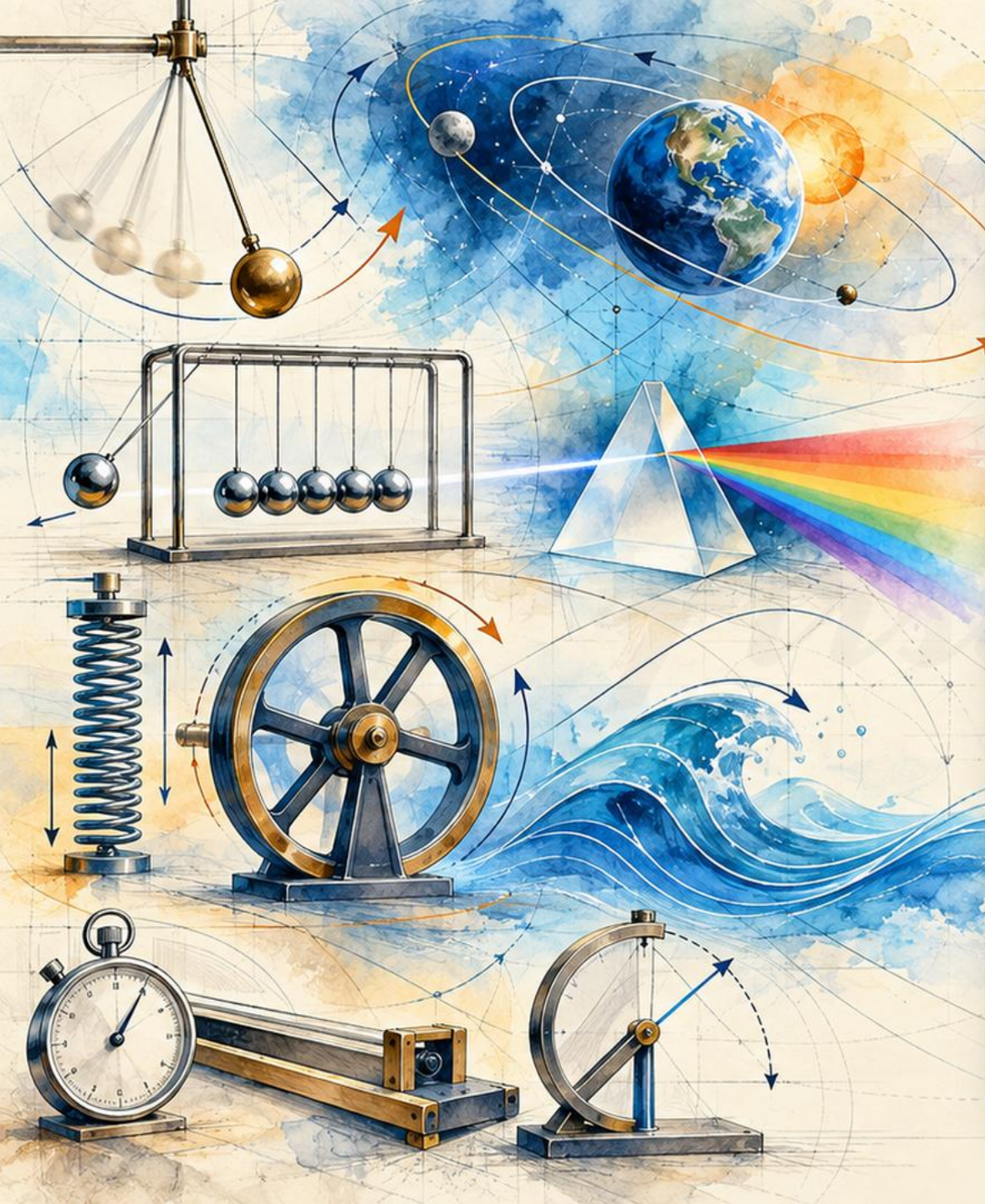




PHYSICS • CLASS 11

10

CHAPTER

Thermal Properties of Matter

NCERT SOLUTIONS

EXERCISE SOLUTION: QUESTION 10.1

Q. 10.1 The triple points of neon and carbon dioxide are 24.57 K and 216.55 K respectively. Express both temperatures on the Celsius and Fahrenheit scales.

$$t_C = T_K - 273.15$$

$$t_F = \left(\frac{9}{5}\right)t_C + 32$$

Neon

$$t_C = 24.57 - 273.15 = -248.58 \text{ } ^\circ\text{C}$$

$$\begin{aligned} t_F &= \left(\frac{9}{5}\right)(-248.58) + 32 \\ &= -415.444 \text{ } ^\circ\text{F} \approx -415.44 \text{ } ^\circ\text{F} \end{aligned}$$

Carbon dioxide

$$t_C = 216.55 - 273.15 = -56.60 \text{ } ^\circ\text{C}$$

$$\begin{aligned} t_F &= \left(\frac{9}{5}\right)(-56.60) + 32 \\ &= -69.88 \text{ } ^\circ\text{F} \end{aligned}$$

First convert the kelvin reading to Celsius. Then apply the Fahrenheit relation, retaining the negative sign.

Neon: $-248.58 \text{ } ^\circ\text{C}$; $-415.44 \text{ } ^\circ\text{F}$

Carbon dioxide: $-56.60 \text{ } ^\circ\text{C}$; $-69.88 \text{ } ^\circ\text{F}$

EXERCISE SOLUTION: QUESTION 10.2

Question 10.2: Two absolute temperature scales A and B assign the triple point of water the readings 200 A and 350 B. Find the relation between readings T_A and T_B for the same temperature.

Answer:

Both absolute scales have the same physical zero: absolute zero. Their readings are proportional; only the size of the unit differs. Compare each reading with its scale's triple-point reading.

$$\frac{T_A}{200} = \frac{T_B}{350}$$

$$350 T_A = 200 T_B$$

$$T_B = \frac{350}{200} T_A = \frac{7}{4} T_A$$

$$\text{Equivalently, } T_A = \frac{4}{7} T_B.$$

A larger numerical reading for the same temperature means a smaller unit interval. No additive temperature offset is needed between these two absolute scales.

EXERCISE SOLUTION: QUESTION 10.3

Question 10.3: A thermometer obeys $R = R_0[1 + \alpha(T - T_0)]$. Its resistance is $101.6 \, \Omega$ at $273.16 \, \text{K}$ and $165.5 \, \Omega$ at the normal melting point of lead, $600.5 \, \text{K}$. Find the temperature when the resistance is $123.4 \, \Omega$.

Solution:

The given law makes resistance a linear function of temperature. Use the two calibration points to remove the unknown constants.

$$\frac{R - R_1}{R_2 - R_1} = \frac{T - T_1}{T_2 - T_1}$$

$$T = T_1 + \left(\frac{R - R_1}{R_2 - R_1} \right) (T_2 - T_1)$$

$$T = 273.16 + \left[\frac{123.4 - 101.6}{165.5 - 101.6} \right] (600.5 - 273.16)$$

$$T = 273.16 + \left(\frac{21.8}{63.9} \right) (327.34)$$

$$T \approx 384.835 \, \text{K}$$

Temperature $\approx 384.8 \, \text{K}$.

This reading lies between the two calibration temperatures, as expected because its resistance lies between the two calibration resistances.

EXERCISE SOLUTION: QUESTION 10.4 (a–b)

(a) Why is water's triple point useful as a thermometric fixed point? Why are the melting point of ice and boiling point of water less suitable without extra controls?

Answer: At the triple point, pure ice, liquid water and water vapour coexist in equilibrium at a unique temperature and pressure. This makes it highly reproducible.

Melting and boiling temperatures depend on pressure and impurities, so those conditions must be specified and controlled.

(b) The original Celsius scale used the ice and steam points as 0°C and 100°C . In the historical Kelvin calibration, water's triple point was assigned 273.16 K . What is the other fixed reference?

Answer: Absolute zero: 0 K .

It fixes the zero of the absolute scale; the triple-point assignment fixed the unit interval in that historical definition.

This question uses the historical triple-point calibration. The current SI defines the kelvin through the Boltzmann constant.



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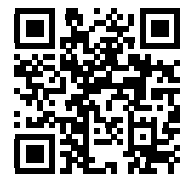


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