Name: Enrolment No:	

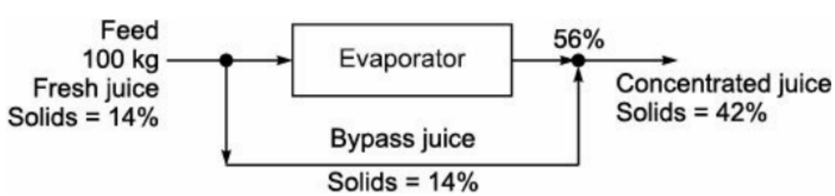
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2022

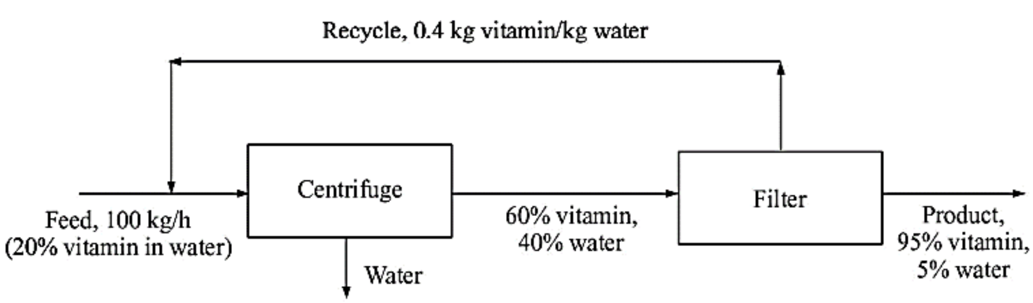
Course: Process Calculation — **Semester: III**
Program: B. Tech. Biotechnology — **Time : 03 hrs.**
Course Code: HSBT 2003 — **Max. Marks: 100**

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

Q. 1	**Section-A (20Q x 1.5M= 30)**		**COs**
I	1 BTU/ft^3 is approximately equal to …………….. kcal/m^3. (a) 1 (b) 9 (c) 4 (d) 252	**1.5**	CO1
II	Volume (L) representation of a real gas is given by the equation $V = a\,T + b\,T\,P + c\,T\,P\,n$ where: a, b, c are constants and T, P, n are temperature (K), pressure (atm) and number of moles, respectively. What is the unit of c? (a) L/K-atm (b) L/K-atm-mol (c) K/L-atm-mol (d) None of these	**1.5**	CO1
III	Number of moles of the solute dissolved in 1 kg of solvent is called its (a) normality (b) molarity (c) molality (d) equivalent weight	**1.5**	CO1
IV	Hydrogen and nitrogen react to form ammonia according to the reaction, $3\,H_2 + N_2 \rightarrow 2\,NH_3$ If 4.0 moles of H_2 and 2.0 moles of N_2 are fed, which is a limiting reactant? (a) Hydrogen (b) Nitrogen (c) Ammonia (d) None of the given	**1.5**	CO2
V	Concept of material balance is based upon ……… (a) Conservation of mass (b) Conservation of energy (c) Conservation of momentum (d) Conservation of Volume	**1.5**	CO2
VI	A fluid enters system at the rate of 10 liters/s and leaves in two pathways one with 7 liters/s and other with 3 liters/s. The type of flow it is ………. (a) Steady state (b) Unsteady state (c) batch (d) None of these	**1.5**	CO2
VII	In the given tank, there are two feeds and one output. Consider a 2 hour operation; the feed rates are 4000 kg/hr and 6000 kg/hr. The accumulated material inside the tank is 2000 kg. What is the output rate kg/hr of the material?	**1.5**	CO2

	(a) 9000 (b) 7000 (c) 8000 (d) 6000		
VIII	15 kg of oxygen and 15 kg of hydrogen are mixed together. Which one will have greater partial pressure in the resulting mixture? (a) Hydrogen (b) Oxygen (c) Both have same partial pressure (d) Partial pressure depends on their vapor pressure	**1.5**	CO2
IX	In the following, steam reforming reaction of methane $$2CH_4 + H_2O \rightarrow CO + CO_2 + 7H_2$$ The limiting reactant is ………………….. . (a) CH_4 (b) H_2O (c) CO (d) CO_2	**1.5**	CO2
X	For the given reaction $$C_5H_{12} + 8\ O_2 \rightarrow 5\ CO_2 + 6\ H_2O$$ If 2 moles of C_5H_{12} and 8 moles of O_2 are present initially, which is the excess reactant in the reaction (a) O_2 (b) C_5H_{12} (c) CO_2 (d) H_2O	**1.5**	CO2
XI	In the van der Waals equation of state, the term that accounts for the intermolecular forces is (a) V – b (b) a/V^2 (c) RT (d) $(RT)^{-1}$	**1.5**	CO1
XII	Two effluent streams are mixed. One stream contains 10% salt and the other contains 0% salt. The combined stream contains 2% salt. The ratio of the two streams is ……… (a) 1 : 4 (b) 1 : 5 (c) 1 : 2 (d) 1 : 8	**1.5**	CO2
XIII	The compressibility factor for an ideal gas is……….. (a) 1 (b) 0 (c) 100 (d) None of these	**1.5**	CO2
XIV	The volume of an ideal gas, when you double the pressure at a fixed temperature, becomes (a) double (b) half (c) doesn’t change (d) None of these	**1.5**	CO2
XV	A cooking gas cylinder can withstand a pressure of 15 atm. The pressure inside the cylinder is 12 atm at 27 ^{0}C. During sudden fire in the building the temperature starts rising. At what temperature will the cylinder explode? (a) 306.75 K (b) 240 K (c) 375 K (d) 510 K	**1.5**	CO2
XVI	Zero percent relative saturation means (a) 100 % vapor in the air (b) 75 % vapor in the air (c) 30 % vapor in the air (d) No vapor in the air	**1.5**	CO1

XVII	The usual temperature of a gas or liquid is (a) Dry bulb temperature (b) Wet bulb temperature (c) Normal temperature (d) special temperature	**1.5**	CO1
XVIII	The absolute humidity of air at 101.3 kPa is measured to be 0.02 kg of water per kg of dry air. The partial pressure of water vapor in the air is ………………………. . (a) 3.16 kPa (b) 1.26 kPa (c) 5.96 kPa (d) 6.32 kPa	**1.5**	CO2
XIX	Heat capacity of a gas can be approximately expressed as $C_p = 26.693 + 7.365 \times 10^{-3}$ T, where C_p is in J/mol-K and T is in K. The heat given off by one mol of air, when cooled at 1 atmospheric pressure from 773 K to 173 K is …………….. . (a) 8.11 kJ (b) 18.11 kJ (c) 12.11 kJ (d) 50 kJ	**1.5**	CO2
XX	At higher temperature, molal heat capacities of most of the gases at constant pressure ……….. with increase in temperature. (a) increases (b) decreases (c) doesn't change (d) None of these	**1.5**	CO1
Section-B (4Q x 5M = 20 M)			
2.	Define the following terms (any two): (a) Limiting reactant (b) Percent conversion (c) Selectivity	**5**	CO1
3.	What are the characteristics of an ideal gas?	**5**	CO3
4.	Fresh juice contains 14% solids and 86% water by weight and is to be concentrated to contain 42% solids by weight. In a single evaporator system, it is found that the volatile constituents of juice escape with water leaving the concentrated juice 56%, with a flat taste. To overcome this problem part of the fresh juice, bypass the evaporator. Calculate the fraction of juice that bypass the evaporator. 	**5**	CO4
5.	The vapor pressure P^s of n-heptane is given by the Antonie equation $$lnP^s = 13.8587 - \frac{2911.32}{T - 56.56}$$ where P^s is in kPa and T is in K. Calculate (a) The vapor pressure of n-heptane at 325 K	**5**	CO3

	(b) The normal boiling point of n-heptane		
Section-C (2Q x 15M = 30 M)			
6.	The dry bulb temperature and dew point of ambient air were found to be 302 K and 291 K respectively. The barometer reads 100.0 kPa absolute. The vapor pressure of water at dew point is 2.0624 kPa. Compute (a) the molar humidity (b) the absolute humidity (c) the percent relative humidity (d) the percent saturation (e) the humid heat	15	CO3
7.	Pure naphthalene is fed to a jacketed heater at 32^{o}C and is vaporized at atmospheric pressure by condensing Dowtherm-A vapors in a jacket at 1.15 kg/m^2 (T_{sat}=260^{o}C and latent heat of vaporization is 68.6 kcal/kg). Assume no subcooling of vapors. Calculate the quantity of Dowtherm-A condensed per 10 kg of naphthalene evaporated. Boiling point: 218^{o}C Melting point: 80^{o}C Latent Heat of Vaporization: 75.5 kcal/kg Latent Heat of Fusion: 36 kcal/kg Use the average C_p of solid is given by : C_s=0.28+0.0011T kcal/kg ^{o}C Use the average C_p of liquid is given by: C_l =0.35+0.0008T kcal/kg ^{o}C where T is in ^{o}C.	15	CO4
Section-D (2Q x 10M = 20 M)			
8.	Estimate the molar volume of CO_2 at 500 K and 100 bar using the (a) ideal gas equation (b) van der Waals equation The van der Waals constants are a = 0.364 N m^4/mol^2 and b = 4.267 × 10^{-5} m^3/mol	10	CO3
9.	Final Purification stage in the preparation of vitamins from natural sources requires centrifuging and continuous filtration as depicted in figure. Determine the flow rate of recycle stream.  	10	CO4

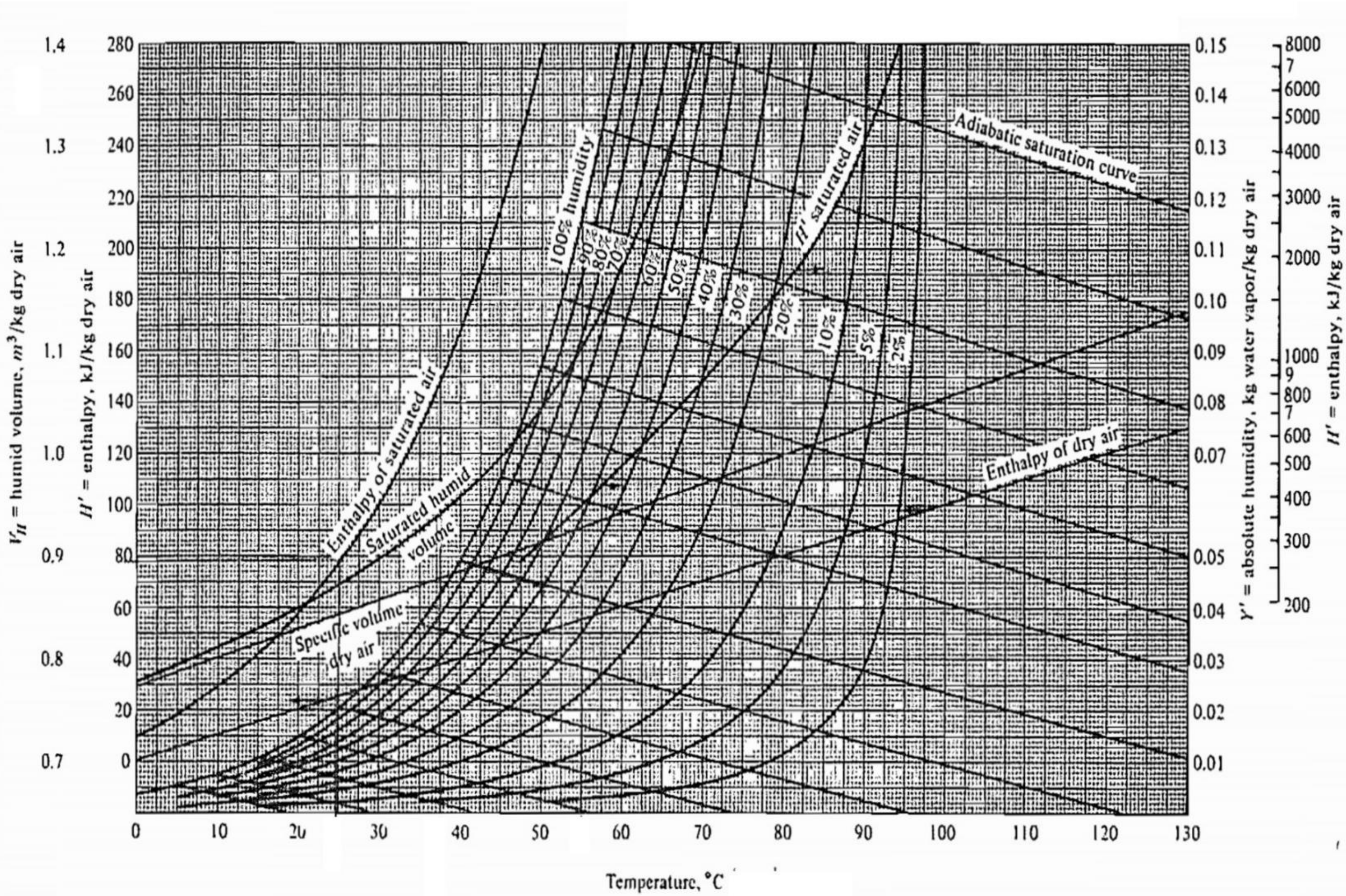


Figure: Psychrometric Chart for air-water vapor system at 1 atm pressure