

KATHMANDU UNIVERSITY
End Semester Examination [C]
November, 2023

Marks Scored:

Level : B.Tech.

Year : II

Course : ENVE 204

Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No.:

Date 27 NOV 2023

SECTION "A"

[20Q. × 0.5 = 10 marks]

Encircle the most appropriate answer.

- In the material balance of a process, which component will not be considered on the input side?
a. Chemicals b. Water/air c. Recycle d. Byproduct
- In a chemical process of two reactants A (200 kg) and B (200 kg) is used as reactants. If the conversion is 50% and A and B reacts in equal proportion then calculate the weight of the product formed.
a. 150 kg b. 200 kg c. 250 kg d. 400 kg
- In a coal fired boiler, hourly consumption of coal is 1000 kg. The ash content in the coal is 3%. Calculate the quantity of ash formed per day if boiler operates 24 hours a day.
a. 50 kg b. 33 kg c. 300 kg d. 720 kg
- In a drying process, moisture content is reduced from 60% to 30%. Initial weight of material is 200 kg. Calculate the final weight of the product to the nearest whole number?
a. 100 b. 114 c. 120 d. 130
- How many significant figures does the number 0.0024 have?
a. 1 b. 2 c. 3 d. 4
- Convert 23 lbf.ft/min² to its equivalent in kg.cm/s².
a. 0.075 b. 0.12 c. 0.088 d. 0.25
- The total energy of a stationary system is equivalent to:
a. The kinetic energy of the system
b. The potential energy of the system
c. The internal energy of the system
d. The sum of kinetic, potential and internal energies of the system
- The mathematical relation used to estimate the vapor pressure is called
a. Raoult's law b. Henry's law c. Hess's law d. Antoine's equation
- Which of the following is NOT an intensive variable?
a. Pressure b. Volume c. Density d. Specific volume
- 1 lb mol of ideal gas occupies _____ at standard temperature and pressure?
a. 22.415 m³ b. 22.415 L c. 359.05 ft³ d. 380 ft³

11. The off gas of a process contains 10% CO₂, 10% O₂ and 80% N₂. If the temperature and pressure are 300 F and 765 mm Hg respectively, what is the partial pressure of nitrogen?
a. 45.9 mm Hg b. 107.1 mm Hg c. 612 mm Hg d. 765 mm Hg
12. Which of the following is a fundamental unit of measurement?
a. Force b. Acceleration c. Molar amount d. Pressure
13. Convert 0.6 mg mol/mL.min to lbmol/liter.day.
a. 1.90 b. 2.54 c. 3.19 d. 4.21
14. A solution of HCl in water has a specific gravity of 1.05 at 25 C. The concentration of HCl is 10 g/L of solution. What is the PPM of HCl in solution?
a. 7600 b. 8200 c. 9500 d. 10300
15. For problem described in question 14, what is the mass of water in the solution assuming a basis of 100 g solution?
a. 96.979 b. 97.989 c. 99.990 d. 100
16. A _____ stream is a stream bled off from the process to remove an accumulation of inerts or unwanted material.
a. Recycle b. Bypass c. Purge d. Mixing
17. Steam with an inlet enthalpy of 2600 kJ/kg enters a pump with a flow rate of 2000 kg/h. If the outlet enthalpy of the steam is 3200 kJ/kg, determine the work input to the pump neglecting kinetic and potential energies.
a. - 437 kW b. - 292 kW c. 333 kW d. - 333 kW
18. The standard heat of combustion of butane (C₄H₁₀) vapor is -2500 kJ/mol. Assuming reactants and products are all at 25 C, what is the enthalpy change of the combustion reaction if 10 mole/s of CO₂ is produced in the reaction,
a. -5000 kJ/s b. -6250 kJ/s c. -6875 kJ/s d. -7250 kJ/s
19. A semi-batch process differ from an open process in _____
a. Input b. Output c. Generation d. Consumption
20. If air consists of 77% by weight of nitrogen and 23% by weight of oxygen, what is the mole fraction of nitrogen?
a. 0.21 b. 0.45 c. 0.67 d. 0.79

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Time : 2 hrs. 30 mins.

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Semester : I
F. M. : 40

SECTION "B"

Attempt *ALL* questions.

1. An aqueous solution of sodium hydroxide contains 20% NaOH by mass. It is desired to produce an 8% NaOH solution by diluting a stream of the 20% solution with a stream of pure water. Determine the feed rate of the 20% solution and the amount of pure water needed to produce 2310 lbm/min of the 8% solution. [5]

2. Acrylonitrile is produced by the reaction of propylene, ammonia and oxygen.

$$\text{C}_3\text{H}_6 + \text{NH}_3 + 1.5\text{O}_2 \rightarrow \text{C}_3\text{H}_3\text{N} + 3\text{H}_2\text{O}$$

The feed contains 10 mole% propylene, 12% ammonia and 78% air. A fractional conversion of 30% of the limiting reactant is achieved. Determine

 - a. The limiting reactant [1]
 - b. % by which other reactants are in excess [1.5]
 - c. Molar flow rates of all product gas constituents [2.5]

3. A natural gas fuel contains 85 mol% methane, 10% ethane and 5% and nitrogen. The fuel is supplied to a furnace with 50% excess air. Fuel and air both enter at 25 °C and the products leave at 600 °C. If the combustion is complete, what is the ΔH for the process? The heat of formation of methane, ethane, carbon dioxide and water are -74520, -83820, -393509 and -241818 J/mol respectively. The moles of input and output stream components.
 - a. Write the balanced reaction. [2]
 - b. Calculate the inlet and outlet composition [3]
 - c. The standard heat of reaction. [2]
 - d. Total enthalpy change of the process. [3]

$C_p/R = A + BT + CT^2 + DT^2$				
Components	A	10^3B	10^6C	10^5D
CO ₂	5.457	1.045	-	-1.157
H ₂ O	3.47	1.45	-	0.121
N ₂	3.28	0.593	-	0.04
O ₂	3.639	0.506	-	-0.227

4. 500 kg/hr of steam drives a turbine. The steam enters the turbine at 44 atm and 450 °C at a linear velocity of 60 m/s and leaves at a point 5 m below the turbine inlet at atmospheric pressure and a velocity of 360 m/s. The turbine delivers shaft work at a rate of 70 kJ/s and the heat loss from the turbine is estimated to be 11.6 kJ/s.
 - a. Write the energy balance equation for this process. [1]
 - b. Calculate the specific enthalpy change associated with the process. [4]

5. Superheated steam at 10 bar (1MPa) and 370 °C is fed to a turbine at a rate of 2000 kg/hr. The turbine operation is adiabatic, and the output is saturated steam at 1 bar. Calculate the work output of the turbine in kW neglecting kinetic and potential energy changes. [5]
6. $\text{H}_2\text{C}_2\text{O}_4$ is burned with 5% excess air so that 60% of the carbon turns to CO. Determine the dew point pressure of the product gas. [5]
7. 100 g moles/s of CO at 300 °C is completely burned with 600 g moles/s of air which is at 100 °C. Calculate the adiabatic product temperature using the following data: [5]

The heat capacities of the species involved in the reaction are assumed to be constant at 29 J $\text{gmol}^{-1}\text{K}^{-1}$ for CO, 29 J $\text{gmol}^{-1}\text{K}^{-1}$ for N_2 , 37 J $\text{gmol}^{-1}\text{K}^{-1}$ for CO_2 . The heat of formations at 25 °C are =110.52 kJ/ g mol for CO, 0 kJ/ g mol for O_2 , and -393.51 kJ/ g mol for CO_2 .

TABLE A-2 Properties of Saturated Water (Liquid-Vapor): Temperature Table

Temp. °C	Press. bar	Specific Volume m ³ /kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg·K		Temp. °C
		Sat. Liquid $v_f \times 10^3$	Sat. Vapor v_g	Sat. Liquid u_f	Sat. Vapor u_g	Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Sat. Vapor s_g	
.01	0.00611	1.0002	206.136	0.00	2375.3	0.01	2501.3	2501.4	0.0000	9.1562	.01
4	0.00813	1.0001	157.232	16.77	2380.9	16.78	2491.9	2508.7	0.0610	9.0514	4
5	0.00872	1.0001	147.120	20.97	2382.3	20.98	2489.6	2510.6	0.0761	9.0257	5
6	0.00935	1.0001	137.734	25.19	2383.6	25.20	2487.2	2512.4	0.0912	9.0003	6
8	0.01072	1.0002	120.917	33.59	2386.4	33.60	2482.5	2516.1	0.1212	8.9501	8
75	.3858	1.0259	4.131	313.90	2475.9	313.93	2321.4	2635.3	1.0155	7.6824	75
80	.4739	1.0291	3.407	334.86	2482.2	334.91	2308.8	2643.7	1.0753	7.6122	80
85	.5783	1.0325	2.828	355.84	2488.4	355.90	2296.0	2651.9	1.1343	7.5445	85
90	.7014	1.0360	2.361	376.85	2494.5	376.92	2283.2	2660.1	1.1925	7.4791	90
95	.8455	1.0397	1.982	397.88	2500.6	397.96	2270.2	2668.1	1.2500	7.4159	95
100	1.014	1.0435	1.673	418.94	2506.5	419.04	2257.0	2676.1	1.3069	7.3549	100
110	1.433	1.0516	1.210	461.14	2518.1	461.30	2230.2	2691.5	1.4185	7.2387	110
120	1.985	1.0603	0.8919	503.50	2529.3	503.71	2202.6	2706.3	1.5276	7.1296	120
130	2.701	1.0697	0.6685	546.02	2539.9	546.31	2174.2	2720.5	1.6344	7.0269	130
140	3.613	1.0797	0.5089	588.74	2550.0	589.13	2144.7	2733.9	1.7391	6.9299	140

Properties of Superheated Water Vapor

P=1.00 MPa (179.9°C)

Temp deg C	volume v(m ³ /kg)	energy u(kJ/kg)	enthalpy h(kJ/kg)	entropy s(kJ/kg.K)
Sat.	0.1944	2582.7	2777.1	6.585
200	0.2060	2622.2	2828.3	6.696
250	0.2328	2710.4	2943.1	6.927
300	0.2580	2793.6	3051.6	7.125
350	0.2825	2875.7	3158.2	7.303
400	0.3066	2957.9	3264.5	7.467
450	0.3305	3040.9	3371.3	7.620

