

B.E. Power Engineering, 4th Year, 2nd Semester Examination, 2023**Combustion**

Time: Three Hours

Full Marks: 100

Answer any five (5) questions

- CO1 1. a) What do you mean by multicomponent system? State its physical significance.
 b) What is system equilibrium? Briefly describe their significance.
 c) What do you mean by order of reaction? State its physical significance.
 d) What is enthalpy of vaporisation? State its physical significance.
 e) What is the equivalence ratio in a combustion system? State its physical significance.
 f) A natural gas has the following molar analysis: $\text{CH}_4=80.62\%$, $\text{C}_2\text{H}_6=5.41\%$, $\text{C}_3\text{H}_8=1.87\%$, $\text{C}_4\text{H}_{10}=1.6\%$, $\text{N}_2=10.5\%$. The gas is burned with dry air giving products having a molar analysis on the dry basis as: $\text{CO}_2=9.0\%$, $\text{CO}=0.37\%$, $\text{O}_2=4.7\%$ and $\text{N}_2=85.93\%$. Determine a) the air-fuel ratio on a molar basis, b) the percent of theoretical air supplied and the equivalence ratio of the fuel-air mixture. Assume that one-mole fuel gas burns in A mole of oxygen from air to produce B mole of dry product gas and D moles of water vapour.

Marks: 3 + 3 + 2 + 2 + 2 + 8 = 20

- CO1 2. a) What do you mean by the term molecular reaction? State its physical significance.
 b) What do you mean by chain reaction? State its physical significance.
 c) For a Cartesian coordinate system, derive the following expression for the conservation of species:

$$\frac{\partial y_i}{\partial t} + (v_x \frac{\partial y_i}{\partial x} + v_y \frac{\partial y_i}{\partial y} + v_z \frac{\partial y_i}{\partial z}) = \rho \left(\frac{\partial^2 y_i}{\partial x^2} + \frac{\partial^2 y_i}{\partial y^2} + \frac{\partial^2 y_i}{\partial z^2} \right) + \dot{m}_i'''$$

where symbol denotes the usual notations, ρ is the diffusion coefficient, \dot{m}_i''' is the generation of i^{th} species per unit volume per unit time.

Marks: 2 + 3 + 15 = 20

- CO2 3. a) What do you mean by flame quenching in a premixed flame of gaseous fuels? State its physical significance.
 b) Briefly write down the description of a pre-mixed gaseous flame.

c) Consider the reaction $\text{A} + \text{B} \rightarrow \text{C}$, where the rate law is given as $\frac{d[X_A]}{dt} = -k[X_A]^2[X_B]^0$,

where $k = 0.1 \text{ m}^3/\text{kmol}\cdot\text{s}$. In the initial mixture, the concentrations of A and B are 2 kmol/m^3 and 5 kmol/m^3 , respectively with no C. What will be the concentration of A, B and C after 5 sec?

Marks: 3 + 3 + 14 = 20

[Turn over

- C02** 4. a) What do you mean by flammability limits for any flame? State its physical significance.
b) Briefly describe about the structure of a laminar premixed flame.
c) A premixed methane-air flame is stabilized on a burner of diameter 8 mm. The methane flow rate is 0.72 lpm and the equivalence ratio of the mixture is 0.9. If the flame height is measured to be 3 cm, find the flame speed of the mixture

Marks: 3 + 3 + 14 = 20

- C03** 5. a) What is droplet combustion? State its physical significance.
b) What is the heterogeneous reaction? State its physical significance.
c) What are the processes for the gas-solid reactions?
d) What do you mean by kinetically controlled and diffusion-controlled burning during the combustion of solid fuel?
e) Briefly describe about the different types of liquid fuel atomizers.

Marks: 3 + 3 + 3 + 3 + 8 = 20

- C04** 6. a) Briefly describe about the different applications of the combustion process.

- C05** b) Briefly describe about the combustion emissions and their control strategy.

Marks: 8 + 12 = 20