

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

Question (1)

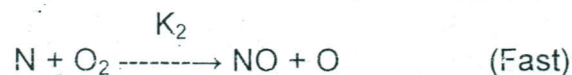
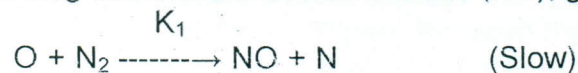
- Normal octane C_8H_{18} is burned with dry air. The volumetric analysis of products on dry basis is $CO_2 = 11\%$, $O_2 = 4\%$, $CO = 1\%$ and $N_2 = 84\%$. Determine: (I) A/F ratio. (II) the equivalence ratio. (III) the percentage of excess air used.
- What are the higher and lower heating values of a fuel? How do they differ?
- 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 $77^\circ C$ and 400 kPa and with 2.5 kmol of air at $25^\circ C$ 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)

- Explain major constituents of pollutants emitted by combustion systems and their effects on the environment.
- Derive an expression for reaction rate of NO atom using the famous Zeldovich mechanism during the formation of nitric oxide (NO), given as below:



Question (4)

A laminar butane gas (C_4H_{10}) get issued from a tube into the air has a flame height of 12 cm. Determine volumetric fuel flow rate and heat release rate. If the 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 is 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
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