



POSTAL BOOK PACKAGE 2026

MECHANICAL ENGINEERING

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CONVENTIONAL Practice Sets

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REFRIGERATION AND AIR CONDITIONING

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CHAPTER

Refrigeration and Air Conditioning

Introduction and Basic Concepts

Practice Questions : Level-I

- Q.1** A reversed Carnot cycle refrigerator maintains a temperature of -5°C . The ambient air temperature is 35°C . The heat gained by the refrigerator at a continuous rate is 2.5 kJ/s . What is the power required to run the heat pump?

Solution:

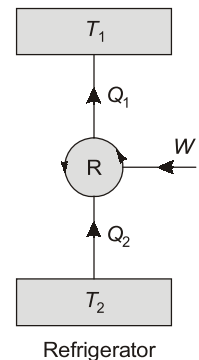
Given data: $T_2 = -5^{\circ}\text{C} = (-5 + 273) \text{ K} = 268 \text{ K}$; $T_1 = 35^{\circ}\text{C} = (35 + 273) \text{ K} = 308 \text{ K}$
 $Q_2 = 2.5 \text{ kJ/s} = 2.5 \text{ kW} = 2500 \text{ W}$

$$(\text{COP})_R = \frac{T_2}{T_1 - T_2} = \frac{268}{308 - 268} = 6.7$$

Also, $(\text{COP})_R = \frac{Q_2}{W}$

$$\therefore 6.7 = \frac{2500}{W}$$

or $W = \frac{2500}{6.7} = 373.13 \text{ W}$



- Q.2** A refrigerator has working temperatures in the evaporator and condenser as -23°C and 37°C respectively. The environment temperature is 27°C . The required refrigeration temperature is -13°C . What is the maximum COP possible? If the actual COP of the refrigerator is 0.65 of the maximum, calculate the required power input for a refrigerating effect of 5 kW .

Solution:

Given data: $T_e = -23^{\circ}\text{C} = 250 \text{ K}$, $T_c = 37^{\circ}\text{C} = 310 \text{ K}$, $T_{\text{surrounding}} = 27^{\circ}\text{C} = 300 \text{ K}$

$$\text{Maximum COP} = \frac{T_e}{T_c - T_e} = \frac{250}{310 - 250}$$

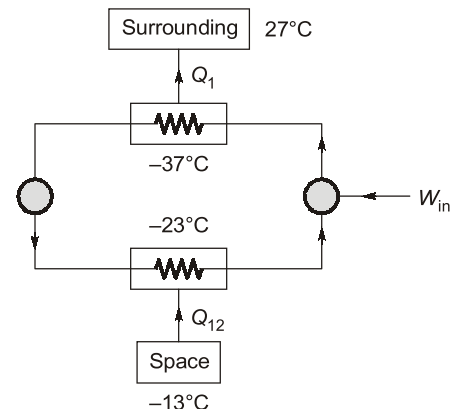
$$(\text{COP})_{\text{max}} = 4.166$$

Now it is given that, $(\text{COP})_{\text{actual}} = 0.65(\text{COP})_{\text{max}}$
 $= 0.65 \times 4.166 = 2.708$

\Rightarrow COP is defined as refrigerating effect/power

$$\Rightarrow \text{COP} = \frac{5}{\text{Power}} = 2.708$$

$$\Rightarrow \text{Power required} = \frac{5}{2.70} = 1.846 \text{ kW}$$



- Q.3** A thermoelectric refrigerator is powered by a car battery and has a COP of 0.1. The refrigerator cools a $0.35 \times 10^{-3} \text{ m}^3$ canned drink from 20°C to 4°C in 30 minutes. The properties of canned drink are same as that of water at room temperature, i.e., $\rho = 1000 \text{ kg/m}^3$ and $c = 4.18 \text{ kJ/kg K}$. Neglecting the heat transfer through the walls of the refrigerator, determine the average electric power consumed by the thermoelectric refrigerator.

Solution:

Given data: COP = 0.1; Volume = $0.35 \times 10^{-3} \text{ m}^3$; $\Delta T = 20 - 4 = 16^\circ\text{C}$;
 $t = 30 \text{ minutes}$; $\rho = 1000 \text{ kg/m}^3$; $c_p = 4.18 \text{ kJ/kg-K}$

$$\text{Refrigeration capacity} = \frac{mc_p \Delta T}{t} \quad (m = \rho V)$$

$$= \frac{10^3 \times 0.35 \times 10^{-3} \times 4.18 \times 16}{30 \times 60} = 0.013 \text{ kW}$$

$$\text{COP} = \frac{\text{Refrigeration capacity}}{\text{Power input}}$$

$$\text{Power input} = \frac{0.013}{0.1} = 0.13 \text{ kW}$$

Q4 A cold storage plant is required to store 20 tonnes of fish. The fish is supplied at a temperature of 30°C . The specific heat of fish above freezing point is 2.93 kJ/kgK . The specific heat of fish below freezing point is 1.26 kJ/kgK . The fish is stored in cold storage which is maintained at -8°C . The freezing point of fish is -4°C . The latent heat of fish is 235 kJ/kg . If the plant requires 75 kW to drive it, find:

1. The capacity of the plant
2. Time taken to achieve cooling

Assume actual COP of the plant as 0.3 of the Carnot COP.

Solution:

$$(i) \quad \text{Carnot COP} = \frac{T_1}{T_2 - T_1} = \frac{265}{303 - 265} = 6.97$$

$$\therefore \quad \text{Actual COP} = 0.3 \times 6.97 = 2.091$$

$$\begin{aligned} \text{Heat removed by the plant} &= \text{Actual COP} \times \text{Work required} \\ &= 2.091 \times 75 = 156.8 \text{ kW} = 156.8 \times 60 \text{ kJ/min} = 9408 \text{ kJ/min} \end{aligned}$$

$$\therefore \quad \text{Capacity of the plant} = \frac{9408}{210} = 44.8 \text{ TR}$$

(ii) Heat removed from the fish above freezing point

$$\begin{aligned} Q_1 &= m \times c_{AF} (T_2 - T_3) \\ &= 20 \times 1000 \times 2.93 (303 - 269) = 1.992 \times 10^6 \text{ kJ} \end{aligned}$$

Similarly, heat removed from the fish below freezing point,

$$\begin{aligned} Q_2 &= m \times c_{BF} (T_3 - T_1) = 20 \times 1000 \times 1.26 \times (269 - 265) \\ &= 0.101 \times 10^6 \text{ kJ} \end{aligned}$$

$$\begin{aligned} \text{Total latent heat of fish, } Q_3 &= m \times (h_{fg})_{\text{fish}} \\ &= 20 \times 1000 \times 235 = 4.7 \times 10^6 \text{ kJ} \end{aligned}$$

$$\begin{aligned} \therefore \quad \text{Total heat removed by the plant} \\ &= Q_1 + Q_2 + Q_3 = (1.992 + 0.101 + 4.7) \times 10^6 = 6.793 \times 10^6 \text{ kJ} \end{aligned}$$

$$\therefore \quad \text{Time taken to achieve cooling} = \frac{\text{Total heat removed by the plant}}{\text{Heat removed by the plant per min}}$$

$$= \frac{6.793 \times 10^6}{9408} = 722 \text{ min} = 12.03 \text{ hr}$$

Practice Questions : Level-II

Q5 A customer complained of poor cooling for an air-conditioning system of 100 TR capacity. The supplier carried out test on condenser which is water cooled and noted power input to the motor. The observations made are as under:

Cooling water flow rate : 10 litre/s
 Inlet water temperature : 30°C
 Outlet water temperature : 41.12°C
 Power input to motor : 120 kW (94.92% efficiency)

Determine the actual refrigerating capacity and state whether the cooling capacity is lower, higher or as per specifications.

Solution:

Given data: Capacity = 100 TR; $T_{w1} = 30^\circ\text{C}$, $T_{w2} = 41.12^\circ\text{C}$

Water flow rate, $\dot{V} = 10 \text{ litre/s} = 10 \times 10^{-3} \text{ m}^3/\text{s}$,

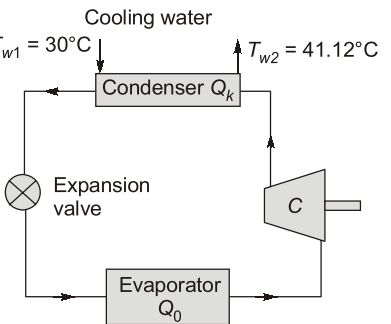
Consider the refrigerating/AC system as shown

Heat rejection rate in condenser = rate of heat gain by water

$$\begin{aligned} \Rightarrow Q_k &= \dot{m}_w c_{p,w} (T_{w2} - T_{w1}) = \rho_w \dot{V} c_{p,w} (T_{w2} - T_{w1}) \\ &= 10^3 \times 10 \times 10^{-3} \times 4.18 \times (41.12 - 30) \\ &= 464.81 \text{ kW} \end{aligned}$$

Power input to motor = 120 kW

Actual power input to cycle = $120 \times 0.9492 = 113.904 \text{ kW}$



[As motor efficiency = 94.92%]

From 1st law of thermodynamics,

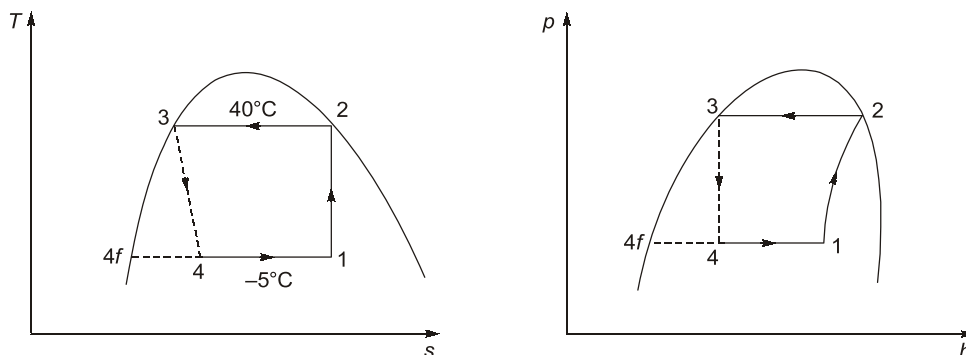
$$\begin{aligned} \Rightarrow Q_k &= Q_0 + W \\ Q_0 &= Q_k - W = 464.81 - 113.904 = 350.906 \text{ kW} \end{aligned}$$

$$\therefore \text{Refrigeration capacity, } Q_0 = \frac{350.906}{3.5167} = 99.78 \text{ TR}$$

This is slightly lower than ideal or specified cooling capacity.

Q6 A refrigerator machine uses R-12 as the working fluid. The temperature of R-12 in the evaporator coil is -5°C , and the gas leaves the compressor as dry saturated at a temperature of 40°C . The mean specific heat of liquid R-12 between the above temperatures is 0.963 kJ/kg K . The enthalpy of evaporation at 40°C is 203.2 kJ/kg . Neglecting losses, find the COP.

Solution:



Given data: $(h_{fg}) = 203.2 \text{ kJ/kg}$; $(c_p)_l = 0.963 \text{ kJ/kg K}$