Ref. No. : **Ex/PE/T/321/2017**

B.Power Engineering Third Year, Second Semester Examination, 2017

Subject : Combustion & IC Engine **Time : Three hours** **Full Mark : 100**

Answer Question No. 1 and any five from the rest. Use tables given at the back of the question paper.

1. Answer the following questions (any five) **(5×4 = 20)**

(a) Define equivalence ratio. What is the percentage excess air in a propane-air mixture having equivalence ratio of 0.8?

(b) How does the adiabatic flame temperature of a fuel-air mixture vary with the mixture quality? Explain the reason behind such variation.

(c) The equivalence ratios at rich and lean flammability limits for a methane-air mixture are 1.67 and 0.5 respectively. Will it be possible to burn a methane-air mixture of equivalence ratio 1.8 issuing from a circular burner in open atmosphere? Justify your answer with proper reasoning.

(d) Which type of atomizer (fuel injector) is used in C.I.engine and why?

(e) Why is it required to optimize the spark timing in a spark ignition engine?

(f) Why does knocking occur in C.I. engine and what are its bad effects?

2. A mixture of ethylene (C_2H_4) and air having air-fuel ratio of 18 by mass is burned in a closed combustion chamber where a constant pressure of 500 kPa is maintained. The initial volume and temperature of the reactant mixture in the chamber are 0.25 m^3 and 25°C. The mixture is ignited and heat is transferred from the chamber such that a final temperature of 1227°C is reached. Assuming complete combustion determine the amount of heat transfer from the combustion chamber. **(16)**

3. An equimolar mixture of CO and O_2 enters a constant pressure steady flow combustion chamber at 1 atm pressure and 500 K temperature. The final product leaves the combustor at 2200 K. Determine the percentage difference in heat transfer from the combustion chamber considering complete oxidation and considering equilibrium composition of the product mixture. The equilibrium constant for $CO_2 \Leftrightarrow CO + \frac{1}{2}O_2$ at 2200 K is 0.006. **(16)**

4. (a) Differentiate between (i) global and elementary reactions, (ii) molecularity and order of reaction. **(4)**

(b) What are radicals and what is their significance in combustion reactions? How do you classify different reactions in a chain reaction mechanism based on the radicals participating in the reactions? **(4+2)**

(c) Consider the reaction A + B → C, where the rate law is given as $\frac{d[X_A]}{dt} = -k[X_A]^2[X_B]^0$, with k = 0.1 m^3/kmol-s. In the initial mixture, the concentrations of A and B are 2 kmol/m^3 and 3.5 kmol/m^3, respectively with no C. What will be the concentrations of A, B and C after 3 secs? **(6)**

5. (a) Define laminar burning velocity of a premixed fuel-air mixture. Discuss the effects of different parameters which influence the laminar burning velocity. **(8)**

(b) Explain the differences among flash back, lift off and blow off in case of a premixed flame? What is flame quenching? **(8)**

6. (a) Define indicated mean effective pressure, brake thermal efficiency, brake specific fuel consumption and mechanical efficiency for an internal combustion engine. **(8)**

(b) Discuss the various factors which alter the actual engine cycle from the theoretical cycles. **(8)**

7. (a) A single cylinder, four stroke, square engine having bore 80 mm operates at 2400 rpm. The bsfc of the engine is 0.25 kg/kWh and heating value of the fuel is 42000 kJ/kg. Determine the average piston speed and brake thermal efficiency for the engine. (6)

(b) What do you mean by spark ignition engine of MPFI type? What are its benefits over the carburetor engine? (6)

(c) Why is valve overlap required in a four stroke engine? (4)

8. (a) Draw the pressure-crank angle diagram of a four stroke spark ignition engine to show the different stages of combustion in it. Discuss the stages of combustion from the diagram. (8)

(b) Differentiate between (i) swirl motion and squish motion in engine cylinder, (ii) ignition lag in S.I. engine and ignition delay in C.I. engine. (8)

9. In a trial of a four stroke, two cylinder diesel engine the following observations were made. Compression ratio = 18, fuel consumption = 9.5 kg/h, CV of fuel = 43500 kJ/kg, air consumption = 3.65 kg/min, speed = 2000 rpm, torque on the brake drum = 175 N-m, cooling water supplied = 16 kg/min, temperature rise of cooling water = 32°C, exhaust gas temperature = 410°C, ambient temperature = 20°C. The bore and stroke of the engine cylinder are 90 mm and 100 mm, respectively. Calculate the brake mean effective pressure, brake specific fuel consumption and brake thermal efficiency for the engine. Also draw a heat balance sheet of the engine indicating the percentage of the input energy flowing in different outputs. Assume the specific heat of the exhaust gas c_p= 1.17 kJ/kg-K. (16)

Table: 1 – Heat of formation and Heating Values

Species	Enthalpy of Formation (kJ/kmol)	Higher Heating Value (kJ/kg)	Lower Heating Value (kJ/kg)
CO_2	- 393520	-	
H_2O (v)	- 241820	-	
H_2O (l)	-285830	-	
CO	- 110530	-	
C_2H_6	- 84667	51901	47489
C_3H_8	- 103847	50368	46357
C_6H_6 (g)	82930	42270	40580
C_8H_{18} (g)	-208450	48260	44790

Table-2: $\Delta h = \left(h_T^0 - h_{298}^0\right)$ at different temperatures for species

Temperature (K)	$\Delta h = \left(h_T^0 - h_{298}^0\right)$ (kJ/kmol)				
	CO_2	CO	H_2O	O_2	N_2
298	0	0	0	0	0
500	8,301	5,943	6,947	6,097	5,920
800	22,810	15,176	18,005	15,838	15,046
1000	33,425	21,697	25,993	22,721	21,468
1500	61,681	38,847	48,181	40,590	38,404
2000	91,420	56,737	72,805	59,169	56,130
2200	103,562	64,020	83,160	66,773	63,360