M.E. AUTOMOBILE ENGINEERING FIRST YEAR FIRST SEMESTER EXAM 2024

Subject: Combustion, Thermodynamics and Heat Transfer

Time: **3** hours | Full Marks: **100**

50 Marks for each Group
Use separate Answer Script for each Group

Group – A
Answer any two questions

1. A spherical vessel of diameter 20 cm is filled with stoichiometric H2 – O2 mixture at 298 K, 1 bar. The mixture is ignited and water is added in the form of liquid spray. If the mass of water added is 0.15% of the mass of hydrogen, find the final temperature and pressure in the vessel if the added water evaporates completely. Assume that the evaporation takes place at 100°C. 25

2. (a) For an equivalence ratio of $\Phi = 0.6$, determine the associated air–fuel ratios (mass) for methane, propane, and decane ($C_{10}H_{22}$). 10

   (b) Consider the reaction $CO_2 \leftrightarrow CO + 0.5O_2$. Calculate Kp and Kc at 2000 K, 1.5 bar. 15

3. (a) Describe the effect of increasing temperature on the equilibrium composition of combustion products. 3

   (b) Describe the effect of increasing pressure on the equilibrium composition of combustion products. 4

   (c) Why does flue-gas recirculation decrease flame temperatures? What happens if the flue gas recirculated is at the flame temperature? 3

   (d) Derive the half-life of a second-order reaction with identical reactants. 15

   $A+A \rightarrow P$

Group – B
Answer any two questions

1. (a) Why is radiation mode generally considered for heat exchange from the engine to the surroundings? 3

   (b) Using the electrical analogy concept to consider an engine surface as a real body, establish a radiation heat exchange rate between the engine and surroundings. 10

   (c) What fundamental aspects are associated with calculating radiation heat transfer? 4

   (d) When is the radiosity matrix constructed for the analysis of engine heat exchange? 8

2. Overheating of an SI engine can be avoided by attaching a longitudinal trapezoidal fin, which enhances the heat transfer from the engine to the surroundings due to convection only. The engine's outer surface is at a constant temperature. Heat transfer in the fin only occurs in the length direction, and the convective heat transfer coefficient at the lateral fin surfaces is assumed to be a constant. By choosing an appropriate coordinate, derive the above fin's equation based on Fourier's law of heat transfer. Determine the fin's temperature distribution and heat transfer rate for the insulated tip. The above derivation can be performed using conventional notations. 25

3. The engine is made of an anisotropic material. Derive the governing equation for conducting heat in engine walls for the motion of the engine based on Fourier's law. How is the temperature response to be determined? 25