

B.E. Power Engineering, 4th Year, 2nd Semester Examination, 2025**Combustion****Time: Three Hours****Full Marks: 100****Group A: CO1 (30 Marks)**

1. Answer the following questions briefly (any four questions)
 - a) Discuss key properties of fuels and how they influence their applications in combustion systems.
 - b) How is the reaction order defined in chemical kinetics? Explain its practical significance in combustion processes.
 - c) Explain the concept of enthalpy of formation and its application in combustion analysis. Why is it significant in thermodynamic analysis of combustion?
 - d) Define the equivalence ratio in a combustion setup. Discuss its importance in determining combustion characteristics.
 - e) Define adiabatic flame temperature and explain the factors affecting it. Discuss its importance in determining combustion characteristics.

Marks: 4 × 4 = 16

2. Answer the following question (any one question)
 - a) A small, low-emission, stationary gas turbine engine operates at full load (3950 kW) at an equivalence ratio of 0.286 with an air flow rate of 16.8 kg/s. The equivalent composition of the fuel (natural gas) is $C_{1.16}H_{4.32}$. Determine the fuel mass flow rate and the operating air-fuel ratio for the engine.
 - b) A natural gas has the following molar analysis: $CH_4=80.62\%$, $C_2H_6=5.41\%$, $C_3H_8=1.87\%$, $C_4H_{10}=1.6\%$, $N_2=10.5\%$. The gas is burned with dry air giving products having a molar analysis on the dry basis as: $CO_2=9.0\%$, $CO=0.37\%$, $O_2=4.7\%$ and $N_2=85.93\%$. 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: 1 × 16 = 14**Group B: CO2 (20 Marks)**

3. Answer the following questions briefly (all questions)
 - a) Define premixed flame and differentiate it from diffusion flame with examples.
 - b) Define adiabatic flame temperature and explain the factors affecting it.
 - c) Explain the techniques used to stabilize flames in combustion systems.
 - d) For a Cartesian coordinate system, derive the following expression for the conservation of species:

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

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

Marks: 3 + 2 + 3 + 12 = 20

Group C: CO3 (15 Marks)

4. Answer the following questions briefly (any three questions)
 - a) Explain the concept of droplet combustion and discuss its relevance in combustion systems from a physical standpoint.
 - b) Explain the different stages of combustion in solid fuel, and explain its physical implications.
 - c) What is meant by combustion that is controlled by chemical kinetics versus one controlled by diffusion in the context of solid fuel burning?
 - d) Provide a short overview of the various types of atomizers used for liquid fuels and their operational characteristics.

Marks: 3 × 5 = 15

Group D: CO4 (15 Marks)

5. Answer the following questions briefly (any two questions)
 - a) Explain the mechanism of combustion in fuel sprays and outline the key stages involved in the spray combustion process.
 - b) Provide a concise explanation of the corner-firing technique used in pulverized coal combustion systems.
 - c) Summarize the various industrial and practical uses of combustion technology across different sectors.

Marks: 2 × 5 = 10

Group E: CO5 (20 Marks)

6. Answer the following questions briefly (any two questions)
 - a) Critically assess the environmental aspects of combustion processes, highlighting the types of pollutants generated, their formation mechanisms.
 - b) Describe the impact of combustion processes on the environment and human health, and strategies for emission control.
 - c) Briefly describe about the emission of particulate matter and their control strategy.

Marks: 2 × 10 = 20