Exam Date & Time: 07-Dec-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING

SEVENTH SEMESTER B.TECH END SEMESTER EXAMINATIONS, NOV/DEC 2023

INTRODUCTION TO COMBUSTION [MME 4070]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions. Section Duration: 180 mins

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) Find the stoichiometric air-fuel ratio for the combustion of ethyl alcohol (C_2H_6O) in a petrol engine. Calculate the air-fuel ratios for the extreme mixture strengths of 80 percent and 130 percent. Also determine the wet and dry analyses by volume of the exhaust gases for each mixture strength. (5)

A)

B) With a sketch, demonstrate the combustion triangle. (3)

C) Demonstrate the importance of gaseous fuels over liquid and solid fuels. (2)

2) Calculate the stoichiometric air-fuel ratio for the combustion of a sample of dry anthracite of the following composition by mass:

A) Carbon (C) = 88 percent; Oxygen (O_2) = 3.5 percent; Sulphur (S) = 0.5 percent; Hydrogen (H_2) = 4 percent; Nitrogen (N_2) = 1 percent; Ash = 3 percent. (5)

If 20 percent excess air is supplied determine:

(i) Air-fuel ratio

(ii) Wet dry analysis of the products of combustion by volume.

B) Illustrate the various applications of combustion with examples. (3)

C) Demonstrate the effects of different air-fuel mixture ratio. (2)

3) Estimate the constant pressure adiabatic flame temperature for the combustion of a stoichiometric CH_4 – air mixture. The pressure is 1 atm and the initial reactant temperature is 298 K. (5)

A)

Use the following assumptions:

(i) “Complete combustion” (no dissociation), i.e., the product mixture consists of only CO_2, H_2O, and N_2.

(ii) The product mixture enthalpy is estimated using constant specific heats evaluated at 1200 K ($\approx 0.5(T_i+T_{ad})$, where T_{ad} is guessed to be about 2100 K.

Enthalpy of formation at 298K, h_{fi} (kJ/kmol):

CH_4= -74831; CO_2= -393546; H_2O= -241845; N_2= 0; O_2= 0.

Specific heat at 1200K, C_{pi} (kJ/kmol-K)

CO_2= 56.21; H_2O= 43.87; N_2= 33.71

B) Illustrate the importance of adiabatic flame temperature in combustion analysis. Use suitable assumptions to estimate adiabatic flame temperature. (3)

C) Apply Fick's law to mass transfer process. (2)

4) A) A full propane cylinder from a camp stove leaks its content of 0.5 kg into a 3.5m x 4.5m x 2.5m room at 20 ºC and 1 atm. After a long time, the fuel and air are well mixed. Is the mixture in the room flammable? (R= 8315 J/kmol-K, Propane-air flammable limits $0.51< \varphi< 2.83$, $A/F)_{stoic}$ for the mixture is 15.6). (5)

B) Illustrate the factors affecting reaction rates with examples. (3)

C) Distinguish between laminar combustion and turbulent combustion with suitable examples. (2)

5) A) Ammonia gas (A) is diffusing through a uniform tube (0.15 m long) containing nitrogen (B) at a pressure of 1 atm and 298 K. At point 1, $p_A = 1.013x10^4$ Pa and at point 2, $p_A=0.507x10^4$Pa. The diffusivity, $D_{(AB)}=D_{(BA)}= 0.230x10^{-4}m^2/s$. Calculate molar fluxes of ammonia and nitrogen gases at steady state. (5)

B) Analyze the effects of carbon monoxide emissions from the combustion on human health. (3)

C) Analyze the factors affecting the formation of NOx in combustion. (2)

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