

KATHMANDU UNIVERSITY
End Semester Examination [C]
December, 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 : 22 DEC 2024

SECTION "A"

[20Q. \times 0.5 = 10 marks]

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

- Which of the following is not a fundamental unit?
a. Mass b. Mole c. Force d. Length
- How many moles are present in 10 g of NaCl? (Molecular weight = 58.44 g/mol)
a. 0.171 b. 1.71 c. 0.0171 d. 17.1
- Calculate the density of a gas if its mass is 2 g and its volume is 0.5 L.
a. 4g/L b. 2.5g/L c. 1g/L d. 5 g/L
- In a steady-state system:
a. No material enters or leaves the system.
b. Accumulation equals zero.
c. The system changes with time.
d. Both a and c.
- What is the SI unit of energy?
a. Watt b. Newton c. Joule d. Pascal
- If the temperature of a gas is increased, its volume at constant pressure:
a. Increases b. Decreases c. Remains constant d. Depends on other factors
- What does the term "enthalpy" signify in a system?
a. Heat transfer b. Total energy
c. Internal energy + PV work d. None of the above
- What is the percentage composition of air by volume?
a. 78% N₂, 21% O₂, 1% Ar and others b. 50% N₂, 50% O₂
c. 99% O₂, 1% others d. 80% O₂, 20% N₂
- What is the value of R in the ideal gas equation $PV=nRT$?
a. 8.314 J/mol·K b. 10 J/mol·K
c. 0.0821 atm·L/mol·K d. Both a and c
- The specific heat at constant pressure for air is approximately:
a. 0.718 kJ/kg·K b. 1.005 kJ/kg·K c. 4.18 kJ/kg·K d. None of the above

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Semester : I
F. M. : 40

SECTION "B"

[2Q. × 7 = 14 marks]

Attempt ALL questions. All the necessary constants and values are given in italics.

1. A stream containing 10% CH₄, and 90% air by volume is to be heated from 20°C to 300°C. Calculate the required rate of heat input in kilowatts if the flow rate of the gas is 2.00 × 10³ litres (STP)/min.

Assume ideal gas behaviour.

1 mole of ideal gas at STP = 23.6442L

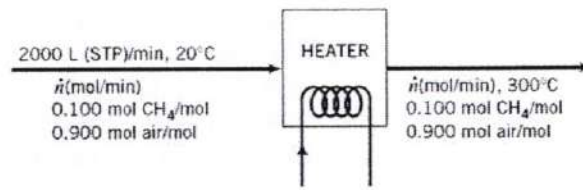
Reference State : CH₄ → g, 20°C, 1 atm

Air → g, 25°C, 1 atm

Methane: $C_p = 0.03431 + 5.469 \cdot 10^{-5}T + 0.3661 \cdot 10^{-8}T^2 - 11.0 \cdot 10^{-12}T^3$

Air: $H_m = -0.15 \text{ kJmol}^{-1}$

$H_{out} = 8.17 \text{ kJmol}^{-1}$



2. Answer both question a) and b)
- a. NADH (nicotinamide adenine dinucleotide) supplies hydrogen in living cells for biosynthesis reaction such as
- $$\text{CO}_2 + 4\text{H} \longrightarrow \text{CH}_2\text{O} + \text{H}_2\text{O}$$

If you saturate 1 L of deaerated water with CO₂ gas at 20 degree celsius (the solubility is 1.81 g CO₂/L) and add enough NADH to provide 0.0057 g of H into a bioreactor used to imitate the reactions in cells, and obtain 0.7g of CH₂O, what is the extent of reaction for this reaction? Use the extent of reaction to determine the number of grams of CO₂ left in solution.

- b. If 10.0 kg of acetic acid is mixed with 90.0kg of water to prepare vinegar. What are the mass or mole fraction of acetic acid and water in this mixture? Given: MW of acetic acid = 60.1 kg/kmol, water = 18.0 kg/kmol. Fill the table below.

Component	Mass (kg)	Mass fraction	MW (kg/kmol)	Mole (kmol)	Mole fraction
Acetic acid	10	x	60.1	a	c
Water	90	y	18.0	b	D
Total					

P.T.O.

SECTION "C"

[26 marks]

Attempt **ALL** questions.

3. Define the following terms: [5Q × 1 = 5 marks]
- a. Fed batch process
 - b. Volumetric flow rate
 - c. Isothermal system
 - d. Mole fraction
 - e. Specific Density
4. Differentiate between: [2Q × 2.5 = 5 marks]
- a. Material balance and Energy balance
 - b. Fundamental Unit and Derived Unit
5. A fermentation slurry containing *Streptomyces kanamyceticus* cells is filtered using a continuous rotary vacuum filter. 120 kg/h slurry is fed to the filter; 1 kg slurry contains 60 g cell solids. To improve filtration rates, particles of diatomaceous-earth filtrate aid are added at a rate of 10 kg/h. The concentration of kanamycin in the slurry is 0.05% by weight. Liquid filtrate is collected at a rate of 112 kg/h; the concentration of kanamycin in the filtrate is 0.045%. Filter cake containing cells and filter aid is continuously removed from the filter cloth. [2Q × 2 = 4 marks]
- a. What is the percentage of liquid in the filter cake?
 - b. If the concentration of kanamycin in the filter-cake liquid is the same as in the filtrate, how much kanamycin is absorbed per kg filter aid?
6. Fresh orange juice contains 12.0 wt% solids and the balance water, and concentrated orange juice contains 42.0 wt% solids. Initially a single evaporation process was used for the concentration, but volatile constituents of the juice escaped with the water leaving the concentrate with a flat taste. The current process overcomes this problem by bypassing the evaporator with a fraction of the fresh juice. The juice that enters the evaporator is concentrated to 58 wt% solids, and the evaporator product stream is mixed with the bypassed fresh juice to achieve the desired final concentration. [2Q × 2.5 = 5 marks]
- a. Draw and label a flowchart of this process, neglecting the vaporisation of everything in the juice but water.
 - b. Calculate the amount of product (42% concentrate) produced per 100 kg fresh juice fed to the process and the fraction of the feed that bypasses the evaporator.
7. If penicillin has a specific gravity of 1.41, what is the density in: [3Q × 1 = 3 marks]
- a. g/cm³
 - b. lbm/ft³
 - c. kg/m³

8. A gas stream containing 60.0 wt % ethane and 40.0 wt% butane is to be heated from 150 K to 250 K at a pressure of 5 bar. Calculate the required heat input per kg of the mixture, neglecting potential and kinetic energy changes, using the enthalpy data given for ethane and butane and assuming ideal gas behaviour. [4 marks]

- $\Delta\hat{H}_{e|i} = 314.3 \text{ kJ/kg}$; $\Delta\hat{H}_{e|o} = 973.3 \text{ kJ/kg}$
- $\Delta\hat{H}_{b|i} = 30 \text{ kJ/kg}$; $\Delta\hat{H}_{b|o} = 237.0 \text{ kJ/kg}$

