Name:	
Enrolment No:	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2020

Course: Engineering Thermodynamics — **Semester : III**

Program: B. Tech. (APE-Gas) — **Time : 3 hr**

Course Code: MECH 2001 — **Max. Marks : 100**

Instructions: Assume any missing data. The notations used here have the usual meanings. Draw the diagrams, wherever necessary.

SECTION - A (6 × 5 = 30 marks)

(Answer all the questions)

S. No.		Marks	CO
1.	A Carnot engine operates between temperature levels of 600 K and 300 K. It derives a Carnot refrigerator, which provides cooling at 250 K and discards heat at 300 K. Determine the numerical value for the ratio of heat extracted by refrigerator to the heat delivered to the engine. (a) 1 (b) 1.5 (c) 2 (d) 2.5	**5**	**CO2**
2.	50 kmol/h of air is compressed from 1.2 bar to 6 bar in a steady flow compressor. Delivered mechanical power is 98.8 kW. Temperatures and velocities at the inlet point are 300 K and 10 m/s & exit point are & 520 K and 3.5 m/s. Estimate the rate of heat transfer from the compressor. Assume for air that C_p = 3.5R and enthalpy is independent of pressure. (a) – 5.9 kW (b) – 10.5 kW (c) – 15.9 kW (d) – 18.9 kW	**5**	**CO2**
3.	At 286 K and 139.3 bar, the compressibility factor of methane is found to be 0.8. At approximately what temperature and pressure, nitrogen will give the compressibility	**5**	**CO3**

	factor of 0.8. The critical temperature and pressure are 190.7 K and 45.8 bar for methane & 126.2 K and 33.5 bar for nitrogen. (a) 189 K and 101 bar (b) 229 K and 111 bar (c) 286 K and 33.5 bar (d) 84 K and 11.2 bar		
4.	Assuming that CO_2 obeys the ideal gas law, calculate the density of CO_2 in kg/m^3 at 540 K and 202 kPa (a) 1 (b) 2 (c) 3 (d) 4	**5**	**CO3**
5.	An ideal solution containing 40 % A and 60% B is in equilibrium with its vapor. The vapor pressures of pure liquids at equilibrium temperature are 80 kPa for A and 40 kPa for B. The Vapor composition is (a) 80% A (b) 67% A (c) 57% A (d) 40% A	**5**	**CO4**
6.	One ton of refrigeration is equal to (a) 21 kJ/min (b) 210 kJ/min (c) 420 kJ/min (d) 620 kJ/min	**5**	**CO5**
SECTION - B (5 × 10 = 50 marks) **(Answer all the questions)**			
S. No.		**Marks**	**CO**
1.	A steel casting weighing 2 kg has an initial temperature of 500 ^{0}C, 40 kg of water initially at 25 ^{0}C is contained in a perfectly insulated steel tank weighing 5 kg. The casting is immersed in the water and the system is allowed to come to equilibrium. What is the	**10**	**CO1**

	final temperature? Ignore any effect of expansion or contraction, and assume constant specific heats of 4.18 kJ/kg-K for water and 0.50 kJ/kg-K for steel.		
2.	For an ideal gas, prove that $$\frac{\Delta S}{R} = \int_{T_0}^{T} \frac{C_v^{ig}}{R}\frac{dT}{T} + \ln\frac{V}{V_0}$$ where T_0 and V_0 are initial temperature and molar volume, respectively.	**10**	**CO2**
3.	One cubic meter of an ideal gas at 600 K and 1000 kPa expands to five times its initial volume by a mechanically reversible, adiabatic process. Calculate the final temperature, pressure and work done by the gas for both cases. C_p = 21 J/mol-K.	**10**	**CO3**
4.	The excess Gibbs energy of a binary mixture at T and P is given by $$\frac{G^E}{RT} = (-2.6\,x_1\ - 1.8\,x_2)x_1x_2$$ Find expressions for $\ln\gamma_1$ and $\ln\gamma_2$.	**10**	**CO3**
5.	A mixture of 25% n-pentane, 45% n-hexane and rest n-heptane is brought to a condition of 93 ^{0}C and 2 atm. All percentages are mole percentages. The K_i values of n-pentane, n-hexane and n-heptane are 2.150, 0.960 and 0.430, respectively. (a) What molar fraction of the system is liquid? (b) What are the phase composition of liquid and vapor?	**10**	**CO4**
SECTION – C (1 × 20 = 20 marks) (Answer all the questions)			
1.	A refrigerator with tetrafluoroethane as refrigerant operates with an evaporation temperature of -26 ^{0}C and a condensation temperature of 27 ^{0}C. Saturated liquid refrigerant from the condenser flows through an expansion valve into the evaporator, from which it emerges as saturated vapor. (a) For a cooling rate of 5.275 kW, what is the circulation rate of the refrigerant? (b) By how much would the circulation rate be reduced if the throttle valve were replaced by a turbine in which the refrigerant expands isentropically? (c) Determine the coefficient of performnce for isentropic compression of the vapor for part (a) and (b).	**20**	**CO5**

Table: 1 Thermodynamic properties of Saturated Tetrafluoroethane

Temperature (^{0}C)	Saturation pressure MPa	Liquid density kg/m^3	Specific volume of vapor m^3/kg	Enthalpy (kJ/kg)		Entropy (kJ/kg-K)	
	P	ρ^l	V^v	H^l	H^v	S^l	S^v
-26	0.10133	1374.3	0.19016	166.07	382.90	0.8701	1.7476
24	0.64566	1210.1	0.03189	233.05	411.93	1.1149	1.7169
28	0.72676	1194.9	0.02829	238.77	413.95	1.1338	1.7155

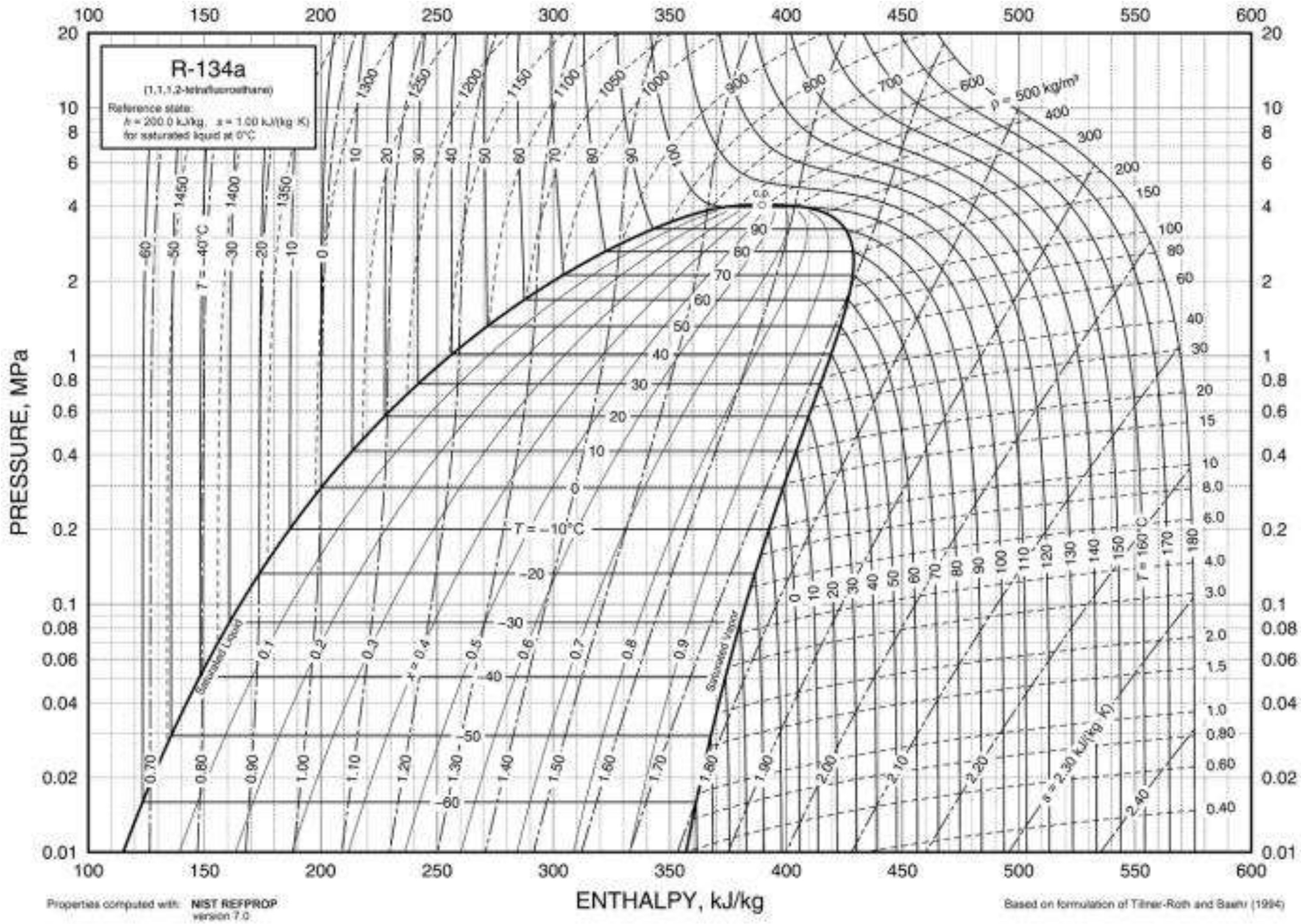

Figure 1: PH diagram of Tetrafluoroethane