KING FHAD UNIVERSITY OF PETROLEUM & MINERALS
DEPARTMENT OF PHYSICS

PHYSICS 102 (992)
SOLUTION (CHAPTER 20)

Q.1 It is possible to melt ice by rubbing one block of it against another. How much work, in joules, would you have to do to get 1.00 g of ice to melt?

Mechanical energy is transformed into heat.

$$W = Q = m L_f = 1\times10^{-3}\ kg \times 3.33\times10^{5}\ J/kg$$

$$W = 333\ J$$

Q.2 Calculate the specific heat of a metal from the following data. A container made of metal has a mass 3.6 kg and contains 14 kg of water. A 1.8 kg piece of the metal initially at a temperature of 180 °C is dropped into the water. The container and water initially have a temperature of 16.0 °C, and the final temperature of the entire system is 18.0 °C.

mass of container = $m_c = 3.6$ kg

" " water = $m_w = 14$ kg

" " the metal = $m_x = 1.8$ kg

$$m_x c_x (180 - 18) = m_c c_x (18 - 16) + m_w c_w (18 - 16)$$

$$m_x c_x (162) = m_c c_x (2) + m_w c_w (2)$$

$$c_x (m_x 162 - 2 m_c) = 2 m_w c_w$$

$$c_x = \frac{2 (14) (4186)}{(1.8) (162) - 2(3.6)} = 412 \text{ J/kg °C}$$

$$\boxed{c_x = 412 \text{ J/kg °C}}$$

Q.3 A sample of gas expands from 1.0 m^3 to 4.0 m^3 while its pressure decreases from 40 Pa to 10 Pa. How much work is done by the gas if its pressure changes with volume via each of the three paths shown in the P-V diagram in Figure 20.3?

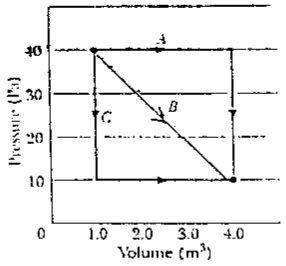

FIG. 20.3

W = Area under the curve in P-V diagram.

$$W_A = 40 \times (4-1) = 120\ J$$

$$W_B = \left(\frac{40+10}{2}\right) \times (4-1) = \frac{50}{2} \times 3 = 75\ J$$

$$W_C = 10 \times (4-1) = 30\ J$$

Q.4 Figure 20.4a shows a cylinder containing gas and closed by a movable piston. The cylinder is kept submerged in an ice-water mixture. The piston is quickly pushed down from position 1 to position 2 and then held at position 2 until the gas is again at the temperature of the ice-water mixture; it then is slowly raised back to position 1. Figure 20.4b is a P-V diagram for the process. If 100 g of ice is melted during the cycle, how much work has been done on the gas?

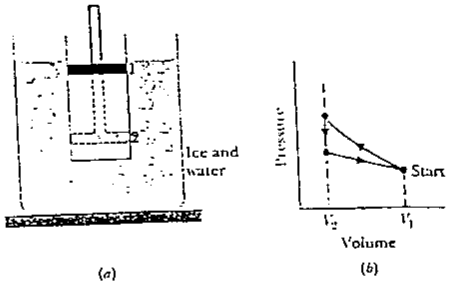

FIG. 20.4

$Q_{AB} = 0$, adiabatic (done quickly)

$\Delta U = 0$, complete cycle

$\Delta U = Q - W$

$W = Q = (0.100)(3.33 \times 10^5) = 0.333 \times 10^5 \text{ J}$

$= 33.3 \text{ KJ}$

Q.5 Gas within a chamber passes through the cycle shown in the figure 20.5. Determine the net heat added to the system during process CA if the heat Q_{AB} added during process AB is 20.0 J, no heat is transferred during process BC, and the net work done during the cycle is 15.0 J.

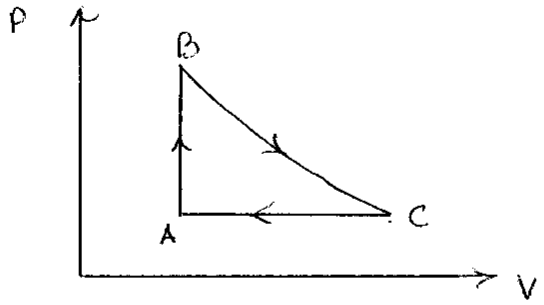

FIG. 20.5

$Q_{AB} = 20.0\ J$, $Q_{BC} = 0$, $W_{ABCA} = 15.0\ J$

$\Delta U = Q - W$

$0 = Q_{AB} + Q_{BC} + Q_{CA} - W_{ABCA}$

$Q_{CA} = 15 - 0 - 20 = -5\ J$.

5 J of heat is given off by the system.