Ref. No.: EX/PG/ME/T/129F/2018

M.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAMINATION - 2018

Combustion Engineering

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

Answer any four questions. All parts of the same question must be answered together. Use of tables permitted. Assume any unfurnished data suitably.

1a)	Starting from equilibrium thermodynamic relation $(dG)_{T,P,m} = 0$, show that $K_P = \exp(-\Delta G_T^0 / R_U T)$	15
b)	For a reaction NO+O→N+O_2, the forward reaction rate coefficient may be written as $$k_f = 3.8 \times 10^9 . T . \exp\left(\frac{20820}{T}\right) \frac{cm^3}{gmol\ s}$$ Determine the reverse rate coefficient at 2300K. Assume $\bar{g}_{f,N}^0 = 326331\ kg/kmol$, $\bar{g}_{f,O_2}^0 = 0\ kg/kmol$, $\bar{g}_{f,NO}^0 = 61243\ kg/kmol$, $\bar{g}_{f,O}^0 = 101627\ kg/kmol$	10
2a)	Derive the necessary expressions to find out dT/dt, dP/dt and $d[X_i]/dt$ for a constant pressure fixed mass reactor. Also comment on the boundary conditions to solve for the above variables. The variables bear their usual meaning.	20
b)	50% H_2 and 50% CO by volume are mixed to form a fuel. Find out the stoichiometric fuel-air ratio for the fuel.	5
3a)	Derive the expression for laminar flame speed in a uniform fuel-oxygen mixture assuming a linear temperature profile in flame.	20
b)	A premixed fuel-oxidizer mixture is coming out of a slot burner with a velocity $u = U(1 - x/L)$ Where, U is the maximum velocity, the slot width is 2L with x=0 at the centre. Find out an expression for flame shape for this burner.	5
4a)	Derive the Shvab-Zeldovich form of energy equation.	13
b)	Derive the steady conservation equation of absolute enthalpy $[h = \sum Y_i h_{f,i}^0 + \int_{T_{Ref}}^{T} c_p dT]$ as a conserved scalar.	12
5a)	Derive the expression for mixture fraction on a slot burner assuming Burke-Schumann flame.	20
b)	Find out the stoichiometric mixture fraction for Acetylene (C_2H_2) diluted with 20% Nitrogen by mass and air.	5
6a)	Write a short note on soot generation in non-premixed flame.	10
b)	Write down the utility of a counter flow flame. Write a note on the locations of the stagnation plane and the flame. Show that $\frac{\partial p}{\partial x}$ and $\frac{1}{r}\frac{\partial p}{\partial r}$ are functions of x only, where p is the pressure and x, r are the axial and radial coordinates respectively.	3+2+10