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10ME/IP/IM/MA/AU/TL/PM/AE33

Third Semester B.E. Degree Examination, December 2011
Basic Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting at least TWO questions from each part.***
2. Use of thermodynamic data hand book is allowed.

PART – A

1 a. Distinguish between :
i) Open system and closed system.
ii) Macroscopic and microscopic approaches.
iii) Point function and path function.
iv) Intensive and extensive properties.
v) Diathermic and adiabatic walls. **(10 Marks)**

b. A thermocouple with test junction and T°C as a gas thermometer scale and reference junction at ice point given e.m.f. as $e = 0.20t - 5 \times 10^{-4} t^2$ mV. The milli voltmeter is calibrated at ice and steam point. What will b e the reading on this thermometer, where the gas thermometer reads 70°C? **(10 Marks)**

2 a. Distinguish between heat and work in thermodynamics. **(04 Marks)**

b. A system undergoes a process in which the pressure and volume are related by an equation of the form pv^n = a constant. Derive an expression for displacement work during this process. **(06 Marks)**

c. A cylinder contains 1 kg of certain fluid at an initial pressure of 20 bar. The fluid is allowed to expand reversible behind a piston according to a law $pv^2 = c$ until the volume is doubled, the fluid is then cooled reversibly at constant pressure until the piston regains its original positions, heat is then supply reversibly with the piston firmly locked in position until the pressure rises to the original value. Calculate the net work done by the fluid for an initial volume of 0.05 m^3. **(10 Marks)**

3 a. Starting from the first law of thermodynamics for a closed system undergoing a non – cyclic process derive the steady state, steady flow energy equation for a control volume (open system). **(06 Marks)**

b. The work and heat transfer per degree temperature change for a system executes a steady non – flow process are given by $\frac{dW}{dT} = \frac{1}{8}$ kJ/°C and $\frac{dQ}{dT} = 0.4$ kJ/°C. Determine the change in internal energy of the system, when the temperature increases from 100°C to 260°C. **(05 Marks)**

c. A fluid contained in a cylinder by a spring loaded frictionless piston so that the pressure in the fluid is the linear function of volume, P = a + bv. The internal energy of the fluid is given by u = 34 + 3.15 PV, where u is in kJ, p is in kPa and v is in m^3. If the fluid changes from 170 kPa, 0.03m^3 to a final state of 400 kPa and 0.06m^3 with no work other than that done on the piston. Find the magnitude and direction of heat and work transfers. **(09 Marks)**

4 a. State and prove that Kelvin planck and Clausius statements of second law of thermodynamics are equivalent. **(10 Marks)**

b. A reversible engine working in a cycle takes 4800 kg/min of heat from a source at 800 K and develops 20 kW power. The engine rejects heat to two reservoirs at 300 K and 360 K. Determine the heat rejected to each sink. **(10 Marks)**

PART – B

5 a. Show that entropy is a property. **(05 Marks)**

b. State and prove Clausius inequality. **(08 Marks)**

c. A heat engine absorbs 200 kJ/sec of heat at 227°C and rejects heat at 27°C. Three separate case of heat rejection are reported.
   i) 180 kJ/sec heat is rejected.
   ii) 120 kJ/sec heat is rejected.
   iii) 60 kJ/sec heat is rejected.
   Classify each cycle. **(07 Marks)**

6 a. Define the following :
   i) Pure substance
   ii) Triple point
   iii) Critical point
   iv) Quality and
   v) Subcooled liquid. **(10 Marks)**

b. A vessel of volume 0.04m^3 contains a mixture of saturated water and saturated steam at a temperature of 240°C. The mass of the liquid present is 8 kg. Find the pressure, the mass, the specific volume, the enthalpy, the entropy and the internal energy. **(10 Marks)**

7 a. Show that the change in entropy when a perfect gas undergoes a polytropic change pv^n = constant is given by the expression $s_2 - s_1 = \frac{\gamma - n}{n-1} c_v \ln\left(\frac{T_1}{T_2}\right)$. **(10 Marks)**

b. One kg of air initially at 1 bar and 160°C is compressed isothermally till the volume reduces to 0.28 m^3. Determine the work done, heat transfer, change in internal energy and the entropy. **(10 Marks)**

8 a. Obtain expressions for the constants 'a', 'b' and 'R' in terms of the critical properties for a vander waal gas. **(08 Marks)**

b. Write a note on compressibility factor and compressibility chart. **(06 Marks)**

c. Determine the pressure exerted by CO_2 in a container of 1.5 m^3 capacity when it contains 5 kg at 27°C using i) Ideal gas equation ; ii) Vander waals equation constants a and b are 365.6kN-m^2/(kg mol)^2 and b=0.0428m^3/kg-mol, $\overline{R}$ =universal gas constant = 8.3143 kJ/kg mol k. **(06 Marks)**

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