



**MADE EASY**

India's Best Institute for IES, GATE & PSUs

**Test Centres:** Delhi, Hyderabad, Bhopal, Jaipur, Pune, Kolkata

**ESE 2025 : Prelims Exam**  
CLASSROOM TEST SERIES

**MECHANICAL  
ENGINEERING**

**Test 2**

**Section A : Thermodynamics [All Topics]**

**Section B : Refrigeration and Air-Conditioning [All Topics]**

**ANSWER KEY**

1. (a)	16. (d)	31. (a)	46. (b)	61. (b)
2. (a)	17. (a)	32. (a)	47. (c)	62. (d)
3. (a)	18. (a)	33. (c)	48. (b)	63. (d)
4. (d)	19. (c)	34. (a)	49. (a)	64. (a)
5. (c)	20. (a)	35. (b)	50. (c)	65. (a)
6. (c)	21. (a)	36. (a)	51. (c)	66. (a)
7. (a)	22. (a)	37. (c)	52. (c)	67. (c)
8. (a)	23. (a)	38. (d)	53. (b)	68. (b)
9. (a)	24. (a)	39. (b)	54. (b)	69. (a)
10. (c)	25. (c)	40. (b)	55. (d)	70. (d)
11. (a)	26. (b)	41. (b)	56. (d)	71. (c)
12. (b)	27. (a)	42. (c)	57. (b)	72. (c)
13. (a)	28. (c)	43. (c)	58. (c)	73. (d)
14. (c)	29. (c)	44. (b)	59. (d)	74. (b)
15. (a)	30. (a)	45. (a)	60. (d)	75. (a)

## Section A : Thermodynamics

1. (a)

$$W_d = \int_{\text{Balloon}} PdV + \int_{\text{Bottle}} PdV = p\Delta V + 0$$

$$P_1 = 13.6 \times 10^3 \times 9.81 \times 1.520 = 202.792 \text{ kN/m}^2$$

∴

$$W_d = 202.792 \text{ kN/m}^2 \times 1 \text{ m}^3 = 202.792 \text{ kJ} \approx 202.8 \text{ kJ}$$

2. (a)

Heat absorbed by 1 mole of gas in one cycle

$$\begin{aligned} Q &= Q_{ab} + Q_{bc} \\ &= C_v(T_b - T_a) + C_p(T_c - T_b) \end{aligned}$$

$$T_c = T_b \frac{v_2}{v_1}$$

$$T_b = \frac{T_a P_2}{P_1}$$

$$\begin{aligned} Q &= C_v T_b \left(1 - \frac{P_1}{P_2}\right) + C_p T_b \left(\frac{v_2}{v_1} - 1\right) \\ &= \frac{P_2 v_1}{R} \left[ C_v \frac{(P_2 - P_1)}{P_2} + C_p \frac{v_2 - v_1}{v_1} \right] \quad \left[ \because T_b = \frac{P_2 v_1}{R} \right] \end{aligned}$$

$$\text{Efficiency, } \eta = \frac{W}{Q}$$

$$\begin{aligned} W &= \text{Area of cycle} \\ &= (P_2 - P_1)(v_2 - v_1) \end{aligned}$$

$$\eta = \frac{(P_2 - P_1)(v_2 - v_1)}{\frac{P_2 v_1}{R} \left[ C_v \left(\frac{P_2 - P_1}{P_2}\right) + C_p \left(\frac{v_2 - v_1}{v_1}\right) \right]}$$

$$\eta = \frac{R(P_2 - P_1)(v_2 - v_1)}{C_v v_1 (P_2 - P_1) + C_p (v_2 - v_1) P_2}$$

$$= \frac{C_p - C_v}{C_v \frac{v_1}{v_2 - v_1} + C_p \frac{P_2}{P_2 - P_1}}$$

$$= \frac{\gamma - 1}{\frac{v_1}{v_2 - v_1} + \frac{\gamma P_2}{P_2 - P_1}}$$

3. (a)

$$P_{in} = \frac{\text{Area of the diagram}}{\text{Length of the diagram}} \times \text{Spring constant}$$

$$= \frac{8}{8} \times 4 = 4 \text{ bar}$$

$$i_p = \frac{P_{in} L A n}{60000}$$

$$= \frac{4 \times 10^5 \times 0.4 \times \frac{\pi}{4} \times (0.2)^2 \times \frac{200}{2}}{60000}$$

$$= 8.37 \text{ kW}$$

4. (d)

Process  $A \rightarrow B$ ,

$$U_A + \delta Q = U_B + \delta W_1$$

$$\delta W = \frac{\pi \times 7 \times 7}{2} + (14 \times 1) = \frac{22}{7} \times \frac{7 \times 7}{2} + 14$$

$$\delta W = 91 \text{ (ve) (+ve)}$$

$$U_A - 400 = U_B + 91$$

...(i)

For return process  $B \rightarrow A$ ,

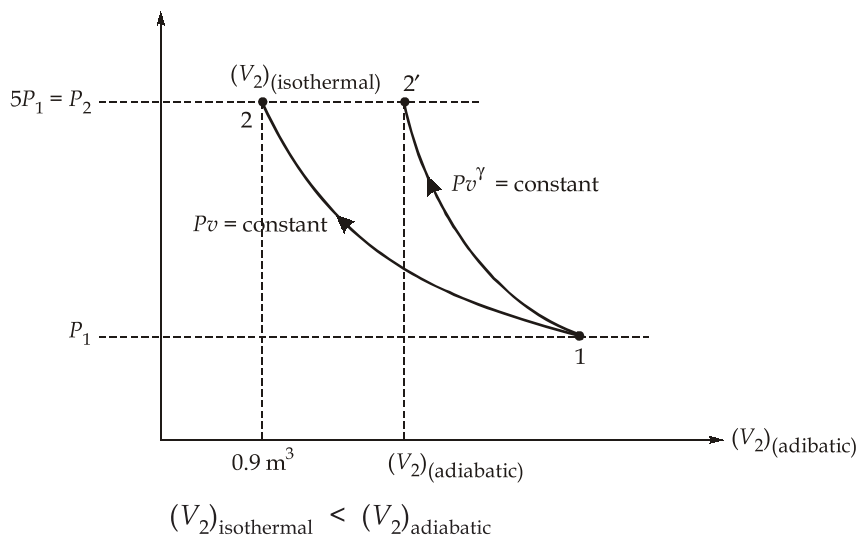
$$U_B + \delta Q = U_A + \delta W$$

$$U_B - U_A = \delta W \quad (\because \delta Q = 0)$$

$$(-400 - 91) = \delta W$$

$$\delta W = -491 \text{ kJ}$$

5. (c)



6. (c)

$$W_{\text{Turbine}} = \frac{1}{2}(V + 2V) \times (4P - P) = \frac{9PV}{2}$$

$$(WD)_{\text{on turbine}} = -(WD)_{\text{by turbine}}$$

$$= -\frac{9PV}{2}$$

7. (a)

$\oint \frac{\partial Q}{T} > 0$ , It violets the second law of thermodynamics.

8. (a)

By Clausius inequality, for reversible cycle,

$$\frac{\dot{Q}_h}{1000} - \frac{\dot{Q}_c}{200} = 0$$

$$\dot{Q}_h = 5\dot{Q}_c$$

According to first law equation,

$$\dot{Q}_h - \dot{Q}_c = W$$

$$\dot{Q}_h - \dot{Q}_c = 100 \text{ kW}$$

$$5\dot{Q}_c - \dot{Q}_c = 100$$

$$4\dot{Q}_c = 100$$

$$\dot{Q}_c = 25 \text{ kW}$$

$$\dot{Q}_H = 125 \text{ kW}$$

The entropy generation rate,  $\dot{\sigma} = -\left[\frac{\dot{Q}_h}{1000} - \frac{\dot{Q}_c}{200}\right] = 0$

No entropy generation for reversible cycle.

9. (a)

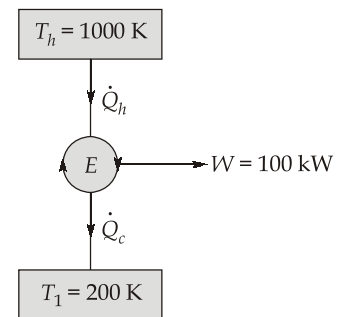
Since the engine is internally reversible but experience external irreversibility during the heat transfer to and from the thermal reservoirs.

$$\frac{\dot{Q}_h}{900} - \frac{\dot{Q}_c}{300} = 0$$

$$\dot{Q}_h = 3\dot{Q}_c$$

$$\dot{Q}_h - \dot{Q}_c = 100 \text{ kW}$$

$$3\dot{Q}_c - \dot{Q}_c = 100 \text{ kW}$$



$$\dot{Q}_c = 50 \text{ kW}$$

$$\dot{Q}_h = 150 \text{ kW}$$

The total entropy generation is

$$-\left[ \frac{Q_h}{1000} - \frac{Q_c}{200} \right] = \sigma$$

$$\dot{\sigma} = -\left[ \frac{150}{1000} - \frac{50}{200} \right]$$

$$= 0.1 \text{ kW/K}$$

11. (a)

$$\eta_{II} = \frac{\text{Increase in availability/Maximum work possible}}{\text{Energy input}}$$

$$\delta Q = (u_2 - u_1) + \delta W$$

$$W_e = -(450 - 50) \quad [\because \delta Q = 0]$$

$$= -400 \text{ kJ/kg} \times 1 \text{ kg}$$

$$= 400 \text{ kJ}$$

Increase in availability,

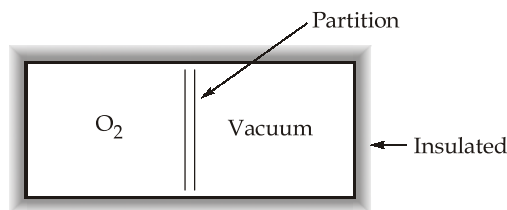
$$\phi_2 - \phi_1 = m_w [(u_2 - u_1) - T_0 (s_2 - s_1)]$$

$$= 1 [(450 - 50) - 300(1.5 - 0.4)]$$

$$= 400 - 330 = 70$$

$$\eta_{II} = \frac{70}{400} \times 100 = 17.5\%$$

13. (a)



$$V_1 = \frac{8}{2} \text{ m}^3 = 4 \text{ m}^3$$

$$V_2 = 8 \text{ m}^3$$

$$\delta Q = dU + \delta W$$

$$T_1 = T_2 \quad (\because \delta Q = 0)$$

Change in entropy due to removal of partition

$$s_2 - s_1 = c_v \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}$$

$$= \frac{8.314}{32} \ln\left(\frac{8}{4}\right) \quad [\because T_1 = T_2]$$

$$\begin{aligned} \text{Energy lost} &= T_0 \Delta s \\ &= 300 \times \frac{8.314}{32} \ln 2 \\ &= 54.026 \text{ kJ/kg} \end{aligned}$$

14. (c)

$$\text{We know,} \quad T ds = dH - V dP$$

For reversible adiabatic process,  $ds = 0$ 

$$\int_{H_1}^{H_2} dH = \int_{P_1}^{P_2} v dP$$

$$\begin{aligned} H_2 - H_1 &= \int_{P_1}^{P_2} \left[ \frac{P_1 V_1^n}{P} \right]^{1/n} dP \\ &= \frac{n(P_2 V_2 - P_1 V_1)}{n-1} = \frac{1.5(11.3 \times 0.1 - 2 \times 0.4)}{0.5} \\ &= 0.99 \text{ kJ} \end{aligned}$$

15. (a)

$$\begin{aligned} \text{Given :} \quad P &= 1 \text{ bar, } T_1 = 27^\circ\text{C, } T_2 = 177^\circ\text{C} \\ T_H &= 577^\circ\text{C} = 850 \text{ K} \\ T_0 &= 20^\circ\text{C} = 293 \text{ K} \end{aligned}$$

The heat transfer to air at constant pressure

$$\begin{aligned} Q_H &= c_p (T_2 - T_1) \\ Q_H &= 1.005(177 - 27) = 150.75 \text{ kJ/kg} \end{aligned}$$

$$\text{Unavailable energy, } Q_{\text{unav}} = T_0 \Delta s = T_0 \left( 1.005 \ln \frac{450}{300} \right) = 293 [0.4054] = 118.7822 \text{ kJ/kg}$$

$$\% \text{ of heat added as } Q_{\text{available}} \text{ energy} = \frac{150.75 - 118.7822}{150.75} \times 100 = 21.20\%$$

19. (c)

$$\begin{aligned} C_n &= C_V \left[ \frac{\gamma - n}{1 - n} \right] = 0.718 \left[ \frac{1.4 - 1.25}{1 - 1.25} \right] \\ &= -0.43 \text{ kJ/kg-K} \end{aligned}$$

20. (a)

$$\eta_I = \frac{W_{\max}}{Q}; W_{\max} = 0.6 \times 100 = 60 \text{ kJ}$$

$$\eta_{II} = \frac{W_{act}}{W_{\max}}$$

$$0.7 = \frac{W_{act}}{60}$$

⇒

$$W_{\text{actual}} = 42 \text{ kJ}$$

$$\begin{aligned} \text{Energy lost, } I &= W_{\max} - W_{\text{actual}} = 60 - 42 \\ &= 18 \text{ kJ} \end{aligned}$$

21. (a)

$$\text{Unavailable energy} = \text{Irreversibility} = T_0 s_{\text{gen}}$$

$$= T_0 m C_v \ln \frac{T_2}{T_1}$$

$$= 300 \times 1 \times 0.718 \times \ln \left( \frac{3000}{300} \right)$$

$$= 495.976 \text{ kJ}$$

22. (a)

$$\text{Given : } T_1 = 1000 \text{ K; } P_1 = 16 \text{ bar; } T_2 = 500 \text{ K, } P_2 = 1 \text{ bar}$$

$$W_{\text{actual}} = h_1 - h_2 = 1.005(1000 - 500)$$

$$W_{\text{actual}} = 502.5 \text{ kJ/kg}$$

$$s_1 - s_2 = c_p \ln \frac{T_1}{T_2} - R \ln \frac{P_1}{P_2}$$

$$= 1.005 \ln \frac{1000}{500} - 0.287 \ln(16) = -0.09912 \text{ kJ/kgK}$$

$$W_{\max} = (h_1 - h_2) - T_0 (s_1 - s_2)$$

$$= 502.5 - 300(-0.09912) = 532.236$$

$$\eta_{II} = \frac{W_{\text{actual}}}{W_{\max}} = \frac{502.5}{532.236} = 94.4\%$$

24. (a)

$$\Delta s = m c_v \ln \frac{T_2}{T_1} + m R \ln \frac{V_2}{V_1}$$

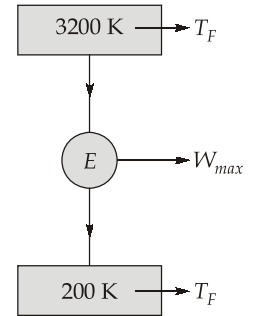
$$= 1 \times 0.287 \ln \frac{2V}{V} \quad [ \because T_1 = T_2 ]$$

$$= 0.1989 \text{ kJ/K}$$

25. (c)

For reversible engine process,

$$\begin{aligned}
 (\Delta s)_{\text{universe}} &= 0 \\
 \Delta s_1 + \Delta s_2 + \Delta s_3 &= 0 \\
 c \ln \frac{T_f}{3200} + c \ln \frac{T_f}{200} &= 0 \\
 T_f^2 &= 3200 \times 200 \\
 T_f &= 800 \text{ K} \\
 W_{\text{max}} &= Q_1 - Q_2 \\
 &= 2.5(3200 - 800) - 2.5(800 - 200) \\
 W_{\text{max}} &= 4500 \text{ kJ}
 \end{aligned}$$



27. (a)

$$\begin{aligned}
 (\Delta S)_{\text{resistor}} &= \frac{\delta Q}{T} + s_{\text{gen}} \\
 s_{\text{gen}} &> 0 \\
 (\delta S)_{\text{resistor}} &> 0
 \end{aligned}
 \quad \left[ \because \frac{\delta Q}{T} = 0 \right]$$

28. (c)

(i) For process to be feasible

$$\begin{aligned}
 \delta Q &= \delta W \\
 Q_1 + Q_2 - Q_3 &= W_{\text{out}} \\
 5 + 2 - 3 &= 4 \\
 4 &= 4
 \end{aligned}$$

(ii) For process to be reversible

$$\begin{aligned}
 \oint \frac{\delta Q}{T} &= 0 \\
 \frac{5}{200} + \frac{2}{500} - \frac{3}{100} &< 0 \\
 -\frac{1}{1000} &< 0
 \end{aligned}$$

Irreversible process.

29. (c)

$$\frac{T_2}{T_1} = \left( \frac{P_2}{P_1} \right)^{\frac{\gamma-1}{\gamma}}$$



$$\frac{T_2}{300} = \left(\frac{100}{200}\right)^{0.4}$$

$$T_2 = 246 \text{ K}$$

30. (a)

(i)  $pdV + vdP = d(pV)$

It is an exact differential, the quantity  $d(pV)$  is a property.

(ii)  $pdV$ ;  $p$  is a functionally related with  $V$  and its integration cannot be evaluated unless the relationship between  $p$  and  $V$  is known. So  $pdV$  is not a property.

(iii) same as (ii)

31. (a)

During adiabatic mixing,  $dU = 0$

$$n_{O_2} = \left(\frac{PV}{R_v T}\right)_{O_2} = \frac{(5 \times 100) \times (1)}{8.314 \times 293} = 0.205 \text{ kmol}$$

$$n_{CO} = \frac{1 \times 100 \times 2}{8.314 \times 278} = 0.086 \text{ kmol}$$

$$n_{O_2} U_{O_2} + n_{CO} U_{CO} = [n_{O_2} \bar{C}_{V_2} + n_{CO} \bar{C}_{V_{CO}}] T$$

$$0.205 \times 21.07 \times 293 + 0.086 \times 20.86 \times 278 = (0.205 \times 21.07 + 0.086 \times 20.86) \times T_f$$

$$T_f = 288.6 \text{ K}$$

32. (a)

$$\begin{aligned} \text{Workdone (W)} &= P\Delta V \\ &= 100 \times 10^3 \times (5 - 2) \\ &= 300000 \text{ J} = 300 \text{ kJ} \end{aligned}$$

$$\begin{aligned} \text{Change in internal energy } (\Delta U) &= Q - W \\ &= 1500 - 300 = 1200 \text{ kJ} \end{aligned}$$

33. (c)

Given :  $V = 1 \text{ m}^3$ ,  $m = 1 \text{ kg}$ ,  $N = 700$  rotations

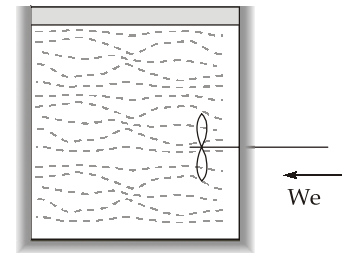
$$\begin{aligned} R &= c_p - c_v \\ &= 1000 - 800 = 200 \text{ J/kgK} \end{aligned}$$

$$\begin{aligned} P_1 V_1 &= mRT_1 \\ 1 \times 10^4 \times 1 &= 1 \times 200 \times T_1 \end{aligned}$$

$$T_1 = 50 \text{ K}$$

$$P = T \cdot \omega$$

$$= T \times 2\pi \times N = 100 \times 2 \times \frac{22}{7} \times 700$$



$$\begin{aligned}
 W_e &= 440000 \\
 \delta Q &= \Delta U + \delta W \\
 mc_v(T_2 - T_1) &= W_e \\
 1 \times 800 \times (T_2 - 50) &= W_e \\
 800 \times (T_2 - 50) &= 440000 \\
 T_2 &= 600 \text{ K}
 \end{aligned}$$

34. (a)

Entropy of mixture,

$$\begin{aligned}
 s &= s_f + xs_{fg} \\
 v &= \frac{V}{m} \text{ m}^3/\text{kg} = \frac{1}{20} = 0.05 \text{ m}^3/\text{kg} = v_f + xv_{fg} \\
 0.05 &= 0.001157 + x \times (0.12736 - 0.001157) \\
 x &= 0.387 \\
 s &= s_f + xs_{fg} \\
 &= 2.3309 + (0.387 \times 4.1014) \\
 &= 3.918 \simeq 3.92
 \end{aligned}$$

36. (a)

In cyclic process, the system returns to its initial state, so  $\Delta U = 0$ 

$$\therefore \oint Q = \oint W$$

37. (c)

A reversible adiabatic process,  $dQ = 0$ 

$$dS = \frac{dQ}{T} + s_{gen}$$

$$\frac{dQ}{T} = 0 \quad [\because s_{gen} = 0]$$

So,  $dS = 0$ For irreversible process,  $dS = \frac{dQ}{T} + s_{gen}$  $s_{gen}$  will be positive alwaysif  $\frac{dQ}{T}$  is negative then  $dS = 0$

## Section B : Refrigeration and Air-Conditioning

38. (d)

In the analysis of thermo-electric refrigeration we assume negligible Thomson coefficient.

39. (b)

As the temperature of cold side of the thermo-electric device decreases the electric resistance of the thermo-electric materials (typically semiconductors) increases. This leads to higher power consumption for the same amount of refrigeration which reduces the COP.

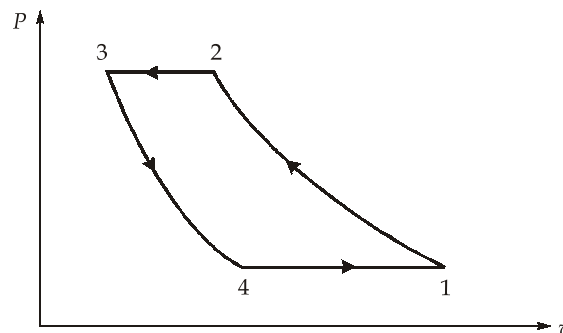
40. (b)

They are generally used only in larger sizes because in the larger sizes they are much lower in first cost, low running cost and requires considerably less space than reciprocating compressors.

41. (b)

1. The baffles must be provided in the suction path of refrigerant to prevent the flow of liquid droplets with vapour.
2. The power requirement of the compressor drastically increase with an increase in pressure of the system.

42. (c)



$$T_3 = T_4 \left( \frac{P_2}{P_1} \right)^{\left( \frac{n-1}{n} \right)}$$

$$T_4 = \frac{30 + 273}{\left( \frac{8}{1} \right)^{\left( \frac{1.5-1}{1.5} \right)}} = \frac{303}{(8)^{0.5/1.5}} = \frac{303}{(8)^{1/3}} = \frac{303}{2} = 151.5 \text{ K}$$

Heat extracted from the cold chamber =  $c_p(T_1 - T_4) = 1(283 - 151.5) = 131.5 \text{ kJ/kg}$

43. (c)

The induced draught fan is more desirable than forced draught one as it has following advantages.

- It provides even air distribution over the coil.
- It eliminates the chance of recirculating discharged hot air which is possible with the forced fan.

44. (b)

Total enthalpy change across compressor = Enthalpy change between suction and discharge + Heat loss to cooling water Jackets

$$\begin{aligned} \therefore \quad \text{Total enthalpy change} &= 46 + 9 \\ &= 55 \text{ kJ/kg} \end{aligned}$$

$$\text{COP} = \frac{\text{Refrigeration effect}}{\text{Total enthalpy drop across compressor}} = \frac{165}{55}$$

$$\therefore \quad \text{COP} = 3$$

45. (a)

$$T_1 = 12^\circ\text{C} = 12 + 273 = 285 \text{ K}$$

$$T_2 = 42^\circ\text{C} = 42 + 273 = 315 \text{ K}$$

$$\text{Actual COP} = 0.6(\text{COP})_{\text{rev. carnot}}$$

$$\text{COP} = \frac{T_2}{T_2 - T_1} \quad [\text{Rev. carnot cycle}]$$

$$\text{COP} = \frac{315}{315 - 285} = \frac{315}{30} = 10.5$$

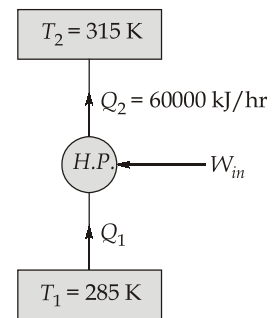
$$\text{Actual COP} = 10.5 \times 0.6 = 6.3$$

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

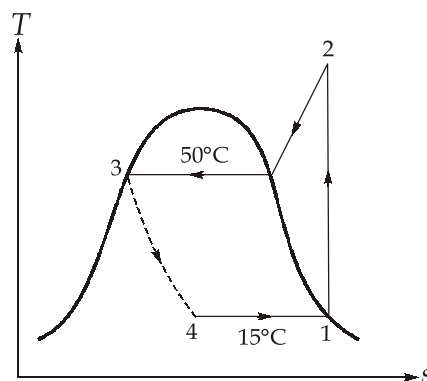
$$P_{\text{in}} = \frac{\text{Heating capacity}}{\text{COP}} = \frac{60000}{6.3} \text{ kJ/hr}$$

$$P_{\text{in}} = \frac{60000}{6.3} \times \frac{1}{3600} \text{ (kJ/s or kW)}$$

$$P_{\text{in}} = \frac{100}{37.8} = 2.64 \text{ kW}$$



46. (b)



∴

$$\text{R.C.} = 360 \text{ MJ/hr}$$

$$\therefore m_r(h_1 - h_4) = \frac{360 \times 10^3}{3600}$$

$$m_r(194.3 - 84.3) = 100 \quad [\text{as } h_4 = h_3 = 84.3]$$

$$m_r = \frac{100}{110} = 0.9090 \approx 0.91 \text{ kg/sec}$$

For process 3-4,

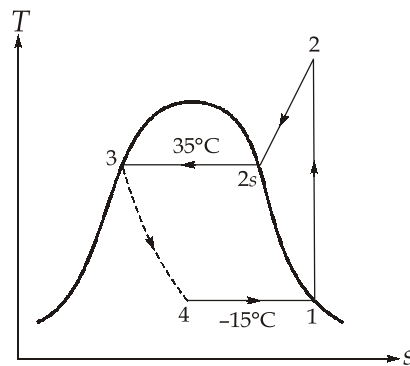
$$h_3 = h_4$$

$$h_{f3} = h_{f4} + xh_{fg4}$$

$$84.3 = 50.3 + x(194.3 - 50.3)$$

$$\Rightarrow x = 0.236$$

47. (c)



For process 1 - 2,

$$h_2 = (h_g) + c_{pv}(T_2 - T_{2s})$$

$$h_2 = 1471 + 2.8(408 - 308)$$

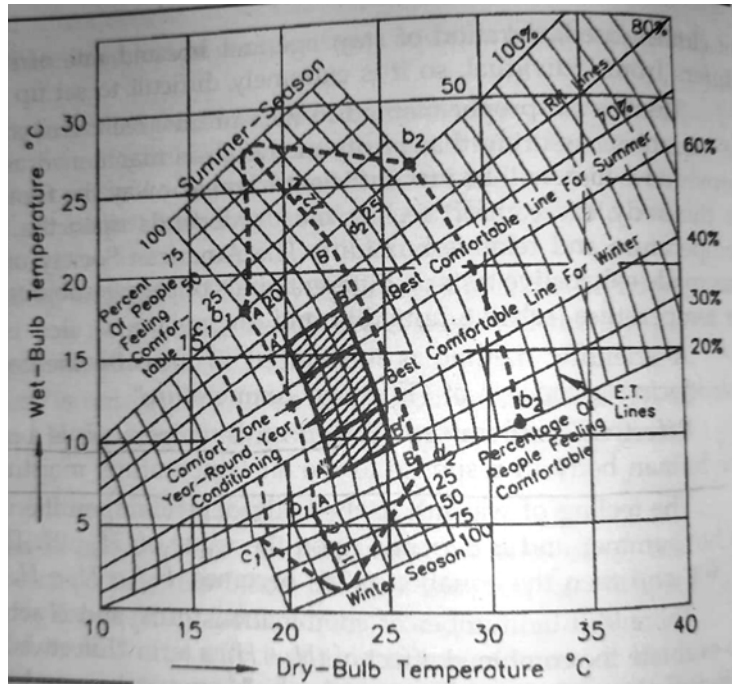
$$h_2 = 1751 \text{ kJ/kg}$$

$$\text{Power required for compressor} = \frac{\dot{m}_r (h_2 - h_1)}{\eta_{ise} \times \eta_{mech}}$$

$$= \frac{0.025 \times (1751 - 1415)}{0.8 \times 0.7} = 15 \text{ kW}$$

48. (b)

When relative humidity increases, the body's ability to dissipate heat through evaporation decreases, leading to increased discomfort. This is why higher humidity levels can make warm temperature feel hotter.



49. (a)

$$\begin{aligned}\dot{m}_{air} &= \text{Volumetric flow rate} \times \text{Density of air} \\ &= 3 \times 1.164 = 3.492 \text{ kg/s}\end{aligned}$$

Mass flow rate of moisture,

$$\begin{aligned}\dot{m}_{moisture} &= \dot{m}_{air} \times \text{Specific humidity} \\ &= 3.492 \times 0.0105 \\ \dot{m}_{moisture} &= 0.0367 \text{ kg/sec}\end{aligned}$$

50. (c)

As the value of adiabatic efficiency of compressor ( $\eta_{ac}$ ) is always considerably small, therefore the COP of the vortex tube will also be very small of the order of 0.15 to 0.2 under normal operating conditions.

$$(\text{COP})_{\text{vortex tube}} = \eta_{ab} \eta_{ac} \left( \frac{P_a}{P_i} \right)^{\frac{\gamma-1}{\gamma}}$$

where,

 $\eta_{ab} \rightarrow$  Adiabatic efficiency of vortex tube $\eta_{ac} \rightarrow$  Adiabatic efficiency of compressor $P_a \rightarrow$  Atmospheric pressure $P_i \rightarrow$  Inlet pressure $r \rightarrow$  Ratio of specific heats

51. (c)

Low specific heat of liquid refrigerant and high specific heat of vapour refrigerant are desirable because both tends to increase the refrigerating effect per kg of refrigerant. The low specific heat of liquid refrigerant helps in increasing the sub cooling of liquid and high specific heat of vapour helps in decreasing the superheating of vapour.

52. (c)

The basic components of the steam jet refrigeration system are : Steam ejector, Flash chamber fitted with spray nozzle and baffles, steam condensers, chilled water circulating pump, condensate removal pump and air removal ejector for steam condenser.

53. (b)

$$\eta_{ab} = 0.75; \eta_{ac} = 0.6; P_a = 1 \text{ bar}; P_i = 27 \text{ bar}; \gamma = 1.5$$

$$\begin{aligned} \text{COP} &= \eta_{ab} \eta_{ac} \left( \frac{P_a}{P_i} \right)^{\frac{\gamma-1}{\gamma}} \\ &= 0.75 \times 0.6 \times \left( \frac{1}{27} \right)^{\frac{1.5-1}{1.5}} = 0.75 \times 0.6 \times \left( \frac{1}{27} \right)^{\frac{1}{3}} \\ \text{COP} &= 0.75 \times 0.6 \times \frac{1}{3} = 0.15 \end{aligned}$$

54. (b)

Freon 12  $\rightarrow R_{012}$ ,  $R(m-1)(n+1)P$   
 We know that,  $n+p+q = 2m+2$  on comparing  $m=1, n=0, P=2$   
 $0+2+q = 2 \times 1 + 2$   
 $q = 2$   
 The chemical formula of F-12  $C_m H_n F_p Cl_q$   
 $\therefore C_1 H_0 F_2 Cl_2$   
 $CCl_2 F_2$

55. (d)

Dichlorodifluoro methane  $\rightarrow$  R-12  
 Water  $\rightarrow$  R-718  
 Methyl chloride  $\rightarrow$  R-40  
 Monochlorodifluoromethane  $\rightarrow$  R-22

56. (d)

Given:  $T_e = 12 + 273 = 285 \text{ K}$   
 $T_0 = 27 + 273 = 300 \text{ K}$   
 $\text{COP} = 4$

$$(\text{COP})_{\text{VARS}} = \frac{(T_G - T_0)}{T_G} \times \left( \frac{T_e}{T_0 - T_e} \right)$$

$$4 = \frac{(T_G - 300) \times 285}{T_G (300 - 285)}$$

$$4 = \frac{(T_G - 300) \times 19}{T_G}$$

$$4T_G = 19T_G - 5700$$

$$15T_G = 5700$$

$$T_G = 380 \text{ K}$$

$$T_G = 380 - 273 = 107^\circ\text{C}$$

57. (b)

$$Q_e = \text{R.E.} = 1 \text{ kW}; \quad (\text{COP})_{\text{VARS}} = 0.8$$

$$(\text{COP})_{\text{VARS}} = \frac{R.C.}{Q_g + W_p} = \frac{R.C.}{Q_g} \quad [\text{As pump work} = 0]$$

$$0.8 = \frac{1}{Q_g}$$

$$Q_g = 1.25 \text{ kW}$$

We know that,

$$Q_e + Q_g = Q_a + Q_c$$

$$1 + 1.25 = Q_a + Q_c$$

$$Q_a + Q_c = 2.25 \text{ kW}$$

58. (c)

$$\text{R.H.} = 0.8,$$

$$\text{Saturated steam pressure, } P_{vs} = 5 \text{ kPa}$$

$$\text{Total pressure, } P_t = 1 \text{ bar} = 100 \text{ kPa}$$

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

Also,

$$\phi = \frac{P_v}{P_{vs}}$$

$$P_v = \phi \times P_{vs}$$

$$P_v = 0.8 \times 5$$

$$P_v = 4 \text{ kPa}$$

∴

$$\omega = 0.622 \times \frac{4}{100 - 4} = 0.622 \times \frac{4}{96}$$

$$= 0.02591 \text{ kg w/v/kg.d.a}$$



59. (d)

$$\begin{aligned}\text{Specific humidity for mixture, } \omega_{\text{mix}} &= \frac{m_1\omega_1 + m_2\omega_2}{m_1 + m_2} \\ &= \frac{2 \times 0.03 + 1 \times 0.015}{3} = \frac{0.075}{3} \\ \omega_{\text{mix}} &= 0.025 \text{ kg/kg of d.a.}\end{aligned}$$

60. (d)

$$\begin{aligned}\text{RTH} &= 100 \text{ kW} \\ \text{RSHF} &= 0.85 \\ \text{Volume flow rate of air} &= 150 \text{ m}^3/\text{min} \\ \omega_2 &= 0.003 \text{ kg/kg of d.a.} \\ \text{RSHF} &= \frac{\text{RSH}}{\text{RTH}} \\ \text{RSH} &= 0.85 \times 100 = 85 \text{ kW} \\ \text{RLH} &= \text{RTH} - \text{RSH} \\ \text{RLH} &= 100 - 85 = 15 \text{ kW} \\ \text{RLH} &= 50 \times C_{mm} \times \Delta\omega \text{ kW} \\ 15 &= 50 \times 150 \times \Delta\omega \\ \Delta\omega &= 0.002 \text{ kg/kg/d.a.} \\ \Delta\omega &= \omega_2 - \omega_1 \\ \omega_1 &= 0.003 - 0.002 \\ \omega_1 &= 0.001 \text{ kg/kg of dry air}\end{aligned}$$

61. (b)

$$\begin{aligned}\text{Heat rejection factor} &= \frac{\text{Heat rejected in condenser}}{\text{Refrigeration effect}} \\ \text{Heat rejected in condenser} &= 1.2 \times 2100 = 2520 \text{ kJ/min} \\ \text{COP} &= \frac{\text{Refrigeration effect}}{w_{in}} = \frac{2100}{420} = 5\end{aligned}$$

62. (d)

This type of evaporator gives high heat transfer rates so that smaller evaporators can be used for the required capacities.

63. (d)

**Advantages:**

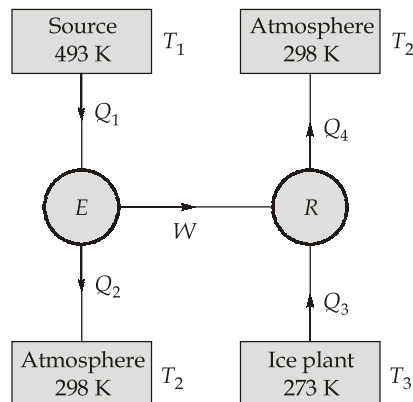
- This is more economical when the place to be cooled is far away from refrigeration system.
- Leaks are more serious in refrigerant piping than in water or brine piping.
- Long refrigerants lines create the problems in oil return and cause excessive pressure loss.

64. (a)  
Automatic expansion valve maintains a constant pressure throughout the varying load operation on the evaporators controlling the quantity of refrigerant flowing into evaporator.
65. (a)  
When the compressor stops, the refrigerant continues to flow from high pressure side to low pressure side until the pressure is equalised. This requires less starting torque to start the compressor so a low starting torque motor can be used.
66. (a)  
The flash chamber or evaporator is a large vessel and is heavily insulated to avoid the rise in temperature of water due to high ambient temperature.
67. (c)  
Saturation temperature of the water vapour in the moist air is known as dew point temperature.
68. (b)

$$\begin{aligned}\text{Spray water temperature} &= 38^\circ\text{C} \\ \text{Air stream conditions} &= \text{DBT} = 35^\circ\text{C} \\ &= \text{WBT} = 20^\circ\text{C}\end{aligned}$$

Since, temperature of spraying water is greater than that of air stream temperature. Hence, air gets heated and humidified.

69. (a)



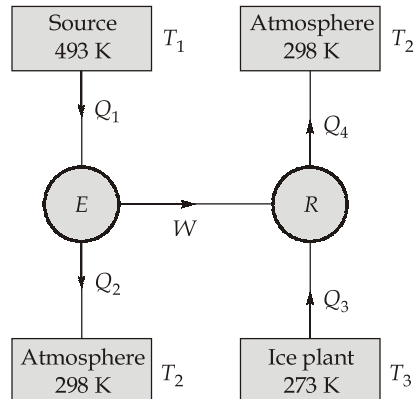
$Q_3$  is the heat removed by the refrigerator to produce the required ice.

$$Q_3 = \frac{15000 \times 335}{24} = 209375 \text{ kJ/hr}$$

$$(\text{COP}) \text{ of refrigerator} = \frac{T_3}{T_2 - T_3} = \frac{Q_3}{W}$$

$$W = Q_3 \left( \frac{T_2 - T_3}{T_3} \right) = 209375 \left( \frac{298 - 273}{273} \right) = 19173.5 \text{ kJ/hr}$$

70. (d)



Efficiency of carnot engine is given by

$$\eta = \frac{W}{Q_1} = \frac{T_1 - T_2}{T_1}$$

$$Q_1 = W \left( \frac{T_1}{T_1 - T_2} \right) = 19173.5 \times \frac{493}{493 - 298} = 48474.6 \text{ kJ/hr}$$

$$m_f (\text{mass of fuel used/hr}) = \frac{Q_1}{CV} = \frac{48474.6}{44500} = 1.089 \text{ kg/hr}$$

71. (c)

The quantity of heat which can be measured by measuring the DBT of air is sensible heat.

72. (c)

The effective temperature is the measure of feeling warmth or cold to the human body in response to the air temperature, moisture content and air motion.

73. (d)

$$\text{By pass factor of 4 depth coil} = (0.8)^4 = 0.41$$

74. (b)

Heat absorbed = Mass flow rate  $\times$  Specific heat capacity  $\times$  Temperature difference

$$\begin{aligned} Q &= 0.1 \times 2.5 \times [30 - (-20)] \\ &= 0.1 \times 2.5 \times 50 \\ &= 12.5 \text{ kJ/s} \end{aligned}$$

75. (a)

$$\text{COP} = \frac{R.E.}{W_{in}} = \frac{6.5}{1} = 6.5$$

Also,

$$(\text{COP})_{\text{carnot}} = \frac{260}{t - 260}$$

$$6.5 = \frac{260}{t - 260}$$

 $\Rightarrow$ 

$$6.5t - 1690 = 260$$

$$6.5t = 1950$$

$$t = 300 \text{ K}$$

$$t = 27^\circ\text{C}$$

○○○○

