Adkins 3.7 (3)

We plung a macc of copper into a bath of water. If we know the initial and final temperatures of the mass and the water, we can determine the specific heat capacity of the copper.

The heat which leaves the copper is

$$dQ_{cu} = m_{cu} C_{cu} \left(T_{cu,init} - T_{cu,final} \right)$$

The heat which enters the water is

$$dQ_{H_2O} = -M_{H_2O} C_{H_2O} \left(T_{H_2O,init} - T_{H_2O,final} \right)$$

Using conservation of energy, $dQ_{cu} = dQ_{H_2O}$

$$M_{cu} C_{cu} \left(T_{cu,i} - T_{cu,f} \right) = -M_{H_2O} C_{H_2O} \left(T_{H_2O,i} - T_{H_2O,f} \right)$$

Solving for C_{cu} gives

$$C_{cu} = \frac{m_{H_2O} C_{H_2O} \left(T_{H_2O,f} - T_{H_2O,i} \right)}{m_{cu} \left(T_{cu,i} - T_{cu,f} \right)}$$

We convert the given volume of water into mass and plug in numbers to obtain

$$C_{cu} = \frac{\left(\frac{1000\,kg}{m^3}\right)\left(2e\text{-}4\,m^3\right)\left(\frac{4186\,J}{kg}\right)\left(18.8-15.0\right)}{\left(0.1\,kg\right)\left(100-18.8\right)}$$

$$= \frac{(837)(3.8)}{8.12}$$

$$\boxed{C_{cu} = 391.7\ J/kg}$$

This, incidentally, is the constant pressure specific heat, C_p. How much different is C_p than C_v under these conditions? Unfortunately, Adkins does not cover this topic until Ch. 8, in which he shows that

$$C_p - C_v = v T \beta^2 / K_T \qquad \text{(eq. 8.5)}$$

where
β = isobaric cubic expansivity $= 51 \times 10^{-6}/deg.$
K_T = isothermal compressibility $\doteq 9.5 \times 10^{-13}\ cm^2/dyne$
v = molar volume. $= 7.1\ cm^3/mol$

Using the values for copper,

$$C_p - C_v = 12e6\ ergs/mol = 1.2\ Joules/mol \cdot \frac{1\,mol}{.064\,kg}$$

$$C_p - C_v = 0.018\ J/g = \boxed{18\ J/kg}$$