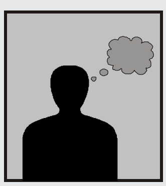
ESE GATE PSUs

State Engg. Exams

MADE EASY WORKBOOK 2025



Detailed Explanations of Try Yourself *Questions*

Mechanical Engineering

Refrigeration and Air-conditioning

MADE EASY PUBLICATIONS

1 Heat Engine, Heat Pump, Refrigerator & Reversed Carnot Cycle

Detailed Explanation of Try Yourself Questions

T1 : Solution

$$(COP)_{RE} = (COP)_{HP} - 1 = 4 - 1 = 3$$

$$(COP)_{RE} = \frac{\text{Required cooling effect}}{\text{Power input}}$$

$$\Rightarrow \quad \text{Required cooling effect} = 3 \times 3 = 9 \text{ kW} = 9 \times 60 \text{ kJ/min}$$

$$= 540 \text{ kJ/min}$$

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2 Vapour Compression Refrigeration System

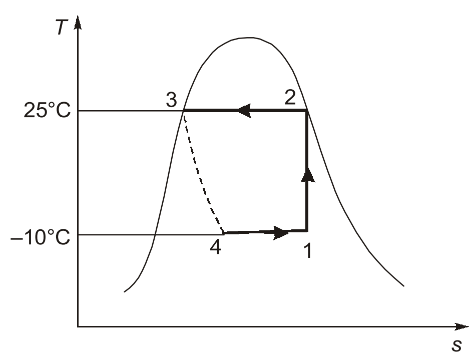
Detailed Explanation *of* Try Yourself Questions

T1 : Solution

$$h_3 = h_4 = 298.9 \text{ kJ/kg}$$

$$h_2 = h_{g@25°C} = 1465.84 \text{ kJ/kg}$$

$$\text{COP} = \frac{h_1 - h_4}{h_2 - h_1} \quad \text{...(i)}$$



Compression process 1–2:

$$s_1 = s_2$$

$$s_f + x\, s_{fg} = s_2 \qquad \left[s_g = s_f + \frac{h_{fg}}{T}\right]$$

$$0.5443 + x \times \frac{(1433.05 - 135.37)}{263} = 1.1242 + \frac{(1465.84 - 298.9)}{298}$$

$$x = 0.911$$

$$h_1 = h_f + x h_{fg}$$

$$= 135.37 + 0.911\,(1433.05 - 135.37)$$

$$h_1 = 1317.556 \text{ kJ/kg}$$

From equation (i)
$$\text{COP} = \frac{1317.556 - 298.9}{1465.84 - 1317.556} = 6.87$$

T2 : Solution (a)

Given: Rated capacity = 140.7 kW, Mass flow rate = $4 \times 10^{-3} \times 10^3$ = 4 kg/sec, Water inlet temperature (T_i) = 30°C, Water outlet temperature (T_o) = 40°C, Power input to motor = 48 kW, Motor efficiency (η) = 95%

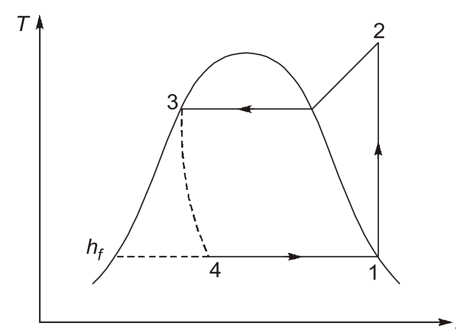
Heat rejected in condensor (Q_c) = $\dot{m}c_w \times (T_o - T_i)$

$$Q_c = 4 \times 4.1868 \times (40 - 30)$$
$$= 167.472 \text{ kW}$$

Actual refrigeration capacity (RC_a)

$$RC_a = Q_c - P \times \eta$$
$$= 167.472 - 48 \times 0.95$$
$$= 121.872 \text{ kW} = 34.82 \text{ TR}$$

T3 : Solution (b)



Given: h_1 = 250 kJ/kg, h_2 = 300 kJ/kg, $h_{f/evap}$ = 50 kJ/kg

$$\text{COP} = \frac{h_1 - h_4}{h_2 - h_1} - \frac{250 - h_1}{300 - 250}$$

$$h_4 = 100 \text{ kJ/kg}$$

For dryness fraction at, point 4,

$$h_4 = h_{f/evap} + x(h_1 - h_2)$$
$$100 = 50 + x(250 - 50)$$

or,
$$x = 0.25$$

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3 Vapour Absorption Refrigeration System

Detailed Explanation of Try Yourself Questions

T1 : Solution

$$COP = \frac{T_G - T_0}{T_G} \times \frac{T_R}{T_0 - T_R}$$

T_R = Evapourator Temperature
T_G = Generator Temperature
T_0 = Ambient Temperature (condenser temperature)

$$COP = \frac{360 - 310}{360} \times \frac{260}{310 - 260}$$

$$= 0.72$$

$$0.72 = \frac{T_G - 310}{T_G} \times \frac{250}{310 - 250}$$

$$T_G = 374.9 \text{ K}$$

T2 : Solution (b)

- The vapour absorption system uses heat energy to change the condition of the refrigerant from the evaporator. The vapour compression system uses mechanical energy to change the condition of refrigerant from the evaporator.
- The load variation do not affect the performance of a vapour absorption system. The load variations are met by controlling the quantity of steam supplied to the generator. The performance of vapour compression system at partial loads is however, poor.

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4 Refrigerants

Detailed Explanation of Try Yourself Questions

T1 : Solution (a)

$$R_{114} = R_{(m-1)(n+1)p}$$

then,
$$m - 1 = 1, \ m = 2$$
$$n + 1 = 1, \ n = 0$$
$$p = 4$$

We know,
$$n + p + q = 2m + 2$$
$$0 + 4 + q = 2 \times 2 + 2$$
$$q = 2$$

So, the formula is

$$C_mH_nF_pCl_4 = C_2H_oF_4Cl_4 = C_2F_4Cl_4$$

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5 Refrigeration Equipment & Gas Refrigeration

Detailed Explanation of Try Yourself Questions

T1 : Solution (b)

- Gas cycle refrigeration is used in aircraft.

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6 Air-conditioning

Detailed Explanation of Try Yourself Questions

T1 : Solution

$$P_{atm} = 1 \text{ bar} = 100 \text{ kPa}$$
$$DBT = 30°C$$
$$\phi = 70\% = 0.7$$
$$P_{vs} = 4.25 \text{ kPa}$$

Specific humidity, ω = ?

$$\phi = \frac{P_v}{PV_s}$$

$$0.7 = \frac{P_v}{4.25}$$

$$P_v = 2.975 \text{ kPa}$$

Specific humidity,

$$\omega = 0.622 \times \frac{P_v}{P - P_v} = 0.622 \times \frac{2.975}{100 - 2.975}$$

$$= 00.0191 \frac{\text{kg water vapour}}{\text{kg dry air}}$$

T2 : Solution

$$\text{Wet bulb depression at the inlet} = (t_{db} - t_{wb})_{inlet} = (38 - 18)_{inlet} = 20°C$$

$$\text{Wet bulb depression at the outlet} = (24 - 18) = 6°C \qquad (\because t_{wb\ inlet} = t_{wb\ exit})$$

$$\text{Percentage change} = \frac{20 - 6}{20} = 70\%$$

T3 : Solution

In cooling tower:

We know,

$$\text{Approach} = T_{c2} - T_{WB}$$

$$\text{Range} = T_{c1} - T_{c2}$$

$$\text{Wet bulb depression} = T_{DB} - T_{WB}$$

Where,

T_{c2} : Cooling water exit temperature

T_{WB} : Wet bulb temperature of air

T_{DB} : Dry bulb temperature of air

T_{c1} : Incoming warm water temperature

As give in question,

$$W_{BD} = A + R$$

$$T_{DB} - T_{WB} = T_{c2} - T_{WB} + T_{c1} - T_{c2}$$

or,

$$T_{c1} - T_{DB} = 0$$

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