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06ME/IP/IM/MA/AU33

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

Basic Thermodynamics

Time: 3 hrs. Max. Marks: 100

Note: 1. ***Answer FIVE full questions, selecting at least TWO questions from each part.***
2. ***Use of steam tables permitted.***

PART – A

1 a. Define : i) State ii) Process iii) System iv) Quasi-static process. **(04 Marks)**

b. With neat diagram, explain the working of constant volume gas thermometer for measurement of temperature. **(08 Marks)**

c. Define zeroth law of thermodynamics. A constant volume gas thermometer containing helium gas gives readings of gas pressure of 1000 and 1366 mm of Hg (mercury) at the ice and steam point respectively. i) Express the gas thermometer Celsius temperature in terms of gas pressure ii) The thermometer, when left standing in atmosphere, registers 1075 mm of mercury. Determine the atmospheric temperature. **(08 Marks)**

2 a. Starting from a convenient common state point on a P-V diagram, show the four expansion processes for $n = 0$, $n = 1$, $n = \gamma$ and $n = \infty$. What are these processes called and also discuss the work done during these processes. **(08 Marks)**

b. Show that the displacement work done by a closed system consisting of an ideal gas undergoing an isothermal expansion from state 1 to state 2 is given by $W_{1-2} = MRT_1 \ln \frac{V_2}{V_1}$. **(06 Marks)**

c. An engine cylinder has a piston of area 0.12 m^2 and contains gas at a pressure of 1.5 MPa. The gas expands according to a process which is represented by a straight line on a P-V diagram. The final pressure is 0.15 MPa. Calculate the work done by the gas on the piston if the piston stroke is 0.30 m. Show the process on P-V diagram. **(06 Marks)**

3 a. Using the first law of thermodynamics for a non-flow system, show that the heat transfer is equal to the enthalpy change of a system during constant pressure process. **(05 Marks)**

b. Showing the control volume approximately, modify the SFEE for the following cases: i) Adiabatic expansion of steam in turbine ii) Horizontal steam nozzle with negligible entrance velocity. **(06 Marks)**

c. A nozzle is a device used for increasing the velocity of a steadily flowing fluid. At inlet to a nozzle, the enthalpy of the fluid is 3000KJ/kg and velocity is 60 m/s. At the discharge end the enthalpy is 2762 KJ/kg. The nozzle is horizontal and the flow through the nozzle can be assumed to be adiabatic. Find i) The velocity of the fluid at the exit section of the nozzle ii) the mass flow rate through the nozzle if the area at the inlet section is 0.1 m^2 and the specific volume of the fluid at the inlet is 0.187 m^3/kg iii) if the specific volume at the exit section is 0.498 m^3/kg find the diameter of the exit section of the nozzle. **(09 Marks)**

4 a. State the Kelvin-plank and Clausius statements of the second law of thermodynamics and show that the violation of the former results in the violation of the latter. **(08 Marks)**

b. What is refrigeration and heat pump? Prove that $(COP)_{Heatpump} = (COP)_{Ref} + 1$ **(04 Marks)**

c. A perfect reversed heat engine is used for making ice at -5°C from water available at 25°C. The temperature of freezing mixture is -10°C. Calculate the quantity of ice formed per kwh. For ice, specific heat = 2.1 KJ/kgK and Latent heat 335 KJ/kg. **(08 Marks)**

PART – B

5 a. Prove that entropy is a property of a system. **(06 Marks)**

b. Starting from first law of thermodynamics. Show that the change in entropy for a reversible isobaric compression process is given by,

$$[S_2-S_1]=mC_p\log_e\left(\frac{T_2}{T_1}\right)$$ **(06 Marks)**

c. A fluid undergoes a reversible adiabatic compression from 0.5 MPa, 0.2 m^3 to 0.05 m^3 according to the law, $PV^{1.3}$ = Constant. Determine i) the change in enthalpy internal energy and entropy. ii) find the heat transfer and work transfer during the process. **(08 Marks)**

6 a. Derive an expression for decrease in available energy when heat is transferred through a finite temperature difference. **(07 Marks)**

b. What is the effectiveness of a system and how does it differ from efficiency? **(05 Marks)**

c. Calculate the decrease in available energy when 20 kg of water at 90°C mixes with 30 kg of water at 30°C, the pressure being taken as constant and the temperature of the surroundings being 10°C. Take C_p of water as 4.187 KJ/kgK. **(08 Marks)**

7 a. Select a point in a wet region and show the following processes starting from this common point on a h-s diagram for steam: i) Throttling of steam ii) Isobaric process to superheated state iii) Constant dryness fraction line iv) Isentropic compression till it becomes dry saturated v) Isothermal compression till it becomes superheated. **(05 Marks)**

b. Define i) Critical point ii) Triple point iii) Dryness fraction. **(06 Marks)**

c. What are limitations of throtting calorimeter? During a test to find the dryness fraction of steam with separating and throttling calorimeters in series, the following readings were obtained:

Pressure of steam in the main steam pipe – 10 bar

Manometer reading after throttling – 956 mm of water

Barometer reading – 754.91 mm of Hg

Temperature of steam after throttling - 111°C

Condensate from throttling calorimeter – 0.5 kg

Drainage from separating calorimeter – 28.5 kg

Calculate the dryness fraction of the entering calorimeter from the boiler assuming C_P of super heated steam as 2.1 KJ/kgK. **(09 Marks)**

8 a. Derive Vander Waal's constant's in terms of critical properties. **(08 Marks)**

b. Explain briefly Dalton's law and Gibbs-Dalton law. **(06 Marks)**

c. A steel flask of 0.04 m^3 capacity is to be used to store nitrogen at 120 bar 20°C. The flask is to be protected against excessive pressure by a fusible plug which will melt and allow the gas to escape if the temperature rises too high.

i) How many kg of nitrogen will the flask hold at the designed conditions?

ii) At what temperature must the fusible plug melt in order to limit the pressure of a full flask to a maximum of 150 bars? **(06 Marks)**

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