PHYSICS

NCERT - NCERT PHYSICS(ENGLISH)

THERMAL PROPERTIES OF MATTER

Solved Example

1. Show that the coefficient of area expansions $(\Delta A / A) / \Delta T$ of a rectangular sheet of the solid is twice its linear expansivity α.

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2. A blacksmith fixes iron ring on the rim of the wooden wheel of a bullock cart. The diameter of the rim and the ring are $5.243m$ and $5.231m$ respectively at $27^{\circ}C$. To what temperature should the ring be heated so as to fit the rim of the wheel ? Coefficient of linear expansion of iron $=1.20 \times 10^{-5}K^{-1}$

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3. A sphere of aluminium of mass 0.047 kg placed for sufficient time in a vessel containing boling water, so that the sphere is at $100^\circ C$. It is then immediately transferred to 0.14 kg copper calorimeter containing 0.25 kg of water at $20^\circ C$. The temperature of water rises and attains a steady state at $23^\circ C$. calculate the specific heat capacity of aluminum. Specific heat capacity of copper = $0.386 \times 10^3 Jkg^{-1}K^{-1}$.

Specific heat capacity of water = $4.18 \times 10^{-3} Jkg^{-1}K^{-1}$

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4. When 0.15 kg of ice at $0^\circ C$ is mixed with 0.30 kg of water at $50^\circ C$ in a container, the resulting temperature is $6.7^\circ C$. Calculate the heat of fusion of ice. $\left(s_{water} = 4186 J kg^{-1} K^{-1}\right)$

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5. Calculate the heat required to convert 3 kg of ice at $-12^\circ C$ kept in a calorimeter to steam at $100^\circ C$ at atmospheric pressure. Given, specific heat capacity of ice = $2100 J kg^{-1} K^{-1}$

specific heat capicity of water = $4186 J kg^{-1} K^{-1}$

Latent heat of fusion of ice = $3.35 \times 10^{5} J kg^{-1}$

and latent heat of steam = $2.256 \times 10^{6} J kg^{-1}$.

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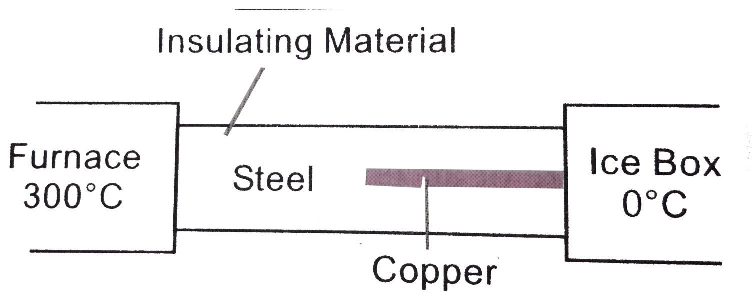
6. What is the temperature of the steel-copper junction in the steady state system show in Fig. $7(e).17$? Length of steel rod = 15.0 cm, length of the copper rod = 10.0 cm, temperature of the furnace $= 300^{\circ} C$, temperature of other end

$0^{\circ} C$. The are of cross-section of the steel rod is twice that of the copper rod. (Thermal conductivity of steel $= 50.2 js^{-1} m^{-1} K^{-1}$ and of copper $= 3895 js^{-1} m^{-1} K^{-1}$).



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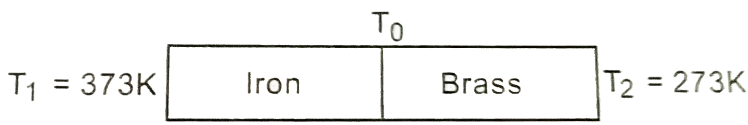
7. An iron bar ($L_1 = 0.1 m, A_1 = 0.02 m^2, K_1 = 79 W m^{-1} K^{-1}$) and a brass bar

$(L_2 = 0.1m, A_2 = 0.02m^2, K_2 = 109Wm^{-1}K^{-1}$) are soldered end to end as shown in fig. the free ends of iron bar and brass bar are maintained at 373 K and 273 K respectively. Obtain expressions for and hence compute (i) the temperature of the junction of the two bars, (ii) the equivalent thermal conductivity of the compound bar and (iii) the heat current through the compound bar.



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8. A pan filled with hot food cools from $94^{\circ} C$ to $86^{\circ} C$ in 2 minutes when the room temperature is at $20^{\circ} C$. How long will it take to cool from $71^{\circ} C$ to $69^{\circ} C$? Here cooling takes place according to Newton's law of cooling.

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Exercise

1. The triple point of neon and carbon dioxide are $24.57K$ and $216.55K$ respectively. Express these temperature on the Celsius and Fahrenheit scales.

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2. Two absolute scales A and B have triple points of water defined to be $200A$ and $350B$. What is the relation between T_A and T_B?

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3. The electrical resistance in ohms of a certain thermometer varies with temperature according to the approximate law: $R = R_0[1 + \alpha(T - T_0)]$

The resistances is 101.6Ω at the triple-point of water $273.16K$, and 165.5Ω at the normal melting point of lead $(600.5K)$. What is the temperature when the resistance is 123.4Ω?

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4. Answer the following :

(a) The triple-point of water is a standard fixed point in modern thermometry. Why ? What is wrong in taking the melting point of ice and the boiling point of water as standard fixed points (as was originally done in the Celsius scale) ?

(b) There were two fixed points in the original Celsius scale as mentioned above which were assigned the number $0^{\circ}C$ and $100^{\circ}C$ respectively. On the absolute scale, one of the fixed points is the triple-point of water, which on the Kelvin absolute scale is assigned the number 273.16 K. What is the other fixed point on this (Kelvin) scale ?

(c) The absolute temperature (Kelvin scale) T is related to the temperature t_c on the Celsius scale by

$$t_c = T - 273.15$$

Why do we have 273.15 in this relation, and not 273.16 ?

(d) What is the temperature of the triple-point of water on an absolute scale whose unit interval size is equal to that of the Fahrenheit scale ?

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5. Two ideal gas thermometer A and B use oxygen and hydrogen respectively . The following observations are made:

Temperature, Pressure therometer A, Pressure therometer B

Triple point of water, $1.250 \times 10^5 Pa$, $0.200 \times 10^5 Pa$

Normal melting point of sulphur, $1.797 \times 10^5 Pa, 0.287 \times 10^5 Pa$

(a) What is the absolute temperature of normal melting point of sulphur as read by thermometers A and B ?

(b) What do you think is the reason for the slightly different answers from A and B ? (The thermometers are not faulty). what further procedure is needed in the experiment to reduce the discrepancy between the two readings.

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6. A steel tape 1m long is correctly calibrated for a temperature of $27^{\circ} C$. The length of a steel rod measured by this tape is found to be $63.0cm$ on a hot day when the temperature is $45.0^\circ C$. What is the acutual length of the steel rod on that day? what is the length of the same steel rod on a day when the temperature is $27.0^\circ C$? coefficient of linear expansion of steel $= 1.20 \times 10^{-5} . ^\circ C^{-1}$.

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7. a large steel wheel is to be fitted on to a shaft of the same material. At $27^\circ C$, the outer diameter of the shaft is $8.70cm$ and the diameter of the central hole in the wheel is $8.69cm$. The shaft is cooled using 'dry ice' , At what temperature of the shaft does the wheel slip on the shaft? Assume coefficient of linear expansion of the steel to be constant over the required temperature range: $\alpha_{steel} = 1.20 \times 10^{-5} K^{-1}$.

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8. A hole is drilled in a copper sheet. The diameter of the hole is $4.24cm$ at $27.0^{\circ} C$. What is the change in the diameter of the hole when the sheet is heated to $227^0 C$? α for copper

$= 1.70 \times 10^{-5} K^{-1}$

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9. A brass wire $1.8m$ long at $27^\circ C$ is held taut with little tension between two rigid supports. If the wire cooled to a temperature of $-39^\circ C$, what is the tension developed in the wire, if its diameter is $2.0mm$? Coefficient of linear expansion of brass $= 2.0 \times 10^{-5} / ^\circ C$, Young's modulus of brass $= 0.91 \times 10^{11} Pa$.

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10. A brass rod of length $50cm$ and diameter $3.0cm$ is joined to a steel rod of the same length and diameter. What is the change in length of the combined rod at $250^\circ C$, if the original length are at $40.0^\circ C$?

(Coefficient of linear expansion of brass $= 2.0 \times 10^{-5} / ^\circ C, steel = 1.2 \times 10^{-5} / ^\circ C$

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11. The coefficient of volume expansion of glycerine is $49 \times 10^{-5} / {}^{\circ} C$. What is the fractional change in its density (approx.) for $30^{\circ} C$ rise in temperature?

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12. A $10 kW$ drilling machine is used to drill a bore in a small aluminium block of mass $8.0 kg$. How much is the rise in temperature of the block in 2.5 minutes, assuming 50% of power is used up in heating the machine itself or lost to the surrounding? Specific heat of aluminium

$= 0.91 J / g^{\circ} C.$

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13. A copper block of mass $2.5 kg$ is heated in a furnace to a temperature of $500^{\circ} C$ and then placed on a large ice block. What is the maximum amount (approx.) of ice that can melt? (Specific heat copper $= 0.39 J / g^{\circ} C$ heat of fusion of water $= 335 J / g$).

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14. In an experiment on the specific heat of a metal a 0.20 kg block of the metal at 150°C is dropped in a copper calorimeter (of water equivalent 0.025 kg) containing 150 cc of water at 27°C. The final temperature is 40°C. Calcualte the specific heat of the metal. If heat losses to the surroundings are not negligible, is our answer greater or smaller than the actual value of specific heat of the metal?

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15. Given below are observations on molar specific heats at room temperature of some common gases

Gas	Molar specific heat (C_v) (cal mol^{-1} K^{-1})
Hydrogen	4.87
Nitrogen	4.97
Oxygen	5.02
Nitric oxide	4.99
Carbon monoxide	5.01
Chlorine	6.17

The measured molar specific heats of these gases are markedly different from those for monatomic gases. Typically, molar specific heat of a monatomic gas is 2.92 cal/mol K. Explain this difference. What can you infer from the somewhat larger (than the rest) value for chlorine ?

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16. A child running a temperature of 101^F is given and antipyrin (i.e. a madicine that lowers fever) which cause an increase in the rate of evaporation of sweat from his body. If the fever is brought down to $98^\circ F$ in 20 min., what is the averatge rate of extra evaporation caused, by the drug ? Assume the evaporation mechanism to the only way by which heat is lost. The mass of the child is 30 kg. The specific heat of human body is approximately the same as that of water and latent heat of evaporation of water at that temperature is about $580 cal. g^{-1}$.

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17. A thermocole cubical icebox of side 30 cm has a thickness of 5.0 cm if 4.0 kg of ice are put ini the box, estimate the amount of ice remaining after 6 h. The outside temperature is

$45^\circ C$ and coefficient of thermal conductivity of thermocole $= 0.01 J / kg$.

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18. A brass boiler has a base area of $0.15 m^2$ and thickness 1.0 cm it boils water at the rate of $6.0 kg / \min$, When placed on a gas. Estimate the temperature of the part of the flame in contact with the boiler. Thermal conductivity of brass $= 109 J / s - .^\circ C$) and heat of vapourization of water $= 2256 J / g$.

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19. Explain why : (a) A body with large reflectivity is a poor emitter. (b) A brass tumbler feels much colder then a wooden tray on a chilly day. (c) an optical pyrometer (for measuring high temperatures) calibrated for an ideal black body correct value for the temperature when the same piece is in the furnace. (d) The earth without its atmosphere would be inshospitably cold. (e) Heating system based on circulation of steam are more effecient in warming a building than those based on circulation of hot water.

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20. A body cools from $80^\circ C$ to $50^\circ C$ in 5 minutes Calculate the time it takes to cool from $60^\circ C$ to $30^\circ C$ The temperature of the surroundings is $20^\circ C$.

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21. Answer the following questions based on the p-T phase diagram of carbon dioxide as shown in the figure .

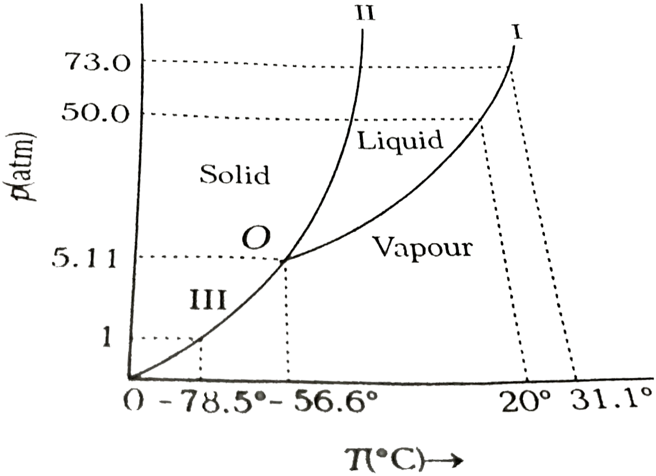
(i) At what temperature and pressure can the solid , liquid and vapour phases of $C0_2$ co-exist in equilibrium?

(ii) What is the effect of decrease of pressure on the fusion and boiling point of $C0_2$?

(iii) What are the critical temperature and pressure for $C0_2$? what is their significance ?

(iv) Is $C0_2$ solid , liquid, or gas at (a) $-70^\circ C$ under 1 atm (b) $-60^\circ C$ under 10 atm (c) $15^\circ C$

under 56 atm ?



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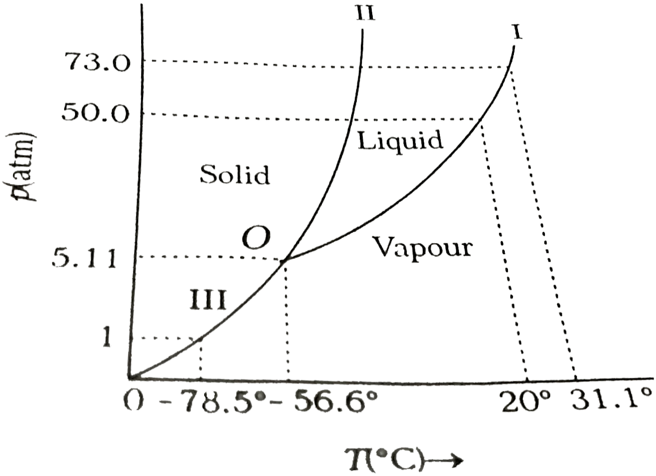
22. Answer the following questions based on the P – T phase diagram of CO_2:

(a) CO_2 at 1 atm pressure and temperature $-60^\circ C$ is compressed isothermally. Does it go through a liquid phase ?

(b) What happens when CO_2 at 4 atm pressure is cooled from room temperature at constant pressure ?

(c) Describe qualitatively the changes in a given mass of solid CO_2 at 10 atm pressure and temperature $-65^\circ C$ as it is heated up to room temperature at constant pressure.

(d) CO_2 is heated to a temperature $70^\circ C$ and compressed isothermally. What changes in its properties do you expect to observe ?



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