PRAYAS

JEE 2025

KPP | **Physics**

Heat Elasticity

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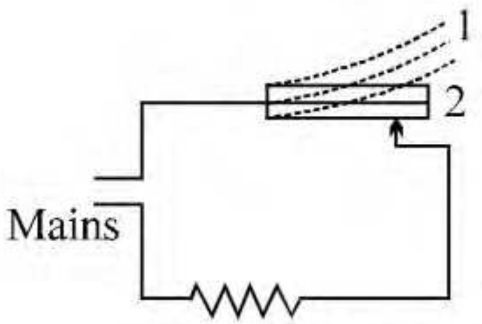
- Level 1 ⇒ Concept Clearing
- Level 2 ⇒ JM PYQ
- Level 3 ⇒ JA PYQ
- Level 4 ⇒ Level up Qus for JA

Figure shows the action of a switch by a bimetallic strip. If α_1 and α_2 are coefficients of thermal expansion of metal 1 and metal 2 respectively.



(A*) $\alpha_1 < \alpha_2$

(B) $\alpha_1 > \alpha_2$

(C) $\alpha_1 > \alpha_2$ if the current in circuit is clockwise

(D) None of these

Ans. (A)

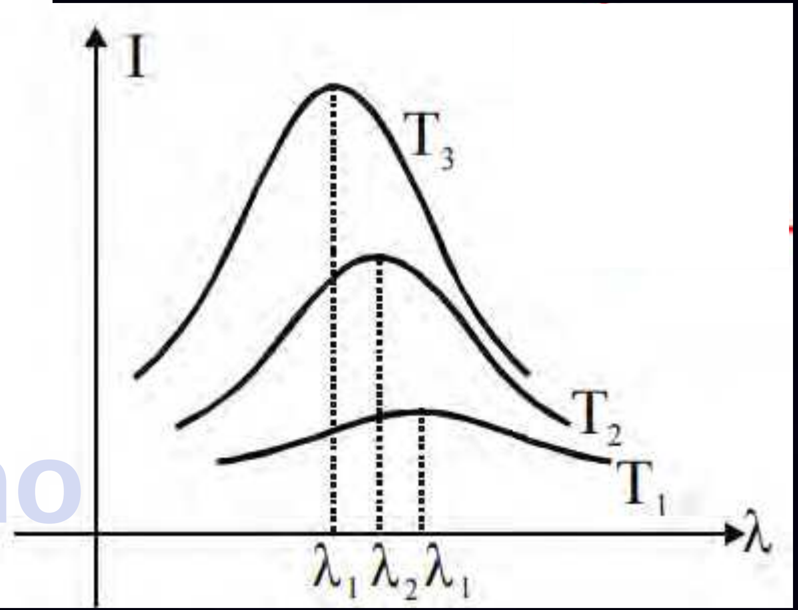
According to Wien's displacement law

(A) total area under the three graphs A_1, A_2, A_3 are equal

(B) areas are in the ratio : $A_1 : A_2 : A_3 = T_1^2 : T_2^2 : T_3^2$

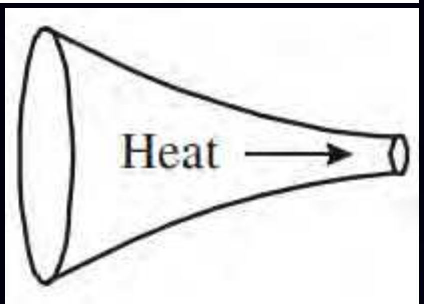
(C) areas are is the ratio : $A_1 : A_2 : A_3 = T_1^4 : T_2^4 : T_3^4$

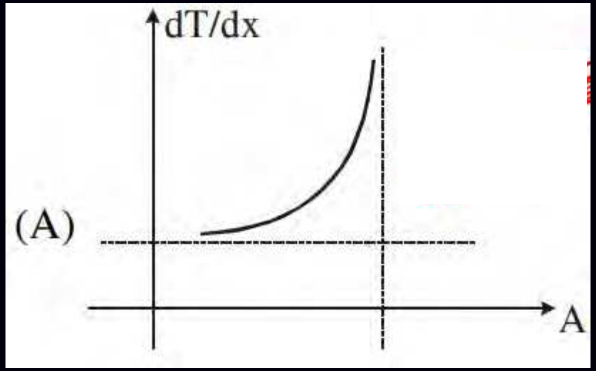
(D) $T_3 > T_2 > T_1$

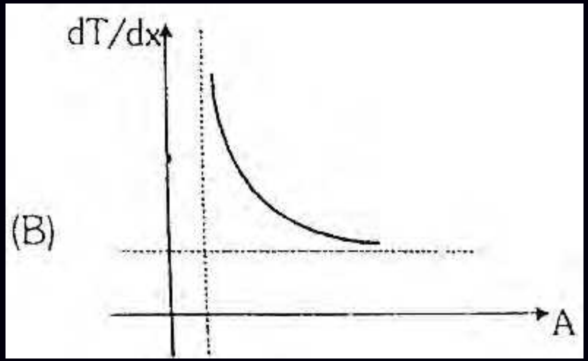


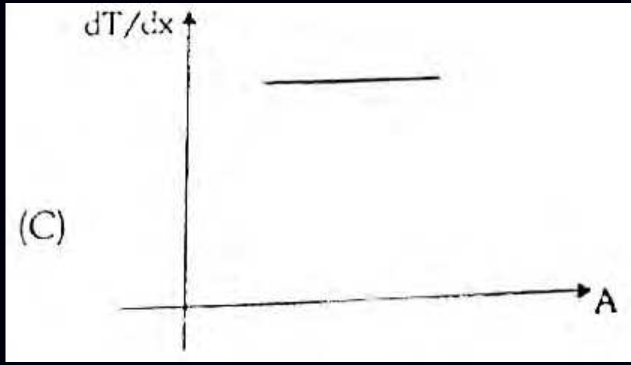
Ans. (D)

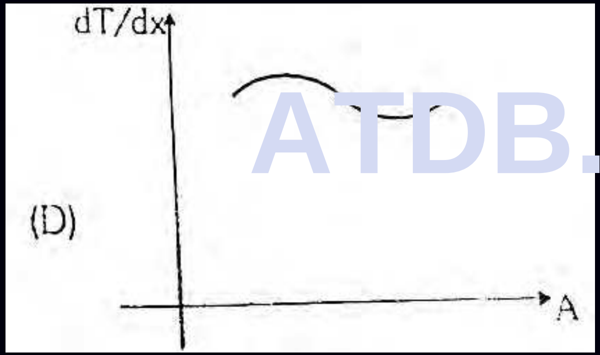
An irregular rod of same uniform material as shown in figure is conducting heat at a steady rate. The temperature gradient at various sections versus area of cross section graph will be







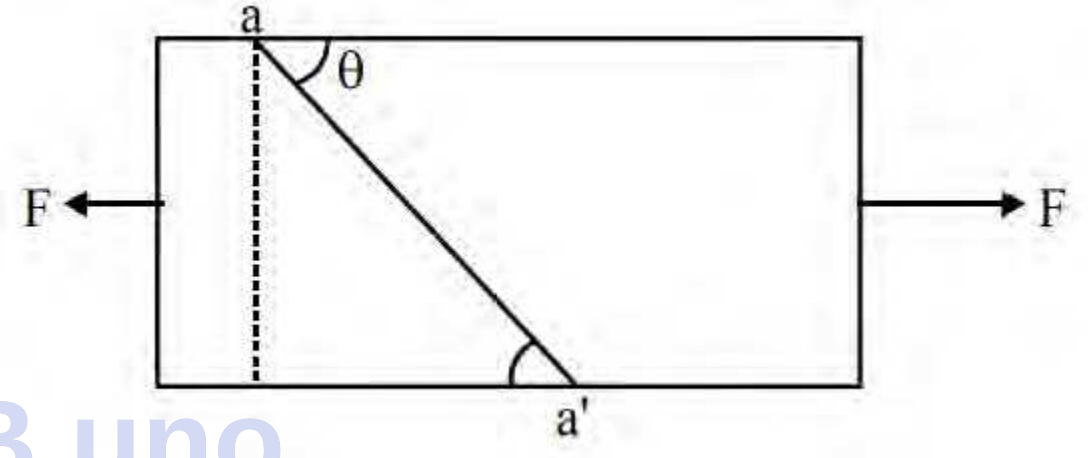




Ans. (B)

Consider a long steel bar under a tensile stress due to forces F acting at the edges along the length of the bar (Fig.). Consider a plane making an angle θ with the length. What are the tensile and shearing stresses on this plane?

(a) For what angle is the tensile stress a maximum?
(b) For what angle is the shearing stress a maximum?



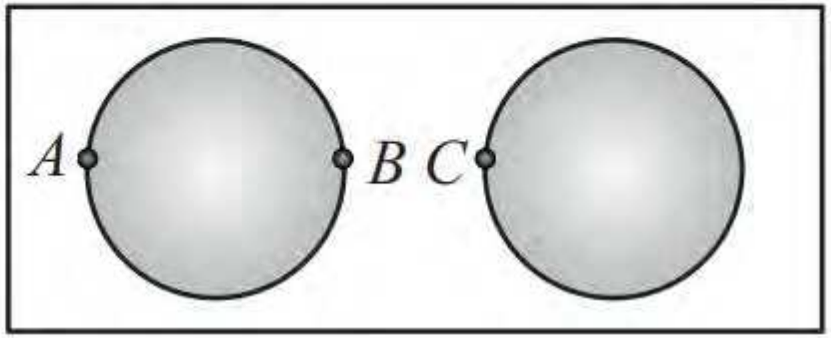
Ans. (a) $\theta = \frac{\pi}{2}$ (b) $\theta = \pi/4$.

When a building is constructed at 10°C, steel beam (cross sectional area 100 cm^2) is put in place with its ends cemented in pillars. If the sealed ends cannot move, what will be the compressional force in the beam when the temperature is 110^0C? For steel $Y = 2 \times 10^{11}\ Nm^{-2}$, $\alpha = 1.2 \times 10^{-5}\ {}^0C^{-1}$

(A) $1.2 \times 10^6 N$ (B) $2.4 \times 10^5 N$ (C) $2.4 \times 10^6 N$ (D) $3.6 \times 10^5 N$

Ans. (C)

Two large holes are cut in a metal sheet. If this is heated, distances AB and BC, (as shown)



(*a*) Both will increase

(*b*) Both will decrease

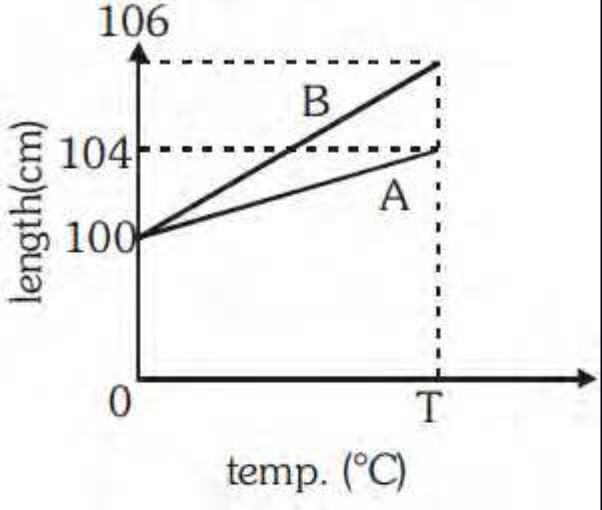
(*c*) AB increases, BC decreases

(*d*) AB decreases, BC increases

Ans. (a)

The variation of lengths of two metal rods A and B with change in temperature are shown in figure. The ratio of $\frac{\alpha_A}{\alpha_B}$ is

(A) $\frac{3}{2}$ (B) $\frac{2}{3}$ (C) $\frac{4}{3}$ (D) $\frac{3}{4}$



Ans. (B)

The temperature of earth is maintained by a dynamic equilibrium between Sun and Earth. Sun & Earth can be assumed to be black bodies :

(A) If the power output of sun would double with changing the temperature, equilibrium temperature of earth also doubles.

(B) If the radius of sun doubles without changing its' power, its surface temperature would decrease by factor of $\sqrt{2}$.

(C) If the radius of earth doubles without any change in sun, it's equilibrium temperature would increase by factor of $\sqrt{2}$.

(D) If the distance between earth and sun would decrease by a factor of 2, the equilibrium temperature of earth would increase by factor of $\sqrt{2}$.

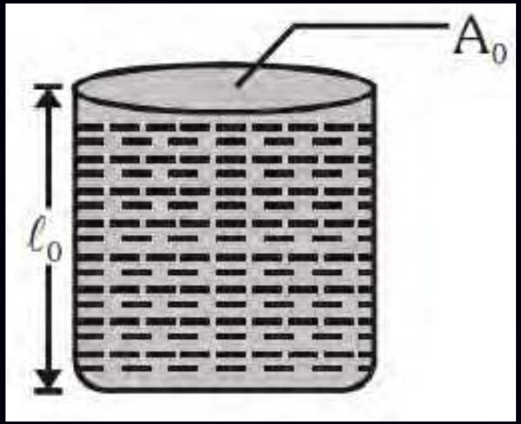
Ans. (B, D)

A clock with a metallic pendulum is 5 seconds fast each day at a temperature of 15°C and 10 seconds slow each day at a temperature of 30°C. Find coefficient of linear expansion for the metal.

Ans. $\alpha = 2.31 \times 10^{-5}\ °C^{-1}$

The figure shows a glass tube (linear co-efficient of expansion is α) completely filled with a liquid of volume expansion co-efficient γ. On heating length of the liquid column does not change. Choose the correct relation between γ and α.

(A) $\gamma = \alpha$ (B) $\gamma = 2\alpha$ (C) $\gamma = 3\alpha$ (D) $\gamma = \frac{\alpha}{3}$



Ans. (B)

A thin copper rod rotates about an axis passing through its end and perpendicular to its length with a speed ω_0. The temperature of the copper rod is increased by 100° C. If the coefficient of linear expansion of copper is 2×10^{-5} / ° C, the percentage change in the angular speed of the rod is

(A) – 2% (B) – 4% (C) – 0.2% (D*) – 0.4%

Ans. (D)

50 gm ice at $-10^\circ C$ is mixed with 10gm steam at $100^\circ C$. When the mixture finally reaches its steady state inside a calorimeter of water equivalent 1.5 gm then : [Assume calorimeter was initially at $0^\circ C$, Take latent heat of vaporization of water = 540 cal/gm, Latent heat of fusion of water = 80 cal/gm and specific heat capacity of water = 1 cal/gm-°C, specific heat of ice = 0.5 cal/gm°C]

(A) Mass of water remaining is 60 gm
(B) Mass of ice remaining is 3 gm
(C) Mass of steam remaining is 1.20 gm
(D) Final temperature is between $0^\circ C$ and $100^\circ C$

Ans. (A, D)

Two spherical black-bodies A and B, having radii r_A and r_B, where $r_B = 2r_A$ emit radiations with peak intensities at wavelengths 400 nm and 800 nm respectively. If their temperature are T_A and T_B respectively in Kelvin scale, their emissive powers are E_A and E_B and energies emitted per second are P_A and P_B then:

(A) $T_A / T_B = 2$ (B) $P_A / P_B = 4$ (C) $E_A / E_B = 8$ (D) $E_A / E_B = 4$

Ans. (A, B)

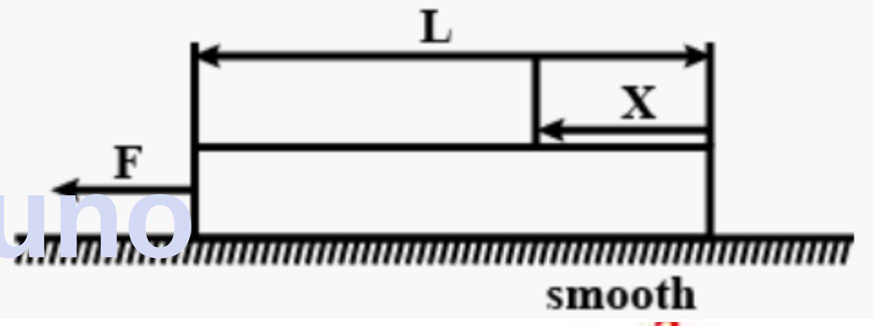
A rod of mass m, uniform cross sectional area A and length L is accelerated by applying force F as shown in figure on a smooth surface. If Young's modulus of elasticity of the material of rod is Y. (Consider x as measured from the right end)

(A) Tension in rod as a function of distance x is $\frac{Fx}{2L}$

(B) Strain in rod is $\frac{F}{2AY}$

(C) Elastic potential energy stored in the rod is $\frac{F^2L}{8AY}$

(D) There is no stress in rod.



A thin steel ring of inner radius r and cross-sectional area A is fitted on to a wooden disc of radius R (R > r). If Young's modulus be Y, then the tension in the steel ring is :-

(A) $AY\left(\frac{R}{r}\right)$ (B*) $AY\left(\frac{R-r}{r}\right)$ (C) $\frac{Y}{A}\left(\frac{R-r}{r}\right)$ (D) $\frac{Yr}{AR}$

Ans. (B)

Two spherical black bodies A and B, having radii r_A and r_B, where $r_B = 2r_A$ emit radiations with peak intensities at wavelengths 400 nm and 800 nm respectively. If their temperature are T_A and T_B respectively in Kelvin scale, their emissive powers are E_A and E_B and energies emitted per second are P_A and P_B then:

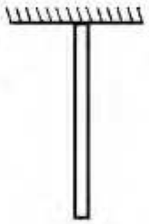
(A*) $T_A / T_B = 2$ (B*) $P_A / P_B = 4$ (C) $E_A / E_B = 8$ (D) $E_A / E_B = 4$

Ans. (A, B)

A steel cylindrical rod of length l and radius r is suspended by its end from the ceiling. Young's modulus of steel is Y. Density of steel is ρ. The elastic deformation energy of the rod is U. The value of $\pi\rho^2 l^3 r^2 g^2 / UY$ is

Ans. (6)

A uniform steel wire hangs from the ceiling and elongates due to its own weight. The ratio of elongation of the upper quarter of the wire to the elongation of the lower quarter of the wire is



(A) $\frac{1}{7}$ (B) $\frac{1}{3}$ (C) $\frac{2}{3}$ (D*) $\frac{7}{1}$

Ans. (D)

50 g of ice at −40 °C is mixed with 50 g of steam at 120 °C. Neglect any heat exchange with the surroundings. What is the final temperature(°C) of the mixture?

(Specific heats of ice, water, and steam are 0.50, 1.00, and 0.481 cal (g °C)$^{-1}$, respectively. The latent heat of fusion of ice is 79.8 cal/g. The latent heat of vaporization of steam is 540 cal/g.)

(A) 35.16 (B) 50.27 (C) 67.45 (D) 100

Ans. (D)

A cube of side "a" has a spherical cavity of radius "a/2" in the centre filled completely with a liquid. The coefficient of linear expansion of material of cube is one-third of the coefficient of cubical expansion of liquid. After heating the cube and liquid by same temperature, the volume of cavity left vacant of liquid is :-

(A) $\frac{\pi a^3}{4}$ (B) $\frac{3\pi a^3}{4}$ (C) $\frac{4\pi a^3}{3}$ (D*) 0

Ans. (D)

A column of liquid of length L is in a uniform capillary tube. The temperature of the tube and column of liquid is raised by ΔT. If γ be the coefficient of volume expansion of the liquid and α be the coefficient of linear expansion of the material of the tube, then the increase ΔL in the length of the column will be.

(A) $\Delta L = L(\gamma - \alpha)\Delta T$

(B) $\Delta L = L(\gamma - 2\alpha)\Delta T$

(C) $\Delta L = L(\gamma - 3\alpha)\Delta T$

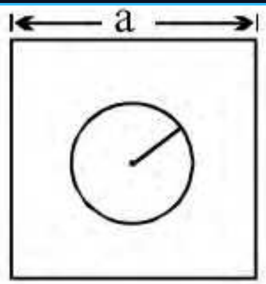
(D) $\Delta L = L\gamma\Delta T$

Ans. (B)

A square plate of a metal has a circular hole with centre at centre of plate. Side length of plate is a and radius of hole is a/2. Now temperature of the plate is changed by ΔT. Coefficient of linear expansion for material of plate is α. Find

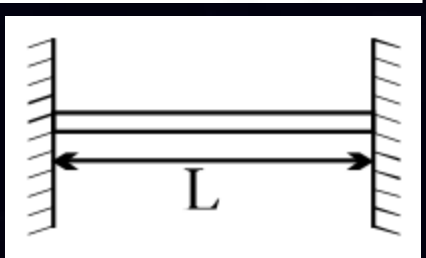
(a) the new area of hole.

(b) the ratio of the area of hole and plate in final situation.



A uniform rod having length L, is made of material having density ρ and young's modulus Y. It is placed between two vertical walls having separation L and coefficient of friction μ. What minimum thermal strain should be generated in the rod by heating it so that it does not fall down on releasing.

(A) $\frac{L\rho g}{Y\mu}$ (B) $\frac{2L\rho g}{Y\mu}$ (C*) $\frac{L\rho g}{2Y\mu}$ (D) None



Ans. (C)

of specific heat 0.2 cal g^{-1} $(C°)^{-1}$ is dropped into A and a 5 gm piece of metal Y into B. The equilibrium temperature in A is 22°C and in B 23°C. The initial temperature of both the metals is 40°C. Find the specific heat of metal Y in cal g^{-1} $(C°)^{-1}$.

Ans. 27/85

The temperature of 100 gm of water is to be raised from 24 °C to 90 °C by adding steam to it. Calculate the mass of the steam required for this purpose.

Ans. 12 gm

A black body has maximum wavelength λ_m at temperature 2000 K. Its corresponding wavelength at temperature 3000 K will be

(a) $\frac{3}{2}\lambda_m$ (b) $\frac{2}{3}\lambda_m$ (c) $\frac{4}{9}\lambda_m$ (d) $\frac{9}{4}\lambda_m$

Ans. (b)

A black body radiates energy at the rate of E W/m^2 at a high temperature TK. When the temperature is reduced to $\frac{T}{2}$K, the radiant energy will be

(a) $\frac{E}{16}$ (b) $\frac{E}{4}$

(c) $4E$ (d) $16E$

Ans. (a)

Two spheres P and Q, of same colour having radii 8 cm and 2 cm are maintained at temperatures 127°C and 527°C respectively. The ratio of energy radiated by P and Q is

(*a*) 0.054 (*b*) 0.0034

(*c*) 1 (*d*) 2

Ans. (c)

If two rods of length L and $2L$ having coefficients of linear expansion α and 2α respectively are connected so that total length becomes $3L$, the average coefficient of linear expansion of the composition rod equals:

(a) $\frac{3}{2}\alpha$

(b) $\frac{5}{2}\alpha$

(c) $\frac{5}{3}\alpha$

(d) None of these

Ans. (c)

A bullet of mass 70 gm traveling at 250 m/s strikes and gets embedded in ice at 0°C. Assuming that temperature of bullet does not change, find the amount of ice that melts.

(a) $\frac{2}{127}$ kg

(b) $\frac{3}{424}$ kg

(c) $\frac{5}{768}$ kg

(d) $\frac{7000}{256}$ kg

Ans. (C)

A block of ice with mass m falls into a lake. After impact, a mass of ice $\left(\frac{m}{5}\right)$ melts. Both the block of ice and the lake have a temperature of 0°C. If L represents the heat of fusion, the minimum distance the ice fell before striking the surface is

(a) $\frac{L}{5g}$ (b) $\frac{5L}{g}$

(c) $\frac{gL}{5m}$ (d) $\frac{mL}{5g}$

Ans. (a)

The density of a material A is 1500 kg/m^3 and that of another mateial B is 2000 kg/m^3. It is found that the heat capacity of 8 volumes of A is equal to heat capacity of 12 volumes of B. The ratio of specific heats of A and B will be

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

Ans. (d)

The specific heat of a solid at low temperature varies according to the relation $c = kT^3$ where k is a constant and T is temperature in kelvin. The heat required to raise the temperature of a mass m of such a solid from $T = 0$ K to $T = 20$ K is :

(a) $2 \times 10^4\, mk$ (b) $4 \times 10^4\, mk$

(c) $8 \times 10^4\, mk$ (d) $16 \times 10^4\, mk$

Ans. (b)

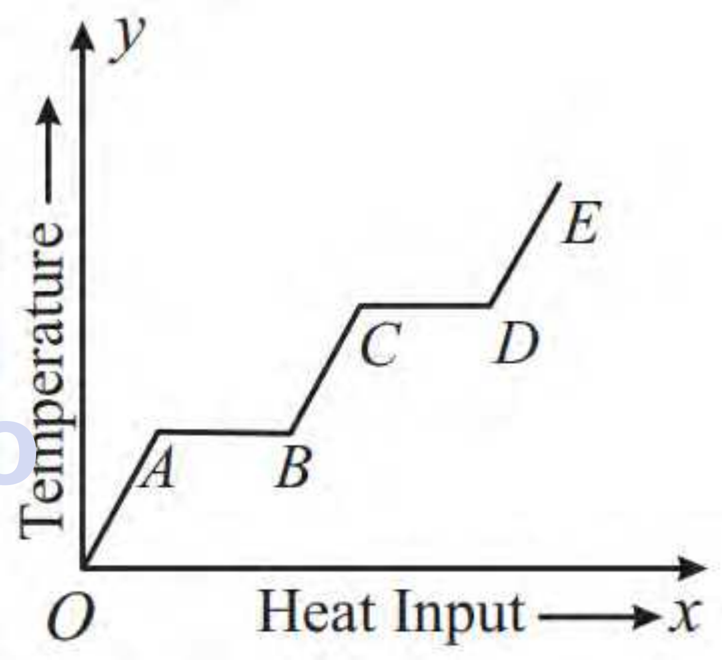
A solid material is supplied with heat at a constant rate. The temperature of material is changing with heat input as shown in the figure. What does slope DE represent?

(a) Latent heat of liquid

(b) Latent heat of vapour

(c) Heat capacity of vapour

(d) Inverse of heat capacity of vapour



Ans. (d)

The temperature drop through each layer of two layer furnace wall is shown in figure. Assume that the external temperature T_1 and T_3 are maintained constant and $T_1 > T_3$. If the thickness of the layers x_1 and x_2 are the same, which of the following statements are correct.

Ans. (*)

the wires has a length of 1m at 10°C. Now the end P is maintained at 10°C, while the end S is heated and maintained at 400°C. The system is thermally insulated from its surroundings. If the thermal conductivity of wire PQ is twice that of the wire RS and the coefficient of linear thermal expansion of PQ is $1.2 \times 10^{-5}\ K^{-1}$, the change in length of the wire PQ is

एक पतले तार PQ के छोर Q को अन्य पतले तार RS के छोर R पर टांका लगाकर जोड़ा गया है। 10°C पर दोनों तारों की लम्बाई 1m है। अब इस निकाय के छोर P तथा छोर S को क्रमशः 10°C तथा 400°C पर स्थिर रखा जाता है। यह निकाय चारों ओर से ऊष्मारोधी है। यदि तार PQ की ऊष्म चालकता तार RS की ऊष्म चालकता से दुगुनी है तथा तार PQ का रेखीय ऊष्मित वृद्धि गुणांक $1.2 \times 10^{-5}\ K^{-1}$ है, तब तार PQ की लम्बाई में परिवर्तन का मान है :- **[JEE-Advance-2016]**

(A) 0.78 mm (B) 0.90 mm (C) 1.56 mm (D) 2.34 mm

Parallel rays of light of intensity $I = 912\ Wm^{-2}$ are incident on a spherical black body kept in surroundings of temperature 300 K. Take Stefan-Boltzmann constant $\sigma = 5.7 \times 10^{-8}\ Wm^{-2}\ K^{-4}$ and assume that the energy exchange with the surroundings is only through radiation. The final steady state temperature of the black body is close to :- **[JEE-Advance-2014]**

एक गोलाकार कृष्णिका को 300 K तापमान वाले वातावरण में रखा गया है। इस पर प्रकाश की समान्तर किरणें, जिनकी तीव्रता $I = 912\ Wm^{-2}$ है, आपतित है। स्टीफन बोल्ट्ज़मान नियतांक $\sigma = 5.7 \times 10^{-8}\ Wm^{-2}\ K^{-4}$ का मान लेकर यह मानते हुए कि ऊर्जा का आदान प्रदान सिर्फ विकिरण द्वारा ही हो रहा है, कृष्णिका का स्थायी अवस्था में तापमान लगभग है :

(A) 330 K (B) 660 K (C) 990 K (D) 1550 K

Level 2

JM

QUESTION

Find the quantity of heat required to convert 40 g of ice at –20°C into water at 20°C. Given L_{ice} = 0.336 × 10^6 J/kg. Specific heat of ice = 2100 J/kg-K, specific heat of water = 4200 J/kg-K.

Ans. (18480 J)

QUESTION

An aluminium container of mass 100 gm contains 200 gm of ice at –20°C. Heat is added to the system at the rate of 100 cal/s. Find the temperature of the system after 4 minutes (specific heat of ice = 0.5 and L = 80 cal/gm, specific heat of Al = 0.5 cal/gm/°C)

Ans. (25.5°C)

QUESTION

The temperature of 100 gm of water is to be raised from 24°C to 90°C by adding steam to it. Calculate the mass of the steam required for this purpose.

Ans. (12 gm)

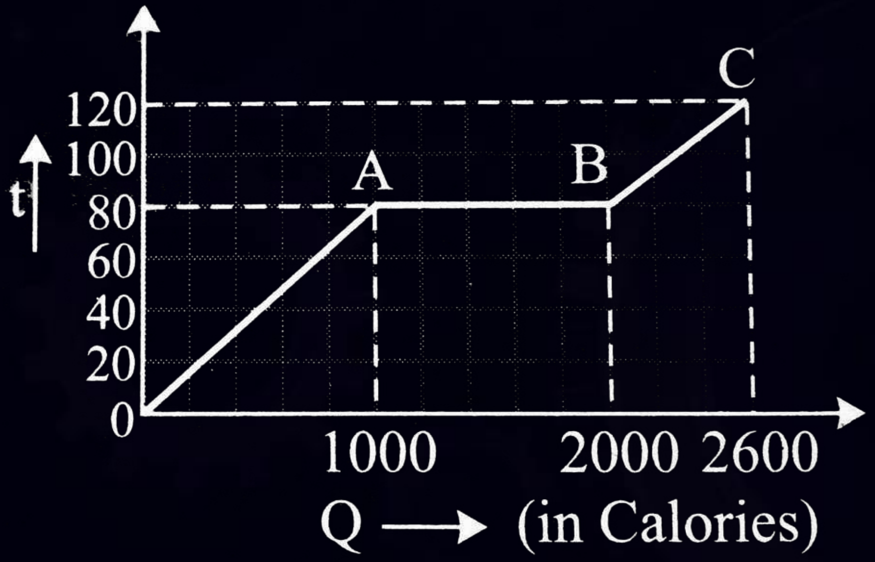
QUESTION

A substance is in the solid form at 0°C. The amount of heat added to this substance and it temperature are plotted in the following graph. If the relative specific heat capacity of the solid substance is 0.5, find from the graph.

(i) The mass of the substance;

(ii) The specific latent heat of the melting process, and

(iii) The specific heat of the substance in the liquid state.



Ans. (i) 0.02 kg, (ii) 40,000 cal kg^{-1}, (iii) 750 cal kg^{-1}K^{-1}

QUESTION

A block of mass 2.5 kg is heated to temperature of 500°C and placed on a large ice block. What is the maximum amount of ice that can melt (approx.). Specific heat for the body = 0.1 Cal/gm°C.

1. 1 kg
2. 1.5 kg
3. 2 kg
4. 2.5 kg

Ans. (2)

QUESTION

10 gm of ice at 0°C is kept in a calorimeter of water equivalent 10 gm. How much heat should be supplied to the apparatus to evaporate the water thus formed? (Neglect loss of heat).

1. 6200 cal
2. 7200 cal
3. 13600 cal
4. 8200 cal

Ans. (D)

QUESTION

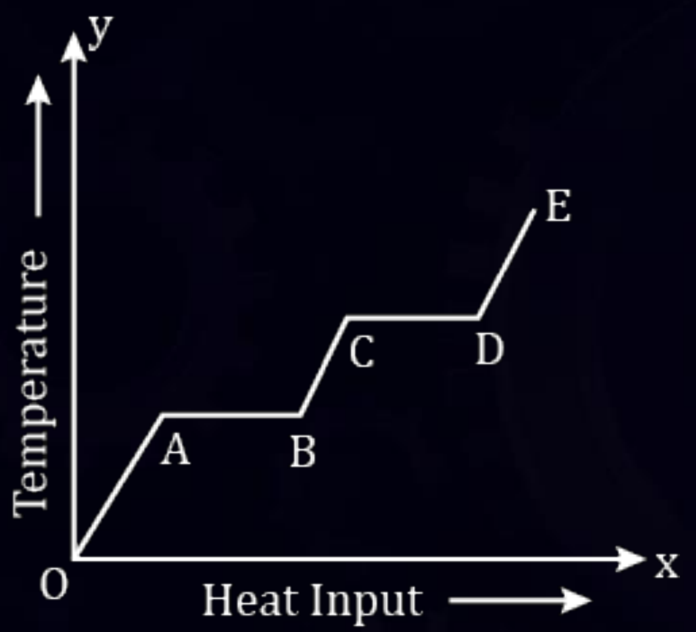
A continuous flow water heater (geyser) has an electrical power rating = 2 kW and efficiency of conversion of electrical power into heat = 80%. If water is flowing through the device at the rate of 100 cc/sec, and the inlet temperature is 10°C, the outlet temperature will be.

1. 12.2 °C
2. 13.8 °C
3. 20 °C
4. 16.5 °C

QUESTION

A solid material is supplied with heat at a constant rate. The temperature of material is changing with heat inpur as shown in the figure. What does slop DE represents?

1. Latent heat of liquid
2. Latent heat of vapour
3. Heat capacity of vapour
4. Inverse of heat capacity of vapour



QUESTION

A block of ice with mass m falls into a lake. After impact a mass of ice m/5 melts. Both the block of ice and the lake have a temperature of 0°C. If L represents the heat of fusion, the minimum distance the ice fell before striking the surface is.

1. L/5g
2. 5L/g
3. gL/5m
4. mL/5g

Ans. (A)

QUESTION

The specific heat of a metal at low temperatures varies according to $S = aT^3$ where a is a constant at T is the absolute temperature. The heat energy needed to raise unit mass of the metal from $T = 1K$ to $T = 2\ K$ is-

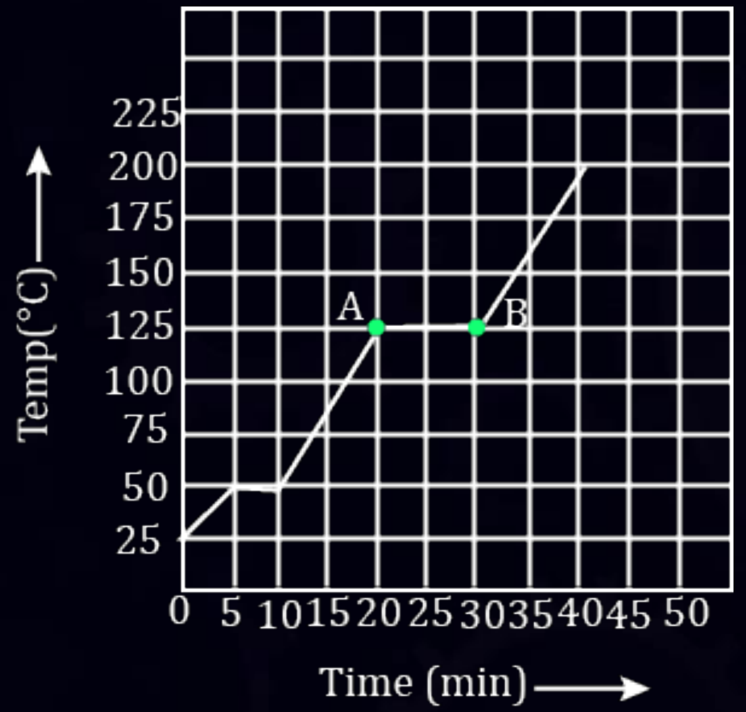
1. $3a$
2. $15a/4$
3. $2a/3$
4. $12a/5$

Ans. (B)

QUESTION

The graph shown in the figure represent change in the temperature of 5 kg of a substance as it absorbs heat at a constant rate of 42 kJ min^{-1}. The latent heat of vaporazation of the substance is:

1. 630 kJ kg^{-1}
2. 126 kJ kg^{-1}
3. 84 kJ kg^{-1}
4. 12.6 kJ kg^{-1}



Ans. (C)

QUESTION

The density of a material A is 1500 kg/m^3 and that of another material B is 2000 kg/m^3. It is found that the heat capacity of 8 volumes of A is equal to heat capacity of 12 volumes of B. The ratio of specific heats of A and B will be.

1. 1 : 2
2. 3 : 1
3. 3 : 2
4. 2 : 1

Ans. (D)

QUESTION

M grams of steam at 100°C is mixed with 200 g of ice at its melting point in a thermally insulated container. If it produces liquid water at 40°C [heat of vaporization of water is 540 cal/g and heat of fusion of ice is 80 cal/g], the value of M is____. **[JEE Mains 2020]**

Ans. (40)

QUESTION

A calorimeter of water equivalent 20 g contains 180 g of water at 25°C 'm' grams of steam at 100°C is mixed in it till the temperature of the mixture is 31°C. The value of 'm' is close to (Latent heat of water = 540 cal g^{-1}, specific heat of water = 1 cal g^{-1} $°C^{-1}$)

[JEE Mains 2020]

1. 2.6
2. 2
3. 4
4. 3.2

Ans. (2)

QUESTION

The specific heat of water = 4200 J kg^{-1} K^{-1} and the latent heat of ice = 3.4×10^5 J kg^{-1}. 100 grams of ice at 0°C is placed in 200 g of water at 25°C. The amount of ice that will melt as the temperature of water reaches 0°C is close to (in grams): **[JEE Mains 2020]**

1. 61.7
2. 63.8
3. 69.3
4. 64.6

Ans. (A)

QUESTION

A bullet of mass 5g, travelling with a speed of 210 m/s, strikes a fixed wooden target. One half of its kinetic energy is converted into heat in the bullet while the other half is converted into heat in the wood. The rise of temperature of the bullet if the specific heat of it material is 0.030 cal/(g–°C) (1 cal = 4.2×10^7 ergs) close to: **[JEE Mains 2020]**

1. 83.3 °C
2. 87.5 °C
3. 119.2 °C
4. 38.4 °C

Ans. (B)

QUESTION

A block of ice of mass 120 g. At temperature 0°C put in 300 gm of water at 25°C. The *xg* of ice melts as the temperature of the water reaches 0°C. The value of *x* is. [Use: Specific heat capacity of water = 4200 $Jkg^{-1}K^{-1}$, latent heat of ice = 3.5×10^5 Jkg^{-1}]

[JEE Mains 2022]

Ans. (90)

QUESTION

A 100 g of iron nail is hit by a 1.5 kg hammer striking at a velocity of 60 ms^{-1}. What will be the rise in the temperature of the nail if one fourth of energy of the hammer goes into heating the nail? [Specific heat capacity of iron = 0.42 $Jg^{-1}°C^{-1}$]

[JEE Mains 2022]

1. 675 °C
2. 1600 °C
3. 16.07 °C
4. 6.75 °C

Ans. (C)

QUESTION

A steam engine intakes 50g of steam at 100°C per minute and cools it down to 20°C. If latent heat of vaporization of steam is 540 cal g^{-1}, then the heat rejected by the steam engine per minute is_______$\times 10^3$cal. **[JEE Mains 2022]**

Ans. (31)

QUESTION

A copper block of mass 5.0 kg is heated to a temperature of 500°C and is placed on a large ice block. What is the maximum amount of ice that can melt?
[Specific heat of copper: 0.39 $Jg^{-1}°C^{-1}$ and latent heat of fusion of water: 335 J g^{-1}]

[JEE Mains 2022]

1. 1.5 kg
2. 5.8 kg
3. 2.9 kg
4. 3.8 kg

Ans. (C)

QUESTION

A lead bullet penertrates into a solid object and melts. Assuming that 40% of its kinetic energy is used to heat it, the initial speed of bullet is:
(Given, initial temperature of the bullet = 127°C, Melting point of the bullet = 327°C, latent heat of fusion of lead = 2.5 × 104J kg^{-1}, Specific heat capacity of lead = 125J/kg K)

[JEE Mains 2022]

1. 125 ms^{-1}
2. 500 ms^{-1}
3. 250 ms^{-1}
4. 600 ms^{-1}

Ans. (B)

QUESTION

100 g of water is heated from 30°C to 50°C Ignoring the slight expansion of the water, the change in its internal energy is (specific heat of water is 4184 J/kg/K): **[AIEEE 2011]**

1. 84 kJ
2. 2.1 kJ
3. 4.2 kJ
4. 8.4 J

Ans. (4)

QUESTION

A copper ball of mass 100 gm is at a temperature T. It is dropped in a copper calorimeter of mass 100 gm, filled with 170 gm of water at room temperature. Subsequently, the temperature of the system is found to be 75°C, T is given by: (Given: room temperature = 30°C, specific heat of copper = 0.1 cal/gm°C)

[JEE Main 2017]

1. 1250 °C
2. 825 °C
3. 800 °C
4. 885 °C

Ans. (4)

QUESTION

2 litre water at 27°C is heated by a 1 kW heater in an open container. On an average heat is lost to surroundings at the rate 160 J/s. The time required for the temperature to reach 77°C is. **[JEE 2005 (Scr)]**

1. 8 min 20 sec
2. 10 min
3. 7 min
4. 14 min

Ans. (1)

QUESTION

1 calorie is the heat required to increased the temperature of 1 gm of water by 1°C from **[JEE 2005 (Scr)]**

1. 13.5 °C to 14.5 °C at 76 mm of Hg
2. 14.5 °C to 15.5 °C at 760 mm of Hg
3. 0 °C to 1 °C at 760 mm of Hg
4. 3 °C to 4 °C to 760 mm of Hg

Ans. (2)

QUESTION

In an insulated vessel, 0.05 kg steam at 372 K and 0.45 kg of ice at 253 K are mixed. Then, find the final temperature of the mixture.

Given, L_{fusion} = 80 cal/g = 336 J/g, $L_{vaporizaton}$ = 540 cal/g = 2268 J/g, S_{ice} = 2100 J/kg K = 0.5 cal/g K and S_{water} = 4200 J/kg K = 1 cal/g K **[JEE 2006]**

Ans. (273 K)

QUESTION

A piece of ice (heat capacity = 2100 J $kg^{-1}°C^{-1}$ and latent heat = 3.36×10^5 J kg^{-1}) of mass m grams is at –5°C at atmospheric pressure. It is given 420 J of heat so that the ice starts melting. Finally when the ice-water mixture is in equilibrium, it is found that 1 gm of ice has melted. Assuming there is no other heat exchange in the process, the value of m is. **[JEE 2010]**

Ans. (8)

Level 3

JA PYQ

1. A metal rod AB of length 10x has its one end A in ice at 0°C and the other end B in water at 100°C. If a point P on the rod is maintained at 400°C, then it is found that equal amounts of water and ice evaporate and melt per unit time. The latent heat of evaporation of water is 540 cal/g and latent heat of melting of ice is 80 cal/g. If the point P is at a distance of λx from the ice end A, find the value of λ.[Neglect any heat loss to the surrounding] **[JEE 2009]**

10x लम्बाई वाली धात्विक छड़ AB का एक सिरा A, 0°C ताप वाले बर्फ में तथा दूसरा सिरा B, 100 °C ताप वाले पानी में है। यदि छड़ पर एक बिन्दु P को 400 °C पर रखा जाता है तो यह पाया जाता है कि प्रति एकांक समय में पानी तथा बर्फ की समान मात्रा वाष्पित होती है तथा गलती है। पानी के वाष्पन की गुप्त ऊष्मा 540 cal/g तथा बर्फ के गलन की गुप्त ऊष्मा 80 cal/g है। यदि बिन्दु P बर्फ वाले सिरे A से λx दूरी पर है तो λ का मान ज्ञात कीजिए। (परिवेश के कारण किसी प्रकार की ऊष्मा हानि को नगण्य मानिये।)

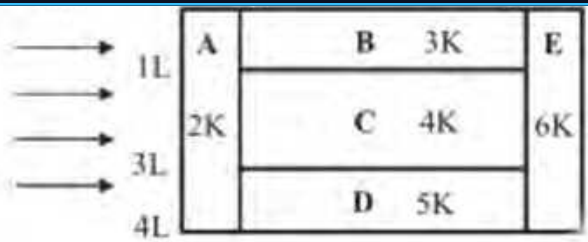
The maximum intensity in the emission spectrum of A is at 500 nm and in that of B is at 1500 nm. Considering then to be black bodies, what will be the ratio of the rate of total energy radiated by A to that of B? **[JEE 2010]**

दो गोलाकार पिण्ड A (त्रिज्या 6 cm) तथा B (त्रिज्या 18 cm) क्रमशः T_1 तथा T_2 तापमान पर है। उनके उत्सर्जन स्पेक्ट्रम की अधिकतम तीव्रता A के लिए 500 nm पर तथा B के लिए 1500 nm पर है। इन पिण्डों को कृष्णिका मानते हुए A तथा B से कुल ऊर्जा उत्सर्जन का अनुपात क्या होगा?

is at –5°C at atmospheric pressure. It is given 420 J of heat so that the ice starts melting. Finally when the ice–water mixture is in equilibrium, it is found that 1 gm of ice has melted. Assuming there is no other heat exchange in the process, the value of m is **[JEE 2010]**

m ग्राम द्रव्यमान का बर्फ का टुकड़ा (विशिष्ट ऊष्मा = 2100 J kg^{-1} $°C^{-1}$ तथा गुप्त ऊष्मा = 3.36×10^5 J kg^{-1}) वायुमण्डलीय दाब पर –5°C पर रखा है। इसे 420 J ऊष्मा दी जाती है जिससे यह पिघलना शुरू हो जाती है। अन्त में जब बर्फ–पानी का मिश्रण साम्यावस्था में है, तब यह पाया जाता है कि 1 ग्राम बर्फ पिघल चुकी है। यह मानते हुए कि इस प्रक्रिया में किसी अन्य ऊष्मा का आदान प्रदान नहीं हुआ है, m का मान (ग्राम में) होगा :- **[JEE 2010]** cross–sectional area is $4.9 \times 10^{-7}\ m^2$. If the mass is pulled a little in the vertically downward direction and released, it performs simple harmonic motion of angular frequency 140 rad s^{-1}. If the Young's modulus of the material of the wire is $n \times 10^9\ Nm^{-2}$, the value of n is **[IIT-JEE 2010]**

0.1 kg का एक द्रव्यमान नगण्य द्रव्यमान वाले एक तार से लटका है। इस तार की लम्बाई 1m तथा इसके अनुप्रस्थ परिच्छेद का क्षेत्रफल $4.9 \times 10^{-7}\ m^2$ है। यदि इस द्रव्यमान को थोड़ा सा उर्ध्वाधर नीचे की ओर खींचकर छोड़ा जाये तो यह 140 rad s^{-1} कोणीय आवृत्ति वाली सरल आवर्त गति करता है। यदि तार के पदार्थ का यंग प्रत्यास्थता गुणांक $n \times 10^9$ Nm^{-2} हो तो n का मान क्या होगा ? **[IIT-JEE 2010]** thermal conductivities (given in terms of a constant K) and sizes (given in terms of length, L) as shown in the figure. All slabs are of same width. Heat 'Q' flows only from left to right through the blocks. Then in steady state **[JEE 2011]**



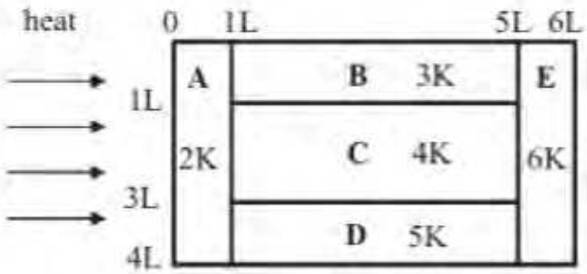
(A) heat flow through A and E slabs are same

(B) heat flow through slab E is maximum

(C) temperature difference across slab E is smallest

(D) heat flow through C= heat flow through B + Heat flow through D

अलग-अलग तापचालकाताओं (K के मात्रक में) तथा अलग-अलग आकारों (L के मात्रक में) के A, B, C, D तथा E स्लैबों (slabs) को चित्र में दर्शाये गये अनुसार जोड़ा गया है। सब स्लैबों की चौड़ाई समान है। ऊष्मा 'Q' का चालन सिर्फ A से E की दिशा में है। तब साम्यावस्था में



(A) A व E स्लैबों में से चालित ऊष्मा बराबर है।

(B) अधिकतम ऊष्मा चालन स्लैब E में से है।

(C) न्यूनतम तापमान-अंतर E स्लैब के फलकों के बीच है।

(D) C में से ऊष्मा चालन = B में से ऊष्मा चालन +D में से ऊष्मा चालन

free end. The wire is cooled down from 40° to 30° C to regain its original length 'L'. The coefficient of linear thermal expansion of the steel is 10^{-5}/°C, Young's modulus of steel is 10^{11} N/m^2 and radius of the wire is 1 mm. Assume that L>> diameter of the wire. Then the value of 'm' in kg is nearly

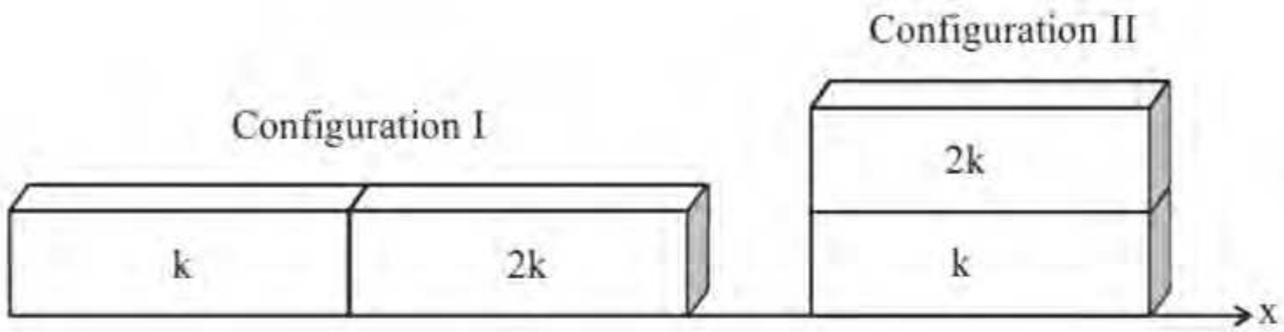
'L' लम्बाई की स्टील-तार, जो 40°C तापमान पर है, को छत से लटकाकर उसके मुक्त सिरे पर द्रव्यमान 'm' संलग्न किया जाता है। अब तार को ठंडा करके उसका तापमान 40° से 30° C लाने पर उसकी लम्बाई फिर से 'L' हो जाती है। स्टील का तापीय-प्रसार गुणांक 10^{-5}/°C है, यंग्स-माडलस 10^{11} N/m^2 है तथा तार की त्रिज्या 1 mm है। मानें कि L>> तार का व्यास 'm' का kg में मान लगभग है **[JEE 2011]** ideal black surfaces and have very high thermal conductivity. The first and third plates are maintained at temperatures 2T and 3T respectively. The temperature of the middle (i.e. second) plate under steady state condition is **[JEE 2012]**

तीन बहुत बड़ी प्लेटें, जिनका क्षेत्रफल बराबर है, समांतर व एक दूसरे के पास रखी गयी हैं। उनको आदर्श–कृष्ण सतह मानें और उनकी ऊष्मा चालकता बहुत अधिक है। पहली और तीसरी प्लेटों को क्रमश: 2T व 3T तापमान पर रखा जाता है। स्थाई अवस्था में बीच की (अर्थात् दूसरी) प्लेट का तापमान है

(A) $\left(\frac{65}{2}\right)^{1/4} T$ (B) $\left(\frac{97}{4}\right)^{1/4} T$ (C*) $\left(\frac{97}{2}\right)^{1/4} T$ (D) $(97)^{1/4} T$

configuration II as shown in the figure. One of the blocks has thermal conductivity k and the other 2k. The temperature difference between the ends along the x-axis is the same in both the configurations. It takes 9s to transport a certain amount of heat from the hot end to the cold end in the configuration I. The time to transport the same amount of heat in the configuration II is :- **[JEE-Advance-2013]**

दो समरूपी आयताकार गुटकों को दर्शाये चित्रानुसार दो विन्यासों I और II में व्यवस्थित किया गया है। गुटकों की ऊष्मा चालकता k व 2k है। दोनों विन्यासों में x-अक्ष के दोनों छोरों पर तापमान का अन्तर समान है। विन्यास I में, ऊष्मा की एक निश्चित मात्रा गरम छोर से ठंडे छोर तक अभिगमन में 9s लेती है। विन्यास II में, समान मात्रा की ऊष्मा के अभिगमन के लिए समय है :-



horizontal thin copper wire of length L and radius R. When the arrangement is stretched by applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is :-

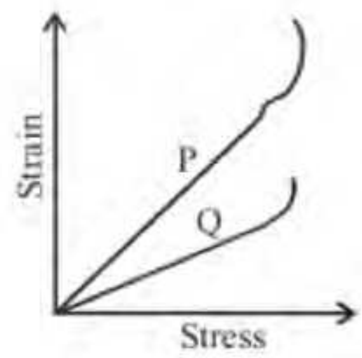
एक 2L लम्बाई व 2R त्रिज्या के मोटे क्षैतिज तार के एक सिरे को L लम्बाई व R त्रिज्या वाले एक पतले क्षैतिज तार से वेल्डिंग के द्वारा जोड़ा गया हे। इस व्यवस्था के दोनों सिरों पर बल लगाकर ताना जाता है। पतले वे मोटे तारों में दैर्ध्यवृद्धि का अनुपात निम्न है:- [JEE-Advance-2013] of temperature 300 K. Take Stefan-Boltzmann constant $\sigma = 5.7 \times 10^{-8}\ Wm^{-2}\ K^{-4}$ and assume that the energy exchange with the surroundings is only through radiation. The final steady state temperature of the black body is close to :- **[JEE-Advance-2014]**

एक गोलाकार कृष्णिका को 300 K तापमान वाले वातावरण में रखा गया है। इस पर प्रकाश की समान्तर किरणें, जिनकी तीव्रता $I = 912\ Wm^{-2}$ है, आपतित है। स्टीफन वोल्ट्जमान नियतांक $\sigma = 5.7 \times 10^{-8}\ Wm^{-2}\ K^{-4}$ का मान लेकर यह मानते हुए कि ऊर्जा का आदान प्रदान सिर्फ विकिरण द्वारा ही हो रहा है, कृष्णिका का स्थायी अवस्था में तापमान लगभग है:

(A) 330 K (B) 660 K (C) 990 K (D) 1550 K emits 10^4 times the power emitted from B. The ratio $\left(\frac{\lambda_A}{\lambda_B}\right)$ of their wavelengths λ_A and λ_B at which the peaks occur in their respective radiation curves is.

दो गोलाकार तारों A तथा B द्वारा कृष्णिका (ब्लैक-बॉडी) विकिरण उत्सर्जित किया जा रहा है। A की त्रिज्या B की त्रिज्या की 400 गुना है तथा A से उत्सर्जित ऊर्जा B से उत्सर्जित ऊर्जा की 10^4 गुना है। उसकी उन तरंगदैर्ध्यों λ_A और λ_B, जि पर उनके विकिरण वक्र उच्चतम हैं, के अनुपात $\left(\frac{\lambda_A}{\lambda_B}\right)$ का मान है। **[JEE-Advance-2015]** y-axis and stress on the x-axis as shown in the figure. Then the correct statement(s) is (are):-

[JEE-Advance-2015]



(A) P has more tensile strength than Q

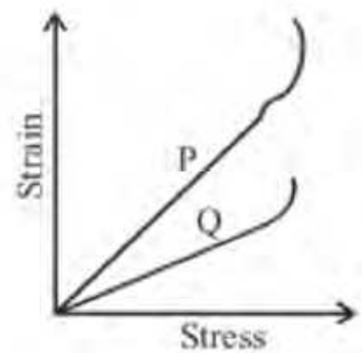
(B) P is more ductile than Q

(C) P is more brittle than Q

(D) The Young's modulus of P is more than that of Q

पदार्थों P तथा Q के प्रतिबल-विकृति (stress-strain) ग्राफ खींचने में छात्र गलती से y-अक्ष पर विकृति तथा x-अक्ष पर प्रतिबल दर्शाता है। तब सही कथन है (हैं)

[JEE-Advance-2015]



(A) P का तनन-सामर्थ्य (tensile strength) Q से अधिक है।

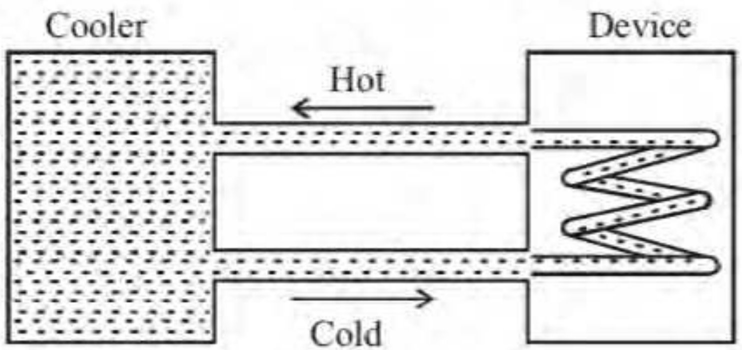
(B) पदार्थ P पदार्थ Q से अधिक तन्य (ductile) है।

(C) पदार्थ P पदार्थ Q से अधिक भंगुर (brittle) है।

(D) पदार्थ P का यंग प्रत्यास्थता गुणांक पदार्थ Q के यंग प्रत्यास्थता गुणांक से अधिक है।

circulation system (as shown schematically in the figure), the water from the cooler is used to cool an external device that generates constantly 3 kW of heat (thermal load). The temperature of water fed into the device cannot exceed 30°C and the entire stored 120 litres of water is initially cooled to 10°C. The entire system is thermally insulated. The minimum value of P (in watts) for which the device can be operated for 3 hours is : **[JEE-Advance-2016]**

120 लीटर क्षमता वाला पानी का एक कूलर समान दर P watts से पानी को ठंडा कर सकता है। एक बंद परिसंचरण में (जैसा व्यवस्था चित्र में दर्शाया गया है) कूलर के पानी से एक बाहरी यंत्र को ठंडा किया जाता है जो हमेशा 3 kW ऊष्मा उत्पन्न करता है। यंत्र को दिया गया पानी का तापमान 30°C से ज्यादा नहीं हो सकता एवं पूरा 120 लीटर पानी प्रारम्भ में 10°C तक ठंडा किया गया है। पूरा निकाय तापरोधी है। इस यंत्र को तीन घंटे तक चालू रखने के लिए कम से कम कितनी शक्ति P (watts में) की जरूरत है?



(Specific heat of water is 4.2 kJ kg^{-1} K^{-1} and the density of water is 1000 kg m^{-3})

(पानी की विशिष्ट ऊष्मा = 4.2 kJ kg^{-1} K^{-1} और पानी का घनत्व = 1000 kg m^{-3})

(A) 1600 (B) 2067 (C) 2533 (D) 3933

radiated (P) by the metal. The sensor has a scale that displays $\log_2(P/P_0)$, where P_0 is a constant. When the metal surface is at a temperature of 487 °C, the sensor shows a value 1. Assume that the emissivity of the metallic surface remains constant. What is the value displayed by the sensor when the temperature of the metal surface is raised to 2767 °C ? **[JEE-Advance-2016]**

एक धातु को भट्टी में गरम करते हुए उसकी विकिरण शक्ति (P) को धातु के ऊपर रखे हुए एक संवेदक (sensor) से पढ़ते है। संवेदक का पैमाना $\log_2(P/P_0)$ को पढ़ता है, यहाँ P_0 एक स्थिरांक है। जब धातु का तापमान 487°C है तो संवेदक का पठन 1 है। मान लीजिये कि धातु की सतह की उत्सर्जकता स्थिर है। धातु की सतह का तापमान 2767°C तक बढ़ाने पर संवेदक का पठन क्या होगा ?

wires has a length of 1m at 10°C. Now the end P is maintained at 10°C, while the end S is heated and maintained at 400°C. The system is thermally insulated from its surroundings. If the thermal conductivity of wire PQ is twice that of the wire RS and the coefficient of linear thermal expansion of PQ is $1.2 \times 10^{-5}\ K^{-1}$, the change in length of the wire PQ is

एक पतले तार PQ के छोर Q को अन्य पतले तार RS के छोर R पर टांका लगाकर जोड़ा गया है। 10°C पर दोनों तारों की लम्बाई 1m है। अब इस निकाय के छोर P तथा छोर S को क्रमशः 10°C तथा 400°C पर स्थिर रखा जाता है। यह निकाय चारों ओर से ऊष्मारोधी है। यदि तार PQ की ऊष्म चालकता तार RS की ऊष्म चालकता से दुगुनी है तथा तार PQ का रेखीय ऊष्मित वृद्धि गुणांक $1.2 \times 10^{-5}\ K^{-1}$ है, तब तार PQ की लम्बाई में परिवर्तन का मान है :-

[JEE-Advance-2016]

(A) 0.78 mm (B) 0.90 mm (C) 1.56 mm (D) 2.34 mm the surrounding room temperature T_0. Take the room temperature to be $T_0 = 300$ K. For $T_0 = 300$ K, the value of $\sigma T_0^4 = 460\ Wm^{-2}$ (where σ is the Stefan-Boltzmann constant). Which of the following options is/are **correct** ? **[JEE-Advance-2017]**

(A) The amount of energy radiated by the body in 1 second is close to 60 Joules

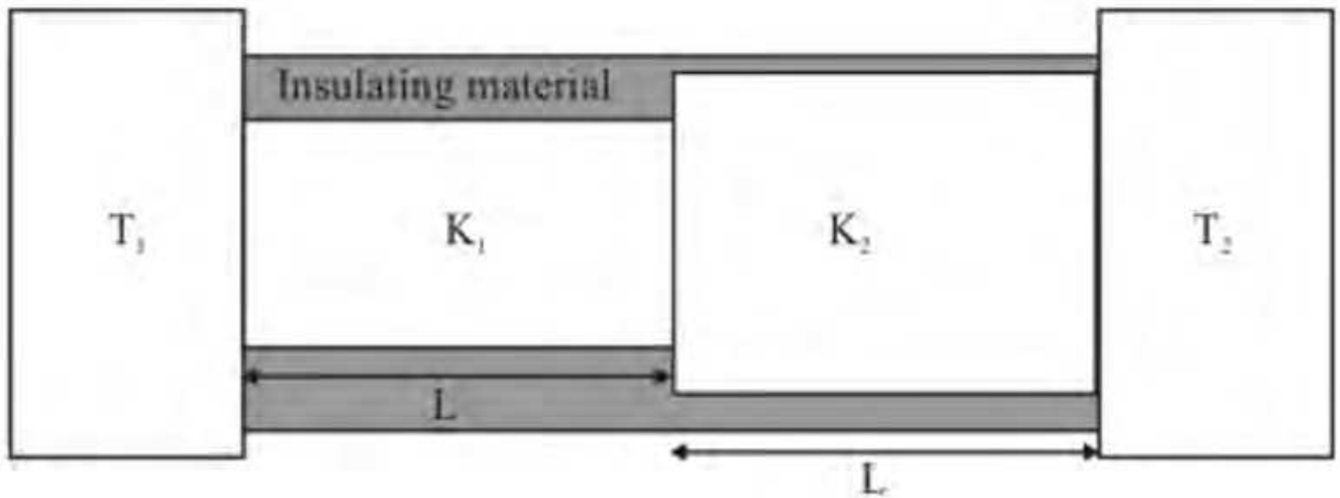
(B) If the surrounding temperature reduces by a small amount $\Delta T_0 << T_0$, then to maintain the same body temperature the same (living) human being needs to radiate $\Delta W = 4\sigma T_0^3 \Delta T_0$ more energy per unit time

(C) Reducing the exposed surface area of the body (e.g. by curling up) allows humans to maintain the same body temperature while reducing the energy lost by radiation

(D) If the body temperature rises significantly then the peak in the spectrum of electromagnetic radiation baths kept at temperatures $T_1 = 300$ K and $T_2 = 100$ K, as shown in the figure. The radius of the bigger cylinder is twice that of the smaller one and the thermal conductivities of the materials of the smaller and the larger cylinders are K_1 and K_2 respectively. If the temperature at the junction of the two cylinders in the steady state is 200 K, then K_1/K_2 = ________.

समान लंबाई परन्तु अलग-अलग त्रिज्याओं वाले दो बेलनाकार चालक (cylindrical conductors) श्रेणीक्रम में (in series) दो ऊष्माशयों (heat baths) के बीच में जोड़े गए हैं, जैसा कि चित्र में दर्शाया गया है। इन ऊष्माशयओं का तापमान $T_1 = 300$ K और $T_2 = 100$ K हैं। बड़े चालक की त्रिज्या छोटे चालक की त्रिज्या की दोगुनी है। छोटे चालक की ऊष्मा चालकता (thermal conductivity) K_1 है और बड़े चालक की ऊष्मा चालकता K_2 है। यदि स्थायी अवस्था (steady state) में, बेलनों के संधि (junction) का तापमान 200 K हो, तब K_1/K_2 का मान ________ होगा।

[JEE-Advance-2018]



(17)

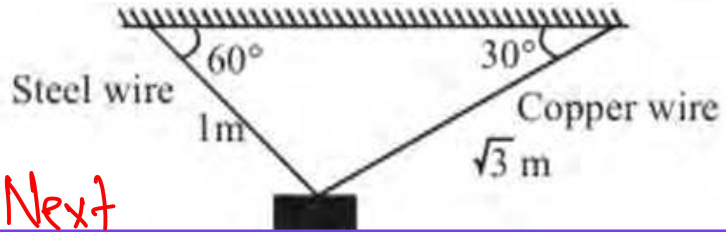
and, length $\sqrt{3}$ m and 1 m, respectively. Their other ends are fixed on a ceiling as shown in figure. The angles subtended by copper and steel wires with ceiling are 30° and 60°, respectively. If elongation in copper wire is $(\Delta\ell_C)$ and elongation in steel wire is $(\Delta\ell_S)$, then the ratio $\frac{\Delta\ell_C}{\Delta\ell_S}$ is ______.

[Young's modulus for copper and steel are 1×10^{11} N/m² and 2×10^{11} N/m² respectively]

एक 100 N भार वाले गुटके को ताँबे और स्टील के तारों, जिनका अनुप्रस्थ काट क्षेत्रफल (cross sectional area) एकसमान तथा 0.5 cm² है और लम्बाई क्रमशः $\sqrt{3}$ m तथा 1 m है, द्वारा लटकाया जाता है। तारों के दूसरे छोर छत पर चित्रानुसार जुड़े हुए है। तांबे और स्टील के तार क्रमशः छत से 30° और 60° का कोण बनाते है। यदि तांबे के तार में लम्बाई वृद्धि $(\Delta\ell_C)$ तथा स्टील के तार में लम्बाई वृद्धि $(\Delta\ell_S)$ है तब $\frac{\Delta\ell_C}{\Delta\ell_S}$ = ______ है।

[तांबे और स्टील का यंग गुणांक (Young's modulus) क्रमशः 1×10^{11} N/m² तथा 2×10^{11} N/m² है]

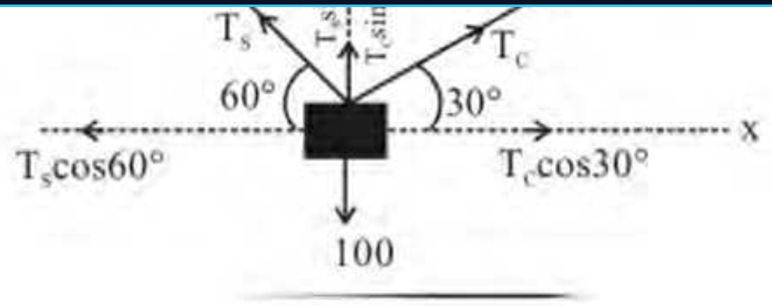
[JEE-Advance-2019]



Ans 2

hint Next page

T_C = Tension in copper wire



in x direction

$T_C\cos30° = T_s\cos60°$

hint

$$T_C \times \frac{\sqrt{3}}{2} = T_S \times \frac{1}{2}$$

$$\sqrt{3}T_C = T_S \;....\;(i)$$

in y direction

$T_C\sin30° + T_s\sin60° = 100$

$$\frac{T_C}{2} + \frac{T_S\sqrt{3}}{2} = 100 \;....\;(ii)$$

Solving equation (i) & (ii)

$T_C = 50$ N

$T_s = 50\sqrt{3}$ N

We know

$$\Delta L = \frac{FL}{AY}$$

$$= \frac{\Delta L_C}{\Delta L_S} = \frac{T_C L_C}{A_C Y_C} \times \frac{A_S Y_S}{T_S L_S}$$

On solving above equation

$$\frac{\Delta L_C}{\Delta L_S} = 2$$

temperature of the liquid is 80°C. It is found that the first 5 gm of the liquid completely evaporates. After pouring another 80 gm of the liquid the equilibrium temperature is found to be 50°C. The ratio of the Latent heat of the liquid to its specific heat will be ______ °C.

[Neglect the heat exchange with surrounding] **[JEE-Advance-2019]**

एक 30°C के द्रव को एक ऊष्मामापी (calorimeter), जिसका तापमान 110°C, में धीरे-धीरे डाला जाता है। द्रव का क्वथनांक (boiling temperature) 80°C है। यह पाया गया कि द्रव का पहला 5 gm पूर्ण रूप से वाष्पित हो जाता है। इसके बाद द्रव की 80 gm और मात्रा डालने पर साम्यावस्था का तापमान 50°C हो जाता है। द्रव की गुप्त (latent) और विशिष्ट (specific) ऊष्माओं का अनुपात ______ °C होगा। **[JEE-Advance-2019]**

[वातावरण के साथ ऊष्मा स्थानान्तरण को उपेक्षणीय माने]

hint Next page

x = specific heat of calorimeter

s = specifc heat of liquid

L = latent heat of liquid

First 5 g of liquid at 30° is poured to calorimter at 110°C

$\therefore m \times x \times (110 - 80) = 5 \times s \times (80 \times 30) + 5 L$

$\Rightarrow mx \times 30 = 250 s + 5 L$ ... (i)

Now, 80 g of liquid at 30° is poured into calorimeter at 80°C, the equilibrium temperature reaches to 50°C.

$\therefore m \times x \times (80 - 30) = 80 \times s \times (50 - 30)$

$\Rightarrow mx \times 30 = 1600 s$ .... (ii)

From (i) & (ii)

$250 s + 5 L = 1600 s \Rightarrow 5L = 1350 s$

$\Rightarrow \frac{L}{-} = 270$

at temperature 2500 K emitting radiation like a point source when viewed from far. At night the light bulb is observed from a distance of 100 m. Assume the pupil of the eyes of the observer to be circular with radius 3 mm. Then

(Take Stefan-Boltzmann constant = 5.67×10^{-8} Wm^{-2} K^{-4}, Wien's displacement constant = 2.90×10^{-3} m-K, Planck's constant = 6.63×10^{-34} Js, speed of light in vacuum= 3.00×10^{8} ms^{-1})-

(A) power radiated by the filament is in the range 642 W to 645 W **[JEE-Advance-2020]**

(B) radiated power entering into one eye of the observer is in the range 3.15×10^{-8} W to 3.25×10^{-8} W

(C) the wavelength corresponding to the maximum intensity of light is 1160 nm

(D) taking the average wavelength of emitted radiation to be 1740 nm, the total number of photons entering per second into one eye of the observer is in the range 2.75×10^{11} to 2.85×10^{11}

एक प्रकाश बल्ब के फिलामेन्ट का पृष्ठीय क्षेत्रफल 64 mm^2 है। फिलामेन्ट को कृष्णिका के रूप में माना जा सकता है, दूरी से देखने पर यह तापमान 2500 K पर एक बिन्दु स्रोत के समान विकिरण उत्सर्जित कर रहा है। रात्रि में प्रकाश बल्ब को 100 m की दूरी से प्रेक्षित किया जाता है। माना प्रेक्षक के आँखों की पुतली 3 mm त्रिज्या के साथ वृत्ताकार है। तब

(स्टीफन बोल्ट्ज़मान नियतांक = 5.67×10^{-8} Wm^{-2}K^{-4}, वीन का विस्थापन नियतांक = 2.90×10^{-3} m-K, प्लांक नियतांक = 6.63×10^{-34} Js, निर्वात में प्रकाश की चाल 3.00×10^{8} ms^{-1} लीजिये।) **[JEE-Advance-2020]**

(A) फिलामेन्ट द्वारा विकिरित शक्ति की परास 642 W से 645 W है।

(B) प्रेक्षक के एक नेत्र के अन्दर प्रवेश करने वाली विकिरित शक्ति की परास 3.15×10^{-8} W से 3.25×10^{-8} W है।

(C) प्रकाश की अधिकतम तीव्रता के संगत तरंगदैर्ध्य 1160 nm है।

(D) उत्सर्जित विकिरण की औसत तरंगदैर्ध्य को 1740 nm लेते हुए, प्रेक्षक के एक नेत्र के अंदर प्रति सेकण्ड प्रवेश करने वाले फोटोनों की कुल संख्या 2.75×10^{11} से 2.85×10^{11} तक की परास में है।

Suns from observer, R_e = radius of pupil of eye)

Point source d = 100 m

$R_e = 3\text{mm}$

(A) $P = \sigma A e T^4$

$= 5.67 \times 10^{-8} \times 64 \times 10^{-6} \times 1 \times (2500)^4$ (e = 1 black body)

= 141.75 w

Option (A) is wrong

(B) Power reaching to the eye

$$= \frac{P}{4\pi d^2} \times (\pi R_e^2)$$

$$= \frac{141.75}{4\pi \times (100)^2} \times \pi \times (3 \times 10^{-3})^2$$

$= 3.189375 \times 10^{-8}$ W

Option (B) is correct

(C) $\lambda_m T = b$

$\lambda_m \times 2500 = 2.9 \times 10^{-3}$

$\Rightarrow \lambda_m = 1.16 \times 10^{-6} = 1160$ nm

Option (C) is correct

(D) Power received by one eye of observer $= \left(\frac{hc}{\lambda}\right) \times \dot{N}$

$\dot{N}$ = Number of photons entering into eye per second

$\Rightarrow 3.189375 \times 10^{-8}$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{1740 \times 10^{-9}} \times \dot{N}$$

$\Rightarrow \dot{N} = 2.79 \times 10^{11}$

Option (D) is correct

20

surroundings. The average energy per unit time per unit area received due to the sunlight is $700 Wm^{-2}$ and it is absorbed by the water over an effective area of $0.05\ m^2$. Assuming that the heat loss from the water to the surroundings is governed by Newton's law of cooling, the difference (in °C) in the temperature of water and the surroundings after a long time will be ______________. (Ignore effect of the container, and take constant for Newton's law of cooling = $0.001\ s^{-1}$, Heat capacity of water = $4200\ J\ kg^{-1}\ K^{-1}$)

एक पात्र में 1 kg जल भरा हुआ है, इसे सूर्य के प्रकाश में रखा जाता है, जिसके कारण जल परिवेश की तुलना में गर्म हो जाता है। सूर्य के प्रकाश के कारण प्राप्त की गई प्रति इकाई क्षेत्रफल प्रति इकाई समय औसत ऊर्जा $700\ Wm^{-2}$ है तथा इसे $0.05\ m^2$ के प्रभावी क्षेत्रफल पर जल द्वारा अवशोषित किया जाता है। माना कि जल से परिवेश की ओर ऊष्मा हानि न्यूटन के शीतलन के नियम द्वारा संचालित होती है, लम्बे समय के बाद जल तथा परिवेश के ताप में अन्तर (°C में) ____________ होगा। (पात्र के प्रभाव को नगण्य मानें तथा न्यूटन के शीतलन के नियम के लिए नियतांक = $0.001\ s^{-1}$ लें, जल की ऊष्मा धारिता = $4200\ J\ kg^{-1}\ K^{-1}$) **[JEE-Advance-2020]**

hint Next page

dt

$$\frac{dQ}{Adt} = e\sigma(T_0 + \Delta T)^4 - T_0^4) = \sigma T_0^4\left[\left(1 + \frac{\Delta T}{T_0}\right)^4 - 1\right]$$

$$= e\sigma T_0^4\left[\left(1 + 4\frac{\Delta T}{T_0}\right) - 1\right]$$

$$\frac{dQ}{Adt} = \sigma e T_0^3 \cdot 4\Delta T \qquad ....(ii)$$

Now from equ. (i)

$$ms\frac{dT}{dt} = \sigma eT(T^4 - T_0^4)$$

$$\frac{dT}{dt} = \frac{\sigma eA}{ms}[(T_0 + \Delta T)^4 - T_0^4]$$

$$= \frac{\sigma eA}{ms}T_0^4 \times \left[\left(1 + \frac{\Delta T}{T_0}\right)^4 - 1\right]$$

$$\frac{dT}{dt} = \frac{\sigma eA}{ms}T_0^4 \cdot 4\Delta T$$

$$\frac{dT}{dt} = e\Delta T \;;\; \left(K = \frac{4\sigma eAT_0^3}{ms}\right)$$

$$\Rightarrow 4\sigma eAT_0^3 = \frac{K}{A}(ms)$$

from equ. (i)

$$\frac{dQ}{Adt} = e\sigma T_0^3 \cdot 4\Delta T$$

700 = (K/A) (ms) ΔT

$$\therefore \Delta T = \frac{700 \times 5 \times 10^{-2}}{10^{-3} \times 4200} = \frac{50}{6} = \frac{25}{3}$$

21

container is maintained at 0 K. At time t = 0, the temperature of the object is 200 K. The temperature of the object becomes 100 K at $t = t_1$ and 50 K at $t = t_2$. Assume the object and the container to be ideal black bodies. The heat capacity of the object does not depend on temperature. The ratio (t_2/t_1) is_____.

एक छोटी वस्तु को एक निर्वातित (evacuated) बड़े खोखले गोले के केन्द्र पर रखा गया है। मानें, गोले का तापमान 0 K पर अनुरक्षित (maintained) है। समय t = 0 पर वस्तु का तापमान 200 K है। वस्तु का तापमान $t = t_1$ पर 100 K तथा $t = t_2$ पर 50 K हो जाता है। वस्तु तथा गोले को आदर्श कृष्णिका (ideal black-body) मानें। वस्तु की ऊष्मा धारिता (heat capacity) तापमान पर निर्भर नहीं करती है। अनुपात (t_2/t_1) का मान _____ होगा। **[JEE-Advance-2021]**

hint Next page

dt

$$\int_{200}^{100} \frac{dT}{T^4} = \int_0^{t_1} k\,dt$$

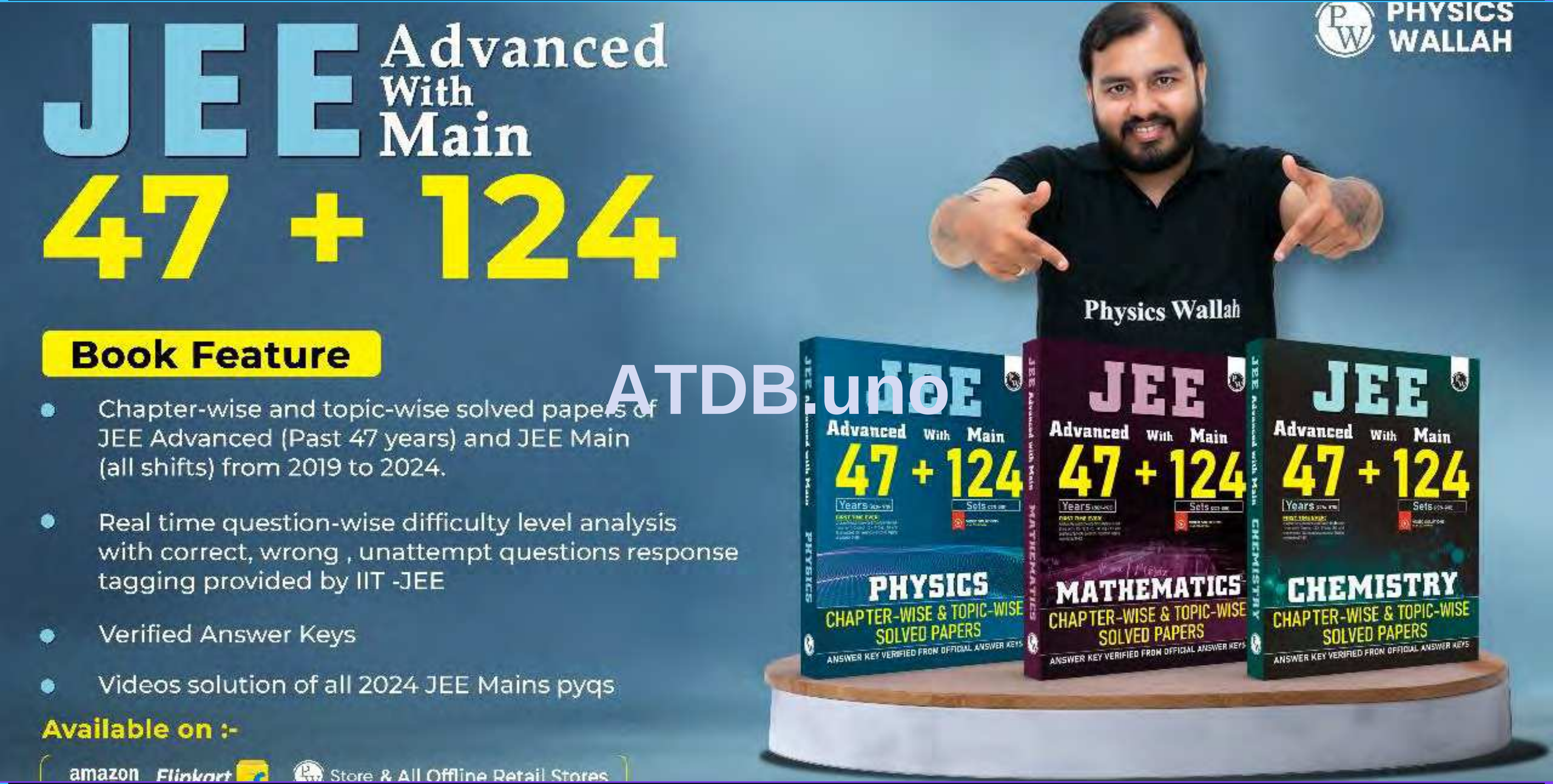
$$\left.\frac{1}{3T^3}\right|_{200}^{100} = kt_1$$

$$\frac{1}{3}\left(\frac{1}{100^3} - \frac{1}{200^3}\right) = kt_1$$

$$\left.\frac{1}{3T^3}\right|_{200}^{50} = kt_2$$

$$\frac{1}{3}\left(\frac{1}{50^3} - \frac{1}{200^3}\right) = kt_2$$

$$\frac{t_2}{t_1} = \left(\frac{200^3 - 50^3}{200^3 - 100^3}\right)\frac{100^3}{50^3} = 9$$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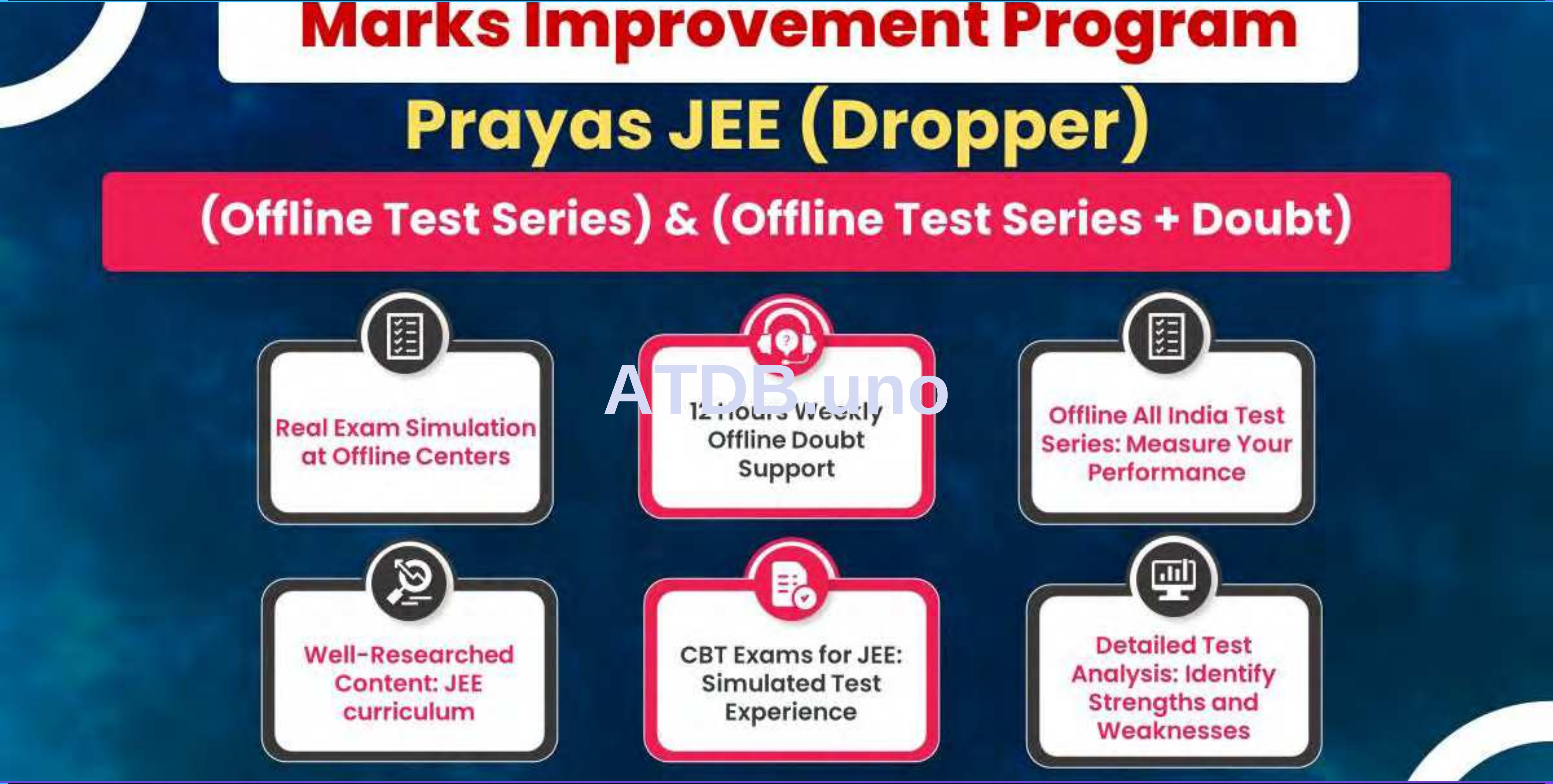
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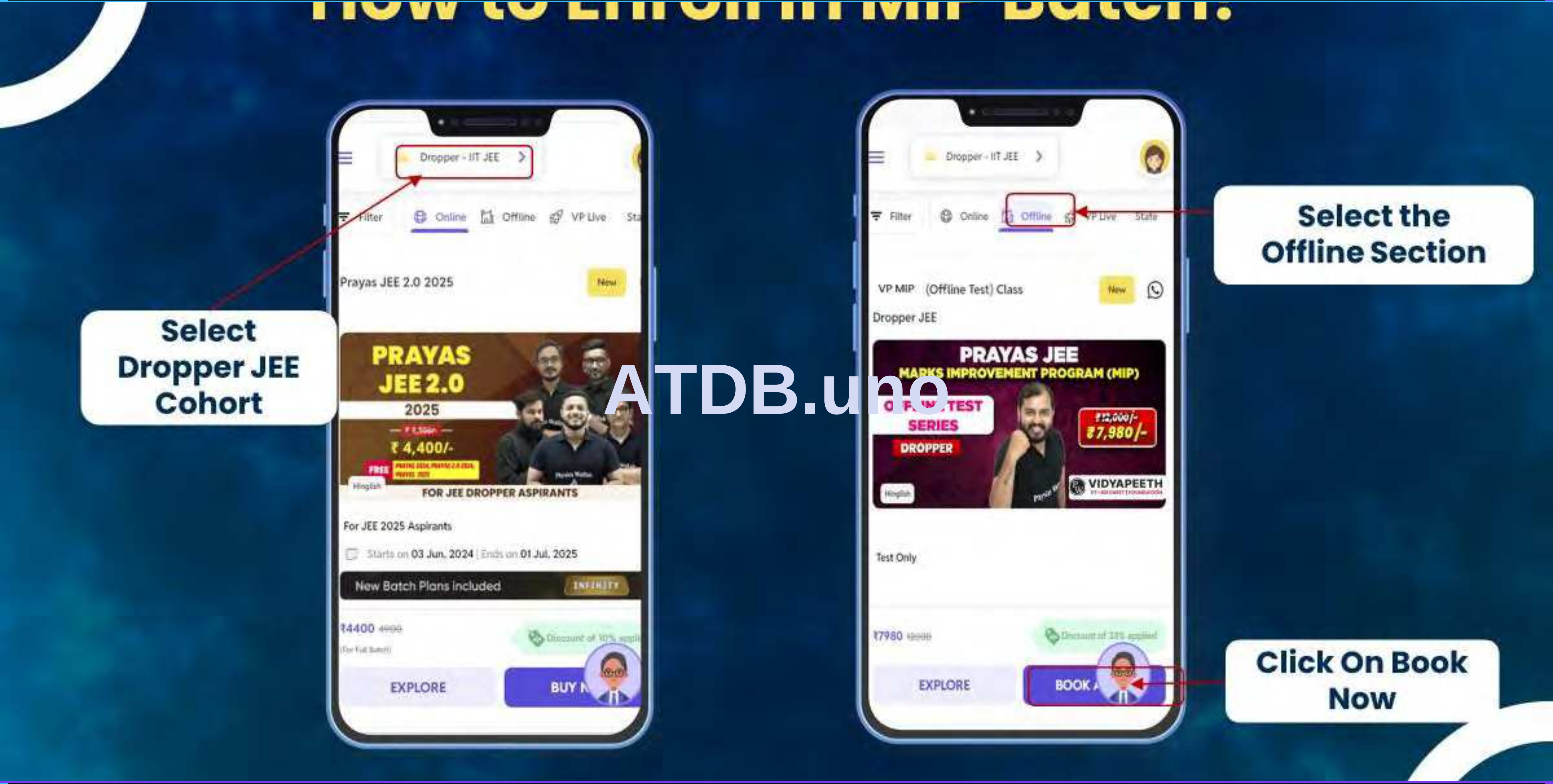
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