

ESE

GATE

State Engg. Exams

MADE EASY
WORKBOOK 2027



**Detailed Explanations of
Try Yourself *Questions***

Mechanical Engineering
Refrigeration and Air-conditioning



1

Heat Engine, Heat Pump, Refrigerator & Reversed Carnot Cycle



Detailed Explanation of Try Yourself Questions

T1 : Solution

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

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

$$\Rightarrow \text{Required cooling effect} = 3 \times 3 = 9 \text{ kW} = 9 \times 60 \text{ kJ/min} \\ = 540 \text{ kJ/min}$$

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Vapour Compression Refrigeration System



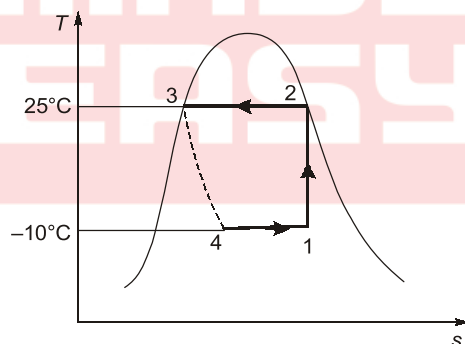
Detailed Explanation of Try Yourself Questions

T1 : Solution

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

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

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



Compression process 1-2:

$$s_1 = s_2$$

$$s_f + x s_{fg} = s_2$$

$$\left[s_g = s_f + \frac{h_{fg}}{T} \right]$$

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

$$x = 0.911$$

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

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

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

From equation (i)

$$\text{COP} = \frac{1317.556 - 298.9}{1465.84 - 1317.556} = 6.87$$

T2 : Solution (b)

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

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

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

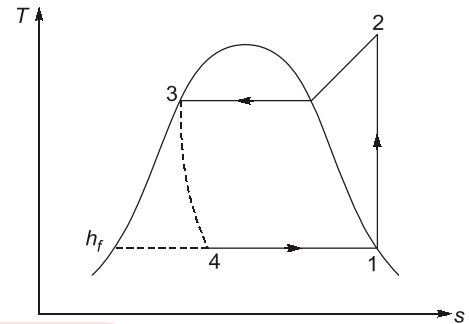
For dryness fraction at, point 4,

$$h_4 = h_{f/\text{evap}} + x(h_1 - h_2)$$

$$100 = 50 + x(250 - 50)$$

or,

$$x = 0.25$$



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Refrigerants



Detailed Explanation
of
Try Yourself Questions

T1 : Solution (a)

then,

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

$$m - 1 = 1, m = 2$$

$$n + 1 = 1, n = 0$$

$$p = 4$$

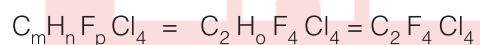
We know,

$$n + p + q = 2m + 2$$

$$0 + 4 + q = 2 \times 2 + 2$$

$$q = 2$$

So, the formula is



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Vapour Absorption Refrigeration System



Detailed Explanation of Try Yourself Questions

T1 : Solution

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

T_R = Evaporator Temperature

T_G = Generator Temperature

T_0 = Ambient Temperature (condenser temperature)

$$\begin{aligned}\text{COP} &= \frac{360 - 310}{360} \times \frac{260}{310 - 260} \\ &= 0.72\end{aligned}$$

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

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

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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Refrigeration Equipments



Detailed Explanation *of* Try Yourself Questions

T1 : Solution (b)

- Gas cycle refrigeration is used in aircraft.

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Air-conditioning



Detailed Explanation of Try Yourself Questions

T1 : Solution

$$P_{atm} = 1 \text{ bar} = 100 \text{ kPa}$$

$$\text{DBT} = 30^\circ\text{C}$$

$$\phi = 70\% = 0.7$$

$$P_{vs} = 4.25 \text{ kPa}$$

Specific humidity, $\omega = ?$

$$\phi = \frac{P_v}{P V_s}$$

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

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

Specific humidity,

$$\begin{aligned} \omega &= 0.622 \times \frac{P_v}{P - P_v} = 0.622 \times \frac{2.975}{100 - 2.975} \\ &= 0.0191 \frac{\text{kg water vapour}}{\text{kg dry air}} \end{aligned}$$

T2 : Solution

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

$$\text{Wet bulb depression at the outlet} = (24 - 18) = 6^\circ\text{C}$$

$$(\because t_{wb \text{ inlet}} = t_{wb \text{ exit}})$$

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

T3 : Solution

In cooling tower:

We know, Approach = $T_{c2} - T_{WB}$
Range = $T_{c1} - T_{c2}$
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, $T_{c1} - T_{DB} = 0$

