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10ME/AU33

Third Semester B.E. Degree Examination, June/July 2015
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 thermodynamic data hand book permitted.***

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.

PART – A

1 a. What do you mean by thermodynamic equilibrium? How does it differ from thermal equilibrium? **(05 Marks)**

b. State zeroth law of thermodynamics. Write its importance in thermodynamics. **(04 Marks)**

c. Consider a particular celsius scale assigned the value of 0°C to steam point and 100°C to ice point.

i) Using ideal gas as the thermometer medium, setup a relationship between 0°C and pressure for a constant volume thermometer, proceed to derive the correction between the two Celsius scales. At what temperature are the two scales are numerically equal?

ii) What is the numerical value of absolute zero for the particular scale? What is 200 K in °C? **(07 Marks)**

d. Two Celsius thermometers A and B with temperature readings T_A and T_B agree at ice point and steam point, but else where they are related by $T_A = p + qT_B + rT_B^2$, where p, q and r are constants. When the thermometers are immersed in an oil bath, A shows a temperature of 51°C, while B shows 50°C. Determine the temperature T_A, when T_B is 25°C. **(04 Marks)**

2 a. Define work and heat. Write the similarities and dissimilarities between them. **(06 Marks)**

b. An automobile vehicle of 1500 kg is running at a speed of 60 km/hr. The brakes are suddenly applied and the vehicle is brought to rest. Calculate the rise in temperature of brake shoes, if their mass is 15 kg. Take the specific heat of brake shoe material as 0.46 KJ/kgK. **(06 Marks)**

c. A quantity of gas is compressed in a piston-cylinder from a volume of 0.8611 m^3 to a final volume of 0.17212 m^3. The pressure (in bar) as a function of volume (m^3) is given by,

$$P = \frac{0.86110}{V} - \frac{8.60673 \times 10^{-5}}{V^2}$$

i) Find the amount of work done in KJ.

ii) If the atmospheric pressure, i.e., 1 bar acting on the other side of piston is considered, find the net work done in KJ. **(06 Marks)**

d. State direction of heat transfer and work transfer in a viscous fluid is stirred by a paddle wheel in an insulated closed tank. **(02 Marks)**

3 a. What is a perpetual motion machine of first kind? Why is it impossible? **(03 Marks)**

b. Apply steady flow energy equation to each of the following:
i) Boiler ii) Nozzle iii) Centrifugal pump. **(06 Marks)**

c. 1200 kg car cruising steadily on a level road at 90 km/hr. Now the car starts climbing a hill that is sloped 30° from the horizontal. If the velocity of the car is to remain constant during climbing, determine the additional power that must be delivered by the engine. **(04 Marks)**

d. A centrifugal pump delivers 50 kg of water per second. The inlet and outlet pressure are 1 bar and 4.2 bar respectively. The suction is 2.2 m below the centre of the pump and delivery is 8.5 m above the centre of the pump. The suction and delivery pipe diameters are 200 mm and 100 mm, respectively. Determine the capacity of electric motor to run the pump. **(07 Marks)**

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4 a. Prove that a reversible engine is more efficient than an irreversible engine operating between the same temperature limits. **(06 Marks)**

b. A house hold refrigerator maintains a space at a temperature of 0°C. Every time the door is opened, warm material is placed inside, introducing an average 400 KJ of heat, but making only a small change in temperature of the refrigerator. The door is opened 25 times a day and the refrigerator operates at 25% and ideal COP. The cost of work is 3.50 per kWh. What is the monthly bill of this refrigerator? The atmospheric temperature is at 30°C. **(06 Marks)**

c. Explain the second law of thermodynamics with reference to Kelvin Planck's statement and Clausius statement hence prove that both the statements are equivalent to each other although they appear to be different. **(08 Marks)**

PART – B

5 a. Prove that for a system executing a cyclic process $\oint \frac{\delta Q}{T} \leq 0$, hence define entropy. **(08 Marks)**

b. In a certain heat exchanger, 50 kg of water is heated per minute from 50°C to 110°C by hot gases which enter the heat exchanger at 250°C. If the flow rate of gases is 100 kg/min, estimate the net change of entropy.
$C_p(\text{water}) = 4.186\ KJ/kgK$, $C_p(\text{gas}) = 1\ KJ/kgK$. **(06 Marks)**

c. A piston-cylinder arrangement contains 0.03 m^3 of nitrogen at 1 bar and 290 K. The piston moves inwards and the gas is compressed isothermally and reversibly until the pressure becomes 4 bar. Determine change in entropy and work done. Assume nitrogen to be a perfect gas. **(06 Marks)**

6 a. Define the following : i) Tripple point ii) Critical temperature iii) Dryness fraction iv) Saturation temperature. **(04 Marks)**

b. Sketch and explain the construction and working of a separting and throttling calorimeter used for determining the dryness fraction of steam in a boiler. **(08 Marks)**

c. Identify the type of steam in the following three cases, using the steam tables and giving necessary calculations supporting your claim.
i) 2 kg of steam at 8 bar with an enthalpy of 5538.0 KJ at a temperature of 170.4°C.
ii) 1 kg of steam at 2550 kPa occupies a volume of 0.2742 m^3. Also find the steam temperature.
iii) 1 kg and steam at 60 bar with an enthalpy of 2470.73 kJ/kg. **(08 Marks)**

7 a. Write notes on the following: i) Clausius-Clapeyron equation. ii) Maxwells equations. **(08 Marks)**

b. Derive an expression for change in entropy for an ideal gas undergoing i) an isobaric process and ii) a polytropic process. **(06 Marks)**

c. One kg of air undergoes a cycle composed of the following three reversible processes.:
i) Constant pressure expansion from 0.1 MPa and 300 K to 400 K.
ii) Constant volume cooling to 300 K.
iii) An isothermal compression to restore the gas to 0.1 MPa.
Sketch the P-V diagram for the above cycle and estimate the entropy changes for the three processes. **(06 Marks)**

8 a. Write notes on the following: i) Compressibility factor ii) Compressibility chart iii) Law of corresponding states. **(09 Marks)**

b. A volumetric analysis of a gaseous mixture yields the following results:
$CO_2 = 12\%$, $O_2 = 4\%$, $N_2 = 82\%$, $CO = 2\%$.
Determine the analysis on a mass basis, and the molecular weight and the gas constant on a mass basis for the mixture. Assume ideal gas behavior. **(08 Marks)**

c. Define the terms partial pressure mole fraction, volume fraction of a gas constituent in a mixture. **(03 Marks)**

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