BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR, HOW-3

B.E. (Mech) Part-II 3rd Semester Final Examination, 2012

Subject : Fundamentals of Thermodynamics | Paper Code : ME-301

Branch : Mech. Engg.

Time : 3 hours | Full Marks : 70

Answer SIX questions, taking THREE from each half

The questions are of equal value

Use separate answer script for each half

FIRST HALF

1 (a) State Gibbs phase rule used for pure substance. Discuss in brief how this rule can be applied for single phase, two phase, and three phase systems.

(b) Discuss in brief Dalton's law and Amagats law. State the assumptions considered for these laws. From the analysis with respect to Dalton's law for the mixture of perfect gasses, prove the Amagats law for the said mixture.

2 (a) Write down the combustion equations and mention the significance of each equation in context of reactive gas mixture. Also deduce the expression of stoichiometric air-fuel ratio. Define mixture strength and dilution coefficient.

(b) The analysis of a fuel by weight is noted to be 81% C, 2% H_2, 4% O_2, 4%S, 1% N_2, and rest is moisture. Estimate (i) theoretical air-fuel ratio, (ii) % of excess air, and (iii) the quantity of dry and wet flue gases per kg of fuel. The results of the analysis of dry flue gas by volume are as 13% CO_2, 6% O_2, and 0.3% CO respectively.

3 (a) With the help of T-h and T-s diagrams, deduce the expressions for specific entropy of liquid, vaporization, and superheating. Also write the expressions of specific entropy for dry, wet and superheated vapours and mention the significance of each term of the expressions.

(b) In a steam turbine, steam expands isentropically from 100 bar and 520^0C to 0.01 bar. Calculate dryness fraction, specific enthalpy, specific entropy, and specific volume of steam after the expansion. Also compute the dryness fraction of steam at the exhaust of turbine when the exhaust pressure is increased to 0.1 bar. Use steam table.

4 (a) With the help of relevant T-s diagrams, explain in brief (a) saturated, humid and supersaturated air mixtures, and (b) dew point temperature, dry bulb temperature, and wet bulb temperature.

(b) From a Sling Psycrometer, dry bulb and wet bulb temperatures of a dry air and water vapour mixture are noted to be 26^0c and 18.5^0c respectively. If the atmospheric pressure is 1 bar, estimate (i) partial pressure of water vapour, (ii) relative humidity, (iii) dew point temperature, and (iii) saturation ratio of mixture.

5 Write short notes on any THREE of the following:

(i) Gibbs-Dalton law

(ii) Sling psychrometer

(iii) Throttling calorimeter

(iv) Psychrometric Chart

SECOND HALF

6 ~~1.~~ **(a)** Ice cube in a glass of liquid water will eventually melt and all the water will approach room temperature. Is this a reversible process?

(b) The steam supplied to an engine comprises of two streams which mix before entering the engine. One stream is supplied at the rate of 0.01 kg/s with an enthalpy of 2950 kJ/kg and a velocity of 20 m/s. the other stream is supplied at the rate of 0.1 kg/s with an enthalpy of 2665 kJ/kg and a velocity of 120 m/s. At the exit from the engine the fluid leaves as two streams, one of water at the rate of 0.001 kg/s with an enthalpy of 421 kJ/kg and other of steam. The fluid velocities at the exit are negligible. The engine develops a shaft power of 25 kW. The heat transfer is negligible. Evaluate the enthalpy of the second exit stream

(c) An inventor has developed a refrigeration unit that maintains the cold space at -10°C, while operating in a 25°C room. A coefficient of performance of 8.5 is claimed. How do you evaluate this?

7. ~~2.~~ **(a)** State with proper explanation whether the following statements are true or false:

(i) The process that violates the second law of thermodynamics also violates the first law of thermodynamics.

(ii) The change of entropy of a closed system must be greater than or equal to zero.

(b) 0.25 kg/s of water is heated from 30°C to 60°C by hot gases that enter at 180°C and leave at 80°C. Calculate the mass flow rate of gases when its specific heat at constant pressure is 1.08 kJ/kg-K. Find the entropy change of water and hot gases. Take specific heat of water as 4.186 kJ/kg-K. Also find the increase of unavailable energy if the ambient temperature is 27°C.

(c) What are the causes of irreversibility in a real process?

8. ~~3.~~ **(a)** Apply first law of thermodynamics to find the exit velocity from a nozzle.

(b) 36 gm of water at 30°C are converted into stream at 250°C at constant atmospheric pressure. The specific heat of water is assumed constant at 4.2 J/gm-K and latent heat of vaporization at 100°C is 2260 J/gm. For water vapour, assume equation of state as $PV = mRT$, where $R = 0.4619$ kJ/kg-K, and $\frac{c_p}{R} = a + bT + cT^2$, with $a =$ 3.634, $b = 1.195\times10^{-3}\ \mathrm{K}^{-1}$ and $c = 0.135\times10^{-6}\ \mathrm{K}^{-2}$. Calculate the entropy change of the system during the process.

(c) Air in a closed stationary system expands in a reversible adiabatic process from 0.5 MPa, 15°C to 0.2 MPa. Find the change in enthalpy and entropy, heat transfer and work done per kg of air.

9. ~~4.~~ **(a)** Show that entropy is a property of the system. What is the significance of temperature-entropy diagram?

(b) Consider an engine in outer space which operates on Carnot cycle between a hot reservoir at T_1 and a radiating panel at T_2. The only way in which heat can be transferred from the engine is by radiation. The rate at which heat is radiated is proportional to the fourth power of the absolute temperature and to the area of the radiating surface. Show that for a given power output and a given T_1, the area of the radiater will be maximum when $\frac{T_2}{T_1} = \frac{3}{4}$.

10. ~~5.~~ Write short notes on any THREE of the following:

(i) Steady Flow Energy Equation

(ii) The Inequality of Clausius

(iii) Heat Transfer in Polytropic Process

(iv) Loss of available energy due to heat transfer through finite temperature difference.