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PHYSICS

NCERT - NCERT PHYSICS(GUJRATI)

THERMAL PROPERTIME OF MATTER

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 expansively, α_l. $(\alpha_l = 10^{-5} K^{-1})$

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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 iron ring are 5.243m and 5.231 m respectively at $27\ ^{\circ}C$. To what temperature should the ring be heated so as to fit the rim of the wheel ? $(\alpha_1 = 1.20 \times 10^{-5} K^{-1})$

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3. A sphere of aluminium of 0.047 kg placed for sufficient time in a vessel containing boiling water, so that 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 aluminium.

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4. When0.15kg of ice at $0^\circ 0$ 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. $\left(S_{\text{water}} = 4186 Jkg^{-1} K^{-1}\right)$

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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 $= 2100 Jkg^{-1} K^{-1}$, specific heat capacity of water $= 4186 Jkg^{-1} K^{-1}$, latent heat of fusion of ice $= 3.35 \times 10^5 Jkg^{-1}$ and latent heat of steam $= 2.256 \times 10^8 Jkg^{-1}$.

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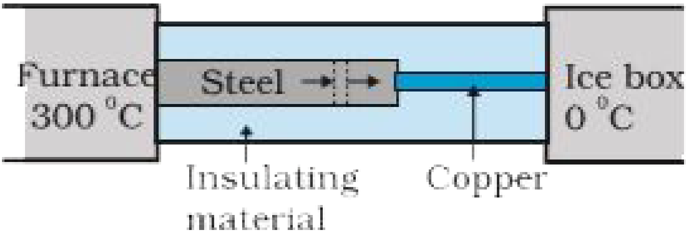
6. What is the temperature of the steel - copper junction in the steady state of the system shown in Fig.11.15.



Length of the steel rod $= 15.0$cm, length of the copper reod $= 10.0$ cm, temperarure of the furnace $= 300^{\circ} C$, temperature of the furnace $= 300^{\circ} C$, temperature of the 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 $= 50.2 J s^{-1} m^{-1} K^{-1}$, and of copper $= 385 J s^{-1} m^{-1} K^{-1}$).

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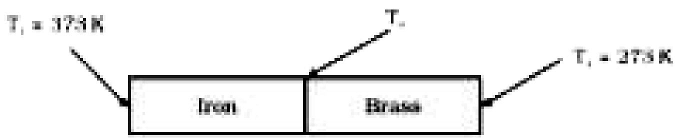
7. An iron bar $(L_1 = 0.1 m, A_1 = 0.02 m^2, K_1 = 79 W m^{-1} K^{-1})$ and a brass bar

$\left(L_2 = 0.1m, A_2 = 0.02m^2, K_2 = 109Wm^{-1}K^{-1}\right)$ are soldered end to end as shown in Fig. 11.16. The free ends of the iron bar and brass bar are maintained at 373 K and 273 K respectively. Obtain expressions for and hence compute (1) the temperature of the function of the two bars, (11) the equivalent thermal conductivity of the compound bar, and (111) 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 $69^\circ C$?

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Exercises

1. The triple points of neon and carbon dioxide are $24.57K$ and $216.55K$ respectively. Express these temperatures 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 200 A and 350 B. 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 resistance 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. 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 bothing point of water as standard fixed points as was originally done in the Celsius scale) ?

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5. There were two fixed points in the original Celsius scale as mentioned above which were assigned the mimber $0^\circ C$ 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 ass ned the number $273.16K$ What is the other ftsed point on this (Kelvin) scale ?

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6. 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?

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7. 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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8. Two ideal gas thermometers A and B use oxygen and hydrogen respectively. The following observations are made:

Temperature	Pressure thermometer A	Pressure thermometer B
Triple - point 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 behind the slight difference in answers of thermometers 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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9. A steel tape Im long is correctly calibrated for a temperature of $27.0^{\circ} C$. The length of a steel rod measured by this tape is found to be 63.0 cm on a hot day when the temperature is $45.0^{\circ} C$ .What is the actual 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 $= 1.20 \times 10^{-5} K^{-1}$.

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10. 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 8.70 cm and the diameter of the central hole in the wheel is 8.69cm. The shaft is cooled using dry Icel. 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:

$\alpha_{\text{steel}} = 1.20 \times 10^{-5} K^{-1}$.

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11. A hole is drilled in a copper sheet. The diameter of the hole is 4.24 cm at $27.0^\circ C$. What is the change in the diameter of the hole when the sheet is heated to $227^\circ C$? Coefficient of Imear expansion of copper $= 1.70 \times 10^{-5} K^{-1}$.

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12. A brass wire1.8m long at $27^\circ C$ is held taut with little tension between two rigid supports. If the wire is cooled to a temperature of $-39^\circ C$. what is the tension developed in the wire, if its diameter is 2.0 mm ? Co-efficient of tear expansion of brass $= 2.0 \times 10^{-5} K^{-1}$, Young's modulus of brass = 0.91×10^{11} Pa.

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13. A brass rod of length 50 cm and diameter 3.0 mm 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 lengths are at $40.0^\circ C$? Is there a "thermal stress developed at the junction ? The ends of the rod are free to expand (Co-efficient of linear expansion of brass $= 2.0 \times 10^{-5} K^{-1}, \quad \text{steel} \quad = 1.2 \times 10^{-5} K^{-1}$).

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14. The coefficient of volume expansion of glycerine is $49 \times 10^{-5} K^{-1}$. What is the fractional change in its density for a $30^\circ C$ rise in temperature ?

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15. A 10 kW drilling machine is used to drill a bore in a small aluminium block of mass 8.0kg. 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 Surroundings. Specific heat of aluminium $= 0.91Jg^{-1}K^{-1}$.

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16. A copper block of mass2.5 kg ts heated in a furnace to a temperature of $500^{\circ}C$ and then placed on a large ice block. What is the maximum amount of ice that can melt? (Specific heat of copper = $0.39Jg^{-1}K^{-1}$, $\text{heat of fusion of water} = 335Jg^{-1}$).

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17. In an experiment on the specific heat of a metal, a 0.20kg block of the metal at $150^\circ C$ is dropped in a copper calorimeter (of water equivalent 0.025 kg containing $150cm^3$ of water at $27^\circ C$. The final temperature is $40^\circ C$. Compute the specific heat of the metal. If heat losses to the surroundings are not negligible. Is your answer greater or smaller than the actual value for specife heat of the metal ?

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

Gas	Molar specific heat (C_v) $\left(\text{cal mol}^1 K^{-1}\right)$
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 monatomie gas is2.52 cal/mol K. Explain this difference. What can you infer from the somewhat larger than the rest) value for chlorine ?

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19. A child running a temperature of $101^\circ F$ is given an antipyrin (1.e. a medicine that lowers fever) which causes an increase in the rate of evaporation of sweat from his body. If the fever is brought down to $98^\circ F$ in 20 minutes, what is the average rate of extra evaporation caused by the drug. Assume the evaporation mechanism to be 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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20. A' thermacole' icebox is a cheap and an efficient method for storing small quantities of cooked food in summer in particular. A cubical icebox of side 30 cm has a thickness of $5.0cm$. if 4.0kg of ice is put in the box, estimate the amount of Ice remaining after 6 h. The outside temperature is $45^\circ C$ and co-efficient of thermal conductivity of thermacole is $0.01Js^{-1}m^{-1}K^{-1}$. [Heat of fusion of water $= 335 \times 10^3 Jkg^{-1}$]

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21. A brass boiler has a base area of $0.15m^2$ and thickness 1.0 cm. It boils water at the rate of 6.0 kg/min when placed on a gas stove. Estimate the temperature of the part of the flame in contact with the boller. Thermal conductivity of brass $= 109Js^{-1}m^{-1}K^{-1}$, Heat of vaporisation of water $= 2256 \times 10^3 Jkg^{-1}$.

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22. Explain why :

(a) a body with large reflectivity is a poor emitter

(b) a brass tumbler feels much colder than a wooden tray on a chilly day

(c) an optical pyrometer (for measuring high temperatures calibrated for an ideal black body radiation gives too low a value for the temperature of a red hot Iron plece in the open, but gives a correct value for the temperature when the same plece is in the fumace

(d) the earth without its atmosphere would be inhospitably cold

(e) heating systems based on circulation of steam are more efficient in warming a building than those based on circulation of hot water

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23. 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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24. Answer the following questions based on the P-T phase diagram of carbon dioxide:

At what temperature and pressure can the solid, liquid and vapour phases of CO_2 co-exist in equilibrum ?

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25. Answer the following questions based on the P-T phase diagram of carbon dioxide:

What is the effect of decrease of pressure on the fusion and boiling point of CO_2 ?

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26. Answer the following questions based on the P-T phase diagram of carbon dioxide:

What are the critical temperature and pressure for CO_2? What is their significance ?

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27. Answer the following questions based on the P-T phase diagram of carbon dioxide:

Is CO_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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28. Answer the following questions based on the P-T phase diagram of CO_2:

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

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29. Answer the following questions based on the P-T phase diagram of CO_2:

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

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30. Answer the following questions based on the P-T phase diagram of CO_2:

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.

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31. Answer the following questions based on the P-T phase diagram of CO_2:

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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