Ref. No. : Ex/PG/PE/T/127A/31/ 2019

M.E. Power Engineering 1st Year 2nd Semester Examination, 2019

Subject : Combustion Technologies

Time : Three hours **Full Marks: 100**

Answer any five questions.

1. a) During cruising operation of a S.I.engine, the equivalence ratio of the fuel-air mixture inducted into the cylinder is 0.92. Is the mixture rich or lean? What is the percent theoretical air for the mixture? Why such mixture is used during the operation? (5)
   b) LPG used in domestic kitchen has 40% propane and 60% butane. The fuel-air mixture prepared in the mixing tube of the LPG burner has an equivalence ratio of 1.4. If the LPG flow rate is 70 liter/h, what is the rate of air entrained in the mixing tube? What is your opinion about the type of flame established on the burner? – justify. (10)
   c) Define enthalpy of formation and discuss its significance in the thermochemical analysis of reacting flow. (5)

2. a) Define adiabatic flame temperature and discuss its significance in practical applications. (6)
   b) Rice husk having a composition of carbon: 50%, hydrogen: 6%, and oxygen: 44% by mass is gasified in a biomass gasifier with oxygen. The gasifier is operated at an equivalence ratio of 2.5. Considering the thermodynamic equilibrium of the species at the gasifier exit calculate the composition of the producer gas from the gasifier, if the gas exit temperature is 1500°C. Given, at 1500°C, $\frac{\bar{g}^o_f}{RT}$ for CO, H_2O, CO_2 and H_2 are -35.613, -45.657, -61.739 and -18.590, respectively. (14)

3. a) What do you mean by a chemical reaction mechanism? What are the individual reactions of the mechanism known as? What is the molecularity of these reactions? How is the specific reaction rate of these reactions expressed? (6)
   b) What are the differences between a global reaction mechanism and a reduced reaction mechanism? Explain two methodologies by which a chemical reaction mechanism can be reduced. (8)
   c) What do you mean by a well stirred reactor? Under which condition a reactor can be modeled as well stirred reactor in practice and why? – explain. (6)

4. a) Define laminar burning velocity of a premixed flame. Explain the influence of various factors on the laminar burning velocity of a premixed fuel-air mixture. (2+6)
   (b) Derive an expression of burning velocity of a laminar premixed flame using a simplified analysis of one-dimensional and steady flame. Clearly state the assumptions considered for the derivation. (12)

5. a) Explain the structure and stabilization principles of open flames, established on a circular burner, burning premixed fuel-air mixtures in lean, stoichiometric and rich regimes. Draw the necessary diagrams for the purpose as required. (15)
   b) What is flame quenching? Under what conditions does flame quenching occur and why? (5)

6. a) Discuss the significance of turbulent length scale, velocity scale and time scale in a turbulent premixed flame. (5)
   b) Using the relevant non-dimensional parameters draw the regime diagram for turbulent premixed combustion to show different flame regimes. Explain the regimes in terms of the non-dimensional parameters and state the regimes which are commonly observed in engines and furnaces. (15)

7. a) Describe the structure of a co-flow, laminar, non-premixed flame using the temperature variations across the flame. How the flame height can be evaluated from the temperature measurements of a non-premixed jet flame? Which type of thermocouple can be used for the flame temperature measurement? (8)

b) Differentiate between an over-ventilated and a under ventilated non-premixed flame structures stating the reasons of their existence. Can you have the latter in case of an unconfined jet diffusion flame? – explain. (6)

c) What is soot? Discuss the processes involved in the formation of soot in a non-premixed flame. (6)