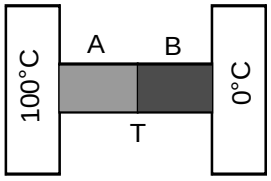
Exercise - V | JEE-Problems

1. 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. **[JEE' 96]**

2. Two metal cubes A & B of same size are arranged as shown in figure. The extreme ends of the combination are maintained at the indicated temperatures. The arrangement is thermally insulated. The coefficients of thermal conductivity of A & B are 300 W/m°C and 200 W/m°C respectively. After steady state is reached the temperature T of the interface will be _____. **[JEE' 96]**



3. A double pane window used for insulating a room thermally from outside consists of two glass sheets each of area 1 m^2 and thickness 0.01 m separated by a 0.05 m thick stagnant air space. In the steady state, the room glass interface and the glass outdoor interface are at constant temperatures of 27°C and 0°C respectively. Calculate the rate of heat flow through the window pane. Also find the temperatures of other interfaces. Given thermal conductivities of glass and air as 0.8 and 0.08 $Wm^{-1}K^{-1}$ respectively. **[JEE '97]**

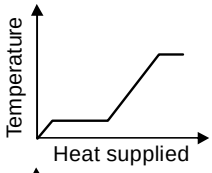
4. A spherical black body with a radius of 12 cm radiates 450 W power at 500 K. If the radius were halved and the temperature doubled, the power radiated in watt would be
(A) 225 (B) 450
(C) 900 (D) 1800

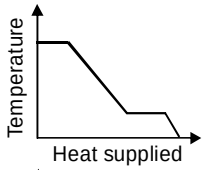
5. Earth receives 1400 W/m^2 of solar power. If all the solar energy falling on a lens of area 0.2 m^2 is focussed on to a block of ice of mass 280 grams, the time taken to melt the ice will be _____ minutes. (Latent heat of fusion of ice = 3.3×10^5 J/kg) **[JEE '97]**

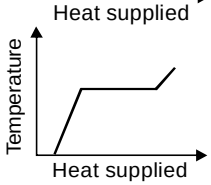
6. A solid body X of heat capacity C is kept in an atmosphere whose temperature is T_A = 300K. At time t = 0, the temperature of X is T_0 = 400K. It cools according to Newton's law of cooling. At time t_1 its temperature is found to be 350K. At this time t_1, the body X is connected to a larger body Y at atmospheric temperature T_A, through a conducting rod of length L, cross-sectional area A and thermal conductivity K. The heat capacity of Y is so large that any variation in its temperature may be neglected. The cross-sectional area A of the connecting rod is small compared to the surface area of X. Find the temperature of X at time t = $3t_1$ **[JEE' 98]**

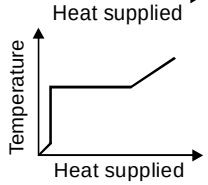
7. A black body is at a temperature of 2880 K. The energy of radiation emitted by this object with wavelength between 499 nm and 500 nm is U_1, between 999 nm and 1000 nm is U_2 and between 1499 nm and 1500 nm is U_3. The Wien constant b = 2.88×10^6 nm K. Then **[JEE'98]**
(A) $U_1 = 0$ (B) $U_3 = 0$
(C) $U_1 > U_2$ (D) $U_2 > U_1$

8. A block of ice at –10°C is slowly heated and converted to steam at 100°C. Which of the following curves represents the phenomenon qualitatively? **[JEE(Scr)2000]**

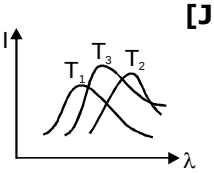
(A) 

(B) 

(C) 

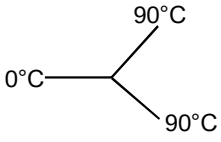
(D) 

9. The plots of intensity versus wavelength for three black bodies at temperature T_1, T_2 and T_3 respectively are as shown. Their temperatures are such that **[JEE(Scr)2000]**



(A) $T_1 > T_2 > T_3$ (B) $T_1 > T_3 > T_2$
(C) $T_2 > T_3 > T_1$ (D) $T_3 > T_2 > T_1$

10. Three rods made of the same material and having the same cross-section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0°C and 90°C respectively. The temperature of the junction of the three rods will be **[JEE (Scr) 2001]**



(A) 45°C (B) 60°C (C) 30°C (D) 20°C

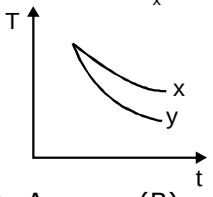
11. An ideal black body at room temperature is thrown into a furnace. It is observed that
(A) initially it is the darkest body and at later

times the brightest.
(B) it the darkest body at all times
(C) it cannot be distinguished at all times.
(D) initially it is the darkest body and at later times it cannot be distinguished. **[JEE(Scr)2002]**

12. An ice cube of mass 0.1 kg at 0°C is placed in an isolated container which is at 227°C. The specific heat S of the container varies with temperature T according the empirical relations = A + BT, where A = 100 cal/kg-K and B = 2×10^{-2} cal/kg-K^2. If the final temperature of the container is 27°C, determine the mass of the container. (Latent heat of fusion for water = 8×10^4 cal/kg. Specific heat of water = 10^3 cal/kg-K)
[JEE'2001]

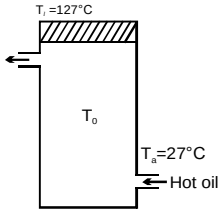
13. 2 kg ice at –20°C is mixed with 5kg water at 20°C. Then final amount of water in the mixture would be ; Given specific heat of ice = 0.5 cal/g°C, specific heat of water = 1 cal/g°C,
[JEE' (Scr) 2003]
Latent heat of fusion of ice = 80 cal/g.
(A) 6 kg (B) 5 kg
(C) 4 kg (D) 2 kg

14. If emissivity of bodies X and Y are e_x and e_y and absorptive power are A_x and A_y then



(A) $e_y > e_x$; $A_y > A_x$ (B) $e_y < e_x$; $A_y < A_x$
(C) $e_y > e_x$; $A_y < A_x$ (D) $e_y = e_x$; $A_y = A_x$

15. Hot oil is circulated through an insulated container with a wooden lid at the top whose t = 5 mm, emissivity = 0.6. Temperature of the top of the lid in steady state is at T_l = 127°. If the ambient temperature T_a = 27°C.
Calculate



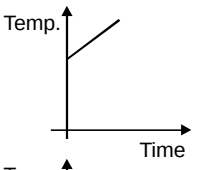
(a) rate of heat loss per unit area due to rediation from the lid.

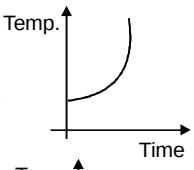
(b) temperature of the oil. (Given $\sigma = \frac{17}{3} \times 10^{-8}$)
[JEE' 2003]

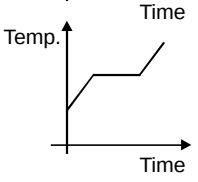
16. Three discs A, B, and C having radii 2 m, 4m and 6m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are 300 nm, 400 nm and 500 nm respectively. The power radiated by them are Q_A, Q_B and Q_C respectively.
[JEE' 2004 (Scr.)]
(A) Q_A is maximum (B) Q_B is maximum
(C) Q_C is maximum (D) $Q_A = Q_B = Q_C$

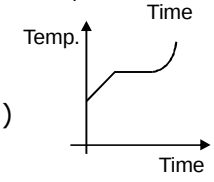
17. Two identical conducting rods are first connected independently to two vessels, one containing water at 100°C and the other containing ice at 0°C. In the second case, the rods are joined end to end and connected to the same vessels. Let q_1 and q_2 g/s be the rate of of ice in the two cases respectively. The ratio q_2/q_1 is **[JEE' 2004(Scr.)]**
(A) 1/2 (B) 2/1
(C) 4/1 (D) 1/4

18. Liquid oxygen at 50 K is heated to 300 K at constant pressure of 1 atm. The rate of heating is constant. Which of the following graphs represents the variation of temperature with time
[JEE'2004(Scr.)]

(A) 

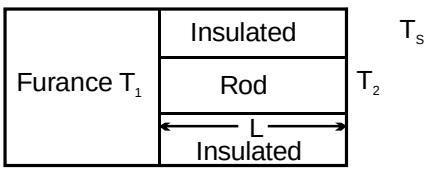
(B) 

(C) 

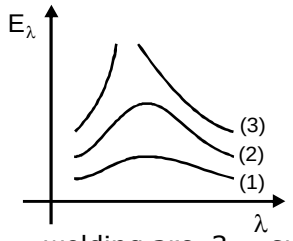
(D) 

19. A cube of coefficient of linear expansion α_s is floating in a bath containing a liquid of coefficient of volume expansion γ_l. When the temperature is raised by ΔT, the depth upto which the cube is submerged in the liquid remains the same. Find the relation between α_s and γ_l, showing all the steps. **[JEE 2004]**

20. One end of a rod of length L and cross-sectional area A is kept in a furnace of temperature T_1. The other end of the rod is kept at a temperature T_2. The thermal conductivity of the material of the rod is K and emissivity of the rod is e. It is given that $T_2 = T_S + \Delta T$ where $\Delta T << T_S$, T_S being the temperature of the surroundings. If $\Delta T \propto (T_1 - T_S)$, find the proportionality constant. Consider that heat is lost only by radiation at the end where the temperature of the rod is T_2. **[JEE 2004]**



21. Three graphs marked as 1,2,3 representing the variation of maximum emissive power and wavelength of radiation of the sun, a welding arc and a tungsten filament. Which of the following combination is correct



(A) 1-bulb, 2 → welding arc, 3 → sun
(B) 2-bulb, 3 → welding arc, 1 → sun
(C) 3-bulb, 1 → welding arc, 2 → sun
(D) 2-bulb, 1 → welding arc, 3 → sun
[JEE'2005(Scr)]

22. In which of the following phenomenon heat convection does not take place **[JEE' 2005 (Scr)]**
(A) land and sea breeze
(B) boiling of water
(C) heating of glass surface due to filament of the bulb
(D) air around the furance

23. 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
(A) 8 min 20 sec (B) 10 min
(C) 7 min (D) 14 min
[JEE' 2005(Scr)]

24. A spherical body of area A, and emissivity e = 0.6 is kept inside a black body. What is the rate at which energy is radiated per second at temperature T
(A) 0.6 σAT^4 (B) 0.4 σAT^4
(C) 0.8 σAT^4 (D) 1.0 σAT^4
[JEE' 2005 (Scr)]

25. 1 calorie is the heat required to increased the temperature of 1 gm of water by 1°C from
(A) 13.5° C to 14.5°C at 76 mm of Hg
(B) 14.5°C to 15.5°C at 760mm of Hg
(C) 0°C to 1°C at 760mm of Hg
(D) 3°C to 4°C to 760mm of Hg
[JEE' 2005(Scr)]

26. In a dark room with ambient temperature T_0, a black body is kept at a temperature T. Keeping the temperature of the black body constant (at T), sunrays are allowed to fall on the black body through a hole in the roof of the dark room Assuming that there is no change in the ambient temperature of the room, which of the following statement(s) is/are correct?
(A) The quantity of radiation absorbed by the black body in unit time will increase.
(B) Since emissivity = absorptivity, hence the quantity of radiation emitted by black body in unit time will increase.
(C) Black body radiates more energy in unit time in the visible spectrum.
(D) The reflected energy in unit time by the black body remains same. **[JEE 2006]**

27. In an insulated vessel, 0.05 kg steam at 373K and 0.45 kg of ice at 253K are mixed. Then, find the final temperature of the mixture.
Given, L_{fusion} = 80 cal/g = 336 J/g, $L_{vaporization}$ = 540 cal/g = 2268 J/g,
S_{ice} = 2100 J/kg K=0.5 cal/gK and S_{water} = 4200 J/kg K = 1 cal/gK **[JEE 2006]**

28. Column I gives some devices and **Column II** gives some processes on which the functioning of these devices depend. Match the devices in **Column I** with the processes in **Column II** and indicate your answer by darkening appropriate bubbles in the 4 × 4 matrix given in the ORS.
[JEE 2007]

Column I	**Column II**
(A) Bimetallic strip	(P) Radiation from a hot body
(B) Steam engine	(Q) Energy conversion
(C) Incandescent lamp	(R) Melting
(D) Electric fuse	(S)Thermal exapansion of solids

29. 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^{-1} and latent heat of melting of ice is 80 cal g^{-1} . If the point *P* is at a distance of l*x* from the ice end *A*, find the value of l. [Neglect any heat loss to the surrounding. **[JEE 2009]**

30. 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]**

31. Three very large plates of same area are kept parallel and close to each other. They are considered as 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

(A) $\left(\frac{65}{2}\right)^{\frac{1}{4}}T$ (B) $\left(\frac{97}{4}\right)^{\frac{1}{4}}T$ **[JEE 2012]**

(C) $\left(\frac{97}{2}\right)^{\frac{1}{4}}T$ (D) $(97)^{\frac{1}{4}}T$