

KATHMANDU UNIVERSITY
End Semester Examination
July/August 2024

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

02 AUG 2024

Course : ENVE 204
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

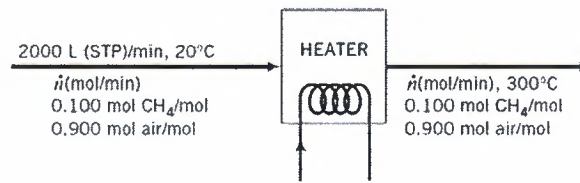
Reference State : CH₄ → g, 20°C, 1 atm

Air → g, 25°C, 1 atm

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

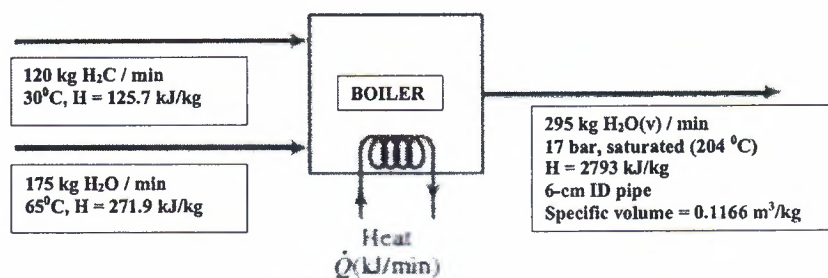
Air: $H_{in} = -0.15 \text{ kJmol}^{-1}$

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



2. Two streams of water are mixed to form the feed to a boiler. Process data are as follows: Feed stream 1: 120 kg/min water at 30°C ($H = 125.7 \text{ kJ/kg}$) Feed stream 2: 175 kg/min water at 65°C ($H_2 = 271.9 \text{ kJ/kg}$) Product stream 3: 295 kg/min saturated water vapour at 17 bar (absolute) and 204°C ($H_3 = 2793 \text{ kJ/kg}$) Knowing that the exit product steam from the boiler flows through a 6 cm ID pipe, and the specific volume of saturated steam at 17 bar is 0.1166 m³/kg, calculate the required heat input to the boiler in kilojoules per minute if the steam leaving is saturated at the fermenter pressure. Neglect kinetic energies of the liquid inlet system.

Assume that the kinetic energies of the liquid inlet streams is equal to zero.



P.T.O.

H for $H_2O(l)$ at $30^\circ C \rightarrow 125.7 \text{ kJ kg}^{-1}$

H for $H_2O(l)$ at $30^\circ C \rightarrow 125.7 \text{ kJ kg}^{-1}$

H for saturated vapour $H_2O (v)$ at 17 bar = 2793.4 kJkg^{-1} at $204^\circ C$

V (specific volume) for exit stream = $0.1166 \text{ m}^3\text{kg}^{-1}$

Volumetric flow rate = $(0.116 * 295) \text{ m}^3\text{min}^{-1}$

SECTION "C"

[26 marks]

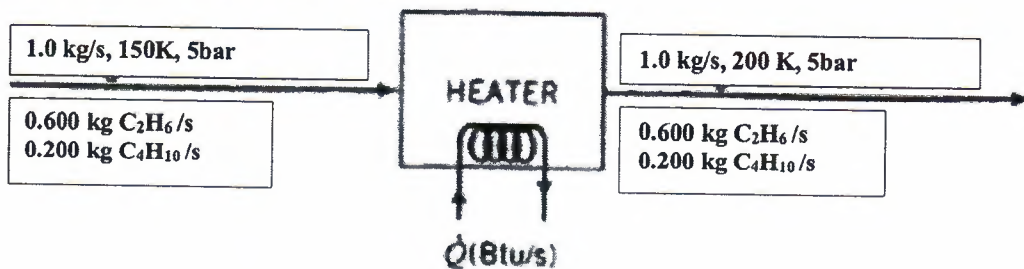
Attempt ALL questions.

3. Define the following terms: [5Q × 1 = 5 marks]
- Closed system
 - Steady state system
 - Isothermal system
 - Mass fraction
 - Specific gravity
4. Differentiate between: [2Q × 2.5 = 5 marks]
- Unit and Dimension
 - 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]
- What is the percentage of liquid in the filter cake?
 - 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. 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]

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

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



7. 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]
- Draw and label a flowchart of this process, neglecting the vaporisation of everything in the juice but water.
 - 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.
8. If penicillin has a specific gravity of 1.41, what is the density in: [3Q × 1 = 3 marks]
- g/cm^3
 - lbm/ft^3
 - kg/m^3

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Marks Scored:

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Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No.:

Date :

02 AUG 2024

SECTION "A"

[20Q. \times 0.5 = 10 marks]

Choose and mark [X] encircle the most appropriate option from each set of choices

- Which one of them is a fundamental unit?
 Velocity Acceleration Metre Force
- How many significant figures does the number 9700 have?
 One Two Three Four
- Calculate the volume of 10g of ethanol. Given density of ethanol = 0.789 g/cm³.
 12.7 cm³ 10.3 cm³ 11.3 cm³ 13.7 cm³
- The mass of acetic acid is 10 kg and the molecular weight of acetic acid is 60.1 kg/kmol.
Calculate the no. of moles (Kmol).
 0.166 1.66 0.0166 16.6
- Molecular Weight refers to:
 Mass of Substance/ No. of moles Mass of Substance/ Total Volume
 No. of moles/ Mass of Substance Total Volume/ Mass of Substance
- In an open system:
 No mass exchange occurs with surroundings
 Material crosses system boundary
 Both A and B
 None of the above
- Which of the following is not a unit of temperature?
 Fahrenheit Celsius Kelvin Rontgen
- What is the SI unit of Pressure?
 Pascal Kelvin Torr mmHg
- 3.5 km hr⁻¹ is equivalent to:
 75000 m day⁻¹ 84000 m day⁻¹ 56000 m day⁻¹ 750 m day⁻¹
- The Watt is:
 1 joule per second 1 kgm¹s⁻³
 The unit for all types of energy 1 ms⁻¹

