Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S7 (S, FE) Examinations May 2026 (2019 Scheme)

Course Code: MET473

Course Name: AIR CONDITIONING AND REFRIGERATION

Max. Marks: 100 **Duration: 3 Hours**

(Refrigeration and air conditioning data book permitted)

PART A

Answer all questions, each carries 3 marks. Marks

1		Define refrigeration and list at least four engineering applications of refrigeration other than the preservation of perishable or edible items.	(3)
2		State at least three valid reasons for preferring air refrigeration systems in aircraft air-conditioning systems.	(3)
3		List the essential components of a vapour compression refrigeration system and sketch the T–s and P–h diagrams of the simple vapour compression cycle.	(3)
4		List the methods of improving COP of a vapour compression refrigeration system?	(3)
5		Compare the vapour absorption refrigeration system with the vapour compression refrigeration system, highlighting their principles, components, and applications.	(3)
6		List any three advantages and limitations associated with the steam jet refrigeration system.	(3)
7		Classify the condensers used in refrigeration systems based on their mode of heat rejection. State the advantages and disadvantages of any one type of condenser.	(3)
8		Explain “pressure test” method of determination of the leakage of refrigerant in a vapour compression system?	(3)
9		Define the following psychrometric properties: a) Dew-point temperature b) Dry-bulb and wet-bulb temperatures c) Humidity ratio	(3)
10		Define the terms EER, IEER, and IPLV as used in air-conditioning and refrigeration systems.	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

Module I

11	a)	Explain the reversed Joule (Bell–Coleman) cycle with a neat schematic and T–s or P–v diagram. Using suitable assumptions, derive an expression for the coefficient of performance (COP) of the Bell–Coleman cycle in terms of the pressure ratio.	(7)
	b)	An aircraft operating on a simple air refrigeration system requires a refrigeration capacity of 10 TR. At cruising altitude, the ambient air pressure and temperature are 0.9 bar and 10 °C, respectively. Due to the ramming effect in the diffuser the air pressure increases to 1.013 bar before entering the main compressor. The compressor discharge pressure is 3.5 bar. The compressed air leaving the heat exchanger is cooled to 94 °C, while the cabin pressure and the air outlet temperature are maintained at 1.01 bar and 25 °C, respectively. Assume that all compression and expansion processes are isentropic, and treat air as an ideal gas with Cp= 1.005 kJ/kg, γ=1.4. Determine:	(7)

(a) The power (in kW) required to supply the refrigeration load in the cabin. (Note: expander work is not recovered.)
(b) The coefficient of performance (COP) of the system.

OR

12 An aircraft employing a boot-strap air refrigeration system requires a refrigeration capacity of 16 TR. The ambient air temperature and pressure are –13 °C and 0.6 bar, respectively. The aircraft flies at a speed of 800 km/h. The ram air is compressed in the main compressor to a pressure of 3.6 bar, and subsequently in the secondary compressor to 4.4 bar. The isentropic efficiency of each compressor is 85%. The air leaving the first heat exchanger is cooled by ram air to 113 °C, while the air from the secondary compressor is further cooled by ram air in the second heat exchanger to 87 °C. This cooled air then expands in the cooling turbine to the cabin pressure of 1 bar, with an isentropic efficiency of 90%. The cabin temperature is to be maintained at 20 °C. (14)
Assuming $\gamma = 1.4$ and $c_p = 1.005$ kJ/kg K, determine the following:
(a) The mass flow rate of air, in kg/min.
(b) The compressor power required to operate the system, in kW.
(c) The coefficient of performance (COP) of the system.

Module II

13 a) With neat schematic and P–h diagrams, explain the working of a multi-pressure (two-stage) vapour compression refrigeration system incorporating flash gas removal and intercooling. (7)
b) Describe the actual vapour compression refrigeration cycle, explaining how it differs from the ideal cycle. (7)

OR

14 a) With the help of a neat schematic, explain the working of a refrigeration system designed to achieve ultra-low temperatures (below −80 °C). (7)
b) R-134a enters the compressor of a vapor-compression refrigeration cycle at 1.2 bar as a saturated vapor and discharges at 9 bar with a temperature of 75 °C. The refrigerant exits the condenser as a saturated liquid. The refrigeration system delivers a cooling capacity of 1.5 TR. (7)
Determine:
(a) The mass flow rate of R-134a, and
(b) The Coefficient of Performance (COP) of the cycle.

Module III

15 a) With a neat schematic, explain the working of an ammonia–water (NH_3–H_2O) absorption refrigeration system. Compare the NH_3–H_2O system with the lithium bromide–water (LiBr–H_2O) absorption system. (7)
b) With the aid of a neat schematic and temperature–entropy (T–s) diagram, explain the working and thermodynamic processes involved in a steam-jet refrigeration system. (7)

OR

16 a) With a neat schematic, explain the working of a three-fluid (Electrolux) absorption refrigeration system. (7)
b) Derive an expression for the maximum coefficient of performance (COP) of a simple vapour absorption refrigeration system. (7)

Module IV

17 a) Discuss the desirable thermodynamic, physical, and chemical properties of refrigerants. (7)

b) Classify the evaporators used in refrigeration systems. Describe in detail the working of any two types of evaporators used in refrigeration systems. (7)

OR

18 a) With a neat schematic diagram, explain the construction and working of a thermostatic expansion valve used in vapour compression refrigeration systems. (7)

b) Explain the significance of Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) in the selection of refrigerants. (7)
List some natural and synthetic refrigerants that have zero ODP and low GWP.

Module V

19 a) Explain ADP (Apparatus Dew Point), Room Sensible Heat Factor (RSHF), and Grand Sensible Heat Factor (GSHF), Effective Room Sensible Heat Factor (ERSHF) and represent them on a psychrometric chart. (7)

b) Moist air at a dry-bulb temperature (DBT) of 35 °C and a wet-bulb temperature (WBT) of 23 °C is at an atmospheric pressure of 100 kPa. Using appropriate psychrometric relations and steam-table data, determine the following properties of the air: (7)
(a) Humidity ratio
(b) Relative humidity
(c) Dew-point temperature
(d) Specific volume
(e) Specific enthalpy

OR

20 a) Discuss the various factors influencing human comfort in an air-conditioned space. Also, explain the term effective temperature and comfort chart. (7)

b) The following data are specified for an air-conditioning system: (7)
Room conditions: 26 °C DBT, 19 °C WBT
Outdoor air conditions: 35 °C DBT, 27 °C WBT
Room heat gains:
Sensible heat = 11.1 kW
Latent heat = 3.9 kW
Conditioned air is supplied to the room at a rate of 50 cmm (cubic metres per minute), consisting of 25% fresh air and 75% recirculated room air.
Determine the following:
(a) The dry-bulb and wet-bulb temperatures of the mixed air before entering the cooling coil.
(b) The dry-bulb and wet-bulb temperatures of the supply air to the room.
(c) The apparatus dew point (ADP) and bypass factor (BPF) of the cooling coil.
(d) The refrigeration load on the coil (kW) and the rate of moisture removal by the coil (kg/min).

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