PHY 2130 Homework solutions
Assignment 11

11.20 The total energy input required is

$$Q = (\text{energy to melt 50 g of ice}) + (\text{energy to warm 50 g of water to 100°C}) + (\text{energy to vaporize 5.0 g water})$$

$$= (50\text{ g})L_f + (50\text{ g})c_{water}(100°\text{C-}0°\text{C}) + (5.0\text{ g})L_v$$

Thus, $Q = (0.050\text{ kg})\left(3.33\times 10^5\ \frac{\text{J}}{\text{kg}}\right)$

$$+(0.050\text{ kg})\left(4186\ \frac{\text{J}}{\text{kg}\cdot°\text{C}}\right)(100°\text{C-}0°\text{C})$$

$$+(5.0\times 10^{-3}\text{ kg})\left(2.26\times 10^6\ \frac{\text{J}}{\text{kg}}\right),$$

which gives $Q = 4.9\times 10^4\text{ J} = \boxed{49\text{ kJ}}$

11.26 Assuming all the ice melts, the conservation of energy equation is

$$m_{ice}L_f + m_{ice}c_w\left(T_f - 0°\text{C}\right) = m_w c_w\left(25°\text{C} - T_f\right),$$

giving

$$T_f = \frac{m_w c_w(25°\text{C}) - m_{ice}L_f}{(m_w + m_{ice})c_w}$$

$$= \frac{(650\text{ g})(4186\text{ J/kg}\cdot°\text{C})(25°\text{C}) - (100\text{ g})(3.33\times 10^5\text{ J/kg})}{(650\text{ g} + 100\text{ g})(4186\text{ J/kg}\cdot°\text{C})} = \boxed{11°\text{C}}$$

Note: If this had yielded a negative answer for T_f, it would have indicated that the assumption of all ice melting was false. The correct answer in that case would have been $T_f = 0°\text{C}$.

11.34 (a) With the outside temperature higher than that in the house, we have $\Delta T = T_h - T_c = 90°\text{F} - 70°\text{F} = 20°\text{F} = \frac{5}{9}(20°) = 11°\text{C}$ and the rate of energy transfer *into* the house is

$$H = kA\left(\frac{\Delta T}{L}\right) = \left(0.84\ \frac{\text{J}}{\text{s}\cdot\text{m}\cdot°\text{C}}\right)\left(0.16\ \text{m}^2\right)\left(\frac{11°\text{C}}{3.0\times10^{-3}\ \text{m}}\right) = 5.0\times10^2\ \frac{\text{J}}{\text{s}}$$

or $H = \boxed{0.50\ \text{kW into the house}}$

(b) With the interior warmer than the outside air, we have $\Delta T = T_h - T_c = 70°\text{F} - 0°\text{F} = 70°\text{F} = \frac{5}{9}(70°) = 39°\text{C}$ and the rate of energy transfer *out of* the house is

$$H = kA\left(\frac{\Delta T}{L}\right) = \left(0.84\ \frac{\text{J}}{\text{s}\cdot\text{m}\cdot°\text{C}}\right)\left(0.16\ \text{m}^2\right)\left(\frac{39°\text{C}}{3.0\times10^{-3}\ \text{m}}\right) = 1.7\times10^3\ \frac{\text{J}}{\text{s}}$$

or $H = \boxed{1.7\ \text{kW out of the house}}$

11.44 The net power radiated is $\wp_{net} = \sigma A e\left(T^4 - T_0^4\right)$, so the temperature of the radiator is $T = \left[T_0^4 + \frac{\wp_{net}}{\sigma A e}\right]^{\frac{1}{4}}$. If the temperature of the surroundings is $T_0 = 22°\text{C} = 295\ \text{K}$,

$$T = \left[(295\ \text{K})^4 + \frac{25\ \text{W}}{\left(5.67\times10^{-8}\ \text{W/m}^2\cdot\text{K}^4\right)\left(2.5\times10^{-5}\ \text{m}^2\right)(0.25)}\right]^{\frac{1}{4}}$$

$$= 2.9\times10^3\ \text{K} = \boxed{2.6\times10^3\ °\text{C}}$$

12.7 The constant pressure is $P = (1.5\ \text{atm})\left(1.013\times10^5\ \text{Pa/atm}\right) = 1.52\times10^5\ \text{Pa}$ and the work done on the gas is $W = -P(\Delta V)$.

(a) $\Delta V = +4.0\ \text{m}^3$ and

$$W = -P(\Delta V) = -\left(1.52\times10^5\ \text{Pa}\right)\left(+4.0\ \text{m}^3\right) = \boxed{-6.1\times10^5\ \text{J}}$$

(b) $\Delta V = -3.0\ \text{m}^3$, so

$$W = -P(\Delta V) = -\left(1.52\times10^5\ \text{Pa}\right)\left(-3.0\ \text{m}^3\right) = \boxed{+4.6\times10^5\ \text{J}}$$

12.15 (a) Along the direct path *IF*, the work done on the gas is

$$W = -(\text{area under curve})$$
$$= -\left[(1.00\text{ atm})(4.00\text{ L} - 2.00\text{ L}) + \frac{1}{2}(4.00\text{ atm} - 1.00\text{ atm})(4.00\text{ L} - 2.00\text{ L})\right]$$
$$W = -(5.00\text{ atm}\cdot\text{L})\left(\frac{1.013\times10^5\text{ Pa}}{1\text{ atm}}\right)\left(\frac{10^{-3}\text{ m}^3}{1\text{ L}}\right) = -506.5\text{ J}$$

Thus, $\Delta U = Q + W = 418\text{ J} - 506.5\text{ J} = \boxed{-88.5\text{ J}}$

(b) Along path *IAF*, the work done on the gas is

$$W = -(4.00\text{ atm})(4.00\text{ L} - 2.00\text{ L})\left(\frac{1.013\times10^5\text{ Pa}}{1\text{ atm}}\right)\left(\frac{10^{-3}\text{ m}^3}{1\text{ L}}\right) = -810\text{ J}$$

From the first law, $Q = \Delta U - W = -88.5\text{ J} - (-810\text{ J}) = \boxed{722\text{ J}}$.

12.28 (a) Using $e = W_{\text{eng}}/|Q_h|$, the energy absorbed by heat each cycle is

$$|Q_h| = \frac{W_{\text{eng}}}{e} = \frac{200\text{ J}}{0.30} = \boxed{6.7\times10^2\text{ J}}$$

(b) From $W_{\text{eng}} = |Q_h| - |Q_c|$, the energy expelled by heat each cycle is

$$|Q_c| = |Q_h| - W_{\text{eng}} = 6.7\times10^2\text{ J} - 200\text{ J} = \boxed{4.7\times10^2\text{ J}}$$

12.36 The energy added to the water by heat is

$$\Delta Q_r = mL_v = (1.00\text{ kg})(2.26\times10^6\text{ J/kg}) = 2.26\times10^6\text{ J},$$

so the change in entropy is

$$\Delta S = \frac{\Delta Q_r}{T} = \frac{2.26\times10^6\text{ J}}{373\text{ K}} = 6.06\times10^3\ \frac{\text{J}}{\text{K}} = \boxed{6.06\text{ kJ/K}}$$