Answer Key

Refrigeration System

1

$$COP = \frac{Q_A}{W_i} = \frac{Q_A}{Q_R - Q_A}$$

$$5 = \frac{(80 * 3.516)\ kW}{Q_R - (80 * 3.516)\ kW}$$

$$Q_R = 337.536\ kW$$

then;

$$Q_R = m\, C_p\, \Delta T$$

$$337.536\ kW = m\left(4.187\ kJ/kg\text{-}K\right)\left(10^\circ C\right)$$

$$m = 8.0615\ kg/s$$

Hence;

$$\rho = \frac{m}{V}$$

$$1000\ kg/m^3 = \frac{8.0615\ kg/s}{V}$$

$$\dot{V} = \left(8.0615 \times 10^{-3}\ \frac{m^3}{s}\right)\left(\frac{1000 L}{1 m^3}\right)\left(\frac{1 gal}{3.78 L}\right)\left(\frac{60 s}{1 min}\right)$$

$$\boxed{\dot{V} = 127.9607\ gal/min}$$

$$Q_A = (85 \text{ tons})\left(\frac{3.516 \text{ kW}}{1 \text{ ton}}\right) = 298.86 \text{ kW}$$

$$COP = \frac{Q_A}{W_c}$$

$$4.5 = \frac{298.86 \text{ kW}}{W_c}$$

$$W_c = 66.4133 \text{ kW}$$

then;

$$\eta_c = \frac{W_c}{EP}$$

$$0.75 = \frac{66.4133 \text{ kW}}{EP}$$

$$\boxed{EP = 88.55 \text{ kW}}$$

3

$$COP = \frac{T_L}{T_H - T_L} = \frac{270\,k}{318\,k - 270\,k}$$

$$COP = 5.625$$

Then;

$$COP = \frac{Q_A}{W_c}$$

$$5.625 = \frac{Q_A}{(50\,kW)\left(\frac{1\,ton}{3.516\,kW}\right)}$$

$$\boxed{Q_A = 80\,tons}$$

4

$$Q_A = m_R (h_1' - h_4)$$

$$80 \text{ kW} = m_R (1476 - 360.1) \text{ kJ/kg}$$

$$m_R = 0.07176 \text{ kg/s}$$

And;

$$Q_R = m_R (h_2 - h_3')$$

$$= (0.07176 \text{ kg/s})(1720 - 360.1) \text{ kJ/kg}$$

$$Q_R = 97.58 \text{ kW}$$

then;

$$Q_R = m C_p \Delta T$$

$$97.58 \text{ kW} = m (4.187 \text{ kJ/kg})(7°C)$$

$$m = (3.3294 \text{ kg/s})\left(\frac{3600 \text{ s}}{1 \text{ hr}}\right)$$

$$\boxed{m = 11985.6763 \text{ kg/hr}}$$

$$\eta_v = 1 + c - c\left(\frac{P_2}{P_1}\right)^{1/n} = \frac{V'}{V_D} \quad ; \quad r_k = \left(\frac{P_2}{P_1}\right)^{1/n} = \frac{V_1}{V_2}$$

$$1 + 0.09 - 0.09(6.5) = \frac{(0.20\ m^3/s)}{V_D}$$

$$V_D = 0.3960\ m^3/s$$

then;

$$V_D = \frac{\pi D^2}{4} L \frac{N}{60} \quad ; \quad D = L$$

$$0.3960\ m^3/s = \frac{\pi D^3}{4}\left(\frac{350\ rpm}{60}\right)$$

$$D = 0.4422\ m$$

$$\boxed{D = 442.1578\ mm}$$

6

Heat Pump

$$P.F. = \frac{T_H}{T_H - T_L} = \frac{298k}{298k - 268k}$$

$$\boxed{P.F. = 10}$$

Heat pump

$$P.F. = \frac{Q_R}{W_c} = \frac{65\text{ kW}}{15\text{ kW}} = 4.33$$

Then;

$$P.F. = \frac{T_H}{T_H - T_L}$$

$$4.33 = \frac{323\text{ k}}{323\text{ k} - T_L}$$

$$T_L = 248.4042\text{ k}$$

$$\boxed{t_L = -24.5958°C}$$

Exponential LEAP ONLINE REVIEW

Heat pump

$$P.F. = \frac{Q_R}{W_c} = \frac{T_H}{T_H - T_L} = \frac{588°R}{588°R - 497°R} = 6.4615$$

then;

$$6.4615 = \frac{489\ Btu/min}{W_c}$$

$$W_c = \left(75.6786\ Btu/min\right)\left(\frac{1.065\ kJ}{1\ Btu}\right)\left(\frac{1\ min}{60\ s}\right)\left(\frac{1\ hp}{0.746\ kW}\right)$$

$$\boxed{W_c = 1.80\ hp}$$

9

Heat Pump

$$P.F. = \frac{Q_R}{W_c} = \frac{T_H}{T_H - T_L}$$

$$\frac{Q_R}{\left(8\frac{kJ}{s}\right)\left(\frac{60\,s}{1\,min}\right)} = \frac{306\,k}{306\,k - 268\,k}$$

$$Q_R = 3865.2632\ kJ/min$$

then;

$$W_c = Q_R - Q_A$$

$$\left(8\,kJ/s\right)\left(\frac{60\,s}{1\,min}\right) = 3865.2632\ kJ/min - Q_A$$

$$\boxed{Q_A = 3385.2632\ kJ/min}$$

Degree of Superheat

$$°SH = t_1 - t_{evap}$$

t_{evap} → temp. in evaporator

t_1 → temp. entering compressor

$$°SH = (10 + 6)°C$$

$$°SH = 16°C$$

$$\boxed{°SH = 60.8\ °F}$$

11

$$P_i = \sqrt{(810\ \text{kPa})(110\ \text{kPa})}$$

$$\boxed{P_i = 298.4962\ \text{kPa}}$$

12

$$Q_A = m C_p \Delta T$$

$$(20\ \text{ton})\left(\frac{3.516\ \text{kW}}{1\ \text{ton}}\right) = m\left(4.187\ \text{kJ}/\text{kg-K}\right)(30+8)\text{K}$$

$$m = \left(0.44197\ \text{kg}/\text{s}\right)\left(12\ \text{hrs}\right)\left(\frac{3600\ \text{s}}{1\ \text{hr}}\right)$$

$$\boxed{m = 19\,093.0826\ \text{kg}}$$

13

LOAD w/ Freezing

$$Q_A = \frac{m_p}{t}\left[C_{p_1}(t_1 - t_f) + L + C_{p_2}(t_f - t_2)\right]$$

$$= \frac{12000\ kg}{(12\ hrs)\left(\frac{3600\ s}{1\ hr}\right)}\left[\left(3.82\ kJ/kg\text{-}K\right)(30+1)°C + 281\ kJ/kg + \left(1.9\ kJ/kg\text{-}K\right)(-1+5)°C\right]$$

$$Q_A = (108.8389\ kW)\left(\frac{1\ ton}{3.516\ kW}\right)$$

$$\boxed{Q_A = 30.9553\ tons}$$

$$Q = m C_p \Delta T = (9\ kg/s)(4.187\ kJ/kg\text{-}K)(31 - 3)°C$$

$$Q = (1055.124\ kW)\left(\frac{1\ ton}{3.516\ kW}\right)$$

$$\boxed{Q = 300\ tons}$$

Heat pump

$$PF = \frac{T_H}{T_H - T_L} = \frac{(48+273)K}{[321 - (-6+273)]K}$$

$$\boxed{PF = 6.0}$$

$$W_c = m_R (h_2 - h_1)$$

$$Q = m_R (h_1 - h_4)$$

$$12\,kW = m_R (350.1 - 241.6)\,kJ/kg$$

$$m_R = 0.1106\,kg/s$$

then;

$$W_c = (0.1106\,kg/s)(378 - 350.1)\,kJ/kg$$

$$\boxed{W_c = 3.0857\,kW}$$

$$Q_R = m(h_2 - h_3)$$

$$Q_A = m(h_1 - h_4)$$

$$(55\ \text{ton})\left(\frac{3.516\ \text{kW}}{1\ \text{ton}}\right) = m(407 - 255)\ \text{kJ/kg}$$

$$m = 1.2722\ \text{kg/s}$$

Subs't;

$$Q_R = (1.2722\ \text{kg/s})(448 - 255)\ \text{kJ/kg}$$

$$\boxed{Q_R = 245.5417\ \text{kW}}$$