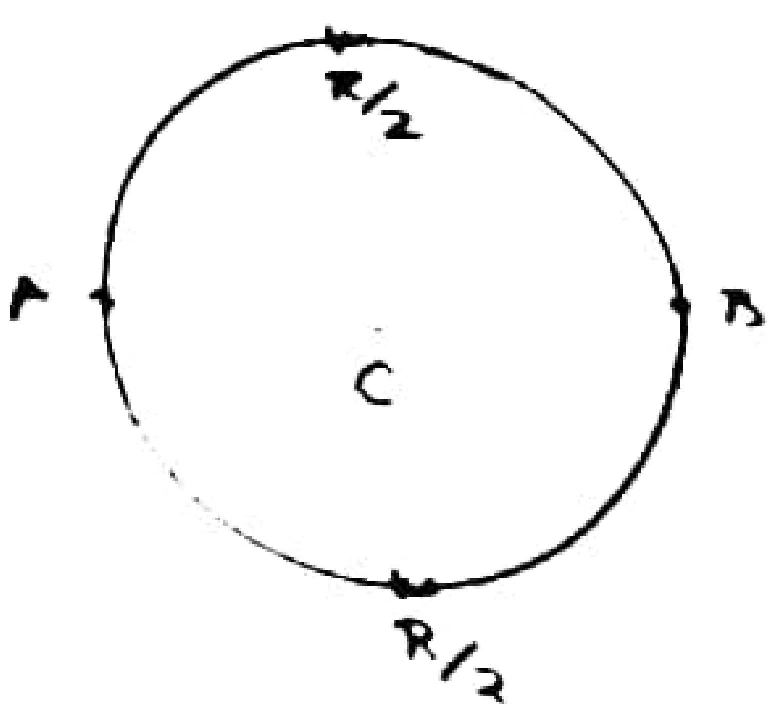
$$= 147 \times 10^{-4}$$

$$= \underline{1.47 \times 10^{-2}}$$

50.

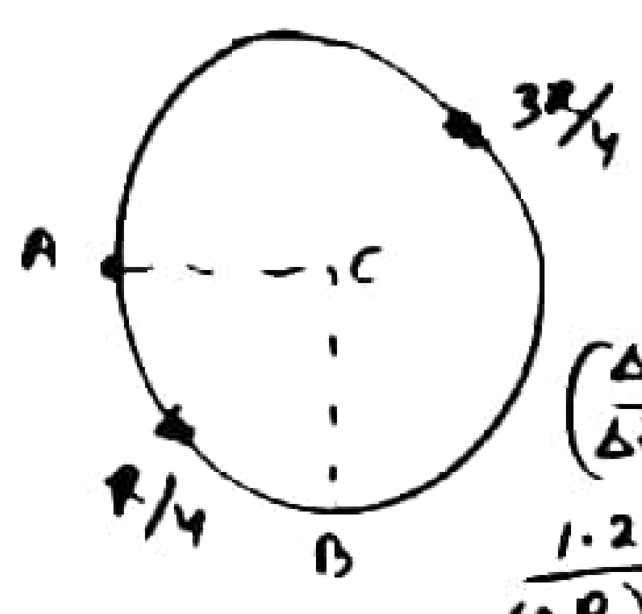
A and B are two points on a uniform metal ring whose centre is C. The angle ACB = θ. A and B are maintained at two different constant temperatures. When θ = 180°, the rate of total heat flow from A to B is 1.2 W. When θ = 90°, this rate will be -

(A) 0.6 W (B) 0.9 W (C*) 1.6 W (D) 1.8 W



$$\frac{\Delta Q}{\Delta t} = \frac{\Delta\theta \times 4}{R}$$

$$1.2W = \frac{\Delta\theta \times 4}{R} \quad \text{---(1)}$$



$$\frac{1}{R_4} = \frac{4}{3R} + \frac{4}{R}$$

$$R_4 = \frac{3R}{16}$$

$$\left(\frac{\Delta Q}{\Delta t}\right)_2 = \frac{\Delta\theta \times 16}{3R}$$

$$\frac{1.2}{\left(\frac{\Delta Q}{\Delta t}\right)_2} = \frac{3}{4} \Rightarrow \left(\frac{\Delta Q}{\Delta t}\right)_2 = 1.6W$$

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