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12MTP14/13MTH14

First Semester M.Tech. Degree Examination, Dec.2013/Jan.2014

Thermodynamics and Combustion Engineering

Time: 3 hrs. Max. Marks: 100

Note: 1. ***Answer any FIVE full questions.***

2. Use of thermodynamic data handbook is permitted.

1 a. Derive an expression for displacement work if the system follows the law pv^n = const. For what value of 'n' the above derived work equation is invalid and hence suggest an equation to calculate the work for that value of 'n'. **(08 Marks)**

b. What are limitations of first law of thermodynamics? **(04 Marks)**

c. In a steam power station, steam flows steadily through a 0.2 m diameter pipeline form the boiler to the turbine. At the boiler end, the steam conditions are found to be: p = 4 MPa, t = 400°C, h = 3213.6 kJ/kg and v = 0.073 m^3/kg. At the turbine end, the conditions are found to be: p = 3.5 MPa, t = 392°C. h = 3202.6 kJ/kg, v = 0.084 m^3/kg. There is heat loss of 8.5 kJ/kg from the pipeline. Calculate steam flow rate. **(08 Marks)**

2 a. Show that a efficiency of a reversible heat engine is maximum when a reversible and an irreversible heat engines are operating between same temperatures. **(06 Marks)**

b. Explain the principle of increase of entropy. **(04 Marks)**

c. Air expands through a turbine from 500 kPa, 520°C to 100 kPa, 300°C. During expansion 10 kJ/kg of heat is lost to the surroundings which is at 98 kPa, 20°C. Neglecting the KE and PE changes, determine per kg of air:

i) The decrease in availability

ii) The maximum work

iii) Irreversibility

For air, take c_p = 1.005 kJ/kgK and assume that air behaves as a perfect gas. **(10 Marks)**

3 a. Derive an expression for maximum work obtainable from two finite bodies at temperature T_1 and T_2. **(06 Marks)**

b. Show that heat transfer through finite temperature difference is irreversible. **(06 Marks)**

c. Two Carnot engines work in series between the source and sink temperatures of 550 K and 350 K. If both engines develop equal power determine the intermediate temperature. **(08 Marks)**

4 a. Draw the phase equilibrium diagram for pure substance on P-T coordinates. Why does the fusion line for water have negative slope? **(05 Marks)**

b. Show that for an ideal gas, the slope of the constant volume line on T-S diagram is more than that of the constant pressure line. **(05 Marks)**

c. A mixture of gas has the following volumetric analysis:

O_2 = 30%, CO_2 = 40%, N_2 = 30%.

Determine:

i) The analysis on a mass basis.

ii) The partial pressure of each component, if the total pressure is 100 kPa and a temperature is 32°C.

iii) The molecular weight of mixture. **(10 Marks)**

5 a. Discuss the criterion for phase and reaction equilibrium. **(06 Marks)**

b. Explain the transport properties of substance and their significance. **(06 Marks)**

c. One kg mole of NH_3 undergoes a reversible non-flow isothermal compression and the volume decreases from 0.2 m^3/kg to 0.1 m^3/kg. the initial temperature being 45°C. If the gas obeys Vander Waal's equation during the compression, determine the work done during the process and final pressure. Take Vander Waal's constants for NH_3 a = 4.25 bar $(m^3/Kmol)^2$. b = 0.0373 m^3/kgmol. **(08 Marks)**

6 a. Explain briefly:

i) Degree of reaction

ii) Law of mass action

iii) Heat of reaction **(12 Marks)**

b. For the chemical reaction $CO_2 + H_2 \rightleftarrows CO + H_2O$ the equilibrium value of the degree of reaction at 1200 K is 0.56. Determine the equilibrium constant and the Gibbs function change. **(08 Marks)**

7 a. Explain with a simple sketch, the structure of a laminar premixed flame. **(08 Marks)**

b. Discuss the factors affecting laminar burning velocities. **(06 Marks)**

c. Explain over-ventilated and under ventilated diffusion flames. **(06 Marks)**

8 a. Explain the diffusion flames in spray combustion. **(10 Marks)**

b. Explain the following:

i) Pulverized coal burning

ii) Gas turbine combustion chamber. **(10 Marks)**

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