KATHMANDU UNIVERSITY
End Semester Examination
July/August 2024

02 AUG 2024

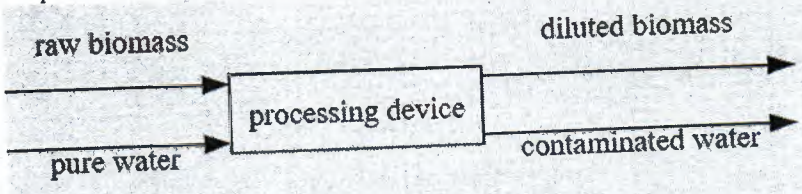
Level : B.E.
Year : II
Time : 2 hrs. 30mins.

Course : CHEG 201
Semester : I
F. M. : 40

SECTION "B"
[40 marks]

Attempt ALL questions.

1. Consider a process designed to process biomass for further processing into biofuels



Stream	Mass flow rate (kg / min)	Heat capacity (J/gK)	Temperature (°C)
raw biomass	15	0.9	90
pure water	120	4.2	?
diluted biomass	45	2.6	60
contaminated water	?	3.5	80

a. If the process is adiabatic, what temperature of pure water is required to produce the diluted biomass at a temperature of 60 °C? Assume a reference temperature of 25 °C for calculation. [3]

b. If the temperature of the pure water is same as in part (a), how much heat must be removed from the process to lower the diluted biomass temperature an additional 10 °C? [3]

2. A hydrocarbon fuel whose composition is unknown but may be represented by C_xH_y is burned with excess air. An aanlysis of the product gas gives the following results on a dry basis: 9.51% CO_2, 1% CO, 5.3% O_2 and 84.19% N_2. Determine:
a. The molar ratio of hydrogen to carbon in the fuel [3]
b. Percentage excess air used in combustion [3]

3. Methane (CH_4) is burned with 10% excess air in a furnace operating at a pressure of 1 bar. It is known that only 90 % of the carbon burned to CO_2 with the remaining carbon forming CO. Determine the dew point temperature of the flue gas. [6]

4. A gas mixture contains 30% CO_2 and 70% CO at 202.73 K and 92.04 atm. The molecular weight, critical temperature, and pressure for CO_2 are 44 g/mol, 304 K, 72.9 atm, respectively. The molecular weight, critical temperature, and pressure for CO are 28 g/mol, 133 K, and 34.5 atm, respectively. Find the molar volume of the gas mixture using Kay's mixing rule. [6]

P.T.O.

5. Methane and oxygen at 25 °C are fed to a continuous reactor in stoichiometric amount according to the following reaction to produce formaldehyde:

$$CH_4\ (g) + O_2\ (g) \rightarrow HCHO\ (g) + H_2O\ (g)$$

In a side reaction, methane is oxidized to carbon dioxide and water:

$$CH_4\ (g) + 2O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (g)$$

The product gases emerge at 400 °C, and the number of moles of CO_2 in the effluent gases is 0.15, and there is no remaining O_2 found in the effluent gas stream. Determine

a. The composition of effluent gas [3]
b. Amount of heat removed from the reactor [5]

The following information is given:

Components	Cp	ΔH_f^0
CH_4	$34.31 + 5.469x10^{-2}T + 0.3661x10^{-5}T^{-2}$	-74.85
HCHO	$34.28 + 4.268x10^{-2}T$	-115.9
H_2O	$33.46 + 0.688x10^{-2}T + 0.7604x10^{-5}T^{-2}$	-241.83
CO_2	$36.11 + 4.233x10^{-2}T - 2.887x10^{-5}T^{-2}$	--393.5
All values have units of kJ/mol		

6. Water exiting the condenser of a power plant at 45 °C enters a cooling tower with a mass flow rate of 15000 kg/s. A stream of cooled water is returned to the condenser from the cooling tower with the same flow rate. Make-up water is added in a separate stream at 20 °C. Atmospheric air enters the cooling tower at 25 °C with a wet bulb temperature of 15 °C. The volumetric flow rate of moist air into the cooling tower is 8000 m^3/s. Moist air exits the tower at 35 °C and 70% relative humidity. Determine

a. The mass flow rate of dry air [2]
b. The temperature of the cooled liquid water exiting the cooling tower [2]
c. The mass flow rate of water lost to the air [2]
d. The mass flow rate of make-up water [2]

$$R = 8.314 \frac{J}{mol * K} = 82.058\ cm^3 . \frac{atm}{K.mole} = 8.2 \times 10^{-5} m^3 . \frac{atm}{K.mole}$$

TABLE A-3 Properties of Saturated Water (Liquid–Vapor): Pressure Table

Press. bar	Temp. °C	Specific Volume m^3/kg		Internal Energy kJ/kg		Enthalpy kJ/kg			Entropy kJ/kg · K		Press. bar
		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	
0.04	28.96	1.0040	34.800	121.45	2415.2	121.46	2432.9	2554.4	0.4226	8.4746	0.04
0.06	36.16	1.0064	23.739	151.53	2425.0	151.53	2415.9	2567.4	0.5210	8.3304	0.06
0.08	41.51	1.0084	18.103	173.87	2432.2	173.88	2403.1	2577.0	0.5926	8.2287	0.08
0.10	45.81	1.0102	14.674	191.82	2437.9	191.83	2392.8	2584.7	0.6493	8.1502	0.10
0.20	60.06	1.0172	7.649	251.38	2456.7	251.40	2358.3	2609.7	0.8320	7.9085	0.20
0.30	69.10	1.0223	5.229	289.20	2468.4	289.23	2336.1	2625.3	0.9439	7.7686	0.30
0.40	75.87	1.0265	3.993	317.53	2477.0	317.58	2319.2	2636.8	1.0259	7.6700	0.40
0.50	81.33	1.0300	3.240	340.44	2483.9	340.49	2305.4	2645.9	1.0910	7.5939	0.50
0.60	85.94	1.0331	2.732	359.79	2489.6	359.86	2293.6	2653.5	1.1453	7.5320	0.60
0.70	89.95	1.0360	2.365	376.63	2494.5	376.70	2283.3	2660.0	1.1919	7.4797	0.70

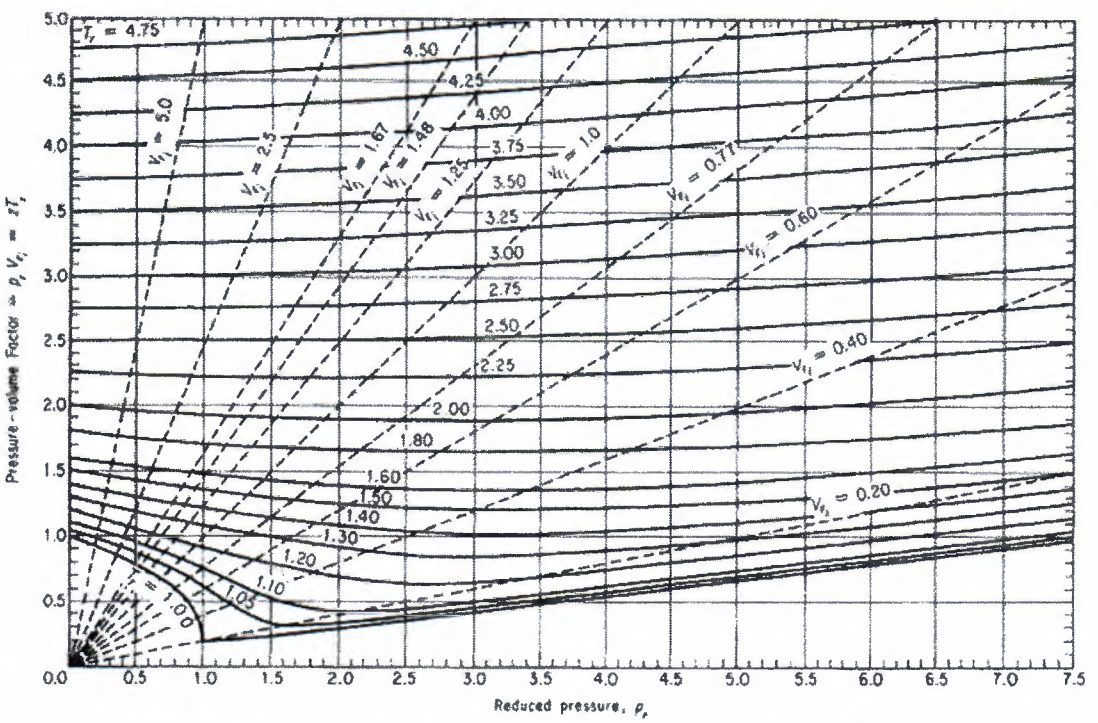
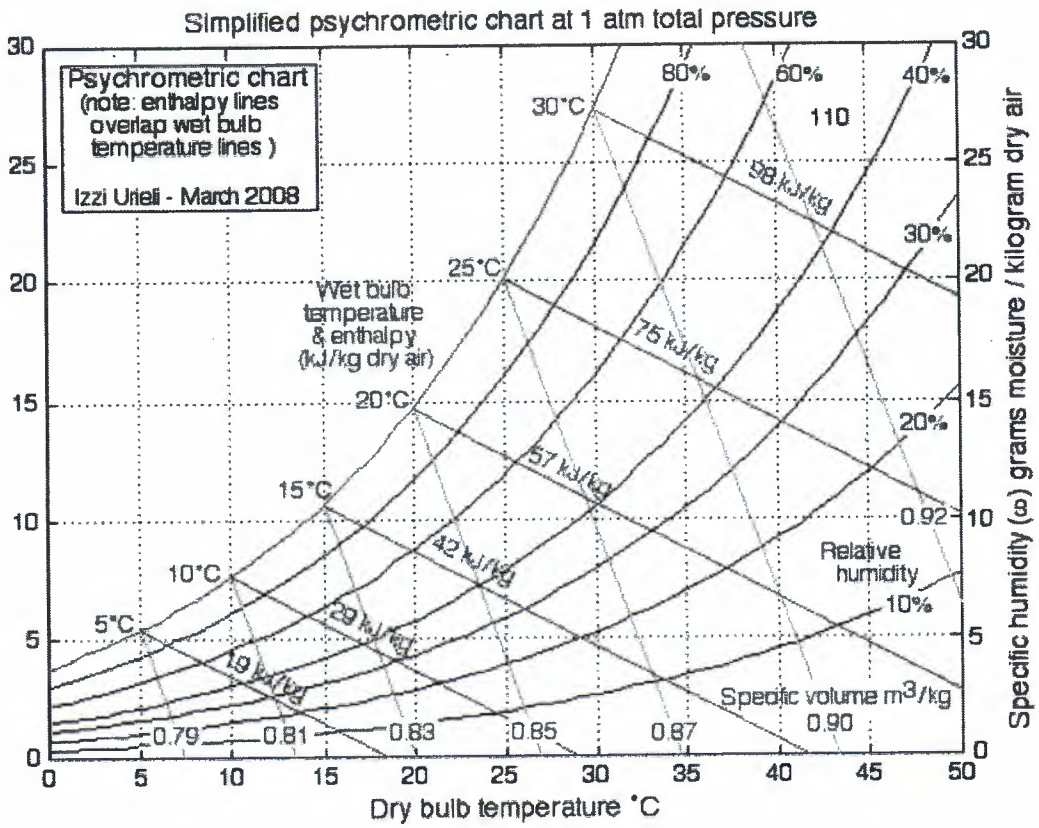


Figure 7.8b. Generalized compressibility chart for higher values of p_r


Simplified psychrometric chart at 1 atm total pressure
Psychrometric chart
(note: enthalpy lines
overlap wet bulb
temperature lines)
Izzi Urieli - March 2008
Wet bulb
temperature
& enthalpy
(kJ/kg dry air)
30°C
25°C
20°C
15°C
10°C
5°C
110
98 kJ/kg
75 kJ/kg
57 kJ/kg
42 kJ/kg
29 kJ/kg
19 kJ/kg
80%
60%
40%
30%
20%
10%
0.92
Relative
humidity
Specific volume m3/kg
0.79
0.81
0.83
0.85
0.87
0.90
Dry bulb temperature °C
Specific humidity (ω) grams moisture / kilogram dry air

KATHMANDU UNIVERSITY
End Semester Examination
July/August 2024

Marks Scored:

Level : B.E.
Year : II

Course : CHEG 201
Semester : I

Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No.:

Date : 02 AUG 2024

SECTION "A"
[20Q. × 0.5 = 10 marks]

Choose and encircle the most appropriate option from each set of choices.

1. The heat required to raise the temperature of 1 kg of water by 1°C is:
   a. 1 J b. 4.18 J c. 100 J d. 4.18 kJ

2. In a phase diagram, the critical point is:
   a. The point at which the substance exists in equilibrium between liquid and gas phases
   b. The point at which the substance exists in equilibrium between solid and liquid phases
   c. The highest temperature and pressure at which a substance can exist as a liquid
   d. The lowest temperature and pressure at which a substance can exist as a liquid

3. 1000 kg of wet solids are to be dried from 60% to 20% moisture by weight. The mass of moisture to be removed in Kg is:
   a. 400 b. 480 c. 500 d. 520

4. The molar composition of a gas is 10% H_2, 10% O_2, 30% CO_2, and the balance H_2O. If 50% H_2O condenses, the final mole percent of H_2 in the gas on a dry basis will be:
   a. 5% b. 10% c. 15% d. 20%

5. The human body is a _____ system:
   a. Open b. Closed c. Isolated d. Adiabatic

6. The _____ is the enthalpy change when stoichiometric quantities of reactants at temperature T and pressure P are consumed completely to form products at same T and P
   a. Heat of mixing b. Heat of reaction
   c. Standard heat of reaction d. Heat of formation

7. A semi-batch process differs from an open process in _____:
   a. Input b. Output c. Generation d. Consumption

8. What is the change in internal energy when 10 kg mol of Oxygen is heated from 200 K to 400 K at constant volume (Cv = 4000 J/(Degree Celsius)(Kg.mole))?
   a. 2 MJ b. 4 MJ c. 6 MJ d. 8 MJ

9. Which one is the correct relation?
   a. Cp + Cv = 0 b. Cp = 1 + R / Cv c. Cp / Cv = 1 d. Cp = R + Cv

10. The compressibility factor (Z) is used to:
    a. Correct the ideal gas law for real gases
    b. Measure the viscosity of a fluid
    c. Calculate the thermal conductivity of a gas
    d. Determine the boiling point of a liquid

11. The term 'enthalpy' refers to:
    a. The total energy of a system
    b. The internal energy of a system plus the product of pressure and volume
    c. The potential energy of a system
    d. The kinetic energy of a system

12. In a phase diagram, the line separating the liquid and gas phases is called the:
    a. Boiling point line
    b. Critical point line
    c. Vapor pressure line
    d. Phase equilibrium line

13. The term 'stoichiometry' refers to:
    a. The study of the rate of chemical reactions
    b. The study of the energy changes in chemical reactions
    c. The study of the composition of substances and their transformations
    d. The quantitative relationship between reactants and products in a chemical reaction

14. Moist air is cooled along the line of constant _____ when it is passed over a cold and drying coil such that no condensation occurs:
    a. Relative humidity
    b. Enthalpy
    c. Dew point temperature
    d. Wet bulb temperature

15. For heat exchangers, the general energy balance equation reduces to:
    a. $\Delta H = 0$
    b. $Q = 0$
    c. $\Delta E = Q + W$
    d. $\Delta E = Q + W - \Delta H$

16. If air consists of 77% by weight of nitrogen and 23% by weight of oxygen, what is the mole fraction of oxygen?
    a. 0.15
    b. 0.21
    c. 0.35
    d. 0.47

17. A reaction is of the form $A + 2B \rightarrow 3C$. If 2 moles of A and 4 moles of B entered the system, what are the numbers of moles of C formed for 50% conversion of A?
    a. 2
    b. 3
    c. 4
    d. 6

18. What is the degree of freedom of a system with ice, water, and neon?
    a. 1
    b. 2
    c. 3
    d. 4

19. 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

20. Which of the following is a fundamental unit of measurement?
    a. Force
    b. Acceleration
    c. Molar amount
    d. Pressure