Mansoura University	**January 2014**	**3 rd Year Mech. Power**
Faculty of Engineering	تخلفـــــــــات	**Theory of Combustion**
Mech. Power Eng. Dept.		**Time allowed : 3 hrs.**

Combustion and steam tables are allowed
Answer the following questions :-

Question (1)

a) Normal octane C_8H_{18} is burnet with dry air. The volumetric analysis of products on dry basis is CO_2 = 11%, O_2 = 4%, CO = 1% and N_2 = 84%. Determine: (I) A/F ratio. (II) the equivalence ratio. (III) the percentage of excess air used.

b) What are the higher and lower heating values of a fuel? How do they differ?

c) Calculate the product temperature of methane, CH_4 – air mixture at 300 K, burning with 15 excess air at 0.1 MPa pressure.

Question (2)

A steady flow combustion chamber is supplied with 1 kmol of CO gas at 77° C and 400 kPa and with 2.5 kmol of air at 25° C and 400 kPa. The combustion products leave the combustion chamber at 3000 K and 400 kPa. If the combustion gases consist of CO_2, CO, O_2, and N_2, determine : (I) the equilibrium composition of the product gases, and (II) the heat transfer from the combustion chamber.

Question (3)

a) Explain major constituents of pollutants emitted by combustion systems and their effects on the environment.

b) Derive an expression for reaction rate of NO atom using the famous Zeldovich mechanism during the formation of nitric oxide (NO), given as below:

$$O + N_2 \xrightarrow{K_1} NO + N \qquad \text{(Slow)}$$

$$N + O_2 \xrightarrow{K_2} NO + O \qquad \text{(Fast)}$$

Question (4)

A laminar butane gas (C_4H_{10}) get issued from a tube into thr air has a flame height of 12 cm. Determine volumetric fuel flow rate and heat release rate. If the fuel tube diameter is increased by 30% and velocity is increased by 30%, what will be the flame height? Take heat of combustion for butane gas = 4000 kJ/kg, and T_F = 2200 K and T_u = 298 K. the flame length h_F can be expressed as:

$$h_F = 1300\, V_F\, (T_u/T_F) / \ln (1 + 1/v)$$

where V_F is the volumetric flow rate m^3 / s and v if the stoichiometric air fuel ratio.

Question (5)

Using neat illustrations, discuss each of the following:

a) Premixed combustion wave categories using Hugoniot curve.
b) Region of stable zone of laminar premixed flames in term of velocity gradient. Also, define each of flashback and blow-off of the flame.
c) Various regimes of primixed turbulent flames using " Borghi diagram "

Question (6)

a) Discuss briefly characteristics of liquid fuels.
b) For laminar premixed flames, discuss briefly each of:
   (i) Quenching diameter. (ii) Flammability limits.
c) Discuss briefly methods of NO_x formation in combustion process.

Good Luck
Dr. Eng. / Azmy S. Kh. Awad