Heat Transfer, Refrigeration and Air Conditioning Test 3

Number of Questions 35 **Time:60 min.**

Directions for questions 1 to 35: Select the correct alternative from the given choices.

1. A refrigeration cycle operates between condenser temperature of 27°C and evaporator temperature of – 23° C. The carnot co-efficient of performance of cycle will be
(A) 0.2 (B) 1.2
(C) 5 (D) 10

2. Air refrigeration operates on
(A) Carnot cycle
(B) Rankine cycle
(C) Erricson cycle
(D) Reversed Brayton cycle

3. The most suitable refrigerant for a commercial ice plant is
(A) Brine (B) NH_3
(C) Freon (D) Air

4. Consider the following statements
1. Azeotropes are the mixtures of refrigerants and behave like pure substances.
2. Isomers refrigerants are compounds with the same chemical formula but have different molecular structures.
3. The formula $n + p + q = 2$ m is used for unsaturated chlorofluoro carbon compounds.

Which of these statements are correct?
(A) 1 and 3 (B) 2 and 3
(C) 1 and 2 (D) 1, 2, and 3

5. Consider the following parameters
(1) Dry-bulb temperature
(2) Humidity ratio
(3) Air velocity
(4) Solar radiation intensity

Which of these parameter are taken into account for determining effective temperature for human comfort?
(A) 1 and 2 (B) 1 and 4
(C) 2, 3 and 4 (D) 1, 2 and 3

6. A metal plate has a surface area of 2 m^2, thickness 100 mm and a thermal conductivity of 200 W/mK. The thermal resistance of the plate in (K/W) is
(A) 4 × 104 (B) 2.5 × 10−3
(C) 1.5 × 10−5 (D) 2.5 × 10−4

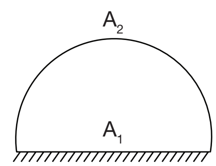
7. Match List – I with List – II and select the correct answer using the code given below the lists.

List – I		List – II	
(Phenomenon)		(Associated Dimensionless parameter)	
P.	Transient conduction	1.	Reynolds number
Q.	Forced convection	2.	Grashoff number
R.	Mass transfer	3.	Biot number
S.	Natural convection	4.	Mach number
		5.	Sherwood number

Codes:

	P	*Q*	*R*	*S*
(A)	3	1	5	2
(B)	1	2	5	3
(C)	3	1	2	5
(D)	4	2	1	5

8. Long semi-circular duct is shown in the given figure. The shape factor F_{22} for this case is



(A) 0.36 (B) 0.50
(C) 0.73 (D) 0.95

9. A cross-flow type air-heater has an area of 60 m^2. The overall heat transfer co-efficient is 120 W/m^2 K and heat capacity of both hot and cold stream is 1200 W/K. The value of NTU is
(A) 2 (B) 4
(C) 6 (D) 8

10. Match the properties with their units

Property		Units	
P.	Bulk modulus	1.	W/s
Q.	Thermal conductivity	2.	N/m^2
R.	Heat transfer coefficient	3.	N/m^2
S.	Heat flow rate	4.	W
		5.	W/mk
		6.	W/m^2 K

Codes:

	P	*Q*	*R*	*S*
(A)	1	2	3	4
(B)	2	5	6	4
(C)	2	5	4	6
(D)	1	4	6	5

11. The efficiency of fin with insulated tip is
(A) $\dfrac{\tan h(mL)}{mL}$ (B) $\dfrac{\tan h(mL)}{(hA/kP)^{0.5}}$
(C) $\dfrac{mL}{\tan h\,(mL)}$ (D) $\dfrac{(hA/kP)^{0.5}}{\tan h\,(mL)}$

12. Heat is lost from a 150 mm diameter stream pipe placed horizontally in ambient at 30°C. If the Nusselt number is 25 and thermal conductivity of air is 0.03 W/mK. The heat transfer co-efficient in W/m^{2}K is
(A) 2 (B) 4
(C) 4.5 (D) 5

13. A composite wall of a furnace has 2 layers of equal thickness having thermal conductivities in the ratio of 3 : 2. The ratio of the temperature drop across the two layers is
(A) 2 : 3 (B) 3 : 5
(C) 2 : 5 (D) 3 : 2

14. In a counter flow heat exchanger, hot fluid enters at 65° C and cold fluid leaves at 30°C. Mass flow rate of the hot fluid is 1 kg/s and that of cold fluid is 2 kg/s. Specific heat of the hot fluid is 10 kJ/kg-K and that of cold fluid is 5 kJ/kg.K. The LMTD for the heat exchanger is
(A) 15 (B) 30
(C) 35 (D) 45

15. The radiative heat transfer rate per unit area (W/m^2) between two plane parallel gray surface (emissivity = 0.8) maintained at 400 K and 300 K is (s_b = Stephan Boltzman constant is 5.67 × 10^{-8} W/m^2 K^4)
(A) 992.5 (B) 661.5
(C) 442.5 (D) 250

16. A steel rod (k = 35 W/m°C), 10 mm in diameter and 50 mm long, with an insulated end, is to be used as a fin. It is exposed to surroundings with a temperature of 60°C and heat transfer coefficient of 60 W/m^2°C. The temperature at the base of fin is 100°C. The efficiency of fin is
(A) 62% (B) 64%
(C) 66% (D) 68%

17. A solid steel ball of mass 1 kg, when quenched in water bath at 30°C cools from 500°C to 400 °C in 10 seconds. The temperature of the ball after the next 10 seconds is
(A) 350° C (B) 345° C
(C) 334° C (D) 321° C

18. In a simple vapour compression refrigeration cycle, the enthalpy at different state points are given. Before compression = 375 kJ/kg, after compression = 425 kJ/kg, after throttling = 125 kJ/kg. The COP is
(A) 3.5 (B) 6
(C) 5 (D) 2.8

19. For a current carrying wire of 25 mm diameter exposed to air (h = 25 W/m^2 K), maximum heat dissipation occurs when thickness of insulation (0.5 W/mK) is
(A) 7.5 mm (B) 10 mm
(C) 15 mm (D) 20 mm

20. The time constant of thermo couple is
(A) the time taken to attain 100% initial temperature difference
(B) time taken to attain 63.2% of initial temperature difference
(C) time taken to attain 50% of initial temperature difference
(D) the minimum time taken to record a temperature reading

21. A body at 600 K cools by radiating heat to ambient atmosphere maintained at 300 K. When the body has cooled to 500 K, the cooling rate as a percentage of original cooling rate is about.
(A) 33% (B) 44%
(C) 55% (D) 66%

22. Match List – I with List – II and select the correct answer using the codes given below the lists:

List – I		List – II	
P.	Fourier's law	1.	q = hA (T1 –T2)
Q.	Newton's law of cooling	2.	E = sEb
R.	Stefan-oltzmann law	3.	q = $\frac{kA}{L}$ (T1 – T2)
S.	Kirchhoff's law	4.	q = sA (T14 – T24)

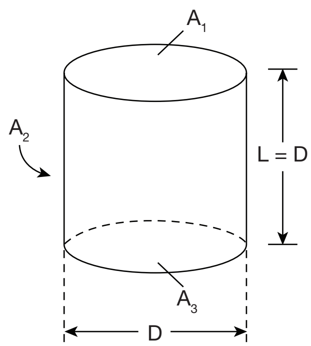
Codes:

	P	Q	R	S
(A)	3	1	4	2
(B)	3	1	4	2
(C)	4	3	2	1
(D)	1	2	3	4

23. A thin flat plate 3 m × 3 m is hanging freely in air. The temperature of the surroundings is 30°C. Solar radiation is falling on one side of the plate at the rate of 600 W/m^2. What should be the convective heat transfer coefficient in W/m^2°C, if the temperature of the plate is to remain constant at 35°C?
(A) 30 (B) 40
(C) 50 (D) 60

24. In shell and tube heat exchanger, baffles are mainly used to
(A) Increase the mixing of fluid
(B) Increase the heat transfer area
(C) deflect the flow in desired direction
(D) reduce fouling of the tube surface

25. For the circular tube of equal length and diameter shown in figure, the view factor F_{13} is 0.15. The view factor F_{12} in this case will be



(A) zero (B) 1
(C) 0.85 (D) 0.15

26. Two long parallel plates of same emissivity 0.6 are maintained at different temperatures and have radiative heat exchange between them. The radiation shield of emissivity 0.3 placed in the middle will reduce the radiation heat exchange to

(A) $\frac{1}{2}$ (B) $\frac{1}{4}$
(C) $\frac{7}{24}$ (D) $\frac{8}{25}$

27. Two long rods of the same diameter, one made of brass (k = 85 W/m°C) and other made of copper (k = 375 W/m°C) have one of their ends inserted in to the furnace. Both of the rods are exposed to the same environment. At a distance of 110 mm away form the furnace end, the temperature of the brass rod is 140°C. At what distance from the furnace end the same temperature would be reached in the copper rod?

(A) 220 mm (B) 231 mm
(C) 250 mm (D) 261 mm

28. A solid cylinder (surface 2) is located at the centre of a hollow sphere (surface 1). The diameter of the sphere is 1 m, while the cylinder has a diameter and length of 0.6 m each. The shape factor F_{11} is

(A) 1 (B) 0.82
(C) 0.5 (D) 0.42

29. A spherical thermocouple junction of diameter 0.7 mm is to be used for the measurement of temperature of gas stream. The convective heat transfer co-efficient on bead surface is 400 W/m^2 K. Thermophysical properties of thermocouple material are k = 20 W/m K, C = 400 J/kg.K and ρ = 8500 kg/m^3. If the thermocouple initially at 30° C is placed in a hot stream of 300°C. The time taken by the bead to reach 298°C, is

(A) 4.9 sec (B) 14.7 sec
(C) 16.5 sec (D) 25.5 sec

30. Maximum possible COP of a solar absorption refrigeration system with generator temperature of 400 K, absorber temperature of 300 K and evaporator temperature of 270 K is

(A) 2 (B) 2.1
(C) 2.25 (D) 4

31. Match List – I (Refrigerant) with List – II (chemical constituent) and select the correct answer using the codes given below the lists:

List – I		**List – II**	
P.	R–12	1.	$CCl_2F - CCl\,F_2$
Q.	R – 22	2.	$CHF_2\,Cl$
R.	R –113	3.	NH_3
S.	R – 717	4.	$CCl_2\,F_2$

Codes:

	P	Q	R	S
(A)	1	2	3	4
(B)	1	2	4	3
(C)	4	3	2	1
(D)	4	2	1	3

Common data for questions 32 and 33:

A carnot refrigerator operates between the temperatures of –40° C and 40°C

32. The COP of the refrigerator is

(A) 3 (B) 2.91
(C) 2.5 (D) 2.0

33. If the COP is to be made 4 by changing the temperatures such that increase in upper temperature is equal to decrease in lower temperature. The new temperatures are

(A) 41°C, −41°C (B) 30°C, −31°C
(C) 35°C, 35°C (D) 45°C, −45°C

Linked answer questions 34 and 35:

In a certain double pipe heat exchanger hot water flows at a rate of 50,000 kg/h and gets cooled from 95°C to 65°C. At the same time 50,000 kg/h of cooling water at 30°C enter the heat exchanger. The flow conditions are such that over all heat transfer co-efficient remains constant at 2250 W/m^2 K. Assuming two streams are in parallel flow, and for both streams Cp = 4.2 kJ/kg K.

34. The logarithmic mean temperature is

(A) 65°C (B) 30°C
(C) 25°C (D) 23.4°C

35. The heat transfer area required is close to

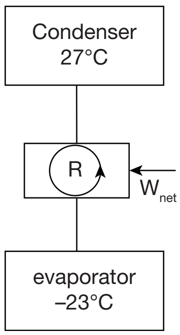
(A) 34 m^2 (B) 40 m^2
(C) 125 m^2 (D) 1125 m^2

Answer Keys

1. C	**2.** D	**3.** B	**4.** C	**5.** D	**6.** D	**7.** A	**8.** A	**9.** C	**10.** B
11. A	**12.** D	**13.** A	**14.** C	**15.** B	**16.** C	**17.** D	**18.** C	**19.** A	**20.** B
21. B	**22.** A	**23.** D	**24.** B	**25.** C	**26.** C	**27.** B	**28.** B	**29.** A	**30.** C
31. D	**32.** B	**33.** C	**34.** D	**35.** A					

Hints and Explanations

1.



Let T_1 = 27°C = 27 + 273 300 K

T_2 = – 23°C = – 23 + 273 = 250 K

$$(C.O.P)_R = \frac{T_2}{T_1 - T_2}$$

$$= \frac{250}{300-250} = \frac{250}{50} = 5$$ Choice (C)

2. Choice (D)

3. Choice (B)

4. Choice (C)

5. Choice (D)

6. Thickness L = 100 mm = 100 × 10 $^{-3}$m

Area A = 2 m^2

Thermal conductivity k = 200 W/mK

Thermal resistance (R) = $\frac{L}{kA}$

$$= \frac{100\times10^{-3}}{200\times2} = 2.5 \times 10^{-4}\text{ K/W}$$ Choice (D)

7. Choice (A)

8. $F_{11} + F_{12} = 1, F_{11} = 0, F_{12} = 1$

$A_1 = D.L$

$$A_2 = \frac{\pi DL}{2}$$

According to reciprocity theorem

$A_1 F_{12} = A_2 F_{21}$

$$F_{21} = \frac{A_1}{A_2} = \frac{D\times L}{\frac{\pi DL}{2}} = \frac{2}{\pi} = 0.637$$

$F_{21} + F_{22} = 1$

$F_{22} = 1 – F_{21} = 1 – 0.637 = 0.363$ Choice (A)

9. A = 60 m^2

U = 120 W/m^2 K

$C_{max} = C_{min}$ = 1200 W/K

$$NTU = \frac{AU}{C_{\min}} = \frac{60\times120}{1200} = 6$$ Choice (C)

11. Choice (A)

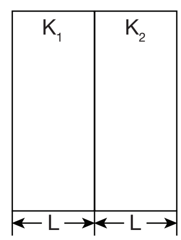
12. D = 120 mm = 0.15 m; k = 0.03

N_u = 25

$$N_u = \frac{h.D}{k}; 25 = \frac{h\times0.15}{0.03}$$

∴ h = 5 W/m^2 K. Choice (D)

13.



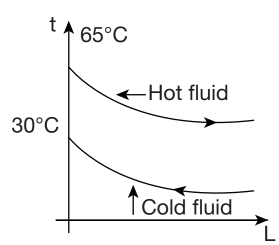
Given that $\frac{K_1}{K_2} = \frac{3}{2}$

Also

$$\frac{K_1 A(\Delta T)_1}{L} = \frac{K_2\, A(\Delta T)_2}{L}$$

$$\frac{(\Delta T)_1}{(\Delta T)_2} = \frac{K_2}{K_1} = 2 : 3$$ Choice (A)

14.



$\dot{m}_h$ = 1 kg/s

$\dot{m}_c$ = 2 kg/s

C_{ph} = 10 kJ/kg.K

C_{pc} = 5 kJ/kg.K

but $\dot{m}_h C_{ph}(t_{h1} - t_{h2}) = \dot{m}_c\, C_{pc}\, (tc_2 - tc_1)$

since $\dot{m}_h\, C_{ph} = m_c\, C_{pc}$

$t_{h1} - t_{c2} = t_{h2} - t_{c1}$
i.e $\theta_1 = \theta_2$
$\therefore \quad \theta_m = t_{h1} - t_{c2} = 65 - 30 = 35°C$ Choice (C)

15. $\varepsilon_1 = \varepsilon_2 = 0.8 \quad T_1 = 400$ K,
$T_2 = 300$ K
$\sigma_b = 5.67 \times 10^{-8}$

$$q_{net} = \frac{1 \times 5.67 \times 10^{-8}(400^4 - 300^4)}{\frac{1}{0.8} + \frac{1}{0.8} - 1}$$

$= 661.5$ W/m^2 Choice (B)

16. $d = 10$ mm $= 0.01$ m
$\ell = 50$ mm $= 0.05$ m
$t_a = 60°$ C, $h = 60$ W/m^2 °C
$t_0 = 100°C$

Efficiency of the fin is $\eta_{fin} = \dfrac{\tan h(m\ell)}{m\ell}$

$$m = \sqrt{\frac{hp}{kA}} = \sqrt{\frac{h \times \pi d}{k \times \pi/4\, d^2}} = \sqrt{\frac{4h}{kd}} = \sqrt{\frac{4 \times 60}{35 \times 0.01}}$$

$m = 26.18$

$$\eta_{fin} = \frac{\tan h(26.18 \times 0.05)}{(26.18 \times 0.05)} = 0.66 = 66\%$$ Choice (C)

17. $t_a = 30°C$
$t_i = 500°C$
$t = 400°C$
$\tau = 10$ sec

$$\frac{t - t_a}{t_i - t_a} = e^{\left(\frac{-hA}{PVC}\tau\right)}$$

$$\frac{400 - 30}{500 - 30} = e^{-\frac{hA}{\rho vc}.10}$$

$$-\frac{hA}{\rho VC} . 10 = \ell_n (37/47) = -0.239$$

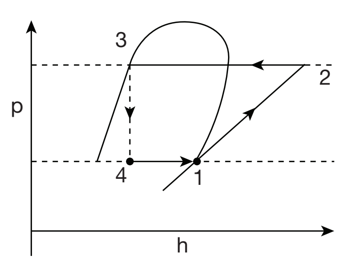
$$\frac{hA}{\rho VC} = 0.0239$$

Temperature of the ball after the next 10 seconds is

$$\frac{t - 30}{500 - 30} = e^{(-0.0239 \times 20)} = 0.619$$

$t = 321°C$ Choice (D)

18.



$h_1 = 375$ kJ/kg
$h_2 = 425$ kJ/kg
$h_4 = 125$ kJ/kg

$$\text{Cop} = \frac{\text{Refrigeration effect}}{\text{Worksupplied}} = \frac{h_1 - h_4}{h_2 - h_1}$$

$$= \frac{375 - 125}{425 - 375} = 5$$ Choice (C)

19. $d = 25$ mm
$h = 25$ W/m^2 K
$k = 0.5$ W/mK
for maximum heat dissipation

$$r_c = \frac{k}{h} = \frac{0.5}{25} = 0.02 \text{ m}$$

$= 20$ mm

$$r_2 = \frac{20}{2}\ \frac{25}{2} = 12.5 \text{ mm}$$

$\therefore$ critical thickness of insulation $= 20 - 12.5 = 7.5$ mm Choice (A)

20. Choice (B)

21. $Q \,\alpha\, (T_1^{\,4} - T_2^{\,4}) \qquad T_1 = 600$ K
$Q^1 \,\alpha\, (T_1^{\,1})^4 - T_2^{\,4}) \qquad T_1^{\,1} = 500$ K
$T_2 = 300\ K$

$$\frac{Q^1}{Q} \times 100 = \frac{500^4 - 300^4}{600^4 - 300^4} \times 100 = 44.77\%$$

Choice (B)

22. Choice (A)

23. Area of plate $= 3 \times 3 = 9$ m^2
ambient temp, $T_a = 30°C$
radiative heat rate $Q_r = 600$ W/m^2 on onside
temp of plate $T_p = 35°C$
At the equilibrium condition of plate
Radiative heat incident on plate = heat transfer by convection from plate to surroundings from both sides
$600 \times A = 2 \times h\, A\, \Delta T$
$600 = 2 \times h\,(35 - 30)$
$h = 60$ W/m^{2}K Choice (D)

25. $F_{13} = 0.15$, $F_{11} = F_{33} = 0$
$F_{11} + F_{12} + F_{13} = 1$
$F_{12} = 1 - F_{13} = 1 - 0.15 = 0.85$ Choice (C)

26. Let $\varepsilon_1 = \varepsilon_2 = 0.6$, $\varepsilon_s = 0.3$

$$\text{Let } Q_1 = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} \text{ without shield}$$

$$Q_2 = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1}{\varepsilon_1} + \frac{2}{\varepsilon_s} + \frac{1}{\varepsilon_2} - 2} \text{ with shield}$$

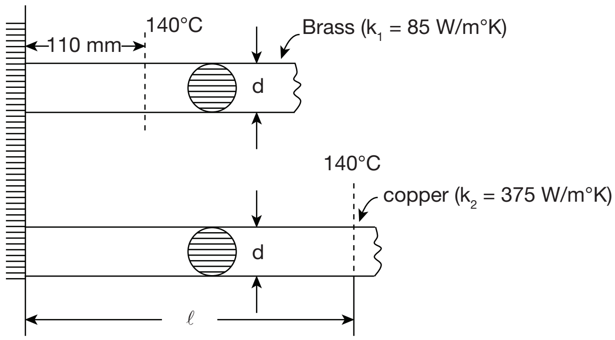
$$Q_1 = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1}{0.6} + \frac{1}{0.6} - 1} = \frac{\sigma(T_1^4 - T_2^4)}{\left(7/3\right)}$$

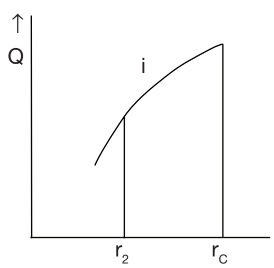
$$Q_2 = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1}{0.6}+\frac{2}{0.3}+\frac{1}{0.6}-2} = \frac{\sigma\,(T_1^4 - T_2^4)}{8}$$

$$\frac{Q_2}{Q_1} = \frac{(1/8)}{(3/7)} = \frac{1}{8}\times\frac{7}{3} = \frac{7}{24}$$

Choice (C)

27.





$t = t_a + (t_0 - t_a)\, e^{-mx}$

For brass rod t = 140°C, x = 110 mm = 0.11 m

$140 = t_a + (t_0 - t_a)\, e^{-(m_1 \times 0.11)}$ ---------(1)

For copper rod, t = 140°C, $x = \ell$

$140 = t_a + (t_0 + t_a)\, e^{-m_1 \ell}$ ----------(2)

From (1) and (2)

$e^{-(m_2 \times 0.11)} = e^{-m_2 \ell}$

but m = $\sqrt{\frac{hp}{kA}}$, $m \propto \frac{1}{\sqrt{k}}$

$$\therefore \quad \frac{m_1}{m_2} = \sqrt{\frac{k_2}{k_1}} = \sqrt{\frac{375}{85}} = 2.1$$

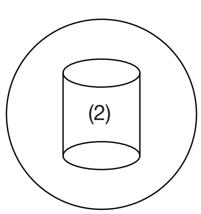
$$\ell = \frac{m_1}{m_2} \times 0.11$$

= 2.1 × 0.11 = 0.231 m

= 231 mm

Choice (B)

28.



Let D = 1 m, ℓ = d = 0.6 m

$A_1 = 4\,\pi R^2$

$A_2 = \pi d\,\ell + 2\frac{\pi}{4}d^2$

$A_1 F_{12} = A_2 F_{21}$

$$F_{12} = \left(\frac{A_2}{A_1}\right) \qquad \rightarrow (1)$$

and also $F_{11} + F_{12} = 1$

$$F_{11} = 1 - F_{12} = 1 - \frac{A_2}{A_1}$$

$$= 1 - \frac{\pi d \ell + 2\left(\pi/4\, d^2\right)}{4\pi R^2}$$

$$= 1 - \frac{(\pi\times0.6\times0.6+\frac{\pi}{2}\times0.6^2)}{4\pi\times0.5^2}$$

$$F_{11} = 1 - \frac{0.5654}{3.1415} = 0.82$$

Choice (B)

29. h = 400 W/m² K; D = 0.7 mm

c = 400 J/kg.K

k = 20 W/mK

ρ = 8500 kg/m³

t_i = 30°C; t_∞ = 300°C; t = 298°C

Biot number = $\frac{hL}{k}$

$$L = \frac{V}{A} = \frac{D}{6}$$

$$B_i = \frac{400\times0.7\times10^{-3}}{6\times20} = 2.33 \times 10^{-3}$$

B_i = < 0.1, lumped heat analysis is applied

$$i.e\,\frac{t-t_\infty}{t_i - t_\infty} = e^{\left(\frac{-hA}{\rho CV}\cdot\tau\right)}$$

$$\frac{298-300}{30-300} = e\left(\frac{400\times6\times\tau}{850\times400\times0.7\times10^{-13}}\right)$$

$7.407 \times 10^{-3} = e^{-\tau}$, τ = 4.9 sec

Choice (A)

30. COP of absorption refrigeration system

$\eta_{carnot} \times (COP)_{carnot}$

$$= \frac{T_G - T_C}{T_G} \times \frac{T_E}{T_C - T_E}$$

$$= \frac{400-300}{400} \times \frac{270}{300-270} = 2.25$$

Choice (C)

31. R – 12 ------ $CCl_2\,F_2$

R – 22 ------ $CHF_2\,Cl$

R – 113 --------$CCl_2F - CClF_2$

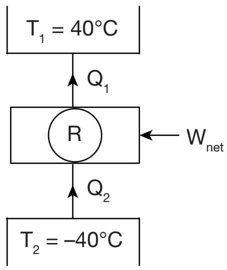
R – 717 ------ NH_3

Choice (D)

Common data for questions 32 and 33

A carnot refrigerator operates between the temperatures of – 40°C and 40°C.

32.



$$\text{C.O.P} = \frac{T_2}{T_1 - T_2}$$

$$= \frac{(-40+273)}{40-(-40)} = 2.91$$ Choice (B)

33. Let x is an increase in temperature in upper value and decrease in lower value to get the C.O.P = 4

$$\text{C.O.P} = 4 = \frac{(T_2 - x)}{(T_1 + x)-(T_2 - x)}$$

$$4 = \frac{(-40+273-x)}{(40+273+x)-(-40+273-x)}$$

$$4 = \frac{233-x}{40+273+x+40-273+x}$$

$$\Rightarrow \quad 4 = \frac{233-x}{80+2x}$$

$320 + 8x = 233 - x$

$9x = -87 \Rightarrow x = -9.66$

New temperatures are

$T_1 + x = 40 + 273 - 9.66 = 303$ K (or) 30°C

$T_2 - x = -40 + 273 + 9.66 = 242.66$ K (or) – 31°C

Choice (C)

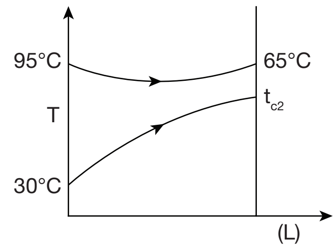
34. $\dot{m}_h = 50{,}000 \text{ kg/h} = \dfrac{50{,}000}{3600} = 13.88 \text{ kg/s}$

$t_{h1} = 90°C$, $t_{h2} = 60°C$

$\dot{m}_c = 50{,}000 \text{ kg/h} = 13.88 \text{ kg/s}$

$C_{pn} = c_{pc} = 4.2$ kJ/kg. K

$t_{c1} = 30°C$, $U = 2250$ W/m^2 K.



Heat received by cold fluid = Heat rejected by hot fluid

$\dot{m}_c C_{pc} (t_{c2} - t_{c1}) = \dot{m}_h C_{ph} (t_{h1} - t_{h2})$

$(t_{c2} - 30) = (95 - 65)$

$t_{c2} = 30 + 30 = 60°C$

$$\text{LMTD} = \frac{\theta_1 - \theta_2}{\ell_n(\theta_1/\theta_2)}$$

$\theta_1 = t_{h1} - t_{c1} = 95 - 30 = 65$

$\theta_2 = t_{h2} - t_{c2} = 65 - 60 = 5$

$$\frac{65-5}{\ell_n(65/5)} = 23.39°C$$ Choice (D)

35. $Q = UA$ (LMTD)

$$A = \frac{Q}{U\,(LMTD)} = \frac{c_{ph}(t_{h1} - t_{h2})}{(U.LMTD)}$$

$$= \frac{13.88 \times 4.2 \times (95-65)}{2250 \times 23.39} \times 1000 = 33.23 \text{ m}^2$$

Choice (A)