Transmission of Heat — SET Self Evaluation Test - 15

1. A rod of 40 cm in length and temperature difference of $80^o C$ at its two ends. Another rod B of length 60 cm and of temperature difference $90^o C$, having the same area of cross-section. If the rate of flow of heat is the same, then the ratio of their thermal conductivities will be

(a) 3 : 4 (b) 4 : 3
(c) 1 : 2 (d) 2 : 1

2. Two vessels of different materials are similar in size in every respect. The same quantity of ice filled in them gets melted in 20 *minutes* and 40 *minutes* respectively. The ratio of thermal conductivities of the materials is **[AFMC 1998]**

(a) 5 : 6 (b) 6 : 5
(c) 3 : 1 (d) 2 : 1

3. In a steady state of thermal conduction, temperature of the ends *A* and *B* of a 20 *cm* long rod are $100^o C$ and $0^o C$ respectively. What will be the temperature of the rod at a point at a distance of 6 *cm* from the end *A* of the rod

(a) $-30^o C$ (b) $70^o C$
(c) $5^o C$ (d) None of the above

4. Four rods of silver, copper, brass and wood are of same shape. They are heated together after wrapping a paper on it, the paper will burn first on

(a) Silver (b) Copper
(c) Brass (d) Wood

5. The two opposite faces of a cubical piece of iron (thermal conductivity = 0.2 CGS units) are at $100^o C$ and $0^o C$ in ice. If the area of a surface is $4 cm^2$, then the mass of ice melted in 10 minutes will be

(a) 30 *gm* (b) 300 *gm*
(c) 5 *gm* (d) 50 *gm*

6. Wein's constant is 2892×10^{-6} MKS unit and the value of λ_m from moon is 14.46 microns. What is the surface temperature of moon

(a) 100 *K* (b) 300 *K*
(c) 400 *K* (d) 200 *K*

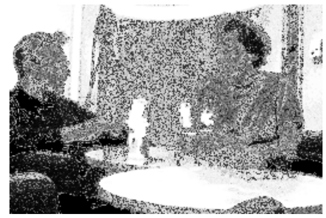
7. If at temperature $T_1 = 1000 K$, the wavelength is $1.4 \times 10^{-6} m$, then at what temperature the wavelength will be $2.8 \times 10^{-6} m$ **[RPMT 2004]**

(a) 2000*K* (b) 500*K*
(c) 250*K* (d) None of these

8. The wavelength of maximum intensity of radiation emitted by a star is 289.8 *nm*. The radiation intensity for the star is : (Stefan's constant $5.67 \times 10^{-8} Wm^{-2}K^{-4}$, constant $b = 2898 \mu mK$) - **[EAMCET 2001]**

(a) $5.67 \times 10^8 W/m^2$ (b) $5.67 \times 10^{12} W/m^2$
(c) $10.67 \times 10^7 W/m^2$ (d) $10.67 \times 10^{14} W/m^2$

9. Two friends *A* and *B* are waiting for another friend for tea. *A* took the tea in a cup and mixed the cold milk and then waits. *B* took the tea in the cup and then mixed the cold milk when the friend comes. Then the tea will be hotter in the cup of

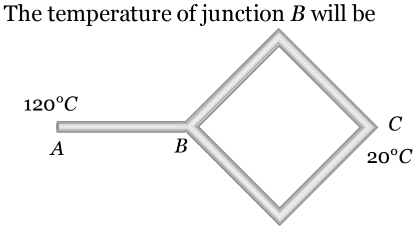


(a) *A*
(b) *B*
(c) Tea will be equally hot in both cups
(d) Friend's cup

10. There are two spherical balls *A* and *B* of the same material with same surface, but the diameter of *A* is half that of *B*. If *A* and *B* are heated to the same temperature and then allowed to cool, then

(a) Rate of cooling is same in both
(b) Rate of cooling of *A* is four times that of *B*
(c) Rate of cooling of *A* is twice that of *B*
(d) Rate of cooling of *A* is $\frac{1}{4}$ times that of *B*

11. Five identical rods are joined as shown in figure. Point *A* and *C* are maintained at temperature 120°*C* and 20°*C* respectively. The temperature of junction *B* will be

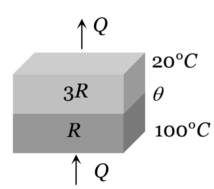


(a) 100°*C*
(b) 80°*C*
(c) 70°*C*
(d) 0°*C*

12. Can we boil water inside the earth satellite by convection

(a) Yes
(b) No
(c) Nothing can be said
(d) In complete information is given

13. In the following figure, two insulating sheets with thermal resistances *R* and 3*R* as shown in figure. The temperature θ is



(a) 20°*C*
(b) 60°*C*
(c) 75°*C*
(d) 80°*C*

14. The top of insulated cylindrical container is covered by a disc having emissivity 0.6 and thickness 1 *cm*. The

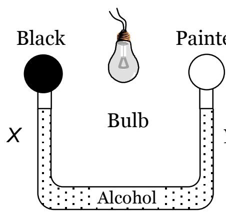
Oil

temperature is maintained by circulating oil as shown in figure. If temperature of upper surface of disc is 127°C and temperature of surrounding is 27°C, then the radiation loss to the surroundings will be (Take $\sigma = \frac{17}{3} \times 10^{-8} W/m^2K^4$)

(a) 595 $J/m^2 \times sec$ (b) 595 $cal/m^2 \times sec$

(c) 991.0 $J/m^2 \times sec$ (d) 440 $J/m^2 \times sec$

15. The following figure shows two air-filled bulbs connected by a U-tube partly filled with alcohol. What happens to the levels of alcohol in the limbs X and Y when an electric bulb placed midway between the bulbs is lighted



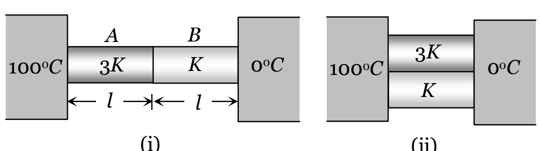
(a) The level of alcohol in limb X falls while that in limb Y rises

(b) The level of alcohol in limb X rises while that in limb Y falls

(c) The level of alcohol falls in both limbs

(d) There is no change in the levels of alcohol in the two limbs

16. Two conducting rods A and B of same length and cross-sectional area are connected (i) In series (ii) In parallel as shown. In both combination a temperature difference of 100°C is maintained. If thermal conductivity of A is $3K$ and that of B is K then the ratio of heat current flowing in parallel combination to that flowing in series combination is



(a) $\frac{16}{3}$ (b) $\frac{3}{16}$

(c) $\frac{1}{1}$ (d) $\frac{1}{3}$

17. The area of the glass of a window of a room is $10\ m^2$ and thickness 2*mm*. The outer and inner temperature are 40^oC and 20^oC respectively. Thermal conductivity of glass in MKS system is 0.2. The heat flowing in the room per second will be **[MP PMT 1989]**

(a) 3×10^4 *joules* (b) 2×10^4 *joules*

(c) 30 *joules* (d) 45 *joules*

18. The spectrum from a black body radiation is a

[MP PMT 1989; RPET 2000]

(a) Line spectrum

(b) Band spectrum

(c) Continuous spectrum

(d) Line and band spectrum both

19. The Wien's displacement law express relation between

[CBSE PMT 2002]

(a) Frequency and temperature

(b) Temperature and amplitude

(c) Wavelength and radiating power of black body

(d) Wavelength corresponding to maximum energy and temperature

20. A black body is heated from 27^oC to 127^oC. The ratio of their energies of radiations emitted will be

[AIIMS 2001]

(a) 3: 4 (b) 9 : 16

(c) 27 : 64 (d) 81: 256

21. A body takes T *minutes* to cool from 62^oC to 61^oC when the surrounding temperature is 30^oC. The time taken by the body to cool from 46^oC to 45.5^oC is

[MP PET 1999]

(a) Greater than T *minutes*

(b) Equal to T *minutes*

(c) Less than T *minutes*

(d) Equal to $T/2$ *minutes*

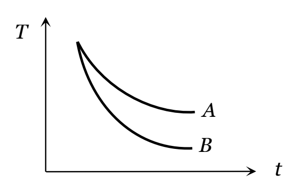
22. A partition wall has two layers A and B in contact, each made of a different material. They have the same thickness but the thermal conductivity of layer A is twice that of layer B. If the steady state temperature difference across the wall is $60K$, then the corresponding difference across the layer A is

[SCRA 1994; JIPMER 2001]

(a) 10 K (b) 20 K

(c) 30K (d) 40 K

23. Water and turpentine oil (specific heat less than that of water) are both heated to same temperature. Equal amounts of these placed in identical calorimeters are then left in air



(a) Their cooling curves will be identical

(b) A and B will represent cooling curves of water and oil respectively

(c) B and A will represent cooling curves of water and oil respectively

(d) None of the above

Answers and Solutions

(SET -15)

1. (a) $\frac{dQ}{dt} = \frac{KA(\theta_1 - \theta_2)}{d}$

$\Rightarrow \frac{K_1 \Delta\theta_1}{l_1} = \frac{K_2 \Delta\theta_2}{l_2}$ $\left(\because \frac{dQ}{dt} \text{ and } A \text{ are same}\right)$

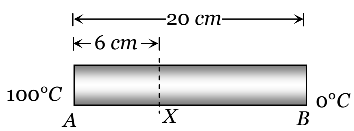
$\Rightarrow \frac{K_1 \times 80}{40} = \frac{K_2 \times 90}{60} \Rightarrow \frac{K_1}{K_2} = \frac{3}{4}$

2. (d) $\frac{Q}{t} = \frac{KA(\theta_1 - \theta_2)}{l} \Rightarrow \frac{mL}{t} = \frac{KA(\theta_1 - \theta_2)}{l}$

$\Rightarrow K \propto \frac{1}{t}$ ($\because$ remaining quantities are same)

$\Rightarrow \frac{K_1}{K_2} = \frac{t_2}{t_1} = \frac{40}{20} = \frac{2}{1}$.

3. (b) In steady state, temperature gradient = constant



$\Rightarrow \frac{(\theta_A - \theta_x)}{6} = \frac{(\theta_A - \theta_B)}{20} \Rightarrow (100 - \theta_x) = \frac{6}{20} \times (100 - 0)$

$\Rightarrow \theta_x = 70°C$

4. (d) In conducting rod given heat transmits so burning temperature does not reach soon. In wooden rod heat doesn't conducts.

5. (b) $Q = mL = KA\frac{(\theta_1 - \theta_2)}{l} t \Rightarrow m = \frac{1}{L} \times KA\frac{(\theta_1 - \theta_2)}{l} \times t$

$= \frac{1}{80} \times 0.2 \times 4 \times \frac{(100 - 0)}{\sqrt{4}} \times 10 \times 60$ $(\because l^2 = 4 \Rightarrow l = \sqrt{4})$

$= \frac{0.2 \times 4 \times 100 \times 600}{80 \times 2} = 300\ gm$

6. (d) $\lambda_m T = 2892 \times 10^{-6} \Rightarrow T = \frac{2892 \times 10^{-6}}{14.46 \times 10^{-6}} = 200\ K$

7. (a) $\lambda_m \propto \frac{1}{T} \Rightarrow \lambda m_1 T_1 = \lambda m_2 T_2$

$\Rightarrow T_2 = \frac{\lambda m_1 T_1}{\lambda m_2} = \frac{1.4 \times 10^{-6} \times 1000}{2.8 \times 10^{-6}} = 2000\ K$

8. (a) We know $\lambda_{max} T = b$

$\Rightarrow T = \frac{b}{\lambda_{max}} = \frac{2898 \times 10^{-6}}{289.8 \times 10^{-9}} = 10^4\ K$

According to Stefan's Law

$E = \sigma T^4 = (5.67 \times 10^{-8})(10^4)^4 = 5.67 \times 10^8\ W/m^2$

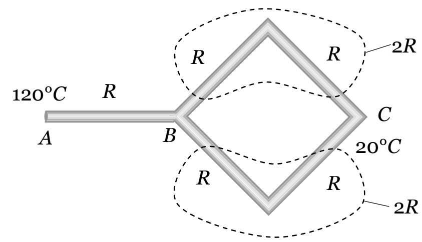
9. (a) The rate of heat loss is proportional to the difference in temperature. The difference of temperature between the tea in cup A and the surrounding is reduced, so it loses less heat. the tea in cup B loses more heat because of large temperature difference. Hence the tea in cup A will be hotter.

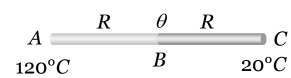
10. (c) Rate of cooling $R_C = \frac{A\varepsilon\sigma(T^4 - T_0^4)}{mc} = \frac{A\varepsilon\sigma(T^4 - T_0^4)}{V\rho C}$

$\Rightarrow R_C \propto \frac{A}{V} \propto \frac{1}{r} \propto \frac{1}{(\text{Diameter})}$ $(\because m = \rho V)$

Since diameter of A is half that of B so it's rate of cooling will be doubled that of B

11. (c) If thermal resistance of each rod is considered R then, the given combination can be redrawn as follows





$(\text{Heat current})_{AC} = (\text{Heat current})_{AB}$

$\frac{(120 - 20)}{R} = \frac{(120 - \theta)}{R} \Rightarrow \theta = 70°C$

12. (b) No, In convection the hot liquid at the bottom becomes lighter and hence it rises up. In this way the base of the convection is the difference in weight and upthrust. In the state of weightlessness this difference does not occur, so convection is not possible.

13. (b)

14. (d) For the two sheets $H_1 = H_2$ (H = Rate of heat flow)

$\Rightarrow \frac{(100 - \theta)}{R} = \frac{(\theta - 20)}{3R} \Rightarrow \theta = 80°C$

15. (a) Rate of heat loss per unit area due to radiation *i.e.* emissive power $e = \varepsilon\sigma(T^4 - T_0^4)$

$= 0.6 \times \frac{17}{3} \times 10^{-8} \times [(400)^4 - (300)^4]$

$= 3.4 \times 10^{-8} \times (175 \times 10^8) = 3.4 \times 175 = 595\ J/m^2 \times \sec$

16. (a) Black bulb absorbs more heat in comparison with painted bulb. So air in black bulb expands more. Hence the level of alcohol in limb X falls while that in limb Y rises.

17. (a) Heat current $H = \frac{\Delta\theta}{R} \Rightarrow \frac{H_P}{H_S} = \frac{R_S}{R_P}$

In first case : $R_S = R_1 + R_2 = \frac{l}{(3K)A} + \frac{l}{KA} = \frac{4}{3}\frac{l}{KA}$

In second case : $R_P = \frac{R_1R_2}{R_1+R_2} = \frac{\frac{l}{(3K)A}\times\frac{l}{KA}}{\left(\frac{l}{(3K)A}+\frac{l}{KA}\right)} = \frac{l}{4KA}$

$\therefore \frac{H_P}{H_S} = \frac{\frac{4l}{3KA}}{\frac{l}{4KA}} = \frac{16}{3}$

17. (b) $\frac{Q}{t} = \frac{KA(\theta_1-\theta_2)}{l} = \frac{0.2\times10\times20}{2\times10^{-3}} = 2\times10^4\, J/\sec$

18. (c) All wavelengths are emitted.

19. (d)

20. (d) $\frac{Q_1}{Q_2} = \frac{T_1^4}{T_2^4} = \left(\frac{273+27}{273+127}\right)^4 = \left(\frac{300}{400}\right)^4 = \frac{81}{256}$

21. (b) In first step

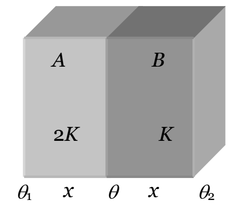
$\frac{62-61}{T} = K\left[\frac{62-61}{2} - 30°\right] \Rightarrow \frac{1}{T} = K[81.5]$ ...(i)

In second step, suppose process takes T' min then

$\frac{46-45.5}{T'} = K\left[\frac{46-45.5}{2} - 30\right]\frac{0.5}{T'} = K[15.75]$ ...(ii)

On diving equation (i) and (ii) $\frac{2T'}{T} = 2 \Rightarrow T' = T$

22. (b) Suppose conductivity of layer B is K, then it is $2K$ for layer A. Also conductivity of combination layers A and B is $K_S = \frac{2\times2K\times K}{(2K+K)} = \frac{4}{3}K$



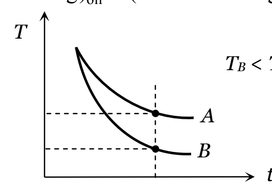
Hence $\left(\frac{Q}{t}\right)_{Combination} = \left(\frac{Q}{t}\right)_A$

$\Rightarrow \frac{4}{3}\frac{KA\times60}{2x} = \frac{2K.A\times(\Delta\theta)_A}{x} \Rightarrow (\Delta\theta)_A = 20\,K$

23. (b) As we know, Rate of cooling $\propto \frac{1}{\text{specific heat(c)}}$

$\because c_{\text{oil}} < c_{\text{Water}}$

$\Rightarrow$ (Rate of cooling)$_{\text{oil}}$ > (Rate of cooling)$_{\text{Water}}$



It is clear that, at a particular time after start cooling, temperature of oil will be less than that of water.

So graph B represents the cooling curve of oil and A represents the cooling curve of water

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