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10ME/AU/TL33

Third Semester B.E. Degree Examination, Dec.2013/Jan.2014
Basic Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: ***Answer FIVE full questions, selecting at least TWO questions from each part.***

PART – A

1 a. Distinguish between:
   i) Microscopic and macroscopic point of view.
   ii) Temperature and thermal equilibrium and
   iii) Intensive and extensive properties. **(06 Marks)**

b. Classify the following into open, closed and isolated system:
   i) Evaporator; ii) Thermoflask; iii) Passenger's train when stop at platform; iv) Refrigerant in a refrigerator; v) Pressure cooker; vi) I.C. engine during compression/expansion stroke; vii) Boiler and viii) Throttle valve. **(08 Marks)**

c. Define a Quasi-static process. A platinum wire is used as a resistance thermometer. The wire resistance was found to be 10ohm and 16ohm at ice point and steam point respectively, and 30ohm at sulphur boiling point of 444.6°C. Find the resistance of the wire at 750°C, if the resistance varies with temperature by the relation. $R = R_0(1 + \alpha t + \beta t^2)$. **(06 Marks)**

2 a. Does heat transfer inevitably causes a temperature rise? What is the other cause for rise in temperature? **(02 Marks)**

b. With a neat p-V diagram, derive an expression for workdone in each case of the following:
   i) Isochoric process.
   ii) Isobaric process.
   iii) Isothermal process and
   iv) Polytropic process. **(10 Marks)**

c. A piston device contains 0.05m^3 of a gas initially at 200kPa. At this state, a linear spring having a spring constant of 150 kN/m is touching the piston but exerting no force on it. Now heat is transferred to the gas, causing the piston to rise and to compress the spring until the volume inside the cylinder doubles. If the cross-sectional area of the piston is 0.25m^2, determine: i) a final pressure inside the cylinder; ii) the total work done by the gas and iii) the fraction of work done against the spring to compress it. **(08 Marks)**

3 a. For a non-flow system, show that the heat transferred is equal to the change in enthalpy of a system. **(04 Marks)**

b. A gas undergoes a thermodynamic cycle consisting of the following processes: i) Process 1-2: constant pressure P = 1.4 bar, $V_1 = 0.028\text{m}^3$, $W_{12} = 10.5\text{kJ}$; ii) Process 2-3: compression with pV = constant, $U_3 = U_2$ and iii) Process 3-1: constant volume, $U_1 - U_3 = -26.4$ kJ. There are no significance change in KE and PE. i) Calculate the net work for the cycle; ii) Calculate the heat transfer for the process 1 – 2; ii) Show that $\sum_{cycle} Q = \sum_{cycle} W$, and iv) Sketch the cycle on p-V diagram. **(08 Marks)**

c. In a certain steady flow process, 12 kg of fluid per minute enters at a pressure of 1.4 bar, density 25 kg/m^3, velocity 120 m/s and internal energy 920 kJ/kg. The fluid properties at exit are 5.6 bar, density 5 kg/m^3, velocity 180 m/s, and internal energy 720 kJ/kg. During the process, the fluid rejects 60 kJ/s of heat and rises through 60m. Determine work done during the process in kW. **(08 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

4 a. State the limitations of first law of thermodynamics. Illustrate with examples. **(04 Marks)**

b. Prove that Kelvin-Plank and Clausius statements of second law of thermodynamics are equivalent. **(06 Marks)**

c. A heat pump working on the Carnot cycle takes in heat from a reservoir at 5°C and delivers heat to a reservoir at 60°C. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 840°C and rejects heat to a reservoir at 60°C. The reversible heat engine also drives a machine that absorbs 30kW. If the heat pump extracts 17kJ/s from the 5°C reservoir, determine: i) the rate of heat supply from the 840°C source and ii) the rate of heat rejection to the 60°C sink. **(10 Marks)**

PART – B

5 a. Prove that whenever a system executes a compete cyclic process, the quantity $\oint \frac{dQ}{T} \leq 0$. Hence prove that entropy is a property of the system. **(08 Marks)**

b. Explain principle of increase of entropy. **(06 Marks)**

c. In a shell and tube heat exchanger 45kg of water per minute is heated from 30°C to 85°C by hot gases which enter the heat exchanger at 225°C. If the flow rate of gases is 90 kg/min, find the net change of entropy of the universe. **(06 Marks)**

6 a. Draw the phase equilibrium diagram for a pure substance on T-S plot with relevant constant property lines. **(05 Marks)**

b. What is the main objective of quality measurement? With a neat sketch, explain throttling calorimeter. **(07 Marks)**

c. What do you understand by degree of superheat? Steam initially at 1.5MPa, 300°C expands reversibly and adiabatically in a steam turbine to 40°C. Determine the ideal work output of the turbine per kg of steam. **(08 Marks)**

7 a. Derive Clausius Clayperon's equation for evaporation of liquid and explain the significance. **(06 Marks)**

b. Distinguish between: i) Ideal gas and real gas and ii) Perfect gas and semiperfect gas. **(04 Marks)**

c. 0.5 kg of air is compressed reversibly and adiabatically from 80kPa, 60°C to 0.4MPa and is then expanded at constant pressure and to the original volume. Sketch these processes on the p-V and T-s planes. Compute the heat transfer and work transfer for the whole path. **(10 Marks)**

8 a. Explain the following:

i) Generalized compressibility chart.

ii) Law of corresponding states and

iii) Compressibility factor. **(06 Marks)**

b. Derive Vander Waal's constants in terms of critical properties. **(08 Marks)**

c. Determine the pressure exerted by CO_2 in a container of 1.5m^3 capacity when it contains 5kg at 27°C. i) Using ideal gas equation and ii) Using Vander Waal's equation. **(06 Marks)**

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