NCERT Class 11 Physics Solutions: Chapter 11 – Thermal Properties of Matter-Part 6 (For CBSE, ICSE, IAS, NET, NRA 2022)

Question 11.14:

In an experiment on the specific heat of a metal, a $0.20\ \text{kg}$ block of the metal at $150°C$ is dropped in a copper calorimeter (of water equivalent $0.025\ \text{kg}$) containing $150\ \text{cm}^3$ of water at $27°C$. The final temperature is $40°C$. 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 specific heat of the metal?

Answer:

Mass of the metal, $m = 0.20\,\text{kg} = 200g$

Initial temperature of the metal, $T_1 = 150°C$

Final temperature of the metal, $T_2 = 40°C$

Calorimeter has water equivalent of mass, $m' = 0.025\,\text{kg} = 25g$

Volume of water, $V = 150\ \text{cm}^3$

Mass (M) of water at temperature $T = 27°C$

$$= 150 \times 1 = 150g$$

Fall in the temperature of the metal:

$$\Delta T = T_1 - T_2 = 150 - 40 = 110°C$$

Specific heat of water, $\dfrac{C_w = 4.186\frac{j}{g}}{°K}$

Specific heat of the metal $= C$

Heat lost by the metal, $\theta = \text{mC}\,\Delta\,T \cdots (i)$

Rise in the temperature of the water and calorimeter system:

$$\Delta T' = 40 - 27 = 13°C$$

Heat gained by the water and calorimeter system:

$$\Delta\theta'' = m_1 C_w \Delta T'$$

$$= (M + m') C_w \Delta T' \ldots \text{(ii)}$$

Heat lost by the metal = Heat gained by the water and colorimeter system

$$\text{mC} \Delta T = (M + m') C_w \Delta T'$$

$$200 \times C \times 110 = (150 + 25) \times 4.186 \times 13$$

$$\therefore C = \frac{175 \times 4.186 \times 13}{110 \times 200}$$

$$= 0.43 J\ g^{-1}\ K^{-1}$$

If some heat is lost to the surroundings, then the value of C will be smaller than the actual value.

Question 11.15:

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 $2.92\frac{\text{cal}}{\text{mol}}K$. Explain this difference. What can you infer from the somewhat larger (than the rest) value for chlorine?

Answer:

The gases listed in the given table are diatomic. Besides the translational degree of freedom, they have other degrees of freedom (modes of motion) .

Heat must be supplied to increase the temperature of these gases. This increases the average energy of all the modes of motion. Hence, the molar specific heat of diatomic gases is more than that of monatomic gases.

If only rotational mode of motion is considered, then the molar specific heat of a diatomic gas $= \frac{5}{2}R$

$$= \frac{5}{2} \times 1.98 = 4.95 \text{ cal mol}^{-1} \ K^{-1}$$

Except for chlorine, all the observations in the given table agree with $\left(\frac{5}{2}R\right)$. This is because at room temperature, chlorine also has vibrational modes of motion besides rotational and translational modes of motion.