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CONTENTS

MECHANICAL ENGINEERING

Objective Practice Sets

Refrigeration and Air-conditioning

1 CHAPTER

Introduction and Basic Concepts of Refrigerator, Heat Pump & Reversed Carnot Cycle

MCQ and NAT Questions

Q.1 The coefficient of performance of a domestic refrigerator is
(a) less than 1
(b) more than 1
(c) equal to 1
(d) dependent upon the mass of the refrigerant

Q.2 A refrigerating machine working on reversed Carnot cycle takes out 2 kW of heat from the system while between temperature limits of 300 K and 200 K. COP and power consumed by the cycle will be respectively.
(a) 1 and 1 kW (b) 1 and 2 kW
(c) 2 and 1 kW (d) 2 and 2 kW

Q.3 A machine working on a Carnot cycle operates between temperature 300 k and 260 K. The COP of the refrigerating machine and heat pump are respectively
(a) 6.5 and 7.5 (b) 7.5 and 6.5
(c) 6 and 7 (d) 7 and 6

Q.4 Thermal efficiency of heat engine is 30%, the COP of refrigerator will be equal to
(a) 1.33 (b) 2.33
(c) 3.33 (d) 4.33

Q.5 A refrigerator and a heat pump operate between the same temperature limits. If COP of the refrigerator is 5, the COP of the heat pump would be
(a) 5 (b) 6
(c) 4 (d) 7

Q.6 A Carnot refrigerator has a COP of 6. What is the ratio of lower to the higher absolute temperature?
(a) 1/6 (b) 6/7
(c) 1/7 (d) 7/8

Q.7 A condenser of a refrigeration system rejects heat at a rate of 120 kW, while its compressor consumes a power of 30 kW. The COP of the system would be
(a) 2 (b) 3
(c) 4 (d) 5

Q.8 A Carnot refrigerator requires 70 kJ/min of work to produce one ton of refrigeration at –40°C. The COP of this refrigerator is
(a) 4 (b) 3
(c) 5 (d) 6

Q.9 A one ton capacity water cooler cools water steadily from 35° to 20°. The water flow rate will be (if specific heat of water is 4.18 kJ/kg-k)
(a) 51 lit/hr (b) 101 lit/hr
(c) 151 lit/hr (d) 201 lit/hr

Q.10 COP of a Reversed Carnot cycle refrigerator working between higher temperatures T_2 and lower temperature T_1
(a) will increase with increase in T_1 keeping T_2 fixed
(b) will decrease with increase in T_1 keeping T_2 fixed
(c) will first increase with increase in T_1 and then decrease with increase in T_1 keeping T_2 fixed
(d) None of the above

Q.11 A reversible refrigerator working between two fixed temperatures
(a) has the same COP whatever the working substance
(b) has its COP increased for working substance with high enthalpy of evaporation
(c) has its COP increased for working substance with higher specific heats
(d) None of the above

Q.12 Two refrigerator are employed, one for ice-making and other for comfort cooling
(a) the COP of refrigerator for ice making is higher than that for the other
(b) the COP of refrigerator for ice making is lower than that for the other

Q.23 **Statement (I):** COP of heat pump is more than the COP of its refrigerator version.
Statement (II): Pumping of heat requires less work relative to extraction of heat from the evaporator.

Q.24 **Statement (I):** An air-conditioner operating as a heat pump is superior to an electric resistance heater for winter heating.
Statement (II): A heat pump rejects more heat than the heat equivalent of the heat absorbed.

Q.25 **Statement (I):** The COP of an air conditioning plant is higher than the COP of a household refrigerator.
Statement (II): For the same condenser temperature, the suction pressure of the evaporator is higher in air conditioning plant than in household refrigerator.

Multiple Select Questions (MSQ)

Q.26 1.5 kW power is required for 1 tonne of refrigeration to maintain the temperature at –40°C in the refrigerator. If the refrigeration cycle works on Carnot cycle, then which of the following statements is/are correct?
(a) COP of the cycle is 2.33.
(b) Temperature of the sink is 60°C.
(c) Heat rejected to the sink per TR is 2 kW.
(d) COP if the cycle is used as heat pump is 3.33.

Q.27 A cold storage plant is required to store 20 tonnes of fish. The fish is supplied at a temperature of 30°C. The specific heat of fish above freezing point is 2.93 kJ/kgK. The specific heat of fish below freezing point is 1.26 kJ/kgK. The fish is stored in cold storage which is maintained at –8°C. The freezing point of fish is –4°C. The latent heat of fish is 235 kJ/kg. The plant requires 75 kW to drive it. Which of the following statements is/are correct, if actual COP of the plant is 30% of the Carnot COP?
(a) The capacity of the plant is 44.83 TR.
(b) Actual COP of the plant is 2.092.
(c) Time taken to achieve cooling is 722 minutes approximately.
(d) Total heat removed by the plant is 6793.2 MJ.

Q.36 Which of the following statements is/are correct?
(a) Temperature appearing in the expression of reverse Carnot cycle COP are the temperature of working fluid.
(b) 1 Tonne of refrigeration represents heat removal rate.
(c) Rate of heat removal from lower temperature space is called refrigeration capacity.
(d) Refrigeration is a process of maintaining space at a lower temperature as compared to surrounding.

■■■■

Answers — Introduction and Basic Concepts of Refrigerator, Heat Pump & Reversed Carnot Cycle

1. (b)	**2.** (c)	**3.** (a)	**4.** (b)	**5.** (b)	**6.** (b)	**7.** (b)
8. (b)	**9.** (d)	**10.** (a)	**11.** (a)	**12.** (b)	**13.** (a)	**14.** (c)
15. (d)	**16.** (d)	**17.** (d)	**18.** (0.4)	**19.** (7.5)	**20.** (50)	**21.** (a)
22. (c)	**23.** (a)	**24.** (a)	**25.** (a, b, d)	**26.** (a, b, c, d)		**27.** (a, b, c, d)

Explanations — Introduction and Basic Concepts of Refrigerator, Heat Pump & Reversed Carnot Cycle

1. (b)

Coefficient of performance of domestic refrigerator is more than 1.

2. (c)

$$\text{COP} = \frac{T_L}{T_H - T_L} = \frac{200}{300 - 200} = 2$$

$$\text{Power} = \frac{\text{RE}}{\text{COP}} = \frac{2}{2} = 1\,\text{kW}$$

3. (a)

$$\text{COP}_{\text{ref}} = \frac{T_L}{T_H - T_L} = \frac{260}{300 - 260} = 6.5$$

$$\text{COP}_{\text{HP}} = \frac{T_H}{T_H - T_L} = \frac{300}{300 - 260} = 7.5$$

7 CHAPTER

Refrigeration equipments, Duct design and Method of Refrigerations

Q.1 Large sized industrial air conditioning plant are
(a) air cooled (b) ground cooled
(c) water cooled (d) Ammonia cooled

Q.2 Thermoelectric refrigeration system is based on
(a) Peltier effect (b) See beck effect
(c) Joule effect (d) None of these

Q.3 Ammonia is used with
(a) Reciprocating refrigerant compressors
(b) Centrifugal refrigerant compressors
(c) Axial flow refrigerant compressors
(d) All of the above

Q.4 The purpose of refrigerant compressor is to
1. raise the pressure of the refrigerant.
2. raise the temperature of the refrigerant.
3. circulate the refrigerant through the refrigerating system.
4. improve the condenser performance.

Which of the above are correct?
(a) 1 and 3 (b) 1, 3 and 4
(c) 2, 3 and 4 (d) 1, 2 and 3

Q.5 Centrifugal compressor generally used for refrigerants that require
(a) large displacement and large condensing pressure
(b) large displacement and low condensing pressure
(c) low displacement and low condensing pressure
(d) low displacement and large condensing pressure

Q.6 The reciprocating refrigerant compressors are very much suitable for
(a) small displacements and low condensing pressures.
(b) large displacements and high condensing pressures.
(c) small displacements and high condensing pressures.
(d) large displacements and low condensing pressures.

Q.7 If the evaporator & condenser pressures are equal to 1.01 & 80 bar respectively, intermediate pressure will be equal to (if intercooling is perfect)
(a) 8 bar (b) 9 bar
(c) 10 bar (d) 11 bar

Q.8 Work input to the refrigerant compressor with n as the index of compression
(a) increases with increase in value of n
(b) decreases with increase in value of n
(c) remains same whatever the value of n
(d) first increases and then decreases with increase in value of n.

Q.9 Expansion devices are located close to evaporator
(a) to easy the flow of refrigerant
(b) to avoid the flow of refrigerant
(c) to minimise the heat gain
(d) None of these

Q.10 Automatic expansion valve maintain in the evaporator
(a) Constant superheat
(b) Constant level of refrigerant
(c) Constant pressure
(d) Constant temperature

Q.11 In a refrigeration cycle, the flow of refrigerant is controlled by
(a) compressor (b) condenser
(c) expansion valve (d) evaporator

Q.12 The heat rejection factor (HRF) of a condenser is given by
(a) $1 + COP$ (b) $1 - COP$
(c) $1+\frac{1}{COP}$ (d) $1-\frac{1}{COP}$

Answers Refrigeration equipments, Duct design and Method of Refrigerations

1. (c)	2. (a)	3. (a)	4. (d)	5. (b)	6. (c)	7. (b)	8. (a)	9. (c)
10. (c)	11. (c)	12. (c)	13. (c)	14. (d)	15. (a)	16. (c)	17. (c)	18. (a)
19. (b)	20. (b)	21. (c)	22. (b)	23. (d)	24. (d)	25. (c)	26. (a)	27. (d)
28. (c)	29. (d)	30. (c)	31. (a)	32. (a)	33. (c)	34. (c)	35. (d)	36. (b)
37. (c)	38. (c)	39. (b)	40. (d)	41. (a)	42. (b)	43. (c)	44. (d)	45. (c)
46. (b)	47. (d)	48. (a)	49. (b)	50. (b)	51. (c)	52. (b)	53. (b)	54. (a)
55. (b)	56. (a)	57. (d)	58. (12.27)	59. (646153.846)		60. (86.5)	61. (a)	62. (b)
63. (a)	64. (b)							

Explanations Refrigeration equipments, Duct design and Method of Refrigerations

1. (c)

Chilled water is used to cool and dehumidify air in mid-to-large size commercial industrial and institutional facilities.

2. (a)

Thermoelectric refrigeration uses Peltier effect by pumping heat energy out of an insulated chamber in order to reduce the temperature of the chamber below that of the surrounding air.

3. (a)

Ammonia is used with reciprocating refrigerant compressors because we need large stroke length (Rarely used).

4. (d)

Functions of refrigeration compressor:

- To increase pressure and temperature of the refrigerant.
- To circulate the refrigerant (working fluid) through the refrigeration system.

7. (b)

$$P_2 = \sqrt{P_1 \times P_3}$$
$$= \sqrt{80 \times 1.01} = 8.99 = 9 \text{ bar}$$

8. (a)

$$W_{in} = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{n-1}{n}} - 1 \right]$$

with increase in index of compression (n), there will be increase in work.

9. (c)

Expansion devices are located close to evaporator to minimise heat gain from the other parts of refrigeration system.

10. (c)

Automatic expansion valve is used to maintain constant pressure in evaporator. It is used in milk chilling plant.

11. (c)

Expansion valve controls the flow of refrigerants in refrigeration cycle by restricting the flow passage.

12. (c)

$$\text{HRF} = \frac{Q_{\text{condensation}}}{R.E.} = \frac{W_{in} + R.E.}{R.E.}$$
$$= 1 + \frac{W}{R_E} = 1 + \frac{1}{\text{COP}}$$

16. (c)

Alternate overfeeding and starving of refrigerant in the evaporator causes hunting in thermostatic expansion valve.

18. (a)

Pressure loss due to friction,

$$p_f = \frac{f L \rho_a V^2}{2m} = \frac{f L \rho_a}{2m} \left(\frac{Q}{A} \right)^2$$

m is hydraulic mean depth $m = \frac{A}{P}$

for circular duct,