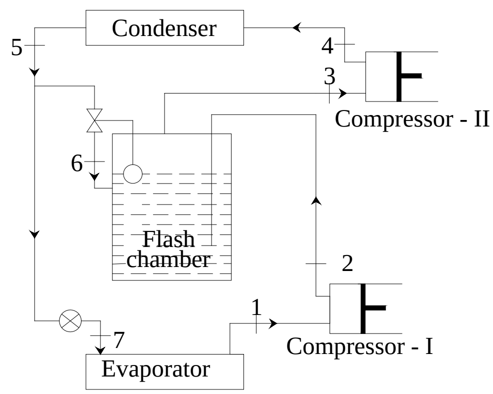
BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
Second Semester 2016-17
ME F461 Refrigeration & Air conditioning
Mid-Semester
Open Book: Only Text Book & Class Notes are allowed. No Data Book is allowed
Max. Time: 90 minutes **Max. Marks: 60**

Make suitable assumptions and state them clearly

Q**1a)** Is refrigeration same as cooling? Using cycle diagrams, discuss the limitations of single stage vapour compression refrigeration systems. Explain with suitable diagrams how these limitations are overcome in large, commercial refrigeration systems.

(2+8)

1b) Shown below is a **100 TR**, ammonia based multi-stage compression refrigeration system with a flash chamber for intercooling. **(4+6+5= 15)**



The system operates at an evaporator temperature of **–40^{o}C** and a condensing temperature of **36^{o}C**. The flash chamber is maintained at **3.6 bar**.

a) Draw the p-h and T-s diagram of the system.

b) Find the required power input to compressor-I and II assuming isentropic compression and system COP.

c) Find the reduction or increase in work input by introduction of multistage compression with flash intercooling, compared to a single stage compression. Assume all the compression process to be isentropic. Comment on the compressor exit temperature for these two cases. Use the data given in the table only.

Assume that the refrigerant is saturated at the exit of evaporator, flash chamber and condenser. The actual volumetric efficiency of the compressors is assumed to be 100%.

Use the property data given below for ammonia:

T (^{o}C)	**Dryness fraction**	**Pressure (bar)**	**Sp. volume (m^3/kg)**	**Enthalpy (kJ/kg)**	**Entropy (KJ/kg.K)**
-40	1.0	0.717	1.553	1408.0	6.243
-4.6	1.0	3.6	0.342	1457.0	5.683
-4.6	0.0	3.6		178.7	
66.2	Superheated	3.6		1626.0	6.243

36	0.0	13.9		371.0	
92.6	Superheated	13.9		1651.0	5.683
183.1	Superheated	13.9		1881	6.243

Q.2 A ammonia based single stage saturated (SSS) (evaporator exit is saturated) compression refrigeration system of capacity **100 TR** , operates between evaporator and condenser temperature of **-30^{o}C** and **36^{o}C** respectively. For this system using the data given below, Find a) COP, b) 2nd law efficiency, c) throttling and superheat losses, d) the entropy generation rate in the expansion valve. Assume the compression process to be reversible adiabatic, and the refrigerant vapor to behave as an ideal gas with constant specific heats. The characteristic gas constant and isentropic index for the refrigerant vapor are **0.4882 kJ/kg-K** and **1.2885** respectively. Average liquid specific heat of ammonia = **4.676 kJ/kg-K.** Use the data given below in the table for ammonia.

T (^{o}C)	**Saturation Pressure (kPa)**	**Heat of Vaporization (kJ/kg)**
-30	119.43	1359.7
36	1390.0	1117.7

[20]

Q.3

A closed air cycle refrigeration system produces a refrigerating capacity of **100 kW.** Air enters the compressor at a pressure **3 bar (absolute)** and **266 K** and leaves compressor at a pressure of **12 bar (absolute).** The compression process is adiabatic. The temperature of the air leaving air cooler is **300 K.** air at this condition enters the turbine and expands reversibly and adiabatically. The isentropic efficiency of the compressor is **85%.** Find a) system COP and second law efficiency, b) mass and volumetric flow rate at the inlet of the compressor. Air may be assumed as an ideal gas with constant specific heats. The C_p and C_v values for air can be taken as **1.005** and **0.718** kJ/kg-K respectively. So the cycle on T-s and p-v plots.

[15]