Registration No. : | | | | | | | | | | |

Total number of printed pages – 4

B. Tech
BE 2103

Second Semester Regular Examination – 2014

THERMODYNAMICS

BRANCH(S) : ALL

QUESTION CODE : F 464

Full Marks – 70

Time : 3 Hours

Answer Question No. 1 which is compulsory and any five from the rest.
The figures in the right-hand margin indicate marks.

1. Answer the following questions : 2×10

(a) What do you mean by thermodynamic equilibrium and how it differs from thermal equilibrium ?

(b) Write the difference between the macroscopic and microscopic form of energy.

(c) Air in a Cylinder at an initial volume of 0.01 m^3 and initial pressure of 6 MPa expands following a Quasi-Static process given by $PV^{1.4}$ = Constant. If the final volume of the gas is 0.025 m^3, determine the work done by the gas.

(d) What is flow of work in a flow system ? How is it different from pdv work ?

(e) Which of the following integrals are properties ? Justify your answer.

(i) $\oint pdv$ (ii) $\oint d(pv)$ (iii) $\oint Tds$

(iv) $\oint d(TS)$ (v) $\oint du$ (vi) $\oint ds$

(f) Convert the following readings of pressure to KPa assuming that the Barometer reads 760 mm of Hg.

(i) 40 cm Hg Vacuum

(ii) 1.2 m of H_2O gauge.

(g) Differentiate between Nozzle and Diffuser and write the steady flow energy equation.

(h) Explain Clausius's Statement of Second Law and compare performance of Heat engine and Reversed Heat Engine.

(i) What do you understand by the entropy principle ?

(j) Show Phase diagram of a pure substance on P-T plane and Spot the Triple Point and Critical Point.

2. (a) Show that Energy is a property of a System. 4

(b) Three grams of nitrogen gas at 6 atm and 160 °C in a frictionless piston-cylinder device is expanded adiabatically to double its volume, then compressed at constant pressure to its initial volume and then compressed again at constant volume to its initial state. Calculate the net work done on the gas. Draw P-V diagram for the process. 6

3. (a) Draw all the Quasi-Static process on the same P-V diagram. 2

(b) A fluid is contained in a cylinder by a spring-loaded, frictionless piston so that the pressure in the fluid is a Linear function of the Volume (p = a + bV). The internal energy of the fluid is given by the following equation U = 42 + 3.6 pV, where U is in Kj,p is in KPa and V is in Cubic m. If the fluid changes from an initial state of 190 KPa, 0.035 m^3 to a final state of 420 KPa, 0.07 m^3, with no work other than that done on the piston, find the direction and magnitude of the work and heat transfer. 8

4. (a) Prove that $C_P - C_V = R$. 4

C_P = Specific heat at constant pressure

C_V = Specific heat at constant volume

R = Ideal gas constant

(b) 12 kg of air per minute is delivered by a centrifugal air compressor. The inlet and outlet conditions of air are V_1 =12 m/s, P_1 = 1 bar, v_1 = 0.5 m^3/kg and V_2 = 90 m/s,p_2 = 8 bar, v_2 = 0.14 m^3/kg. The increase in enthalpy of air passing through compressor is 150 kJ/kg and heat loss to the surroundings is 700 kJ/min. Assume that inlet and outlets are at same level. 6

Determine

(i) Motor power required to drive the compressor

(ii) Ratio of inlet to outlet pipe diameter.

5. (a) Prove that no heat engine working on a cycle between two fixed heat reservoirs can be more efficient than a reversible heat engine operating between the same two reservoirs. 4

(b) It is proposed to use a reversed Carnot engine as a refrigerator and also a heat pump. The Unit Consumes 10 kW power. If the C.O.P is 3.5 of a refrigerator, determine

(i) The Refrigerator capacity in kW

(ii) C.O.P if it is used as a heat pump

(iii) The heating capacity of the heat pump in kW.

Draw the schematic diagram of the reversed Carnot Cycle. 6

6. (a) What is Perpetual Motion Machine of the Second Kind ? Establish the law. 2

(b) A reversible heat engine operates between two reservoirs at temperature of 600 °C and 40 °C. The engine drives a reversible refrigerator which operates between reservoir at temperature of 40 °C and –20 °C. The heat transfer to the engine is 2000 kJ and net work output of the Combined engine-refrigerator plant is 360 kJ.

(i) Find the heat transfer to the refrigerator and the net heat transfer to the reservoir at 40 °C.

(ii) Find the heat transfer considering the efficiency of heat engine and the C.O.P of the refrigerator are each 40% of their maximum possible values. 8

7. (a) A Cylinder contains 0.45 m^3 of gas at 1×10^5 N/m^2 and 80 °C. The gas is compressed to a volume of 0.13 m^3 final pressure being 5×10^5 N/m^2. Determine 7

(i) Mass of the gas

(ii) Value of index 'n' for Compression

(iii) Increase in internal energy of the gas

(iv) Heat rejected or received by the gas during compression, $\gamma = 1.4$, $R = 294.2$ J/kgK.

(b) A heat engine receives 1200 kJ of heat from a thermal reservoir at 800 K and rejects 500 KJ to a thermal sink at 30 °C, while working on a Carnot Cycle, Check whether this engine satisfies the Second Law of thermodynamics and also whether the process is reversible or irreversible. 3

8. (a) Define Dryness fraction, degree of Superheat, Compressed Liquid and Latent heat of Vapourization. 2

(b) Steam is generated at 10 bar absolute pressure from water at 30 °C. Determine the heat Required to produce 1 k.g. of steam when 8

(i) Dryness Fraction is 0.9

(ii) Steam is dry saturated

(iii) Steam is superheated to 300 °C (Specific heat of superheated steam is 2.093 kJ/kg K)

(iv) Draw the P-V diagram and show the condition of steam for the above cases.