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Exercise

Thermo-1

Elasticity, Calorimetry,

Thermal Expansion, Heat Transfer

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Exercise-4

(Miscellaneous Type)

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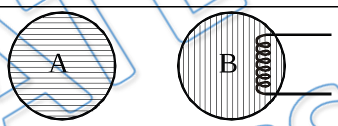
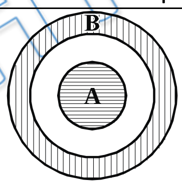
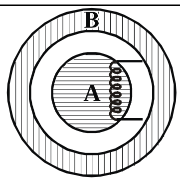
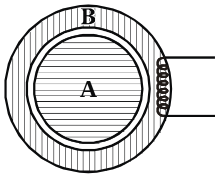
Column Matching

Q 1. If α is the coefficient of linear expansion, Δt is raise in temperature, Y is Young's modulus, A is area of cross section. Then match Column – I, Column – II.

	COLUMN – I		COLUMN - II
A	Thermal stress	P	$3\alpha\Delta t 100$
B	Loss in time of pendulum clock per sec	Q	$\dfrac{d}{(\alpha_2-\alpha_1)\Delta t}$
C	Percentage increase in volume of a solid	R	$Y\alpha\Delta t$
D	Radius of circular arc of a bimetal strip	S	$\dfrac{1}{2}\alpha\Delta t$
		T	$YA\alpha\Delta t$

Q 2. A & B are two black bodies of radii r_A and r_B respectively, placed in surrounding of temperature T_0. At steady state the temperature of A & B is T_A & T_B respectively.

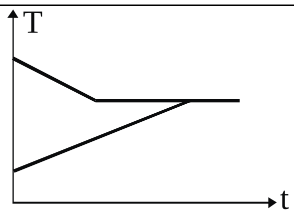
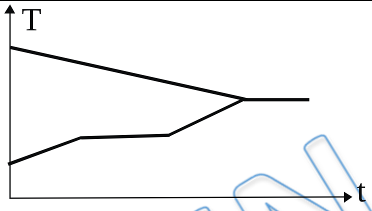
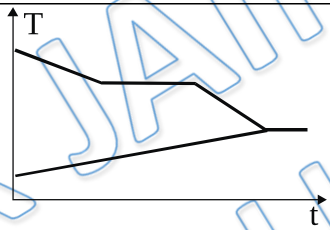
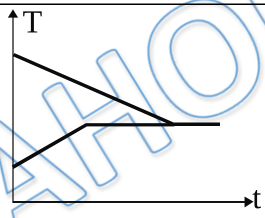
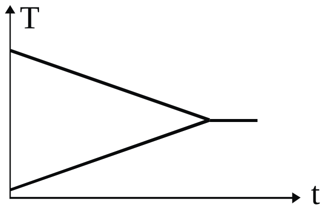
Column I		**Column II**	
(A)	 • A & B are solid sphere • $r_A = r_B$ • Body 'B' is being heated by a heater of constant power 'P'	(P)	$T_A = T_B$
(B)	 • B is thin spherical shell • A is a solid sphere • $r_A < r_B$	(Q)	$T_A < T_B$

(C)	 • B is thin spherical shell • A is a solid sphere • $r_A < r_B$ • Body A is being heated by a heater of constant power 'P'	(R)	Heat received by A is more than heat radiated by it at steady state.
(D)	 • B is thin spherical shell • A is a solid sphere • $r_A \approx r_B$ • Body B is being heated by a heater of constant power 'P'	(S) (T)	Radiation spectrum of A & B is distinguishable Steady state can't be achieved

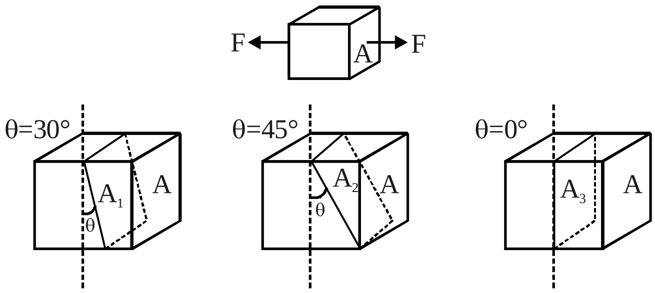
Q 3. A metal ball of mass 1 kg is heated by means of a 20 W heater in a room at 20^0C. The temperature of the ball become steady at 50^0C, assuming Newton's law of cooling hold good then calculate

Column – I	Column – II
(A) The rate of loss of heat to the surrounding when the ball is at 50^0c in (J/s)	(P) 20/3
(B) The rate of loss of heat to the surrounding when the ball is at 30^0C in (J/s)	(Q) 20
(C) Assuming that the temperature of the ball rises uniformly from 20^0C to 30^0C in 5 minutes, the total loss of heat to the surrounding during this period in (J)	(R) 500
(D) The specific heat capacity of metal in J/Kg-k	(S) 1000

Q 4. A sample 'A' of liquid water and a sample B of ice of equal mass are kept in 2 nearby containers so that they can exchange heat with each other but are thermally insulated from the surroundings. The graphs in column-II show the sketch of temperature T of samples versus time t. Match with appropriate description in column-I.

	Column I		Column II
(A)	Equilibrium temperature is above melting point of ice.	(P)	
(B)	At least some of water freezes.	(Q)	
(C)	At least some of ice melts.	(R)	
(D)	Equilibrium temperature is below freezing point of water	(S)	
		(T)	

Q 5. The square block of cross section area A is subjected to two equal and opposite forces F as shown in figure, the block is in equilibrium. Consider the planes A_1, A_2 and A_3 which are passing through the square block and making angle 30°, 45° and 0° respectively with eplane at right angle to the block.



Match the following based on the information given above

	Column-I		Column-II
(A)	Maximum shear stress	(P)	Plane A_1
(B)	Minimum shear stress	(Q)	Plane A_2
(C)	Maximum Normal stress	(R)	Plane A_3
(D)	Minimum Normal stress	(S)	$\frac{F}{2A}$
		(T)	$\frac{F}{A}$

Paragraph based questions

Passage # 1 (Q.6 to Q.7)

A certain amount of ice is supplied heat at a constant rate for 7 mm. For the first one minute the temperature rises uniformly with time. Then it remains constant for the next 4 mm and again the temperature rises at uniform rate for the last 2 mm. Given S, = 0.5 cal/g °Q L, = 80 cal/g

Q 6. The initial temperature of ice is

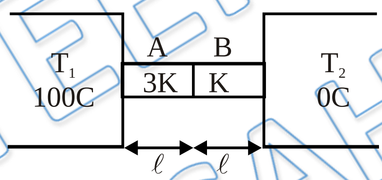
(A) – 10°C (B) – 20°C (C) – 30°C (D) – 40°C

Q 7. Final temperature at the end of 7 min is:

(A) 10°C (B) 20°C (C) 30°C (D) 40°C

Passage # 2 (Q.8 to Q.10)

Two rods A and B of same cross-sectional area A and length ℓ connected in series between a source (T_1 = 100°C) and a sink (T_2 = 0°C) as shown in figure. The rod is laterally insulated.



Q 8. The ratio of thermal resistance of the rod is

(A) $\frac{R_A}{R_B} = \frac{1}{3}$ (B) $\frac{R_A}{R_B} = 3$ (C) $\frac{R_A}{R_B} = \frac{3}{4}$ (D) $\frac{R_A}{R_B} = \frac{4}{3}$

Q 9. If T_A and T_B are the temperature drop across the rod A and B then

(A) $\frac{T_A}{T_B} = \frac{1}{3}$ (B) $\frac{T_A}{T_B} = \frac{3}{1}$ (C) $\frac{T_A}{T_B} = \frac{3}{4}$ (D) $\frac{T_A}{T_B} = \frac{4}{3}$

Q 10. If G_A and G_B are the temperature gradients across the rod A and B then

(A) $\frac{G_A}{G_B} = \frac{1}{3}$ (B) $\frac{G_A}{G_B} = \frac{3}{1}$ (C) $\frac{G_A}{G_B} = \frac{3}{4}$ (D) $\frac{G_A}{G_B} = \frac{4}{3}$

Passage # 3 (Q.11 to Q.13)

A metal block of heat capacity 80 J/°C placed in room at 20°C is heated electrically. The heater is switched off when temperature reaches 30°C. The temperature of block rises at rate 2°C/s just after heater is switched on and falls at rate 0.2°C/s when switch off. Assume newtons law of cooling holds.

Choose the correct answer :

Q 11. Find power of heater

(A) 120 W (B) 140 W (C) 160 W (D) 200 W

Q 12. Find power radiated by block just after heater is switched off

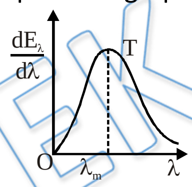
(A) 12 W (B) 14 W (C)16 W (D) 20 W

Q 13. Find power radiated by block when its temperature is 25°C

(A) 16 W (B) 8 W (C) 24 W (D) 4 W

Passage # 4 (Q.14 to Q.15)

The figure shows a radiant energy spectrum graph for a black body at a temperature T.



Q 14. Choose the **CORRECT** statement(s)
(A) The radiant energy is not equally distributed among all the possible wavelengths
(B) For a particular wavelength the spectral intensity is maximum
(C) The area under the curve is equal to the total rate at which heat is radiated by the body at that temperature
(D) None of these

Q 15. If the temperature of the body is raised to a higher temperature T', then choose the correct statement(s)
(A) The intensity of radiation for every wavelength increases
(B) The maximum intensity occurs at a shorter wavelength
(C) The area under the graph increases
(D) The area under the graph is proportional to the fourth power of temperature

Passage # 5 (Q.16 to Q.19)

A metal block of heat capacity 80 J/^{0}C placed in a room at 20^{0}C is heated electrically. The heater is switched off when the temperature reaches 30^{0}C. The temperature of the block rises at the rate of 2 ^{0}C/s just after the heater is switched on and falls at the rate of 0.2^{0}C/s just after the heater is switched off. Assume Newton's law of cooling to hold.

Q 16. Find the power of the heater

(A) zero (B) 60 watt

(C) 160 watt (D) 180 watt

Q 17. Find the power radiated by the block just after the heater is switched off

(A) 16 watt (B) 8 watt

(C) 2 watt (D) 1 watt

Q 18. Find the power radiated by the block when the temperature of the block is 25^0C

(A) zero (B) 1 watt

(C) 4 watt (D) 8 watt

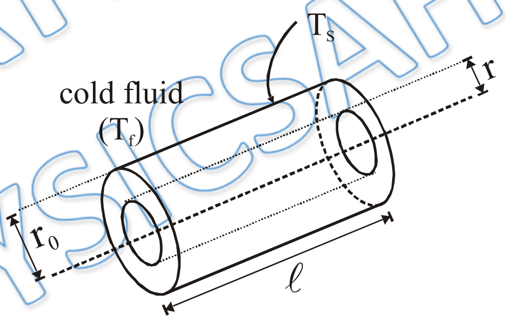
Q 19. At what temperature of the metal block, the power radiated by the block becomes 2 watt only

(A) 20.0^0C (B) 21.25^0C

(C) 22.5^0C (D) 24^0C

Passage # 6 (Q.20 to Q.22)

Heat generation may occur in a variety of radial geometries. Consider a long, solid cylinder as shown in the figure, which could represent a current-carrying wire or a fuel element in a nuclear reactor. For steady state conditions, the rate at which heat is generated within the cylinder must equal the rate at which heat is convected from the surface of the cylinder to a moving fluid.



This condition allows the surface temperature to be maintained at a fixed value of T_S. To determine the temperature distribution in the cylinder, we begin with energy conservation principle. Consider a cylindrical section of radius r. The energy is generated within the volume and is conducted radially outwards.

$$q\,\pi r^2\ell = -K2\pi r\ell\left(-\frac{dT}{dr}\right)$$

where q is the energy generated per unit time per unit volume, K is the thermal conductivity and $\frac{dT}{dr}$ is the temperature gradient at radius r. If q is constant $T(r) = -\frac{q}{4k}r^2 + C$

At $r = r_0$, $T(r_0) = T_S$. Therefore, $T(r) = \frac{q}{4k}r_0^2\left(1-\frac{r^2}{r_0^2}\right)+T_s$

The rate of heat convected to the surrounding fluid (at temperature T_f) by the surface at temperature T_S is proportional to the temperature difference ($T_S - T_f$) and the surface area in contact with the fluid. Thus, rate of heat convection = $h(2\pi r_0 \ell)(T_S - T_f)$ where h is a constant called heat convection coefficient. By overall energy balance, $q(\pi r_0^2 \ell) = h(2\pi r_0 \ell)(T_S - T_f)$

$$\Rightarrow T_s = T_f + \frac{q r_0}{2h}$$

Q 20. The dimension of heat convection coefficient is-

(A) $[ML^2T^{-1}\theta^{-1}]$ (B) $[ML^0T^{-3}\theta^{-1}]$ (C) $[ML^0T^{-2}\theta^{-1}]$ (D) $[ML^4T^{-2}\theta^{-1}]$

Q 21. In the given passage, the difference in temperature at the axis and surface of the cylinder is-

(A) $\frac{qr_0^2}{4k}$ (B) $\frac{qr_0^2}{k}$ (C) $\frac{qr_0^2}{2k}$ (D) $\frac{2qr_0}{k}$

Q 22. In the above passage, the ratio of temperature gradient at $r = r_0/2$ and $r = r_0$ is

(A) 1 (B) 1/4 (C) 1/2 (D) 1/8

Assertion/Reason Type Questions:

Each of the questions given below consist of Statement – I and Statement – II. Use the following Key to choose the appropriate answer.

(A) If both Statement- I and Statement- II are true, and Statement - II is the correct explanation of Statement– I.

(B) If both Statement - I and Statement - II are true but Statement - II is not the correct explanation of Statement – I.

(C) If Statement - I is true but Statement - II is false.

(D) If Statement - I is false but Statement - II is true.

Q 23. STATEMENT – 1 Woollen clothes keep the body warm in winter.
STATEMENT – 2 Air is a bad conductor of heat.
(A) A (B) B (C) C (D) D

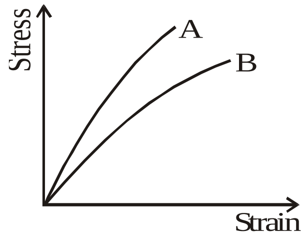
Q 24. STATEMENT – 1 Identical springs of steel and copper are equally stretched. More work will be done on the steel spring.
STATEMENT – 2 Steel is more elastic than copper.
(A) A (B) B (C) C (D) D

Q 25. STATEMENT – 1 Absolute zero temperature is not the temperature of zero energy.
STATEMENT – 2 Only the translational kinetic energy of the molecules is represented by temperature.
(A) A (B) B (C) C (D) D

Q 26. STATEMENT – 1
The expanded length l of a rod of original length l_0 is not correctly given by (assuming α to be constant with T)
$l = l_0 (1 + \alpha \Delta T)$
if $\alpha \Delta T$ is large.
STATEMENT – 2
It is given by
$l = l_0 e^{\alpha \Delta T}$, which cannot be treated as being approximately equal to $l_0 (1 + \alpha \Delta T)$ for large value $\alpha \Delta T$.
(A) A (B) B (C) C (D) D

Q 27. **STATEMENT – 1 :** Greater is the coefficient of thermal conductivity of a material, smaller is the thermal resistance of a rod of that material.
STATEMENT – 2 : Thermal resistance is the ratio of temperature difference between the ends of the conductor and rate of flow of heat.
(A) A (B) B (C) C (D) D

Q 28. STATEMENT – 1
The stress–strain graphs are shown in the figure for two materials A and B are shown in figure. Young's modulus of A is greater than of B.



STATEMENT – 2

The Young's modules for small strain is,

$Y = \dfrac{\text{stress}}{\text{strain}}$ = slope of linear portion, of graph; and slope of A is more than slope that of B.

(A) A (B) B (C) C (D) D

Q 29. Statement-1: At a given temperature radiations emitted by pin hole cavities in different materials are different.

Statement-2: Pin hole cavities in all materials behave like perfect black body.

(A) (A) (B) (B) (C) (C) (D) (D)

Q 30. Statement-1: When temperature difference across the two sides of a wall is increased, its thermal conductivity increases.

Statement-2: Thermal conductivity depends on the nature of material of the wall.

(A) (A) (B) (B) (C) (C) (D) (D)

Q 31. Statement-1: Water can be boiled inside satellite by convection.

Statement-2: Convection is the process in which heat is transmitted from a place of higher temperature to a place of lower temperature by means of particles with their migrations from one place to another.

(A) (A) (B) (B) (C) (C) (D) (D)

Answer Key

Q.1) A-R, B-S, C-P, D-Q	**Q.2)** (A)→ QS; (B)→ P; (C)→ S; (D)→ QS	**Q.3) A-Q, B-P, C-S, D-R**	**Q.4)** (A)→ Q; (B)→ PR; (C)→ QS; (D)→ R	**Q.5)** (A)→ QS; (B)→ R; (C)→ RT; (D)→ QS
Q.6) D	**Q.7) D**	**Q.8) A**	**Q.9) A**	**Q.10) A**
Q.11) C	**Q.12) C**	**Q.13) B**	**Q.14) A,C,D**	**Q.15) A,B,C,D**
Q.16) C	**Q.17) A**	**Q.18) D**	**Q.19) B**	**Q.20) B**
Q.21) A	**Q.22) C**	**Q.23) B**	**Q.24) A**	**Q.25) A**
Q.26) A	**Q.27) B**	**Q.28) A**	**Q.29) D**	**Q.30) D**
Q.31) D				