10ME/AU/TL33

Third Semester B.E. Degree Examination, Dec.2014/Jan.2015
Basic Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting atleast TWO questions from each part.***
2. Use of thermodynamic data handbook is permitted.

PART – A

1 a. Explain what do you understand by thermodynamic equilibrium. **(06 Marks)**

b. Name a few measurements or quantities that can be conveniently used as thermometric properties in order to quantify the temperature. **(04 Marks)**

c. What are intensive and extensive properties? Give examples for each. **(04 Marks)**

d. In 1709, Sir Issac Newton proposed a new temperature scale. On this scale, the temperature was a linear function of Celsius scale. The reading on this at ice point (0°C) and normal human body temperature (37°C) were 0°N and 12°N, respectively. Obtain the relation between the Newton scale and the Celsius scale. **(06 Marks)**

2 a. Show that heat and work are path function and not properties of the system. **(06 Marks)**

b. Specify the most widely used sign convention for work and heat interaction. **(04 Marks)**

c. List the difference between work and heat. **(04 Marks)**

d. The piston of an oil engine, of area $0.0045m^2$ moves downwards 75mm, drawing $0.00028m^3$ of fresh air from the atmosphere. The pressure in the cylinder is uniform during the process at 80kPa, while the atmospheric pressure is 101.325 kPa, the difference being due to the flow resistance in the induction pipe and the inlet valve. Estimate the displacement work done by the air. **(06 Marks)**

3 a. Describe the classic paddle wheel experiment performed by Joule. What conclusion was drawn based on the experimental observations? **(10 Marks)**

b. A turbo compressor delivers 2.33 m^3/s at 0.276 MPa, 43°C which is heated at this pressure to 430°C and finally expanded in a turbine which delivers 1860kW. During the expansion, there is a heat transfer of 0.09 MJ/s to the surroundings. Calculate the turbine exhaust temperature if changes in kinetic and potential energy are negligible. Assume for air R = 0.287 kJ/kg K, C_p = 1.005 kJ/kg K. **(10 Marks)**

4 a. What is thermal energy reservoir? Explain source and sink. **(04 Marks)**

b. Establish equivalence of Kelvin-Plank and Clausius statements. **(06 Marks)**

c. Two reversible heat engines A and B are arranged in series, A rejecting heat directly to B. Engine A receives 200kJ at a temperature of 421°C from a hot source, while engine B is in communication with a cold sink at a temperature of 4.4°C. If the work output of A is twice that of B, find:
i) The intermediate temperature between A and B.
ii) The efficiency of each engine.
iii) The heat rejected to the cold sink. **(10 Marks)**

PART – B

5 a. Establish the inequality of Clausius. **(08 Marks)**

b. What is available and unavailable energy? **(04 Marks)**

c. A lump of steel of mass 10kg at 627°C is dropped in 100kg of oil at 30°C. The specific heats of steel and oil are 0.5 kJ/kg K and 3.5 kJ/kg K respectively. Calculate the entropy change of steel, the oil and the universe. **(08 Marks)**

6 a. What is meant by a pure substance? Can we treat air as a pure substance? **(06 Marks)**

b. Name the widely used thermodynamic diagrams for a pure substance. **(04 Marks)**

c. The following observations were recorded in an experiment with a combined separating and throttling calorimeter.
Pressure in the steam main 15bar,
Mass of water drained from the separator 0.55kg,
Mass of steam condensed after throttle valve 4.2kg,
Pressure and temperature after throttling 1 bar, 120°C.
Evaluate the dryness fraction of the steam in the main. **(10 Marks)**

7 a. Show that the internal energy of an ideal gas is a function of temperature only. **(08 Marks)**

b. A gas of mass 1.5kg undergoes a quasistatic expansion which follows a relationship $P = a + bV$, where a and b are constants. The initial and final pressures are 1000kPa and 200kPa respectively and the corresponding volumes are $0.2m^3$ and $1.2m^3$. The specific internal energy of the gas is given by the relation $u = 1.5\ PV - 85$ kJ/kg, where P is the kPa and V is in m^3/kg. Calculate the net heat transfer and the max internal energy of the gas attained during expansion. **(12 Marks)**

8 a. Explain: i) Dalton's law of partial pressure; ii) Amagat's law of additive volumes; iii) Law of corresponding states. **(06 Marks)**

b. Explain generalized compressibility chart. **(04 Marks)**

c. A balloon of spherical shape 6m in diameter is filled with hydrogen gas at a pressure of 1 bar abs and 20°C. At a later time, the pressure of the gas is 94% of its original pressure at the same temperature.

i) What mass of the original gas must have escaped if the dimensions of the balloon is not changed.

ii) Find the amount of heat removed to cause the same drop in pressure at constant volume. Take C_v for hydrogen as 10400 J/kg K. **(10 Marks)**

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