Exercise

Thermo-1

Elasticity, Calorimetry,

Thermal Expansion, Heat Transfer

(Physicsaholics)

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Exercise-2

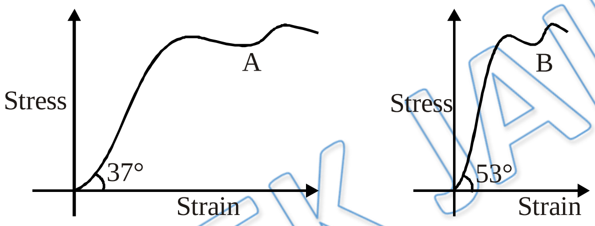
(Subjective Type: Level- 1)

Q 1. a steel wire of length 4m and diameter 5 mm is stretched by 5 kg-wt. find the increase in its length, if the young's modulus of steel of wire is 2.4×10^{12} dyne/cm^2?

Q 2. A steel wire of length 4.5 m and a copper wire of length 3.5 m are stretched same amount under a given load. If ratio of Young's modulli of steel to that of copper is $\frac{12}{7}$, then what is the ratio of cross sectional area of steel wire to copper wire?

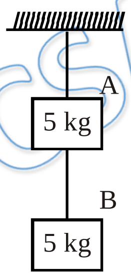
Q 3. One end of a uniform wire of length L and of weight w is attached rigidly to a point in the roof and a weight w_1 is suspended from its lower end. If S is the area of cross-section of the wire, find the stress in the wire at a height (3L/4) from its lower end.

Q 4. Diagram shows stress-strain graph for two material A & B. The graphs are drawn to scale.



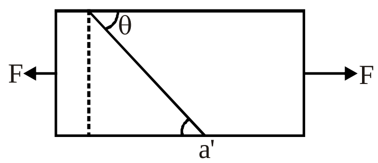
The ratio of young modulli of material A to material B is.

Q 5. Two identical wires A & B of same material are loaded as shown in figure. If the elongation in wire B is 1.5 mm, what is the elongation in A. (Mass of A & B can be neglected)



Q 6. A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force f, its length increases by *l*. Another wire of the same material of length 2L and radius 2r, is pulled by a force 2f. Find the increase in length of this wire.

Q 7. Consider a long steel bar under a tensile stress due to forces $\vec{F}$ 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?

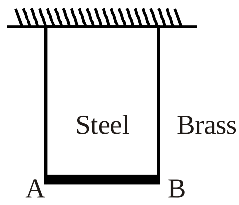
Q 8. A light rigid bar AB is suspended horizontally from two vertical wires, one of steel and one of brass, as shown in figure. Each wire is 2.00 m long. The diameter of the steel wire is 0.60 mm and the length of the bar AB is 0.20 m. When a mass of 10 kg is suspended from the centre of AB bar remains horizontal.

(i) What is the tension in each wire?

(ii) Calculate the extension of the steel wire and the energy stored in it.

(iii) Calculate the diameter of the brass wire.

(iv) If the brass wire were replaced by another brass wire of diameter 1 mm, where should the mass be suspended so that AB would remain horizontal? The Young modulus for steel = 2.0×10^{11} Pa, the Young modulus for brass = 1.0×10^{11} Pa.



Q 9. An iron bar (Young's modulus = 10^{11} N/m^2, $\alpha = 10^{-6}$ /°C) 1 m long and 10^{-3} m^2 in area is heated from 0°C to 100°C without being allowed to bend or expand. Find the compressive force developed inside the bar.

Q 10. A steel wire of 4.0 m in length is stretched through 2.0 mm. The cross-sectional area of the wire is 2.0 mm^2. If Young's modulus of steel is 2.0×10^{11} N/m^2 find

(a) the energy density of wire

(b) the elastic potential energy stored in the wire.

Q 11. One day in the morning, Ramesh filled up 1/3 bucket of hot water from geyser, to take bath. Remaining 2/3 was to be filled by cold water (at room temperature) to bring mixture to a comfortable temperature. Suddenly Ramesh had to attend to something which would take some times, say 5-10 minutes before he could take bath. Now he had two options: (i) fill the remaining bucket completely by cold water and then attend to the work, (ii) first attend to the work and fill the remaining bucket just before taking bath. Which option do you think would have kept water warmer? Explain.

Q 12. 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* = 0.2 cal/gm/°C)

Q 13. A hot liquid contained in a container of negligible heat capacity loses temperature at rate 3 K/min, just before it begins to solidify. The temperature remains constant for 30 min. Find the ratio of specific heat capacity of liquid to specific latent heat of fusion is in K^{-1} (given that rate of losing heat is constant).

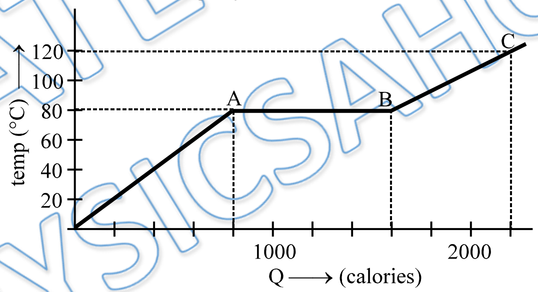
Q 14. Two 50 gm ice cubes are dropped into 250 gm of water into a glass. If the water was initially at a temperature of 25°C and the temperature of ice –15°C. Find the final temperature of water. (specific heat of ice = 0.5 cal/gm/°C and L = 80 cal/gm). Find final amount of water and ice.

Q 15. A flow calorimeter is used to measure the specific heat of a liquid. Heat is added at a known rate to a stream of the liquid as it passes through the calorimeter at a known rate. Then a measurement of the resulting temperature difference between the inflow and the outflow points of the liquid stream enables us to compute the specific heat of the liquid. A liquid of density 0.2 g/cm^3 flows through a calorimeter at the rate of 10 cm^3/s. Heat is added by means of a 250-W electric heating coil, and a temperature difference of 25°C is established in steady-state conditions between the inflow and the outflow points. Find the specific heat of the liquid.

Q 16. 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°)$^{-1}$.

Q 17. The temperature of 100 gm of water is to be raised from 24º C to 90º C by adding steam to it. Calculate the mass of the steam required for this purpose.

Q 18. 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.

Q 19. A vessel containing 100 gm water at 0°C is suspended in the middle of a room. In 15 minutes the temperature of the water rises by 2°C. When an equal amount of ice is placed in the vessel, it melts in 10 hours. Calculate the specific heat of fusion of ice.

Q 20. A steel wire of cross section area 0.5 mm^2 is held between two fixed supports. The tension in the wire is negligible and it is just taut at a temperature of 20^{0}C. Determine the tension when the temperature of the wire falls to 0^{0}C. Assume that the distance between the supports remains constant.(Y=2.1x10^{11}N/m^2,)
α = 12 x 10^{-6}/^{0}C.

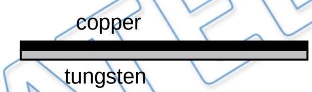
Q 21 A sphere of diameter 7cm and mass 266.5gm floats in a bath of liquid. As the temperature is raised , the sphere just sinks at a temperature of 35°C. If the density of the liquid at 0°C is 1.527gm/cm^3, find the co-efficient of cubical expansion of the liquid. (γ of sphere is negligible)

Q 22. If two rods of length L and 2 L having coefficients of linear expansion α and 2α respectively are connected so that total length becomes 3 L, determine the average coefficient of linear expansion of the composite rod.

Q 23. A steel tape measure the length of a copper rod at 90.00 cm when both are at 10°C, the calibration temperature for the tape. What would the tape reading the length of the rod when both are at 30°C? Given $\alpha_c = 1.7 \times 10^{-15}$ per °C and $\alpha_s = 1.2 \times 10^{-5}$ per °C.

Q 24. A clock pendulum made of invar has a period of 0.5 sec at 20°C. If the clock is used in a climate where average temperature is 30°C, approximately. How much fast or slow will the clock run in 10^6sec. ($\alpha_{invar} = 1 \times 10^{-6}$/°C)

Q 25. A copper and a tungsten plate having a thickness 2mm each are riveted together so that at 0^0C they form a flat bimetallic plate. Find the average radius of curvature of this plate at 200^0C. The coefficients of linear expansion for copper and tungsten are 1.7×10^{-5} k^{-1} and 0.4×10^{-5} k^{-1} respectively.



Q 26. A weight thermometer contains 82 gm of mercury at 0°C. When placed in an oil bath 2 gm is found to overflow. Find the temperature of oil bath. Coefficient of cubical expansion of mercury and glass are 0.00018/°C and 0.000026/°C respectively.

Q 27. A U-tube filled with a liquid of volumetric coefficient of 10^{-5}/°C lies in a vertical plane. The height of liquid column in the left vertical limb is 100 cm. The liquid in the left vertical limb is maintained at a temperature = 0°C while the liquid in the right limb is maintained at a temperature = 100°C. Find the difference in levels in the two limbs.

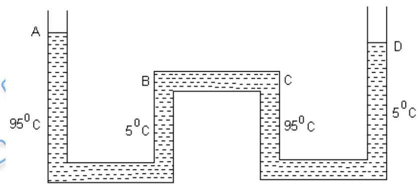
Q 28. A clock with a metallic pendulum is 5 seconds fast each day at a temperature of 15°C and 10 second slow at a temperature of 30°C. Find α for the pendulum metal.

Q 29. Three rods A,B and C having identical shape and size are hinged together at ends to form an equilateral triangle. Rods A and B are made of same material having coefficient of linear expansion α_1 while that of material of rod C is α_2. Temperature through which system of rods to be heated to increase the angle opposite to C by $\Delta\theta$ is $\dfrac{\sqrt{3}\Delta\theta}{x(\alpha_2 - \alpha_1)}$. Then x is

Q 30. Equal masses of three liquids have temperatures $5^0C, 15^0C$ and 20^0C respectively. If first two liquids are mixed, the mixture has temperature of 10^0C. If second and third are mixed, the equilibrium temperature is 16^0C. The final temperature if first and third liquid are mixed (in ^0C) is

Q 31. A vertical cylinder of height 80cm contain air at a constant temperature and in top is closed by a frictionless massless piston at atmosphere pressure (76 am of Hg). If mercury is slowly poured on the piston, due to its weight air is compressed. The maximum height of mercury column (in cm) which can be poured on the piston is

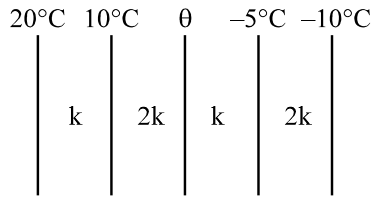
Q 32. The apparatus shown in the figure consists of four glass columns connected by horizontal section. The height of two central columns B and C are 49 cm each. The outer columns A and D are open to atmosphere. A and C are maintained at a temperature of 95^0C while the columns B and D are maintained at 5^0C. The height of the liquid in A and B measured from the base are 52.8 cm and 51 cm respectively. The coefficient of thermal expansion of the liquid is $a \times 10^{-4} /^0 C$ then a is



Q 33. A solid receives heat by radiation over its surface at the rate of 4 kW. The heat convection rate from the surface of solid to the surrounding is 5.2 kW, and heat is generated at a rate of 1.7 kW over the volume of the solid. The rate of change of the average temperature of the solid is 0.5°Cs^{-1}. Find the heat capacity of the solid.

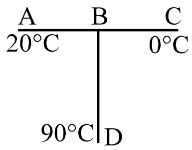
Q 34. A thin walled metal tank of surface area 5m^2 is filled with water and contains an immersion heater dissipating 1 kW. The tank is covered with 4 cm thick layer of insulation whose thermal conductivity is 0.2 W/m/K. The outer face of the insulation is 25°C. Find the temperature of the tank in the steady state

Q 35. 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.

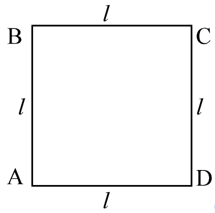


k = thermal conductivity

Q 36. Three conducting rods of same material and cross-section are shown in figure. Temperature of A, D and C are maintained at 20°C, 90°C and 0°C. Find the ratio of length BD and BC if there is no heat flow in AB



Q 37. 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.



Q 38. One end of copper rod of uniform cross-section and of length 1.5 meters is in contact with melting ice and the other end with boiling water. At what point along its length should a temperature of 200°C 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 the surroundings.

Q 39. A hot body placed in air is cooled according to Newton's Law of Cooling, the rate of decrease of temperature being k times the temperature difference from the surrounding. Starting from t = 0, find the time in which the body will loose 90 % of the maximum heat it can loose.

Q 40. A slab of stone of cross-section area 3600 cm^2 and thickness 10 cm is exposed on the lower surface to steam at 100°C. A block of ice at 0°C rests on upper surface of the slab. In one hour 4800 gm of ice is melted. Calculate the thermal conductivity of the stone.

Q 41. The thickness of ice on a lake is 5.0 cm and the temperature of air is –20 ^{0}C. Calculate how long will it take for the thickness of ice to be doubled. Thermal conductivity of ice is 0.005 cal/cm–sec–^{0}C, density of ice is 0.92 gm/cc and latent heat of ice is 80 cal/g.

Q 42. 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.

Q 43. 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?

Q 44. Heat flows radially outwards through a spherical shell of outside radius R_2 and inner radius R_1. The temperature of inner surface of shell is θ_1 and that of outer is θ_2. At what radial distance from the center of shell the temperature is just half way between θ_1 and θ_2.

Q 45. The maximum in the energy distribution spectrum of the sun is at 4753 $\mathring{A}$ and its temperature is 6050K. What will be the temperature of the star whose energy distribution shows a maximum at 9506 $\mathring{A}$.

Q 46. 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 ?

Answer Key

Ans 1. 0.0041 cm

Ans 2. 0.75

Ans 3. $[W_1 + 3W/4]/S$

Ans 4. $\frac{9}{16}$

Ans 5. 3 mm

Ans 6. ℓ

Ans 7. (a) $\theta = \frac{\pi}{2}$; (b) $\theta = \frac{\pi}{4}$

Ans 8. (i) 50 N, (ii) 0.045 J, 1.8×10^{-3} m (iii) 8.4×10^{-4} m, (iv) x=0.12m

Ans 9. 10,000 N

Ans 10. 2.5×10^4 J/m^3., 0.20 J.

Ans 11. The first one

Ans 12. 25.5°C

Ans 13. 1/90

Ans 14. 0 °C, 125/4 g ice, 1275/4 g water

Ans 15. 5000 J/°C kg

Ans 16. 27/85

Ans 17. 12 gm

Ans 18. (i) 0.02kg, (ii) 40,000 cal kg^{-1}, (iii)750 cal kg^{-1}K^{-1}

Ans 19. 80 k cal/kg

Ans 20. 25.2N

Ans 21. $0.00083/°C$

Ans 22. $5\alpha/3$

Ans 23. 90.01 cm

Ans 24. 5 sec. slow

Ans 25. 0.769 m

Ans 26. 162.33°C

Ans 27. 0.1 cm

Ans 28. $2.31 \times 10^{-5} per\ ^0C$

Ans 29. 2

Ans 30. 8

Ans 31. 4

Ans 32. 2

Ans 33. 1000 J (C°)$^{-1}$

Ans 34. 65°C

Ans 35. 5°C

Ans 36. AB

Ans 37. (4/3) ω

Ans 38. 10.34 cm

Ans 39. $\frac{ln\,10}{k}$

Ans 40. 3×10^{-4}k-cal-m^{-1}c^{-1}s^{-1}

Ans 41. 7 hrs 40 min

Ans 42. 2 : 1

Ans 43. $\left(\frac{6}{\pi}\right)^{1/3}$

Ans 44. $\frac{2R_1R_2}{R_1+R_2}$

Ans 45. 3025 K

Ans 46. 10 sec.