Ref. No. : Ex/PE/T/321/2019

B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER, 2019

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

Answer questions from all parts. Questions of a part should be answered together.

Part – I 30 marks

1. Answer **any four** questions

4×5 = 20 marks

(i) Define equivalence ratio of a fuel-air mixture. Establish its relationship with percentage theoretical air and percentage excess air.

(ii) Define heating value of a fuel. What is the difference between higher heating value and lower heating value? Name a fuel for which these two will not be different.

(iii) Define chemical equilibrium constant. The equilibrium constant of the dissociation reaction $H_2 \Leftrightarrow 2H$ at 3000 K temperature and 1 atm pressure is K_p. Express the equilibrium constants of the following in terms of K_p – (a) $H_2 \Leftrightarrow 2H$ at 2 atm pressure, (b) $2H \Leftrightarrow H_2$ at 1 atm pressure, (c) $2H_2 \Leftrightarrow 4H$ at 1 atm pressure.

(iv) Differentiate between (a) molecularity and order of reaction, (b) global and elementary reactions. Give suitable examples.

(v) What do you mean by radicals? How do you classify reactions in a chain reaction mechanism based on the radicals? Give examples.

2. Answer **any one** question

10 marks

(i) A natural gas containing 80% methane and 20% ethane by volume is burned in a reactor with 150% theoretical air in a steady state, steady flow process. Heat is transferred from the reactor for process purpose and the products of combustion leave the reactor at 800 K. The fuel enters the chamber at 25°C and the air supply is preheated to 400 K. Write down the global reaction equation and determine the heat transfer from the reactor per kg of the fuel supplied. The reactor operates at atmospheric pressure.

Given: Enthalpy of formation: CO_2= -393520 kJ/kmol, CO= -110530 kJ/kmol, CH_4= -74850 kJ/kmol, C_2H_6= -84640 kJ/kmol

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
400	4003	2979	3458	3031	2973
800	22810	15176	18005	15838	15046

(ii) Consider the reaction CO + OH → CO_2 + H. The reaction rate expression is given as, $\dot{\omega}_f = 4.76\times10^7 T^{1.23}\exp\left(-\frac{70}{\bar{R}T}\right)[X_{CO}][X_{OH}]$, where the units are in gmol, cm^3, s, cal, K chosen suitably. Determine the specific reaction rate of the reverse reaction CO_2+H → CO+OH at 1800 K. Given, at 1800 K, $\frac{\bar{g}^o_{CO}}{\bar{R}T} = -34.74$, $\frac{\bar{g}^o_{OH}}{\bar{R}T} = -22.96$, $\frac{\bar{g}^o_{CO_2}}{\bar{R}T} = -57.42$, $\frac{\bar{g}^o_{H}}{\bar{R}T} = -1.63$.

Part – II 15 marks

3. Answer **any two** questions 2×7.5 = 15 marks
   (i) What do you mean by flammability limits? Why is a reactant mixture not flammable outside these limits in a confined environment? Do the limits hold in an unconfined environment also? – explain.

   (ii) Draw the stability diagram for an open laminar premixed flame and explain the characteristics of different zones shown in it. Why does the lift-off zone only occur on the rich side of fuel-air mixture?

   (iii) Differentiate between spontaneous ignition and forced ignition with examples. Derive an expression of minimum ignition energy in case of spark ignition igniting a flammable fuel-air mixture.

Part – III 20 marks

4. Answer **any two** questions 2×5 = 10 marks
   (i) How is the fuel-air cycle different from the air standard cycle for a spark ignition engine? – explain.

   (ii) With a neat sketch explain the operating mechanism of inlet valve in case of a four stroke engine.

   (iii) Name the different factors which result in the variation of the actual indicator diagram of a four stroke engine from its corresponding theoretical cycle diagram. Explain the effect of any one of these factors.

5. Answer **any one** question 10 marks
   (i) A car of 1250 kg mass is climbing a slope of 15°. The coefficient of rolling friction between the tyre and the road is 0.015 and the coefficient of drag is 0.3. If the frontal area of the car is 2 m^2 and the transmission efficiency is 92%, find the brake power required to drive the car at a steady speed of 25 km/h. Take the density of air as 1.12 kg/m^3.

   (ii) In an I.C. engine the engine cylinder has 90 mm bore and100 mm stroke length. The connecting rod is 5 times the crank radius. Determine the piston speed at 0°, 90° and 180° crank positions if the crank rotates at 2000 rpm.

Part – IV 20 marks

6. Answer **any two** questions 2×10 = 20 marks

   (i) Define volumetric efficiency. How does it depend on the engine load and exhaust gas recirculation? – explain.
   Why is the part load efficiency of a C.I. engine more than a S.I. engine?
   What is scavenging?

   (ii) Justify the requirements of air-fuel mixture quality at various steady-state and transient operations of a spark ignition engine.
   Explain the different methods of fuel injection in a C.I. engine cylinder with suitable sketches.

   (iii) How is 'detonation' in a S.I. engine different from 'knocking' in a C.I. engine? Explain the effects of compression ratio and engine speed on S.I.engine detonation and C.I.engine knocking.
   What are Octane number and Cetane number?

Part – V 15 marks

7. Answer **any one** question 15 marks

   (i) Following data were recorded during the test of a four stroke petrol engine.
   Air-fuel ratio = 15.5:1, Heating value of fuel = 42000 kJ/kg, mechanical efficiency = 84%, indicated thermal efficiency=37%. volumetric efficiency = 80%, stroke-bore ratio = 1.25, brake power = 72 kW, crank rpm = 2000. The ambient pressure and temperature may be taken as 1 bar and 27 C. Determine the brake specific fuel consumption, bore and stroke of the engine.

   (ii) A six cylinder, four stroke SI engine has 85 mm bore and 90 mm stroke length for the cylinders. The engine runs at 3600 rpm and produces a brake torque of 205 N-m at the dynamometer connected to it. The mechanical efficiency of the engine is 85%. Determine – brake power, indicated power, brake mean effective pressure, indicated mean effective pressure.