Exercise - III (Subjective Problems)

1. In following equation calculate the value of H.
1 kg steam at 200°C = H + 1 Kg water at 100°C
(S_{steam} = Constant = .5 cal/gm°C)

2. From what height should a piece of ice (0°C) fall so that it melts completely ? Only one quarter of the heat produced is absorbed by the ice. The latent heat of ice is 3.4×10^5 J kg^{-1} and g is 10 N kg^{-1}.

3. A copper cube of mass 200 g slides down on a rough inclined plane of inclination 37° at a constant speed. Assume that any loss in mechanical energy goes into the copper block as thermal energy. Find the increase in the temperature of the block as it slides down through 60 cm. Specific heat capacity of copper = 420 J/kg-K.

4. 10 gm ice at −10°C, 10 gm water at 20°C and 2g steam at 100°C are mixed with each other then final equilibrium temperature.

5. Materials A, B and C are solids that are at their melting temperatures. Material A requires 200 J to melt 4 kg, material B requires 300 J to melt 5 kg, and material C requires 300 J to melt 6 kg. Rank the materials according to their heats of fusion, greatest first.

6. In a thermally isolated container, material A of mass m is placed against material B, also of mass m but at higher temperature. When thermal equilibrium is reached, the temperature changes ΔT_A and ΔT_B of A and B are recorded. Then the experiment is repeated, using A with other materials. All of the same mass m. The results are given in the table. Rank the four materials according to their specific heats, greatest first.

Experiment	**Temperature Changes**	
1.	ΔT_A = + 50 C°	ΔT_B = − 50 C°
2.	ΔT_A = + 10 C°	ΔT_C = − 20 C°
3.	ΔT_A = + 2 C°	ΔT_D = − 40 C°

7. Indian style of cooling drinking water is to keep it in a pitcher having porous walls. Water comes to the outer surface very slowly and avaporates. Most of the energy needed for evaporation is taken from the water itself and the water is cooled down. Assume that a pitcher contains 10 kg of water and 0.2 g of water comes out per second. Assuming no backward heat transfer from the atmosphere to the water, calculate the time in which the temperature decreases by 5°C. Specific heat capacity of water = 4200 J/kg−°C and latent heat of vaporization of water = 2.27×10^6 J/kg.

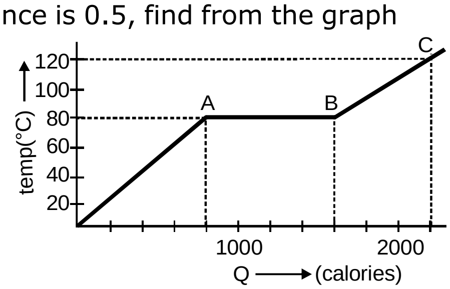
8. An aluminium container of mass 100 gm contains 200 gm of ice at −20°C. Heat is added to the system at the rate of 100 cal/s. Find the temperature of the system after 4 minutes (specific heat of ice = 0.5 and L = 80 cal/gm, specific heat of A*l* = 0.2 cal/gm/°C)

9. A volume of 120 ml of drink (half alcohol + half water by mass) originally at a temperature of 25°C is cooled by adding 20 gm ice at 0°C. If all the ice melts, find the final temperature of the drink.(density of drink = 0.833 gm/cc, specific heat of alcohol = 0.6 cal/gm/°C)

10. Two identical calorimeter A and B contain equal quantity of water at 20°C. A 5 gm piece of metal X 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 $g^{-1}(C°)^{-1}$.

11. Two 50 gm ice cubes are dropped into 250 gm of water into a glass. If the water was initially at a temperature of 25°C and the temperature of ice −15°C. Find the final temperature of water. (specific heat of ice = 0.5 cal/gm/°C and L = 80 cal/gm). Find final amount of water and ice.

12. A substance is in the solid form at 0°C. The amount of heat added to this substance and its 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;

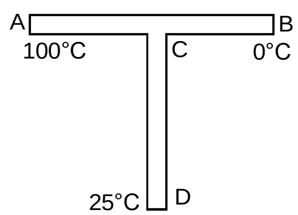
(ii) the specific latent heat of the melting process, and

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

13. A uniform slab of dimension 10cm × 10cm × 1cm is kept between two heat reservoirs at temperatures 10°C and 90°C. The larger surface areas touch the reservoirs. The thermal conductivity of the material is 0.80 W/m–°C. Find the amount of heat flowing through the slab per second.

14. One end of a steel rod (K = 42 J/m–s–°C) of length 1.0m is kept in ice at 0°C and the other end is kept in boiling water at 100°C. The area of cross-section of the rod is 0.04 cm^2. Assuming no heat loss to the atmosphere, find the mass of the ice melting per second. Latent heat of fusion of ice = 3.36×10^5 J/kg.

15. A rod CD of thermal resistance 5.0 K/W is joined at the middle of an identical rod AB as shown in figure. The ends A, B and D are maintained at 100°C, 0°C and 25°C respectively. Find the heat current in CD.



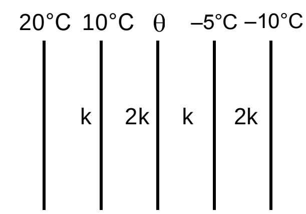
16. A semicircular rod is joined at its end to a straight rod of the same material and same cross-sectional area. The straight rod forms a diameter of the other rod. The junctions are maintained at different temperatures. Find the ratio of the heat transferred through a cross-section of the semicircular rod to the heat transferred through a cross-section of the straight rod in a given time.

17. One end of copper rod of uniform cross-section and of length 1.45 m is in contact with ice at 0°C and the other end with water at 100°C. Find the position of point along its length where a temperature of 200°C should be maintained so that in steady state the mass of ice melting is equal to that of steam produced in the same interval of time [Assume that the whole system is insulated from surroudings]. [take L_v = 540 cal/g L_f = 80 cal/g]

18. Three slabs of same surface area but different conductivities k_1, k_2, k_3 and different thickness t_1, t_2, t_3 are placed in close contact. After steady state his combination behaves as a single slab. Find is effective thermal conductivity.

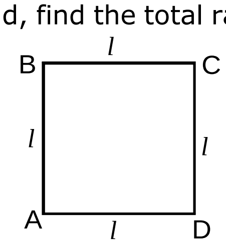
19. A thin walled metal tank of surface area $5m^2$ is filled with water tank and contains an immersion heater dissipating 1 kW. The tank is covered with 4 cm thick layer of insulation whose thermal conductivity is 0.2 W/m/K. The outer face of the insulation is 25°C. Find the temperature of the tank in the steady state.

20. The figure shows the face and interface temperature of a composite slab containing of four layers of two materials having identical thickness. Under steady state condition, find the value of temperature θ.



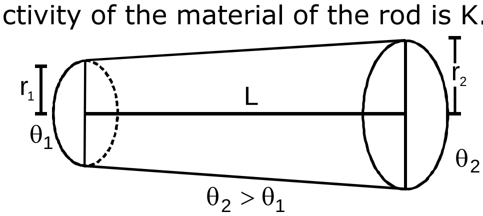
k=thermal conductivity

21. In the square frame of side l of metallic rods, the corners A and C are maintained at T_1 and T_2 respectively. The rate of heat flow from A to C is ω. If A and D are instead maintained T_1 & T_2 respectively find, find the total rate of heat flow.



22. A hollow metallic sphere of radius 20 cm surrounds a concentric metallic sphere of radius 5 cm. The space between the two spheres is filled with a nonmetallic material. The inner and outer spheres are maintained at 50°C and 10°C respectively and it is found that 160 π Joule of heat passes from the inner sphere to the outer sphere per second. Find the thermal conductivity of the material between the spheres.

23. Find the rate of heat flow through a cross-section of the rod shown in figure ($\theta_2 > \theta_1$). Thermal conductivity of the material of the rod is K.



24. A metal rod of cross-sectional area 1.0 cm^2 is being heated at one end. At one time, the temperature gradient is 5.0°C/cm at cross-section A and is 2.6°C/cm at cross-section B. Calculate the rate at which the tempeature is increasing in the part AB of the rod. The heat capacity of the part AB = 0.40 J/°C, thermal conductivity of the material of the rod = 200 W/m–°C. Neglect any loss of heat to the atmosphere.

25. A rod of negligible heat capacity has length 20 cm, area of cross-section 1.0 cm^2 and thermal conductivity 200 W/m–°C. The tempeature of one end is maintained at 0°C and that of the other end is slowly and linearly varied from 0°C to 60°C in 10 minutes. Assuming no loss of heat through the sides, find the total heat transmitted through the rod in these 10 minutes.

26. A pan filled with hot food cools from 50.1 °C to 49.9 °C in 5 sec. How long will it take to cool from 40.1 °C to 39.9°C if room temperature is 30°C ?

27. A solid copper cube and sphere, both of same mass & emissivity are heated to same initial temperature and kept under identical conditions. What is the ratio of their initial rate of fall of temperature ?

28. Two spheres of same radius R have their densities in the ratio 8 : 1 and the ratio of their specific heats are 1 : 4. If by radiation their rates of fall of temperature are same, then find the ratio of their rates of losing heat.

29. The maximum wavelength in the energy distribution spectrum of the sun is at 4753 Å and its temperature is 6050K. What will be the temperature of the star whose energy distribution shows a maximum at 9506 Å.

30. A black body radiates 5 watts per square cm of its surface area at 27°C. How much will it radiate per square cm at 327°C.

31. A 100 W bulb has tungsten filament of total length 1.- m and radius 4×10^{-5} m. The emissivity of the filament is 0.8 and $\sigma = 6.0 \times 10^{-8}$ $W/m^2 - K^4$. Calculate the temperature of the filament when the bulb is operating at correct wattage.

32. A copper sphere is suspended in an evacuated chamber maintained at 300 K. The sphere is maintained at a constant temperature of 500 K by heating it electrically. A total of 210 W of electric power is needed to do it. When the surface of the copper sphere is completely blackened, 700 W is needed to maintain the same temperature of the sphere. Calculate the emissivity of copper.

33. During a certain duration in the day, the earth is in radiative equilibrium with the sun. Find the surface temperature of the earth during that duratian.
[Given, radius of sun = 6.9×10^8 m surface temperature of sun = 6000 K and the distance of earth from the sun = 1.49×10^{11} m. Assume that the sun and earth behave as black bodies.]

34. Estimate the temperature at which a body may appear blue or red. The values of λ_{mean} for these are 5000 and 7500 Å respectively. [Given Wein's constant b = 0.3 cm K]

35. Find the quantity of energy radiated from 1 cm^2 of a surface in one second by a black body if the maximum energy density corresponds to a wavelength of 5000 Å
(b = 0.3 cm K and $\sigma = 5.6 \times 10^{-8}$ w/m^2k^4)

36. The following observations have been noted for a black body spectrum, taken for T = 500 K. Calculate the value of λ_m at T = 1000 K.

λ (in μm)	10	8	6	4
E_λ (in SI units)	10	14	16	12

37. A liquid cools from 70°C to 60°C is 5 minutes. Find the time in which it will further cool down to 50 °C, if its surrounding is held at a constant temperature of 30°C

38. A body cools down from 50°C to 45°C in 5 minutes and to 40°C in another 8 minutes. Find the temperature of the surrounding.