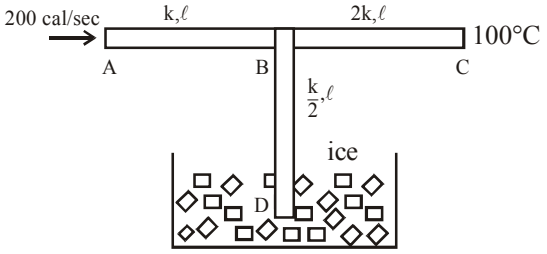
CLASS TEST

PHYSICS SPECIAL CLASS TEST # 13 (HEAT)

SECTION-I

Single Correct Answer Type 13 Q. [3 M (–1)]

1. Three rods AB, BC and BD of same length ℓ and cross-sectional area A are arranged as shown. The end D is immersed in ice whose mass is 440 gm. Heat is being supplied at constant rate of 200 cal/sec from the end A. Time in which whole ice will melt. Given: k (thermal conductivity) = 100 cal/m/sec/°C, A = 10 cm^2, ℓ = 1m, Latent heat of fusion of ice is 80 cal/gm.



(A) 40/3 min (B) 700 sec (C) 20/3 min (D) indefinitely long time

2. There is formation of layer of ice x cm thick on water, when the temperature of air is $-\theta$°C (less than freezing point). The thickness of layer increases from x to y in the time t, then the value of t is given by-

(A) $\frac{(x+y)(x-y)\rho L}{2K\theta}$ (B) $\frac{(x-y)\rho L}{2K\theta}$ (C) $\frac{(x+y)(x-y)\rho L}{K\theta}$ (D) $\frac{(x-y)\rho LK}{2\theta}$

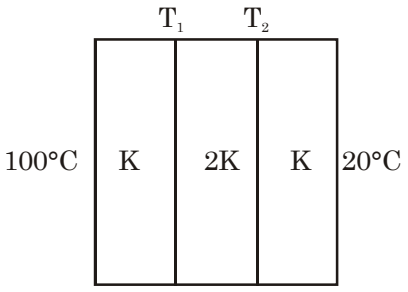
3. A rod of length ℓ and cross section area A has a variable thermal conductivity given by $k = \alpha T$, where α is a positive constant and T is temperature in kelvin. Two ends of the rod are maintained at temperatures T_1 and T_2 ($T_1 > T_2$). Heat current flowing through the rod under steady state will be

(A) $\frac{A\alpha(T_1^2 - T_2^2)}{\ell}$ (B) $\frac{A\alpha(T_1^2 + T_2^2)}{\ell}$ (C) $\frac{A\alpha(T_1^2 + T_2^2)}{3\ell}$ (D) $\frac{A\alpha(T_1^2 - T_2^2)}{2\ell}$

4. The area of cross-section of rod is given by $A = A_0(1 + \alpha x)$ where A_0 & α are constant and x is the distance from one end. If the thermal conductivity of the material is K, what is the thermal resistance of the rod if its length is ℓ_0 ?

(A) $KA_0a\,\ell n(1 + \alpha\ell_0)$ (B) $\frac{1}{KA_0\alpha}\ell n(1+\alpha\ell_0)$ (C) $\frac{\alpha}{KA_0}\ell n(1+\alpha\ell_0)$ (D) $\frac{KA_0}{\alpha}\ell n(1+\alpha\ell_0)$

5. Three slabs of equal area and thickness are arranged as shown in the figure. Find the value of T_1 and T_2 in steady state :-



(A) 68°C & 52°C (B) 62°C & 58°C (C) 60°C & 50°C (D) 50°C & 30°C

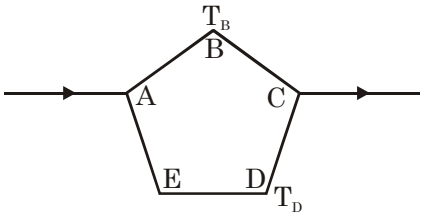
6. A and B are two points on a uniform metal ring whose centre is C. The angle ACB = θ. A and B are maintained at two different constant temperatures. When θ = 180°, the rate of total heat flow from A to B is 1.2 W. When θ = 90°, this rate will be :

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

7. A hollow cylindrical shell of inner radius R_1 = 1m and outer radius R_2 = 2m is placed inside a heat reservoir of temperature T_0 = 100°C. The cylindrical shell is initially filled with water at 50°C. The thermal conductivity of the material K = 4200 ℓn2 W/mK and its heat capacity is negligible. Find the time required to raise the temperature of water to 75°C. Take specific heat of water S = 4.2 kJ/kg°C. Density of water is 1000 kg/m^3.

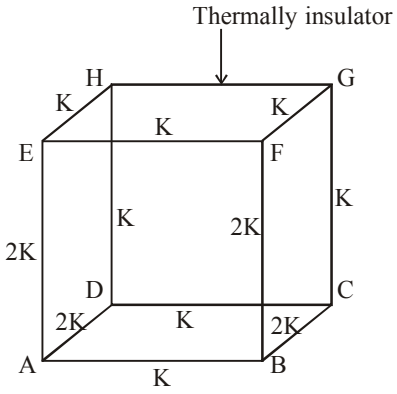
(A) 250 ℓn2 sec (B) 500 ℓn2 sec (C) 750 ℓn2 sec (D) $\frac{500}{\ell n2}$ sec

8. ABCDE is a regular pentagon of uniform wire. The rate of heat entering at A and leaving at C is equal. T_B and T_D are temperature of B and D. Find the temperature T_C :-



(A) $\frac{3T_B + 2T_D}{5}$ (B) $3T_D - 2T_B$ (C) $3T_D + 2T_B$ (D) Can have any value

9. Find effective thermal resistance between A & B of cube made up of 12 rods of same dimensions and shown given thermal conductivity. [ℓ = length of rod, a = cross section area of rod]



(A) $\frac{\ell}{ka}$ (B) $\frac{2\ell}{ka}$ (C) $\frac{4\ell}{7ka}$ (D) $\frac{\ell}{2ka}$

10. Three products are being considered as possible thermal insulators. The thicknesses and conductivities of the three products are as follows

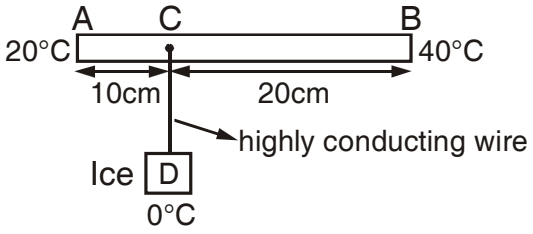
	Conductivity (arbitrary units)	**Thickness (arbitrary units)**
Product I	12	4
Product II	6	6
Product III	4	2

For a given cross-sectional area, which product would make the best thermal insulator?

(A) Product I (B) Product II

(C) Product III (D) they would all give the same insulation

11. In the figure shown, AB is a rod of length 30 cm and area of cross-section 1.0 cm^2 and thermal conductivity 336 S.I. units. The ends A & B are maintained at temperatures 20° C and 40° C respectively. A point C of this rod is connected to a box D, containing ice at 0° C, through a highly conducting wire of negligible heat capacity. The rate at which ice melts in the box is : [Latent heat of fusion for ice L, = 80 cal/gm]



(A) 84 mg/s (B) 84 g/s (C) 20 mg/s (D) 40 mg/s

12. In which of the following phenomenon, heat conduction takes place

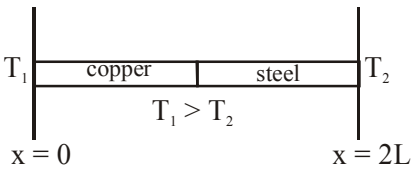
(A)Land and sea breeze

(B)Boiling of water

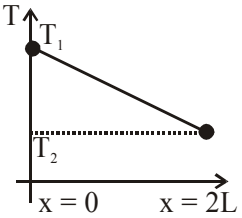
(C)Heating of glass surface due to filament of the bulb

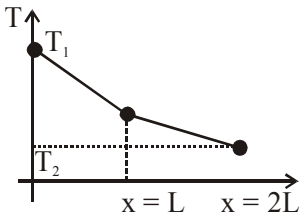
(D)Freezing of ice in a lake

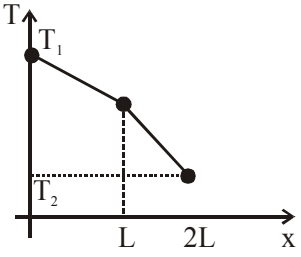
13. A copper rod and a steel rod of equal cross-sections and lengths (L) are joined side by side and connected between two heat baths as shown in the figure.

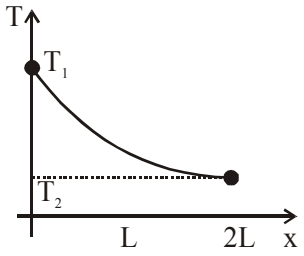


If heat flows through them from x = 0 to x = 2L at a steady rate and conductivities of the metals are K_{cu} & K_{steel} ($K_{cu} > K_{steel}$), then the temperature varies as (convection and radiation are negligible)

(A)


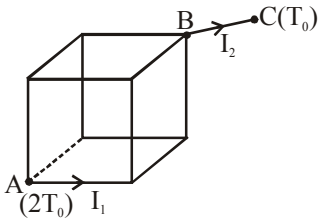
(B)


(C)


(D)


Multiple Correct Answer Type 3 Q. [4 M (–1)]

14. All 13 roads are identical & temperature at A is maintained $2T_0$ and at C is T_0 then :- (Assume no heat loss and I_1 and I_2 are heat current)



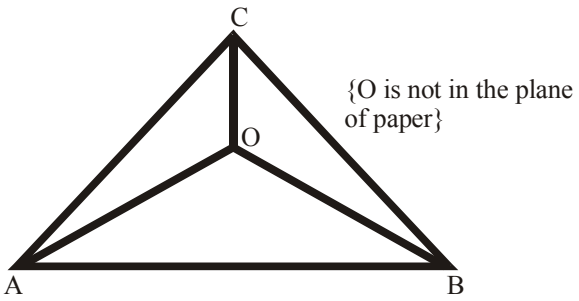
(A) Temperature at B is $\frac{6T_0}{5}$

(B) Temperature at B is $\frac{17T_0}{11}$

(C) Ratio $\frac{I_1}{I_2}$ is $\frac{1}{3}$

(D) Ratio $\frac{I_1}{I_2}$ is $\frac{5}{18}$

15. Six identical rods are joined together to form a network as shown. A temperature difference of ΔT can be maintained between two points. Considering heat flow through conduction only, in steady state :-



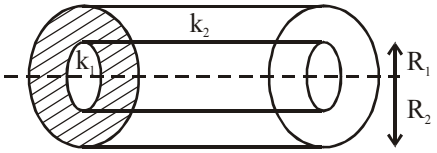
(A) Net rate of heat flow between points where temperature difference is maintained, depends on points chosen.

(B) Net rate of heat flow between points where temperature difference is maintained, is independent of points chosen.

(C) In all the cases of points chosen {where ΔT is to be maintained} there is one rod through which no heat flows.

(D) Heat conduction takes place through all the rods irrespective of choice of points where temperature difference is maintained.

16. A composite cylinder is made by two materials having thermal conductivities k_1 and k_2 as shown. Temperature of the two flat faces of cylinder are maintained at T_1 and T_2.



(A) If $\frac{R_2}{R_1} = 2$ and $\frac{k_2}{k_1} = 3$ then same heat will flow through two materials in a given time.

(B) If $\frac{R_2}{R_1} = 2$ and $\frac{k_1}{k_2} = 3$ then same heat will flow through two materials in a given time.

(C) If $\frac{R_2}{R_1} = \sqrt{2}$ then same heat will never flow through two materials if they are different ($k_1 \neq k_2$)

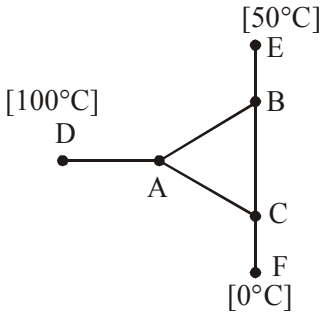
(D) If $\frac{R_2}{R_1} = \sqrt{2}$, then same heat will flow through two materials, irrespective of their materials.

SECTION-III

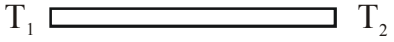
Numerical Grid Type (Ranging from 0 to 9) **4 Q. [4 M (0)]**

1. A body cools from 50°C to 49.9°C in 5 sec. It cools from 40°C to 39.9°C in t sec. Assuming Newtons law of cooling to be valid and temperature of surrounds at 30°C, value of t/5 will be?

2. Identical six rods are used to form given figure. AB, BC and AC form equilateral triangle. Find $\frac{T_B}{10}$ (in °C). [T_B = Temperature at junction B]



3. A rod of length ℓ with thermally insulated lateral surface is made of a material whose thermal conductivity varies as K = C/T, where C is a constant. The ends are kept at temperatures T_1 and T_2. The temperature at a distance x from the first end varies as $T = T_1\left(\frac{T_2}{T_1}\right)^{ax/2\ell}$. Find the value of a.



4. A spherical shell of radius R is filled with water. Temperature of atmosphere is (–θ)°C and then it starts freezing from outer surface towards the centre of the shell. Assuming shell to be highly conducting. If time taken for whole mass of water at 0°C to freeze is $t = \frac{\rho L R^2}{xk\theta}$. Find x. (Thermal conductivity of ice is k and latent heat of fusion is L. Density of water is ρ. Neglect expansion during fusion)

SPECIAL CLASS TEST ON HEAT # 13 **ANSWER KEY**

SECTION-I

Single Correct Answer Type **13 Q. [3 M (–1)]**

1. Ans. (A) **2. Ans. (A)** **3. Ans. (D)** **4. Ans. (B)** **5. Ans. (A)** **6. Ans. (C)**
7. Ans. (B) **8. Ans. (B)** **9. Ans. (D)** **10. Ans. (B)** **11. Ans. (D)** **12. Ans. (D)**
13. Ans. (C)

Multiple Correct Answer Type **3 Q. [4 M (–1)]**

14. Ans. (B,C) **15. Ans. (B, C)** **16. Ans. (B,C)**

SECTION-III

Numerical Grid Type (Ranging from 0 to 9) **4 Q. [4 M (0)]**

1. Ans. 2 **2. Ans. 5** **3. Ans. 2** **4. Ans. 6**