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CLASS TEST 2019-20

MECHANICAL ENGINEERING

Subject : Refrigeration & Air Conditioning

Date of test : 23/02/2019

Answer Key

1.	(b)	7.	(a)	13.	(a)	19.	(d)	25.	(c)
2.	(a)	8.	(b)	14.	(b)	20.	(c)	26.	(a)
3.	(b)	9.	(b)	15.	(b)	21.	(c)	27.	(d)
4.	(a)	10.	(b)	16.	(c)	22.	(b)	28.	(d)
5.	(c)	11.	(d)	17.	(a)	23.	(a)	29.	(a)
6.	(c)	12.	(a)	18.	(d)	24.	(d)	30.	(d)

Detailed Explanations

1. (b)

Since the cycle shown is anti-clockwise

∴ It is work-absorbing device cycle. Hence, it will be used in air-refrigeration. The cycle shown is a reverse Brayton cycle.

3. (b)

$$P_a = 90 \text{ kPa}$$
$$P_s = 4.2469 \text{ kPa}$$
$$\phi = 0.75$$
$$V = 40 \text{ m}^3$$
$$P_v = \phi P_s = 0.75 \times 4.2469 = 3.185 \text{ kPa}$$
$$P_a = P - P_v = 90 - 3.185 = 86.815 \text{ kPa}$$
$$m_a = \frac{P_a V}{RT} = \frac{(86.815)\times 10^3 \times 40}{287 \times 303} = 39.93 \text{ kg}$$

4. (a)

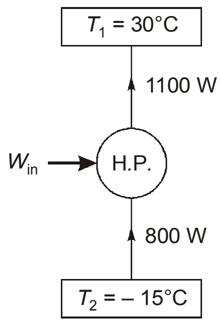
Air passing through silica gel – Chemical dehumidification

Summer air conditioning – Cooling and Dehumidification

Winter air conditioning – Heating and humidification

Cooling tower – Adiabatic evaporative cooling

5. (c)



$$W_{in} = 1100 - 800 \text{ W} = 300 \text{ W}$$

$$\therefore \quad \text{COP} = \frac{\text{Desired effect}}{W_{in}} = \frac{1100}{300} = 3.666$$

6. (c)

$$(\text{COP})_{\text{combined cycle}} = \frac{(\text{COP})_1 \times (\text{COP})_2}{1 + (\text{COP})_1 + (\text{COP})_2}$$
$$= \frac{1.5 \times 2.5}{1 + 1.5 + 2.5} = 0.75$$

7. (a)

The water is used as an absorbent because it has ability to absorb ammonia refrigerant.

8. (b)

Purging is the removal of air from condenser. Priming is the removal of air from pump. Venting is the removal of air from tank.

9. (b)

Heat rejection factor, HRF = 1.2

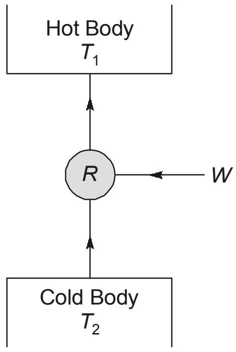
$$\text{HRF} = \frac{\text{Heat rejected in condenser}}{\text{Refrigeration effect}} = \frac{Q_R}{2500}$$

or $$Q_R = 1.2 \times 2500 = 3000 \text{ kJ/min}$$

$$W = Q_R - Q_A = 3000 - 2500 = 500 \text{ kJ/min}$$

$$\text{COP} = \frac{2500}{500} = 5$$

13. (a)



$$(\text{COP})_{\text{cooling}} = \frac{T_2}{T_1 - T_2}$$

or $$\frac{T_1 - T_2}{T_2} = \frac{1}{3.6}$$

or $$\frac{T_1}{T_2} = 1 + \frac{1}{3.6}$$

or $$\frac{T_1}{T_2} = 1.278$$

or $$\frac{T_2}{T_1} = 0.782$$

14. (b)

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

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

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

15. (b)

For the isentropic compression (1 – 2)

$$s_1 = s_2$$

$$s_{g1} = s_{g2}{'} + c_{Pg} \ln\left(\frac{T_2}{T_{2'}}\right)$$

$\therefore$ $$0.6902 = 0.6797 + 0.8 \ln\left(\frac{T_2}{50 + 273}\right)$$

$\Rightarrow$ $$T_2 = 327.27 \text{ K}$$

16. (c)

We know

$$T_1 T_3 = T_2 T_4$$
$$(7+273)(37+273) = (127.6+273)T_4$$
$$\Rightarrow \quad T_4 = 216.67\text{ K} = -56.33°\text{C}$$

17. (a)

As the flash chamber reduces the mass flow of refrigerant through the evaporator, it helps in reduction of size of evaporator.

18. (d)

$$(\text{COR})_R = \frac{T_1}{T_2 - T_1} = \frac{273-23}{45+23} = \frac{250}{68} = 3.67$$

$$(\text{COP})_R = \frac{\text{Refrigeration effect}}{\text{Work input}}$$

$$\therefore \quad \text{Work input} = \frac{10 \times 210 \times 60}{3.67} = 34332\text{ kJ/h}$$

$$\text{Heat rejected} = \text{Refrigerating effect per hour + Work input per hour}$$
$$= 10 \times 210 \times 60 + 34332 = 160332\text{ kJ/h}$$

19. (d)

It is low temperature side when the refrigerant vapour leaves the throttle valve.

20. (c)

$$\text{Specific enthalpy, } h = 1.005\, t_d + \omega[2500 + 1.9\, t_d]$$
$$= 1.005 \times 28 + 0.016\,[2500 + 1.9 \times 28]$$
$$= 69\text{ kJ/kg of d.a.}$$

21. (c)

$$(\text{COP})_{\text{ideal}} = \frac{T_L}{T_4 - T_L} = \frac{268}{40} = 6.7$$

$$(\text{COP})_{\text{actual}} = \frac{\text{Heat leakage}}{\text{Power input}} = \frac{1}{3} \times 6.7 = 2.23$$

$$\text{Power input} = \frac{29}{2.23} = 13\text{ kW}$$

22. (b)

$$\text{Specific humidity, } \omega = 0.622\frac{P_v}{P_t - P_v}$$

$$= 0.622 \times \frac{1479}{101325 - 1479} = 0.009214\text{ kg w.v./kg d.a}$$

Parts by mass of water vapour

$$\frac{m_v}{m} = \frac{\omega}{1+\omega} = \frac{0.009214}{1.009214} = 0.00913\text{ kg.w.v/kg mixture}$$

23. (a)

Mass of dry air/unit mass of moist air:

$$m_{a_1} = \frac{1}{1+\omega_1}\text{kg} = \frac{1}{1+0.0035} = 0.9965\,\text{kg}$$

Mass of dry air for two unit mass of moist air:

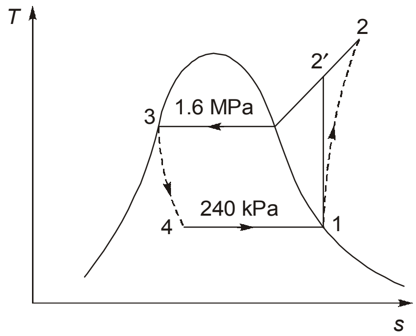
$$m_{a_2} = \frac{2}{1+\omega_2}\text{kg} = \frac{2}{1+0.0076} = 1.9849\text{ kg}$$

$$\text{For the mixture, } \omega = \frac{m_{a_1}\omega_1 + m_{a_2}\omega_2}{m_{a_1} + m_{a_2}}$$

$$= \frac{0.9965 \times 0.0035 + 1.9849 \times 0.0076}{0.9965 + 1.9849}$$

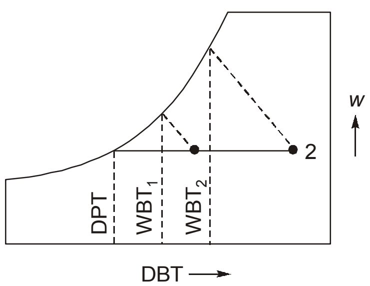
$$= 0.00623 \text{ kg w.v./kg d.a}$$

26. (a)



$$h_4 = h_3 = 134 \text{ kJ/kg}$$
$$h_1 = 244 \text{ kJ/kg}$$
$$h_{2'} = 285 \text{ kJ/kg}$$
$$h_2 = h_1 + \frac{h_{2'} - h_1}{\eta_{comp.}} = 244 + \frac{285 - 244}{0.85} = 292.2\,\text{kJ/kg}$$
$$Q_R = (h_2 - h_3) = 292.2 - 134 = 158.2 \text{ kJ/kg}$$
$$W_{input} = h_2 - h_1 = 292.2 - 244 = 48.2 \text{ kJ/kg}$$
$$\text{COP} = \frac{Q_R}{W_{input}} = \frac{158.2}{48.2} = 3.2821$$

27. (d)



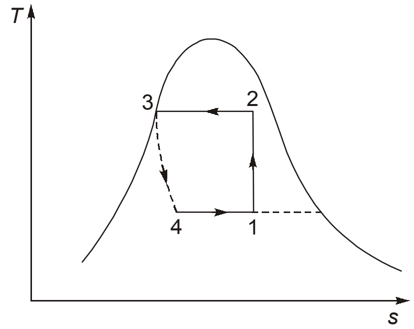
For process $1 \rightarrow 2$:

(i) Wet bulb temperature increases.

(ii) RH decreases.

(iii) Wet bulb depression increases.

28. (d)



$$s_1 = s_{f_1} + \frac{x_1 h_{fg_1}}{T_1} = 0.5443 + \frac{x_1 \times 1297.68}{263} = 0.5443 + 4.934\,x_1$$

$$s_2 = s_{f_2} + \frac{x_2 h_{fg_2}}{T_2} = 1.2037 + \frac{0.95 \times 1145.8}{303} = 4.796$$

$$0.5443 + 4.934\,x_1 = 4.796$$

$$x_1 = 0.86$$

$$h_1 = h_{f_1} + x_1 h_{fg_1}$$
$$= 135.37 + 0.86 \times 1297.68$$
$$= 1251.4 \text{ kJ/kg}$$

$$h_2 = h_{f_2} + x_2 h_{fg_2}$$
$$= 323.08 + 0.95 \times 1145.8$$
$$= 1411.6 \text{ kJ/kg}$$

We know that theoretical C.O.P.

$$= \frac{h_1 - h_{f_3}}{h_2 - h_1} = \frac{1251.4 - 323.08}{1411.6 - 1251.4} = 5.8$$

29. (a)

$$\omega = \frac{0.622\,P_v}{P_b - P_v}$$

$$0.015 = \frac{0.622 \times P_v}{760 - P_v}$$

$$\Rightarrow \quad P_v = 17.896 \text{ mm of Hg}$$

$$\text{Vapour density, } \rho_V = \frac{P_V}{R_v T} = \frac{13600 \times 9.81 \times 0.017896 \times 18}{8314 \times 300}$$

$$\rho_V = 0.0172 \text{ kg/m}^3 \text{ of d.a}$$

30. (d)

$$\text{Cooling capacity} = 128 \text{ kW}$$

$$\dot{m}_a = 3 \text{ kg/s}$$

$$h_1 = 85 \text{ kJ/kg}$$

$$\omega_1 = 20 \text{ g/kg of d.a}$$

$$h_2 = 43 \text{ kJ/kg}$$

$$\omega_2 = 10 \text{ g/kg of d.a}$$
$$h_3 = \text{enthalpy of condensate leaving the coil?}$$

Inlet mass of water vapour

$$\dot{m}_{v_1} = \dot{m}_a \times \omega_1 = 3 \times 20 \times 10^{-3} = 60 \times 10^{-3} \text{ kg/s}$$

Outlet mass of water vapour

$$\dot{m}_{v_2} = \dot{m}_a \times \omega_2$$
$$= 3 \times 10 \times 10^{-3} = 30 \times 10^{-3} \text{ kg/s}$$

Required cooling capacity = Enthalpy of inlet air – Enthalpy of outlet air + Enthalpy of condensate water

$$\Rightarrow \quad Q_c = (m_a h_1 - m_a h_2) + m_v h_3$$
$$\Rightarrow \quad 128 = 3[85 - 43] + 30 \times 10^{-3} \times h_3$$
$$\Rightarrow \quad h_3 = 66.67 \text{ kJ/kg}$$

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