228.

Problem 25.21 (RHK)

Near absolute zero, the molar heat capacity of aluminium varies with the absolute temperature T and is given by $C = \left(3.16 \times 10^{-5}\right) T^3$ J mol^{-1} K^{-1}. *We have to calculate the heat needed to raise the temperature of* 1.2 g *of aluminium from* 6.6 to 15 K.

Solution:

Molar mass of aluminium is $M_{al} = 26.9815$ g.

Molar mass of 1.2 g of aluminium will be

$$m_{al} = \frac{1.2}{26.9815} \text{ mol} = 4.45 \times 10^{-2} \text{ mol.}$$

It is given that the heat capacity of aluminium at low temperatures varies as

$C = \left(3.16 \times 10^{-5}\right) T^3$ J mol^{-1} K^{-1}.

Therefore, the amount of heat needed for heating 1.2 g of aluminium from 6.6 K to 15 K can be calculated by integration

$$Q = 4.45\times10^{-2}\times3.16\times10^{-5}\int_{6.6}^{15} T^3 dT \text{ J}$$

$$= 14.06\times10^{-7}\left[\frac{T^4}{4}\right]_{6.6}^{15} \text{ J} = 3.52\times10^{-7}\left(15^4 - 6.6^4\right) \text{ J}$$

$$= 17.1 \text{ mJ}.$$