53 (ME 301) BTDM

2013

(December)

BASIC THERMODYNAMICS

Full Marks : 100

Pass Marks : 30

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions out of seven.*

1. *(a)* Distinguish between following with an example for each 8

   (i) Microscopic and macroscopic approaches of thermodynamics

   (ii) Homogenous and heterogenous systems

   (iii) System and Control volume

   (iv) Reversible and irreversible process

(b) Explain mechanical, chemical and thermal equilibrium. 6

(c) An engine cylinder has a piston area of $0.12\ m^2$ and containing gas at a pressure of $1.5\ MPa$. The gas expands according to a process which is represented by a straight line on P-V diagram. The final pressure is $0.15\ MPa$. Calculate the work done by the gas on the piston if the stroke length is $0.3m$. 6

2. (a) State Thermodynamics definition of work. Derive expression for displacement work in a polytropic process. 2+5=7

(b) Show that energy is a property of the system. 5

(c) A stationary mass of gas is compressed without friction from an initial state of $0.3m^3$ and $0.105\ MPa$ to a final state of $0.15m^3$ and $0.105\ MPa$, the pressure remaining constant during the process. There is transfer of $37.6\ kJ$ of heat from the gas during the process. How much does the internal energy of the gas change ? 8

3. *(a)* Explain with neat diagram the first law of thermodynamics for a closed system undergoing cycle. 6

(b) A gas undergoes a thermodynamic cycle consisting of three processes beginning at an initial state where P_1=1bar, V_1=1.5m and $U_1 = 512\,kJ$. The processes are as follows :

(i) Process 1–2 : Compression with PV = Constant to P_2 = 2bar and U_2=690 kJ

(ii) Process 2–3 : $W_{2-3} = 0$, $Q_{2-3} = -150\,kJ$ and

(iii) Process 3–1 : W_{3-1}=50kJ

Neglecting the KE and PE changes determine the heat interactions Q_{1-2} and Q_{3-1}. 8

(c) In a steady flow apparatus $135kJ$ of work is done by each kg of fluid. The Specific volume of fluid, pressure and the velocity at the inlet are $0.37\ m^3/kg$, $600\ KPa$ and $16\ m/s$. The inlet is $32m$ above the floor level and the outlet pipe is at the floor level. The outlet conditions are $0.62\ m^3/kg$, $100\ KPa$ and $270\,m/s$. The total heat loss between the inlet and outlet is $9\ kJ/kg$ of fluid. Find the decrease in internal energy. 6

4. (a) Give Kelvin-plank and Clausius statements of second law of thermodynamics. 4

(b) Explain with diagram the violation of Clausius statement leads to the violation of Kelvin-Plank Statement of second law of thermodynamics. 8

(c) A heat pump is used to meet the heating requirements of a house and maintains it at $20^{\circ}C$. On a day when the outdoor air temperature drops to $-2^{\circ}C$, the house is estimated to lose heat at a rate of $80{,}000\ kJ/hr$. If the heat pump under these conditions has a COP of 2.5, determine

(i) the power consumed by the heat pump

(ii) the rate at which heat is absorbed from the cold outdoor air. 8

5. (a) State and prove "Clausius inequality". 6

(b) Define entropy and prove that it is a property of a system. 6

(c) A manufacturer of heat engine claims that his company has developed an engine which produces 0.5 kW of work for a heat addition of $40\,kJ/min$. The heat is supplied at the temperature of $2000K$ and rejected at the temperature of $1000K$. Comment on his claim whether true or false. 8

6. (a) Explain with neat *P-V and T-S* diagram the working principle of 4–Stroke Diesel engine. 8

(b) Difference between 4-Stroke and 2-Stroke cycle engines. 6

(c) An ideal Diesel engine has a diameter $150mm$ and stroke $200mm$. The clearance volume is 10% of swept volume. Determine the compression ratio and the air standard efficiency of the engine if the Cut-off takes place at 6% of the stroke. 6

7. *(a)* Define the following with respect to steam formation

(i) Sub-cooled liquid

(ii) Dryness fraction

(iii) Latent heat of vaporization

(iv) Degree of super heat 8

(b) Draw pressure and volume diagram during formation of steam and indicate the following on the same.

(i) Saturated liquid line

(ii) Saturated vapour line

(iii) Critical point

(iv) Mixture of liquid and vapour. 8

(c) Steam at 5 bar, $250^{\circ}C$ expands isentropically to a pressure of 0.7 bar. Determine the final condition of steam. 4