DPP - Daily Practice Problems

Name : ____________ Date : ____________

Start Time : ____________ End Time : ____________

PHYSICS 23

SYLLABUS : Heat transfer & Newton's law of cooling

Max. Marks : 120 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 30 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.21) : There are 21 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

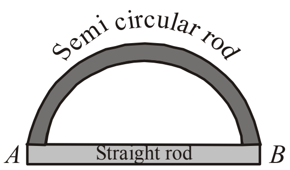
Q.1 Two rods (one semi-circular and other straight) of same material and of same cross-sectional area are joined as shown in the figure. The points A and B are maintained at different temperature. The ratio of the heat transferred through a cross-section of a semi-circular rod to the heat transferred through a cross section of the straight rod in a given time is

(a) $2 : \pi$

(b) $1 : 2$

(c) $\pi : 2$

(d) $3 : 2$



Q.2 A wall is made up of two layers A and B. The thickness of the two layers is the same, but materials are different. The thermal conductivity of A is double than that of B. In thermal equilibrium the temperature difference between the two ends is 36°C. Then the difference of temperature at the two surfaces of A will be

(a) 6°C (b) 12°C (c) 18°C (d) 24°C

Q.3 A room is maintained at 20°C by a heater of resistance 20 ohm connected to 200 volt mains. The temperature is uniform through out the room and heat is transmitted through a glass window of area $1 m^2$ and thickness 0.2 cm. What will be the temperature outside? Given that thermal conductivity K for glass is 0.2 cal/m/°C/sec and J = 4.2 J/cal

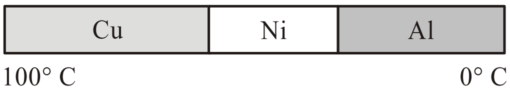
(a) 15.24°C (b) 15.00°C

(c) 24.15°C (d) None of these

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ

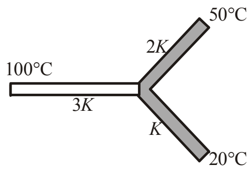
Space for Rough Work

Q.4 A composite metal bar of uniform section is made up of length 25 cm of copper, 10 cm of nickel and 15 cm of aluminium. Each part being in perfect thermal contact with the adjoining part. The copper end of the composite rod is maintained at 100°C and the aluminium end at 0°C. The whole rod is covered with belt so that there is no heat loss occurs at the sides. If $K_{Cu} = 2K_{Al}$ and $K_{Al} = 3K_{Ni}$, then what will be the temperatures of Cu – Ni and Ni – Al junctions respectively



(a) 23.33°C and 78.8°C (b) 83.33°C and 20°C
(c) 50°C and 30°C (d) 30°C and 50°C

Q.5 Three rods of the same dimension have thermal conductivities $3K$, $2K$ and K. They are arranged as shown in fig. with their ends at 100°C, 50°C and 20°C. The temperature of their junction is



(a) 60°C
(b) 70°C
(c) 50°C
(d) 35°C

Q.6 A black body is at a temperature of 2880 K. The energy of radiation emitted by this object with wavelength between 499 nm and 500 nm is U_1, between 999 nm and 1000 nm is U_2 and between 1499 nm and 1500 nm is U_3. The Wein's constant $b = 2.88 \times 10^6$ nm K. Then
(a) $U_1 = 0$ (b) $U_3 = 0$ (c) $U_1 > U_2$ (d) $U_2 > U_1$

Q.7 A body initially at 80° C cools to 64° C in 5 minutes and to 52° C in 10 minutes. The temperature of the body after 15 minutes will be
(a) 42.7° C (b) 35° C (c) 47° (d) 40° C

Q.8 A 5 cm thick ice block is there on the surface of water in a lake. The temperature of air is – 10° C; how much time it will take to double the thickness of the block ($L = 80$ cal/g, $K_{ice} = 0.004$ erg/s-k, $d_{ice} = 0.92$ g cm^{-3})
(a) 1 hour (b) 191 hours
(c) 19.1 hours (d) 1.91 hours

Q.9 A cylindrical rod with one end in a steam chamber and the other end in ice results in melting of 0.1 gm of ice per second. If the rod is replaced by another with half the length and double the radius of the first and if the thermal conductivity of material of second rod is $\frac{1}{4}$ that of first, the rate at which ice melts in gm/sec will be
(a) 3.2 (b) 1.6 (c) 0.2 (d) 0.1

Q.10 An ice box used for keeping eatable cold has a total wall area of 1 metre^2 and a wall thickness of 5.0 cm. The thermal conductivity of the ice box is $K = 0.01$ joule/metre °C. It is filled with ice at 0° C along with eatables on a day when the temperature is 30°C. The latent heat of fusion of ice is 334×10^3 joules/kg. The amount of ice melted in one day is (1 day = 86,400 seconds)
(a) 776 gm (b) 7760 gm
(c) 11520 gm (d) 1552 gm

Q.11 A solid copper sphere (density ρ and specific heat capacity c) of radius r at an initial temperature 200 K is suspended inside a chamber whose walls are at almost 0 K. The time required (in μ s) for the temperature of the sphere to drop to 100 K is
(a) $\frac{72}{7}\frac{r\rho c}{\sigma}$ (b) $\frac{7}{72}\frac{r\rho c}{\sigma}$ (c) $\frac{27}{7}\frac{r\rho c}{\sigma}$ (d) $\frac{7}{27}\frac{r\rho c}{\sigma}$

Q.12 Four rods of identical cross-sectional area and made from the same metal form the sides of square. The temperature of two diagonally opposite points are T and $\sqrt{2}T$ respectively in the steady state. Assuming that only heat conduction takes place, what will be the temperature difference between other two points
(a) $\frac{\sqrt{2}+1}{2}T$ (b) $\frac{2}{\sqrt{2}+1}T$
(c) 0 (d) None of these

Q.13 Consider two hot bodies B_1 and B_2 which have temperature 100° C and 80° C respectively at $t = 0$. The temperature of surroundings is 40° C. The ratio of the respective rates of cooling R_1 and R_2 of these two bodies at $t = 0$ will be
(a) $R_1 : R_2 = 3 : 2$ (b) $R_1 : R_2 = 5 : 4$
(c) $R_1 : R_2 = 2 : 3$ (d) $R_1 : R_2 = 4 : 5$

RESPONSE GRID					
	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ
	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ

Space for Rough Work

Q.14 A body cools from 60° C to 50° C in 10 minutes. If the room temperature is 25° C and assuming Newton's law of cooling to hold good, the temperature of the body at the end of the next 10 minutes will be

(a) 38.5° C (b) 40° C (c) 42.85° C (d) 45° C

Q.15 The rates of cooling of two different liquids put in exactly similar calorimeters and kept in identical surroundings are the same if

(a) The masses of the liquids are equal

(b) Equal masses of the liquids at the same temperature are taken

(c) Different volumes of the liquids at the same temperature are taken

(d) Equal volumes of the liquids at the same temperature are taken

Q.16 For cooking the food, which of the following type of utensil is most suitable

(a) High specific heat and low conductivity

(b) High specific heat and high conductivity

(c) Low specific heat and low conductivity

(d) Low specific heat and high conductivity

Q.17 Two rods A and B are of equal lengths. Their ends are kept between the same temperature and their area of cross-sections are A_1 and A_2 and thermal conductivities K_1 and K_2. The rate of heat transmission in the two rods will be equal, if

(a) $K_1A_2 = K_2A_1$ (b) $K_1A_1 = K_2A_2$

(c) $K_1 = K_2$ (d) $K_1A_1^2 = K_2A_2^2$

Q.18 While measuring the thermal conductivity of a liquid, we keep the upper part hot and lower part cool, so that

(a) Convection may be stopped

(b) Radiation may be stopped

(c) Heat conduction is easier downwards

(d) It is easier and more convenient to do so

Q.19 When fluids are heated from the bottom, convection currents are produced because

(a) Molecular motion of fluid becomes aligned

(b) Molecular collisions take place within the fluid

(c) Heated fluid becomes more dense than the cold fluid above it

(d) Heated fluid becomes less dense than the cold fluid above it

Q.20 If between wavelength λ and $\lambda + d\lambda$, e_λ and a_λ be the emissive and absorptive powers of a body and E_λ be the emissive power of a perfectly black body, then according to Kirchoff's law, which is true

(a) $e_\lambda = a_\lambda = E_\lambda$ (b) $e_\lambda E_\lambda = a_\lambda$

(c) $e_\lambda = a_\lambda E_\lambda$ (d) $e_\lambda a_\lambda E_\lambda$ = constant

Q.21 Two thermometers A and B are exposed in sunlight. The bulb of A is painted black, But that of B is not painted. The correct statement regarding this case is

(a) Temperature of A will rise faster than B but the final temperature will be the same in both

(b) Both A and B show equal rise in beginning

(c) Temperature of A will remain more than B

(d) Temperature of B will rise faster

DIRECTIONS (Q.22-Q.24) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :

(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct

(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q.22 Two bodies A and B have thermal emissivities of 0.01 and 0.81 respectively. The outer surface areas of the two bodies are the same. The two bodies emit total radiant power at the same rate. The wavelength λ_B corresponding to maximum spectral radiancy in the radiation from B is shifted from the wavelength corresponding to maximum spectral radiancy in the radiation from A, by 1.00 μm. If the temperature of A is 5802 K

(1) The temperature of B is 1934 K

(2) $\lambda_B = 1.5$ μm

(3) The temperature of B is 11604 K

(4) The temperature of B is 2901 K

Q.23 A cane is taken out from a refrigerator at 0°C. The atmospheric temperature is 25°C. If t_1 is the time taken to heat from 0°C to 5°C and t_2 is the time taken from 10°C to 15°C, then the wrong statements are

(1) $t_1 > t_2$ (2) $t_1 = t_2$

(3) There is no relation (4) $t_1 < t_2$

RESPONSE GRID					
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	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ

Space for Rough Work

Q.24 The rate of loss of heat from a body cooling under conditions of forced convection is proportional to its
(1) surface area
(2) excess of temperature over that of surrounding
(3) heat capacity
(4) absolute temperature

DIRECTIONS (Q.25-Q.27) : Read the passage given below and answer the questions that follows :

A brass ball of mass 100g is heated to 100°C and then dropped into 200g of turpentine in a calorimeter at 15°C. The final temperature is found to be 23°C. Take specific heat of brass as 0.092 cal/g°C and water equivalent of calorimeter as 4g.

Q.25 The specific heat of turpentine is
(a) 0.42 cal/g°c (b) 0.96 cal/g°c
(c) 0.72 cal/g°c (d) 0.12 cal/g°c

Q.26 Heat lost by the ball is approximately
(a) 810 cal (b) 610 cal
(c) 710 cal (d) 510 cal

Q.27 Heat gained by turpentine and calorimeter is approximately
(a) 810 cal (b) 610 cal
(c) 710 cal (d) 510 cal

DIRECTIONS (Q.28-Q.30) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(c) Statement -1 is False, Statement-2 is True.
(d) Statement -1 is True, Statement-2 is False.

Q.28 **Statement-1 :** The equivalent thermal conductivity of two plates of same thickness in contact (series) is less than the smaller value of thermal conductivity.
Statement-2 : For two plates of equal thickness in contact (series) the equivalent thermal conductivity is given by

$$\frac{2}{K}=\frac{1}{K_1}+\frac{1}{K_2}$$

Q.29 **Statement-1 :** The absorbance of a perfect black body is unity.
Statement-2 : A perfect black body when heated emits radiations of all possible wavelengths at that temperature.

Q.30 **Statement-1 :** As temperature of a black body is raised, wavelength corresponding to maximum energy reduces.
Statement-2 : Higher temperature would mean higher energy and hence higher wavelength.

RESPONSE GRID					
	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ
	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ			

DAILY PRACTICE PROBLEM SHEET 23 - PHYSICS			
Total Questions	30	Total Marks	120
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	30	Qualifying Score	48
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

Space for Rough Work

DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS 23

1. **(a)** $\frac{dQ}{dt} = \frac{KA\Delta\theta}{\ell}$

For both rods K, A and $\Delta\theta$ are same

$\Rightarrow \quad \frac{dQ}{dt} \propto \frac{1}{\ell}$

So, $\frac{(dQ/dt)_{semi\,circular}}{(dQ/dt)_{straight}} = \frac{\ell_{straight}}{\ell_{semi\,circular}} = \frac{2r}{\pi r} = \frac{2}{\pi}$.

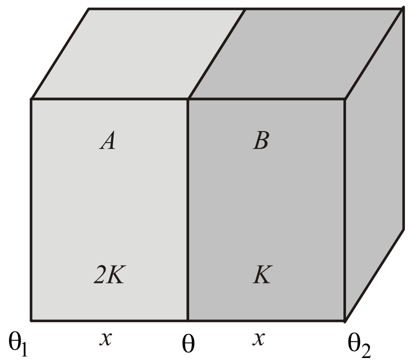
2. **(b)** Suppose thickness of each wall is x then

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

$\Rightarrow \quad \frac{K_s A(\theta_1 - \theta_2)}{2x} = \frac{2KA(\theta_1 - \theta)}{x}$

$\because \quad K_s = \frac{2 \times 2K \times K}{(2K + K)} = \frac{4}{3}K$

and $(\theta_1 - \theta_2) = 36°$



$\Rightarrow \quad \frac{\frac{4}{3}KA \times 36}{2x} = \frac{2KA(\theta_1 - \theta)}{x}$

Hence temperature difference across wall A is

$(\theta_1 - \theta) = 12°$ C

3. **(a)** Heat developed by the heater

$H = \frac{V^2}{R} \cdot \frac{t}{J} = \frac{(200)^2 \times t}{20 \times 4.2}$

Heat conducted by the glass

$H = \frac{0.2 \times 1 \times (20 - \theta)t}{0.002}$

Hence $\frac{(200)^2 \times t}{20 \times 4.2} = \frac{0.2 \times (20 - \theta)t}{0.002}$

$\Rightarrow \quad \theta = 15.24°$ C

4. **(b)** If suppose $K_{Ni} = K \Rightarrow K_{Al} = 3K$ and $K_{Cu} = 6K$

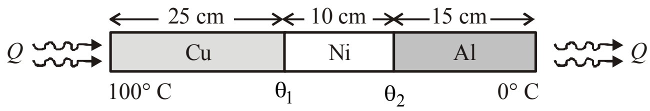
Since all metal bars are connected in series.

So, $\left(\frac{Q}{t}\right)_{Combination} = \left(\frac{Q}{t}\right)_{Cu} = \left(\frac{Q}{t}\right)_{Al} = \left(\frac{Q}{t}\right)_{Ni}$

and $\frac{3}{K_{eq}} = \frac{1}{K_{Cu}} + \frac{1}{K_{Al}} + \frac{1}{K_{Ni}}$

$= \frac{1}{6K} + \frac{1}{3K} + \frac{1}{K} = \frac{9}{6K}$

$\Rightarrow \quad K_{eq} = 2K$



Hence, if $\left(\frac{Q}{t}\right)_{Combination} = \left(\frac{Q}{t}\right)_{Cu}$

$\Rightarrow \quad \frac{K_{eq}A(100 - 0)}{\ell_{Combination}} = \frac{K_{Cu}A(100 - \theta_1)}{\ell_{Cu}}$

$\Rightarrow \quad \frac{2KA(100 - 0)}{(25 + 10 + 15)} = \frac{6KA(100 - \theta_1)}{25}$

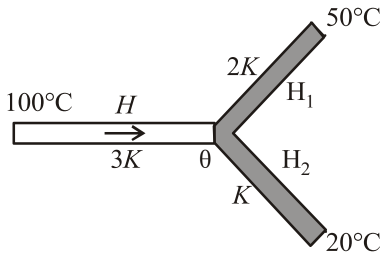
$\Rightarrow \quad \theta_1 = 83.33°$ C

Similar if $\left(\frac{Q}{t}\right)_{Combination} = \left(\frac{Q}{t}\right)_{Al}$

$\Rightarrow \quad \frac{2KA(100 - 0)}{50} = \frac{3KA(\theta_2 - 0)}{15}$

$\Rightarrow \quad \theta_2 = 20°$ C

5. **(b)** Let the temperature of junction be θ then according to following figure.



$$H = H_1 + H_2$$

$$\Rightarrow \quad \frac{3K \times A \times (100-\theta)}{\ell} = \frac{2KA(\theta-50)}{\ell} + \frac{KA(\theta-20)}{\ell}$$

$$\Rightarrow \quad 300 - 3\theta = 3\theta - 120$$

$$\Rightarrow \quad \theta = 70° \text{ C}$$

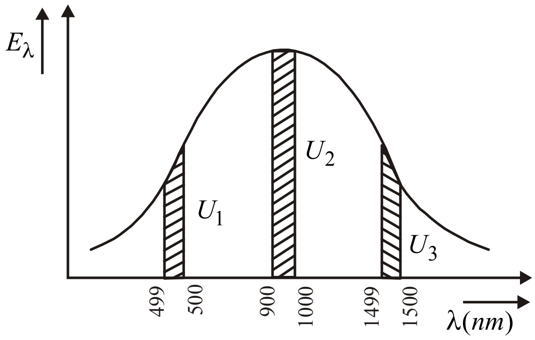
6. **(d)** Wein's displacement law is

$$\lambda_m T = b$$

$$\Rightarrow \quad \lambda_m = \frac{b}{T}$$

$$= \frac{2.88 \times 10^6}{2880} = 1000 \text{ nm}$$

Energy distribution with wavelength will be as follows

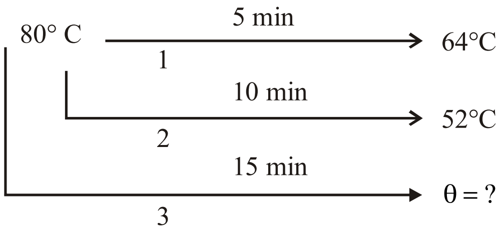


From the graph it is clear that

$$U_2 > U_1$$

7. **(a)** According to Newton law of cooling

$$\frac{\theta_1 - \theta_2}{t} = K\left[\frac{\theta_1 + \theta_2}{2} - \theta_0\right]$$



For first process :

$$\frac{(80-64)}{5} = K\left[\frac{80+64}{2} - \theta_0\right] \quad \text{....... (i)}$$

For second process :

$$\frac{(80-52)}{10} = K\left[\frac{80+52}{2} - \theta_0\right] \quad \text{....... (ii)}$$

For third process :

$$\frac{(80-\theta)}{15} = K\left[\frac{80+\theta}{2} - \theta_0\right] \quad \text{....... (iii)}$$

On solving equation (i) and (ii) we get $K = \frac{1}{15}$ and θ_0 = 24° C. Putting these values in equation (iii) we get θ = 42.7° C.

8. **(c)** $t = \frac{Q\ell}{KA(\theta_1 - \theta_2)}$

$$= \frac{mL\ell}{KA(\theta_1-\theta_2)} = \frac{V\rho L\ell}{KA(\theta_1-\theta_2)}$$

$$= \frac{5 \times A \times 0.92 \times 80 \times \frac{5+10}{2}}{0.004 \times A \times 10 \times 3600}$$

= 19.1 hours.

9. **(c)** $\frac{Q}{t} = \frac{KA\Delta\theta}{\ell}$

$$\Rightarrow \frac{mL}{t} = \frac{K(\pi r^2)\Delta\theta}{\ell}$$

$\Rightarrow$ Rate of melting of ice $\left(\frac{m}{t}\right) \propto \frac{Kr^2}{\ell}$

Since for second rod K becomes $\frac{1}{4}th$, r becomes double and length becomes half, so rate of melting will be twice *i.e.* $\left(\frac{m}{t}\right)_2 = 2\left(\frac{m}{t}\right)_1 = 2 \times 0.1 = 0.2$ gm/sec.

10. **(d)** $\frac{dQ}{dt} = \frac{KA}{\ell} d\theta$

$$= \frac{0.01 \times 1}{0.05} \times 30 = 6 \text{ J/sec}$$

Heat transferred in one day (86400 sec)

Q = 6 × 86400 = 518400 J

Now $Q = mL$

$$\Rightarrow \quad m = \frac{Q}{L} = \frac{518400}{334 \times 10^3} = 1.552 \text{ kg} = 1552 \text{ g.}$$

11. **(b)** $\frac{dT}{dt} = \frac{\sigma A}{mcJ}(T^4 - T_0^4)$

[In the given problem fall in temperature of body dT = (200 – 100) = 100 K, temp. of surrounding T_0 = 0 K, Initial temperature of body T = 200 K].

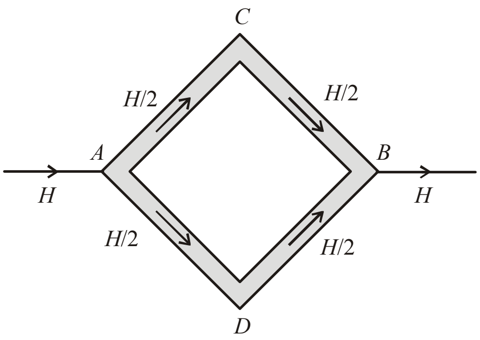
$$\frac{100}{dt} = \frac{\sigma 4\pi r^2}{\frac{4}{3}\pi r^3 \rho c J}(200^4 - 0^4)$$

$$\Rightarrow \quad dt = \frac{r\rho cJ}{48\sigma} \times 10^{-6} s$$

$$= \frac{r\rho c}{\sigma} \times \frac{4.2}{48} \times 10^{-6}$$

$$= \frac{7}{80}\frac{r\rho c}{\sigma}\mu s \simeq \frac{7}{72}\frac{r\rho c}{\sigma}\mu s \quad [\text{As J} = 4.2]$$

12. (c) Suppose temperature difference between A and B is $100° C$ and $\theta_A > \theta_B$



Heat current will flow from A to B via path ACB and ADB. Since all the rod are identical so

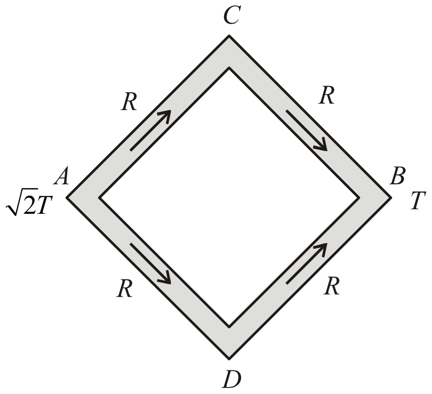
$$(\Delta\theta)_{AC} = (\Delta\theta)_{AD}$$

(Because heat current $H = \frac{\Delta\theta}{R}$; here R = same for all)

$$\Rightarrow \theta_A - \theta_C = \theta_A - \theta_D$$

$$\Rightarrow \theta_C = \theta_D$$

i.e. temperature difference between C and D is zero.



13. (a) Initially at $t = 0$

Rate of cooling $(R) \propto$ Fall in temperature of body $(\theta - \theta_0)$

$$\Rightarrow \frac{R_1}{R_2} = \frac{\theta_1 - \theta_0}{\theta_2 - \theta_0}$$

$$= \frac{100 - 40}{80 - 40} = \frac{3}{2}$$

14. (c) $$\frac{60 - 50}{10} = K\left(\frac{60 + 50}{2} - 25\right) \quad \text{.......... (i)}$$

$$\frac{50 - \theta}{10} = K\left(\frac{50 + \theta}{2} - 25\right) \quad \text{.......... (ii)}$$

On dividing, we get

$$\frac{10}{50 - \theta} = \frac{60}{\theta}$$

$$\Rightarrow \theta = 42.85° C$$

15. (d) $\frac{d\theta}{dt} = \frac{\sigma A}{mc}(T^4 - T_0^4)$. If the liquids put in exactly similar calorimeters and identical surrounding then we can consider T_0 and A constant then

$$\frac{d\theta}{dt} \propto \frac{(T^4 - T_0^4)}{mc}$$

If we consider that equal masses of liquid (m) are taken at the same temperature then

$$\frac{d\theta}{dt} \propto \frac{1}{c}$$

So for same rate of cooling c should be equal which is not possible because liquids are of different nature.

Again from equation (i),

$$\frac{d\theta}{dt} \propto \frac{(T^4 - T_0^4)}{mc}$$

$$\Rightarrow \frac{d\theta}{dt} \propto \frac{(T^4 - T_0^4)}{V\rho c}$$

Now if we consider that equal volume of liquid (V) are taken at the same temperature then

$$\frac{d\theta}{dt} \propto \frac{1}{\rho c}.$$

So for same rate of cooling multiplication of $\rho \times c$ for two liquids of different nature can be possible. So, option (d) may be correct.

16. (d) For cooking utensils, low specific heat is preferred for it's material as it should need less heat to raise it's temperature and it should have high conductivity, because, it should transfer heat quickly.

17. (b) $$\left(\frac{Q}{t}\right)_1 = \frac{K_1 A_1(\theta_1 - \theta_2)}{\ell}$$

and $$\left(\frac{Q}{t}\right)_2 = \frac{K_2 A_2(\theta_1 - \theta_2)}{\ell}$$

Given, $$\left(\frac{Q}{t}\right)_1 = \left(\frac{Q}{t}\right)_2$$

$$\Rightarrow K_1 A_1 = K_2 A_2$$

18. (a) Convection may be stopped

19. (d) Heated fluid becomes less dense than the cold fluid above it

20. (c) According to Kirchoff's law, the ratio of emissive power to absorptive power is same for all bodies is equal to the emissive power of a perfectly black body *i.e.*,

$$\left(\frac{e}{a}\right)_{body} = E_{Black\,body} \text{ for a particular wave length}$$

$$\left(\frac{e_\lambda}{a_\lambda}\right)_{body} = (E_\lambda)_{Black\,body}$$

$$\Rightarrow \quad e_\lambda = a_\lambda E_\lambda$$

21. **(a)** As for a black body rate of absorption of heat is more. Hence thermometer A shows faster rise in temperature but finally both will acquire the atmospheric temperature.

22. **(b)**

According to Stefan's law

$$E = e A\sigma T^4 \Rightarrow E_1 = e_1 A\sigma T_1^4 \text{ and } E_2 = e_2 A\sigma T_2^4$$

$$\because E_1 = E_2 \quad \therefore e_1 T_1^4 = e_2 T_2^4$$

$$\Rightarrow \quad T_2 = \left(\frac{e_1}{e_2} T_1^4\right)^{\frac{1}{4}} = \left(\frac{1}{81} \times (5802)^4\right)^{\frac{1}{4}}$$

$$\Rightarrow \quad T_B = 1934 \text{ K}$$

And, from Wein's law $\lambda_A \times T_A = \lambda_B \times T_B$

$$\Rightarrow \frac{\lambda_A}{\lambda_B} = \frac{T_B}{T_A} \Rightarrow \frac{\lambda_B - \lambda_A}{\lambda_B} = \frac{T_A - T_B}{T_A}$$

$$\Rightarrow \frac{1}{\lambda_B} = \frac{5802 - 1934}{5802} = \frac{3968}{5802} \Rightarrow \lambda_B = 1.5\ \mu\text{m}$$

23. **(a)** According to Newton's law of cooling.

24. **(a)** In forced convection rate of loss of heat

$$\frac{Q}{T} \propto A(T - T_0)$$

25(a), 26(c), 27(c)

Let c be the specific heat of turpentine

Mass of the solid, $M = 100$g

Mass of turpentine $m = 200$g

Water equivalent of calorimeter, $W = 4g$

Initial temperature of calorimeter, $T_1 = 15°C$

Temperature of ball, $T_2 = 100°C$

Final temperature of the liquid, $T = 23°C$

Specific heat of solid, $c_2 = 0.092$ cal/g°C

Heat gained by turpentine and calorimeter is

$$mc\,(T - T_1) + W(T - T_1) = 200c\,(23 - 15) + 4\,(23 - 15)$$
$$= (200c + 4)\,8$$

Heat lost by the ball is

$$Mc_2\,(T_2 - T) = 100\,(0.092)\,(100 - 23)$$
$$= 708.4 \text{ cal.}$$

According to the principle of calorimetry

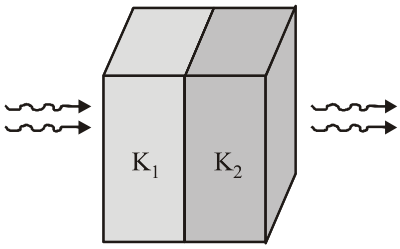
Heat gained = Heat lost

$\therefore \quad (200c + 4)\,8 = 708.4$

$1600c + 32 = 708.4$

or $c = \dfrac{708.4 - 32}{1600} = 0.42$ cal/g°C

28. **(d)** Equivalent thermal conductivity of two equally thick plates in series combination is given by



$$\frac{2}{K} = \frac{1}{K_1} + \frac{1}{K_2}$$

If $K_1 < K_2$

then $\quad K_1 < K < K_2$

29. **(b)** Both statement-1 and statement-2 are true but statement-2 is not correctly explaining the statement-2.

30. **(d)** According to Wein's displacement law the

$$\lambda_m \propto \frac{1}{T}$$

Hence statement-1 is true but statement-2 is false.