PART 1 : THERMOMETRY AND CALORIMETRY

1. **Convert the following as asked**

   a) Into Fahrenheit

   – 37°C, 100°C, – 192°C

   b) Into Centrigrade

   – 108°F, 176°F, – 140°F **[(a) 98.6°F; 212°F; – 313.6°F. (b) – 77.75°C; 80°C; 60°C]**

2. **Determine the temperature on the Fahrenheit scale which is indicated by (a) the same number, (b) double the number, on the Centigrade scale.**

   [(a) – 40°C = – 40°F. (b) 160°C = 320°F]

3. The lower fixed point of a thermometer is marked 10° and the upper fixed point 130°, the interval between the fixed points being divided into 120 equal divisions. What would be the reading indicated by this thermometer when a Centigrade thermometer reads 40°?

   (58°)

4. The fundamental interval of a thermometer x is divided arbitrarily into 40 equal parts and that of another thermometer y into 80 equal parts. If the freezing point of x is marked 20° and that of y is marked 0°, what is the temperature on x when y indicates 70°? What is the temperature in °C?

   (55°; 87.5°C)

5. A Centrigrade thermometer has its lower and upper fixed points marked – 0.5°C and 100.5°. What is the true temperature when this thermometer reads 30°? The bore of thermometer is uniform.

   (30.198°C)

6. A piece of iron weighing 15 g is dropped into a cavity in a block of ice at 0°C. 2.5 g of ice are melted. If the temperature of iron was 113.6°C, calculate the sp. ht of iron. (L for fusion of ice = 80 cal/g)

   (0.12 cal/g/°C)

7. A vessel of thermal capacity 30 calories contains 170 g of water at 30°C. If on dropping a solid at 93°C into the calorimeter, the temperature of the mixture becomes 33°C, find the thermal capacity of the solid.

   (10 cal/°C)

8. A piece of lead at 99°C is placed in a calorimeter containing 200 g of water at 15°C. The temperature after stirring is 21°C. Calculate the thermal capacity of the lead piece if the water equivalent of the calorimeter is 9.3 g.

   (16.1 cal/°C)

9. A quantity of molten lead at its melting point 327°C, if poured into some oil and the temperature of oil is found to rise from 12°C to 25.5°C. The experiment is repeated with the same mass of lead, but the lead is just allowed to solidify before being dropped into oil. The temperature of oil is now found to rise to 20.5°C. Calculate latent heat of fusion of lead. Sp. ht. of lead = 0.03. (It is assumed that oil does not evaporate)

   (5.6 cal/g)

10. A copper calorimeter of mass 50 g contains 500 g of water at 30°C. A piece of ice of mass 10 g and at a temperature – 5°C is dropped into the calorimeter. Find the final temperature of the calorimeter and its contents when all the ice has melted (Sp. heat of copper = 0.09. sp. ht. of ice = 0.5 and latent heat of ice = 80 cal/g)

    (27.81°C)

11. The temperatures of three different miscible liquids A, B and C are maintained at 20°C, 25°C and 30°C respectively. When equal masses A and B are mixed, the resultant temperature is 22°C and when equal masses of B and C are mixed, the resultant temperature is 28°C. What temperature is achieved by mixing equal masses of A and C?

    (25°C)

12. A calorimeter of water equivalent 4 g contains 20 g of water at 30°C. Calculate the minimum mass of ice that will have to be added so as to lower the temperature of the mixture to 0°C. Latent heat of fusion of ice = 80 cal/g. **(9 g)**

13. A gram of ice at 0°C contracts by 0.1 cc. on melting. When a metal ball of sp. ht. 0.1 and at a temperature of 50°C is dropped into a cavity in a block of ice, the change in volume caused is 0.35 cc. Calculate the mass of metal ball. **(56 g)**

14. How much ice at 0°C would a kg of steam at 100°C, melt if the resulting water is at 0°C? L of steam = 540 cal/g. L of ice = 80 cal/g. **(8000 g)**

15. How much heat would be required to evaporate 500 g of ice at – 5°C? Sp. ht. of ice = 0.5; L of fusion of ice = 80 cal/g; L of vaporization of water = 540 cal/g. **(361250 cal)**

16. 3 g of steam at 100°C is passed into a calorimeter containing 20 g of a liquid. The temperature of the liquid rises from 30°C to 40°C. Calculate the water equivalent of the calorimeter and its contents. L of vaporization of water = 540 cal/g. **(180 g)**

17. A copper calorimeter (sp. ht. 0.1) has a mass of 100 g. It contains 90 g of water at 30°C. Find the amount of steam that has to be passed through the calorimeter so that the final temperature of the mixture may be 40°C. L of vaporization of water = 540 cal/g. **(5/3 g)**

18. A piece of copper of mass 100 g is heated to 100°C and immersed in 295 g of brine contained in an aluminium calorimeter of mass 60 g. The temperature of the liquid rises from 12°C to 17°C. The experiment is repeated under identical conditions except that the calorimeter now contains 520.5 g of brine and its temperature rises from 12°C to 15°C. Taking sp. ht. of copper to be 0.1, calculate sp. ht. of brine and aluminium. **(0.52; 0.21)**

19. The temperatures of three different liquids A, B and C are 14°C, 24°C and 34°C respectively. On mixing equal masses of A and B the temperature of the mixture is 20°C. On mixing equal masses of B and C the temperature of the mixture is 31°C. If equal masses of A and C are mixed, what will be the temperature of the mixture? It is assumed that there is no chemical action between the liquids. **(29.55°C)**

PART 2 : THERMAL EXPANSION

1. A metal rod is 64.522 cm long at 12°C and 64.576 cm at 90°C. Find the coefficient of linear expansion of its material. **(10.73×10^{-6}/°C)**

2. A metal bar measures 60 cm at 10°C. What would be its length at 110°C? $\alpha = 15 \times 10^{-6}$/°C. **(60.09 cm)**

3. A rod is found to be 0.04 cm longer at 30°C than it is at 10°C. Calculate its length at 0°C. $\alpha = 20 \times 10^{-6}$/°C. **(100 cm)**

4. The length of an iron rod at 100°C is 300.36 cm and at 150°C it is 300.54 cm. Find the length of rod at 0°C and the coefficient of linear expansion of its material. **(300 cm; 12×10^{-6} /°C)**

5. A steel scale at 50°C is correct. This scale reads the length of a brass rod as 1.5 m at 50°C. What is the actual length of this rod at 100°C? $\alpha_{steel} = 11.2 \times 10^{-6}$/°C and $\alpha_{Brass} = 18 \times 10^{-6}$/°C. **(1.5013 m)**

6. By how much will a steel bar one metre long expand when heated from 25°C to 55°C ? The coefficient of volume expansion of steel is 3×10^{-5}/°C. **(0.03 cm)**

7. A brass rod and an iron rod are each one metre in length at 0°C. Find the difference in their lengths at 100°C. α for brass = 19×10^{-6}/°C and α for iron = 10×10^{-6}/°C. **(0.09 cm)**

8. Two thin rods one of brass and the other of iron have the same length of 1 m each at 20°C. At what temperature will their lengths differ by 1.4 mm if their coefficients of linear expansion are 18.92×10^{-6}/°C and 11.92×10^{-6}/°C? **(220°C)**

9. Two rods, one of brass and other of iron have lengths of 4 m and 4.01 m respectively at 20°C. Find the temperature at which the rods will attain the same length. α for brass = 18×10^{-6}/°C and for iron $\alpha = 12 \times 10^{-6}$/°C. **(438.7°C)**

10. A rod A and a rod B are of equal length at 0°C. If at 100°C they differ in length by 1 mm, find their length at 0°C.
$\alpha_A = 8 \times 10^{-6}$/°C and $\alpha_B = 12 \times 10^{-6}$/°C. **(250 cm)**

11. A metre scale made of steel is correct at 0°C. If it is used for measurement at 15°C, what will be the error per metre? α for steel = 12×10^{-6} /°C. **(0.00018 m)**

12. An iron rod appears to be 1 m long when measured by a brass scale that is correct at 0°C both the rods at the time of observation being at 20°C. Find the length of the iron rod at 0°C and at 100°C. $\alpha_{iron} = 1.2 \times 10^{-5}$/°C and $\alpha_{brass} = 2 \times 10^{-5}$/°C. **(1.0004 m; 1.00136 m)**

13. A metal wire 100 cm long at 20°C, is bent into the shape of a hoop having a gap of 1.2 cm. The temperature of the wire is then increased uniformly to 120°C. The gap now increases in length to 1.224 cm. Find α for the material of the wire. **(2×10^{-4}/°C)**

14. The difference in length between two rods A and B is 60 cm at all temperatures. Find their lengths at 0°C if $\alpha_A = 18 \times 10^{-6}$/°C and $\alpha_B = 27 \times 10^{-6}$/°C. **(A : 180 cm, B : 120 cm)**

15. At 20°C, the gap between the rails each 50 m in length is observed to be 1.65 cm. If the lines are made of steel ($\alpha = 11 \times 10^{-6}$/°C), at what temperature will the lines just touch? At what temperature will the gap increase to 2.75 cm? **(50°C; 70°C)**

16. An iron ring 25 cm in diameter is to be slipped on a cartwheel 25.0275 cm in diameter. If the temperature of the ring is 30°C, to what temperature should it be raised so that it will just slip on the circumference of the cartwheel? α for iron = 11×10^{-6}/°C. **(130°C)**

17. A steel tyre of 1.2 m inner diameter at 20°C is to be fitted on a cartwheel of which the diameter is 3.3 mm larger than the inner diameter of the tyre. Calculate the temperature to which the steel tyre is to be raised so that it will just slip on the wheel. (α steel = 11×10^{-6}/°C) **(270°C)**

18. An aluminium ring of diameter 0.999 cm is to be fitted on an iron rod 1 cm in diameter. What should be the rise of temperature of the ring so that it can just slip on the rod? If the ring is to be subsequently removed by heating both metals together, through how many degrees should the temperature be raised? $\alpha_{Al} = 20 \times 10^{-6}$/°C; $\alpha_{iron} = 12 \times 10^{-6}$/°C **(40.04 °C; 66.67 °C)**

19. A thin copper disc has a hole of 2 cm diameter in the centre. Find the diameter of the hole when the temperature is increased by 15°C ($\alpha = 17 \times 10^{-6}$/°C). **(2.00051 cm)**

20. When the temperature of a metal sphere of radius 0.5 m is raised by 100°C, the radius increases by 1 cm. Calculate γ for metal. **(6×10^{-4}/°C)**

21. The volume of a metal block increases by 0.15% when its temperature is increased by 20°C. Find the coefficient of its linear expansion. **(2.5×10^{-5}/°C)**

PART 3 : THERMAL CONDUCTIVITY & NEWTONS LAW OF COOLING

1. Calculate the rate of flow of heat through 1 sq cm of a plate, 2 cm thick made of iron of conductivity 84 W/mK when the temperatures of its two sides differ by 12K. (5.04 W)

2. Calculate the difference in temperature between the two sides of an iron plate 2 cm thick when heat is conducted at the rate of 2.52×10^6 J per square metre per minute. k for iron = 84 W/mK. (10K)

3. A thickness of 2 cm of wool is required to conduct 42 joule per square metre per second for a temperature difference of 20K. Find k for wool. (0.042 W/mK)

4. An iron plate 2cm thick and of area $0.5 m^2$ has its two sides maintained at 423 K and 413 K respectively. Find the heat conducted through the plate in one minute. Thermal conductivity of iron = 60 W/mK. (9×10^5 J)

5. Calculate the amount of heat passing per second through a glass window which is 0.5 cm thick and of area one square metre if the temperature of the room is 5°C below that of outside. k for glass = 0.714 W/mK, J = 4.2 joule/cal. (170 cal)

6. Temperature inside a room is 20°C and outside it is -5°C. How much heat in k calories will escape per minute through a glass window 2 m long, 1 m wide and 0.5 cm thick? k = 0.95 W/mK. (135.7 kcal)

7. Temperature inside a room is 25°C and outside it is 10°C. How much heat will leave the room in 10 minutes through a glass window 2 m long, 1 m wide and 0.4 cm thick? k = 0.84 S.I. units. (900 kcal)

8. Find the hourly loss of heat through a wall (k = 2.1 W/mK) 5 m long, 3 m broad and 50 cm thick if the inside temperature of the room is 15°C and outside temperature is - 5°C. (1080 kcal)

9. It is required to maintain a steady flow of heat at the rate of 3000 cal/s through a metal plate of area 60 cm^2 and of thickness 0.5 cm. What should be the temperature difference between the faces of the metal plate? k for metal plate = 250 W/mK. (42 K)

10. A glass window pane has an area of 5000 sq cm and is only 3 mm thick. If the snow outside maintains the temperature of the outer surface at 273 K and the heat of the room maintains the inner surface at 283 K, how much heat will be conducted through the glass per minute? k for glass = 0.63 W/mK. (63000 J)

11. The upper surface of a stone slab is covered with ice and the lower surface is in contact with steam at 100°C. The slab is 60 cm × 60 cm and is 10 cm thick. If 80 g of ice are melted in one minute, what is the coefficient of thermal conductivity of the material of slab? Latent heat of fusion of ice = 3.36×10^5 J/kg. (1.24 W/mK)

12. A wooden ice box contains 8 kg of ice at 0°C. The inner dimensions of the box are 60 cm × 40 cm × 40 cm and the wood is 6 cm thick. Find the time in which ice would melt if the surrounding temperature is 20°C. k for wood = 0.0252 W/mK. Latent heat of fusion of ice = 80 kcal/kg. J = 4200 J/kcal. (25×10^4 s)

13. A glass vessel has an average conducting area of 0.01 m^2 and is 1.5 mm thick. It is filled with ice at 0°C and placed in an outer vessel containing a boiling liquid at 100°C. Find how many grams of ice melt per minute. Latent heat of fusion of ice = 80 kcal/kg; k for glass = 2×10^{-4} S.I. units. (100 g)

14. Along a well-lagged bar heated at one end, there are three thermometers T_1, T_2 and T_3 at distances of 3 cm, 8 cm and 11 cm from the hot end. T_1 reads 352 K, T_2 reads 343 K in the steady state. What is the reading on T_3? (337.6 K)

15. Heat flows at the rate of 168 J/s along a well-lagged metal rod 3 cm in radius. At a certain transverse section of the rod, the temperature is 80°C. At which section will the temperature be 60°C? k = 378 W/mK (12.72 cm)

16. One end of a lagged cylindrical metal rod of length 31.4 cm and radius 2 cm is kept in contact with ice at 0°C and the other end in water at 100 °C. Find the rate of melting of ice per minute. L = 80 cal/g, $k = 10^5$ S.I. units. (7.5 g)

17. One end of a 25 cm long lagged metal bar is in steam and the other is in contact with ice. If 12 g of ice melt per minute in the steady state, what is the thermal conductivity of the metal? Cross section of the bar is 25 cm^2 and the latent heat of fusion of ice is 80 kcal/kg. (67.2 W/m K)

18. A metal rod of length 50 cm and diameter 2 cm is lagged. One end of the rod is maintained at 100°C and the other end is kept surrounded with ice. If 23.5 g of ice melt in 10 minutes, find the coefficient of thermal conductivity of the material. Latent heat of fusion of ice = 80 cal/g. (209.5 W/m K)

19. Two conducting sheets of thicknesses 2.5 cm and 1.5 cm are in contact. Their thermal conductivities are respectively 105 and 126 S.I. units. If their outer surfaces are maintained at 98°C and 8°C respectively, find the temperature of interface. (38°C)

20. A slab consists of two parallel layers 4 cm and 2 cm in thickness and of different materials A and B. The coefficients of thermal conductivities of A and B are 226.8 and 151.2 S.I. units. If the outer surfaces of A and B are maintained at 373 K and 273 K respectively, find the temperature of interface. (315.96 K)

21. A boiler of copper plate 2.4 mm thick has a uniform layer of tin 0.2 mm thick inside. Surface area of the boiler exposed to the hot gases at 700°C is 100 cm^2. Calculate the amount of steam obtained per hour at atmospheric pressure. k for Cu = 378W/mK and for tin 63W/mK. L for steam = 2.268×10^6 J/kg. (1000 kg)

22. One end of a uniform brass rod 15 cm long and 20 cm^2 cross-sectional area is kept at 100°C. The other end of the rod is in perfect thermal contact with an iron rod of length 8 cm and identical cross-section. The free end of the iron rod is kept in melting ice and the experimental bars are well-lagged. In steady state, 630 g of ice melt per hour. If k_{brass} = 105 W/mK, find that for iron. Latent heat of fusion of ice = 80 cal/g. (40.55 W/mK)

23. The layer of ice on a pond is 3 cm thick and the temperature of air above it is 20 °C below zero. Find the time in which the thickness of ice on the pond increases by 1 mm. k for ice = 0.005 c.g.s. units. L for ice = 80 cal/g and density of ice = 0.91 g/cc. (222 s)

24. The ice on a pond is 1 cm thick. If the temperature of air is – 10°C, find the time that elapses before the thickness of ice on the pond increases to 2 cm. Density of ice = 0.91 g/cc; L for ice = 80 cal/g and k for ice = 0.005 c.g.s. units. (2160 s)

25. A metal sphere cools at the rate of 3°C per minute when its temperature is 50°C. Find its rate of cooling at 40°C if the temperature of surroundings is 25°C. (1.8°C/min)

26. A body at 50°C cools in surroundings at 30°C. At what temperature will its rate of cooling be half that at the beginning? (40°C)

27. A body cools from 75°C to 55°C in ten minutes when the surrounding temperature is 31°C. At what average temperature will its rate of cooling be $\frac{1}{4}$ th that at the start ? (48°C)

28. A body cools from 60°C to 50°C in 5 minutes. How much time will it take to cool from 50°C to 44°C if the surrounding temperature is 32°C? (4.6 minutes)