# B.E. POWER ENGINEERING THIRD YEAR SECOND SEMESTER, 2018

**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 three** questions 3×5 = 15 marks

(i) What is stoichiometric air-fuel mixture? If an air-fuel mixture has an equivalence ratio of 0.9, what percentage of air excess to stoichiometric is present in the mixture?

(ii) Define enthalpy of formation. How can you calculate the heating value of a hydrocarbon fuel using the relevant heat of formation data only?

(iii) Differentiate between higher heating value and lower heating value of a fuel. Which of these heating values will you use in calculating thermal efficiency of an Internal Combustion engine?

(iv) Define specific reaction rate of a combustion reaction. Express the specific reaction rate of the reverse step of a chemical reaction in terms of the specific reaction rate of the forward step and a thermodynamic quantity.

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

(i) A gaseous fuel mixture contains 70% methane, 12% hydrogen, 10% carbon dioxide and 8% nitrogen by volume. The fuel is completely burnt in air with the equivalence ratio of the fuel-air mixture being 0.7. Write down the stoichiometric reaction equation and find out the air-fuel ratio by mass. What is the mass fraction of water vapour in the product gas mixture?

(ii) A rigid vessel, acting as a combustion bomb, initially contains 3 kmol of carbon (solid) and 3 kmol of oxygen at 25°C temperature and 250 kPa pressure. Combustion occurs in the vessel to burn the carbon to 2.5 kmol carbon dioxide and 0.5 kmol carbon monoxide. The final temperature of the gas in the vessel is found to be 1100 K. Determine (i) the final pressure in the vessel and (ii) heat transfer from the vessel during the process.

Given:
Enthalpy of formation of $CO_2$= -393520 kJ/kmol, Enthalpy of formation of CO= -110530 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 |
| 500 | 8,301 | 5,943 | 6,947 | 6,097 | 5,920 |
| 1100 | 38,911 | 25,046 | 30,191 | 26,232 | 24,770 |

## Part – II 15 marks

3. Answer **any two** questions 2×7.5 = 15 marks

(i) Differentiate between a premixed and a non-premixed flame. Discuss their structures considering the flames to be established on a circular burner.

(ii) Define laminar burning velocity of a premixed fuel-air mixture. How does it depend on equivalence ratio and the temperature of the reactant mixture?

(iii) What do you mean by flashback and blow off of a premixed flame? Explain why these phenomena happen in a flame.

## Part – III 15 marks

4. Answer **any three** questions 3×5 = 15 marks

(i) For which type of I.C.engine dual combustion cycle is the air standard cycle? – Justify.

(ii) What do you mean by ram effect in internal combustion engine?

(iii) Derive an expression to relate the cylinder volume with crank angle in the internal combustion engine. Use standard nomenclature.

(iv) How does the spark timing affect the power output of a spark ignition engine?

## Part – IV 20 marks

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

(i) What is the function of carburetor in an engine? With a neat sketch, explain the working of a simple carburetor. What are the drawbacks of carburetor in engine?

(ii) Explain the different stages of combustion in a spark ignition engine. How is turbulence maintained in charge motion at the time of combustion? What is detonation in S.I. Engine?

(iii) Explain ignition delay in compression ignition engine. How do compression ratio, engine speed and engine load affect ignition delay? Define cetane number.

## Part – V 20 marks

6. Answer **any one** question 5 marks

(i) Define brake specific fuel consumption. How is it related to brake thermal efficiency?

(ii) What is a dynamometer? What are the different types of dynamometers used for testing I.C. Engines?

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

(i) In a test of a four cylinder, four stroke petrol engine of 80 mm bore and 105 mm stroke, the following results were obtained at full throttle at a constant speed and with a fixed setting of fuel supply of 0.084 kg/min.

bp with all cylinders firing = 16.54 kW
bp with cylinder 1 cut-off = 11.45 kW
bp with cylinder 2 cut-off = 11.38 kW
bp with cylinder 3 cut-off = 11.53 kW
bp with cylinder 4 cut-off = 11.40 kW

Estimate the indicated power of the engine under those conditions. If the heating value of the fuel is 42 MJ/kg, find the indicated thermal efficiency, mechanical efficiency and brake specific fuel consumption. If the engine operates at 1500 rpm, with an air-fuel ratio of 16.5 and the density of the fuel is 740 kg/m$^3$, find the volumetric efficiency. Take ambient pressure a 1.013 bar and temperature as 27°C.

(ii) A test on a single cylinder, four stroke diesel engine having bore of 15 cm and stroke 30 cm gave the following results:
Speed = 300 rpm, brake torque = 240 Nm, indicated mean effective pressure = 7 bar, fuel consumption = 2.4 kg/h, cooling water flow rate = 4.4 kg/min, cooling water temperature rise = 35°C, air-fuel ratio = 22, exhaust gas temperature = 410°C, barometer pressure = 1 bar, room temperature = 20°C, heating value of fuel = 42 MJ/kg.
Determine (i) indicated thermal efficiency, (ii) volumetric efficiency.
Draw up a heat balance sheet in terms of kJ/min. Take $c_p$ of exhaust gas as 1.1 kJ/kg K.