QUESTION BANK

1. Thermal conductivity is lower for

(a) wood (b) air

(c) water at 100°C (d) steam at 1 bar

2. Match the property with their units

PROPERTY

A. Bulk modulus

B. Thermal conductivity

C. Heat transfer coefficient

D. Heat flow rate

UNITS

l. W/s

2. N/m^2

3. N/m^3

4. W

5. W/mK

6. W/m^2K

3. Consider the following statements :

1. Temperature of the surface.
2. Emissivity of the surface.
3. Temperature of the air in the room.
4. Length and diameter of the pipe.

The parameter(s) responsible for loss of heat from at hot surface in a room would include

(a) 1 only (b) 1 and 2

(c) 1, 2 and 3 (d) 1, 2, 3 and 4

4. For a given heat flow and for the same thickness, the temperature drop across the material will be maximum for

(a) Copper (b) Steel

(c) Glass wool (d) Refratory brick

5. Heat is mainly transferred by conduction, convection and radiation in

(a) insulated pipes carrying hot water

(b) refrigerator freezer coil

(c) boiler furnaces

(d) condensation of steam in a condenser

6. Match List (Law) with List-II (equation) and select the correct answer using the codes given below the lists:

List-I

A. Stefan-Boltzmann law

B. Newton's law of cooling

C. Fourier's law

D. Kirchoff's law

List-II

1. $q = hA(T_1 - T_2)$
2. $E = \alpha E_b$
3. $q = \dfrac{kA}{L}(T_1 - T_2)$
4. $q = \sigma A(T_1^4 - T_2^4)$
5. $q = kA(T_1 - T_2)$

Codes :

	A	B	C	D
(a)	4	1	3	2
(b)	4	5	1	2
(c)	2	1	3	4
(d)	2	5	1	4

7. In descending order of magnitude, the thermal conductivity of (a) Pure iron, (b) liquid water, (c) Saturated water vapour, (d) Pure aluminum can be arranged as

(a) a, b, c, d (b) b, c, a, d

(c) d, a, b, c (d) d, c, b, a

8. Consider the following statements:

Assertion (A) : Heat transfer at high temperature is dominated by radiation rather than convection.

Reason (R) : Radiation depends on fourth power of temperature while convection depends on unit power relationship.

Of these statements :

(a) both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not a correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

9. One dimensional unsteady state heat transfer equation for a sphere with heat generation at the rate 'q_g', can be written as

(a) $\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right)+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

(b) $\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial T}{\partial r}\right)+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

(c) $\frac{\partial^2 T}{\partial r^2}+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

(d) $\frac{\partial^2}{\partial r^2}(rT)+\frac{q}{k}=\frac{1}{\alpha}\frac{\partial T}{\partial t}$

10. In case of one dimensional heat conduction in a medium with constant properties, T is the temperature at position x, at time t. Then $\frac{\partial T}{\partial t}$ is proportional to

(a) $\frac{T}{x}$ (d) $\frac{\partial T}{\partial x}$

(c) $\frac{\partial^2 T}{\partial_x \partial t}$ (d) $\frac{\partial^2 T}{\partial x^2}$

11. A 100W electric bulb was switched on in a 2.5m × 3m × 3m size thermally insulated room having temperature of 20ºC. Room temperature at the end of 24 hours will be

(a) 321°C (b) 341°C
(c) 450°C (d) 470°C

Statement for linked answer question 12 & 13

Consider steady one-dimensional heat flow in a plate of 20 mm thickness with a uniform heat generation of 80 MW/m^3. The left and right faces are kept at constant temperatures of 160°C and 120°C respectively. The plate has a constant thermal conductivity of 200 W/m.K.

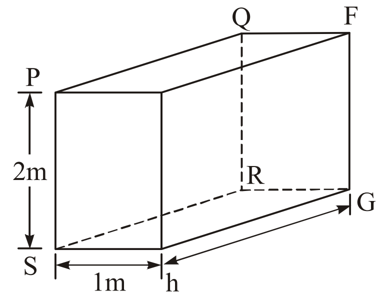
12. The location of maximum temperature within the plate from left face is

(a) 15 mm (b) 10 mm
(c) 5 mm (d) 0 mm

13. The maximum temperature within the plate in degree C is

(a) 160 (b) 165
(c) 175 (d) 250

14. For the three dimensional object shown in the fig below. Five faces are insulated. The sixth face (PQRS), which is not insulated, interacts thermally with the ambient, with a convective heat transfer coefficient of 10 W/m^{2}K. the ambient temperature is 30°C. heat is uniformly generated inside the object at the rate of 100 W/m^3. assuming the face PQRS to be at uniform temperature, its steady state temperature is



(a) 10°C (b) 20°C
(c) 30°C (d) 40°C

15. In MLTθ system (T being time and θ temperature), what is the dimension of thermal conductivity?

(a) $ML^{-1}T^{-1}\theta^{-3}$ (b) $ML^{-1}\theta^{-1}$
(c) $ML\theta^{-1}T^{-3}$ (d) $ML\theta^{-1}T^{-2}$

16. In which one of the following materials, is the heat energy propagation minimum due to conduction heat transfer ?

(a) Lead (b) Copper
(c) Water (d) Air

17. Consider the following statements:

Assertion (A) : Cork is a good insulator.
Reason (R) : Good insulators are highly porous.
Of these statements :

(a) both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

18. A plane wall of thickness 2L has a uniform volumetric heat source q* (W/m^3). It is exposed to local ambient temperature T_∞ at both the ends (x = ± L). The surface temperature t_s of the wall under steady-state condition (where h and k have their usual meanings) is given by

(a) $T_s = T_\infty + \frac{q^*L}{h}$ (b) $T_s = T_\infty + \frac{q^*L}{2k}$

(c) $T_s = T_\infty + \frac{q^*L^2}{h}$ (d) $T_s = T_\infty + \frac{q^*L^3}{2k}$

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ANSWERS AND EXPLANATIONS

1. ***Ans. (b)***

Generally fluids will have lower K than solids and within fluids, gases will have low "K" and out of steam and air the density and viscosity of steam is higher than air hence air has low "K".

2. ***Ans. A-2, B-5, C-6, D-4***

3. ***Ans. (d)***

If considering radiation heat transfer

$$Q = \sigma\varepsilon A(T_1^4 - T_2^4)$$

and $A = \pi DL$

Hence heat transfer will depend upon

1. Temperature of the surface and surrounding.
2. Emissivity of the surface.
3. Length and diameter of the pipe.

4. ***Ans. (d)***

Whichever the material is having lowest thermal conductivity the corresponding material has highest temperature drop.

5. ***Ans. (c)***

Because for radiation to be comparable the magnitude of temperature difference should be large enough. Convection & conduction is also predominate in boiler furnace.

6. ***Ans. (a)***

Stefan Boltzman Law,

$$Q = \sigma A(T_1^4 - T_2^4)$$

Newton law of cooling,

$$Q = hA(T_1 - T_2)$$

Fourier law,

$$Q = \frac{kA}{l}(T_1 - T_2)$$

Kirchoff law,

$$E = \alpha E_b$$

7. ***Ans. (c)***

Out of the given substances pure aluminium has high K and steam has low K.

8. ***Ans. (a)***

9. ***Ans. (b)***

10. ***Ans. (d)***

For one dimensional unsteady state heat conduction without heat generation, the heat conduction equal is

$$\frac{\partial^2 T}{\partial x^2} = \frac{1}{\alpha}\frac{\partial T}{\partial t}$$

11. ***Ans. (d)***

H.G. = 100 W

Volume of room

$$V = 25. \times 3 \times 3 = 22.5\ m^3$$

$$T_i = 20ºC$$

Heat generator during 24 hours

$$= 100 \times 24 \times 3600 = 8640000\ J$$

The heat generated by the bulb is absorbed by the air present in room at constant volume.

Hence $100 \times 24 \times 3600 = mc_v\Delta T$

$$= (\rho V).C_v dT$$

$$\Delta T = \frac{100 \times 24 \times 3600}{22.5 \times C_v \times 1.2}$$

$$\Delta T = 452.61ºC$$

$$T = 472.61°C$$

12. ***Ans. (c)***

For location of maximum temperature

$$\frac{x}{L} = \frac{M-1}{2M}$$

Where $M = \dfrac{Q_g L^2}{2K(T_1 - T_2)}$

$$= \frac{80 \times 10^6 \times 0.02^2}{2 \times 200(160-120)} = 2$$

$$x = \frac{2-1}{2 \times 2} \times 0.02 = 0.005m = 5mm$$

13. ***Ans. (c)***

$$T = t_1 + \frac{Q_g L^2}{8K}\left(1 - \left(\frac{2x}{L}\right)^2\right)$$

$$= 160 + \frac{80 \times 10^6 \times 0.02^2}{8 \times 200}$$

$$\left(1 - \left(\frac{2 \times 0.005}{0.02}\right)^2\right) = 175^o C$$

14. ***Ans. (d)***

$$Q_g = 100 \times \text{volume}$$

$$= 100 \times A \times 1 = 100\ A$$

$$= h.A\ (T_s - T_\alpha)$$

$$T_s = T_\alpha + 10 = 30 + 10 = 40^o C$$

15. ***Ans. (c)***

$$Q = -kA\frac{dT}{dx}$$

$$(ML^2T^{-3}) = k(L^2)\frac{(\theta)}{(L)}$$

$$\Rightarrow \quad ML^2T^{-3} = k(L)(\theta)$$

$$\Rightarrow \quad k = \frac{ML^2T^{-3}}{L\theta} = MLT^{-3}\theta^{-1}$$

16. ***Ans. (d)***

Due to minimum thermal conductivity of air heat conduction is minimum in air.

17. ***Ans. (a)***

18. ***Ans. (a)***

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