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Total No. of Questions : 08

M.Tech. (ME) (2017 Onwards) (Sem.–1)

ADVANCED THERMODYNAMICS

Subject Code : MTME-105

M.Code : 74719

Time : 3 Hrs. Max. Marks : 100

INSTRUCTIONS TO CANDIDATES :

1. Attempt any FIVE questions out of EIGHT questions.
2. Each question carries TWENTY marks.

l. Show that the Joule-Thomson coefficient, □ is given by □ = 1 / cp (T (□v / □T)p – v)

Hence or otherwise show that the inversion temperature (Ti) is Ti = (□T/□v)pv. (20)

2. Derive an expression for the sound speed (c2 = – v2 (□P / □v)s = v/□s) in terms of the measurable properties of a simple compressible substance.

Show that cp/cv = □ = □T/□s. Determine a relation for the sound speed for an ideal gas.

Determine a relation for the sound speed for a VW gas. (20)

3. a) A rubber product contracts upon heating in the atmosphere. Does the entropy increase or decrease if the product is isothermally compressed? Discuss with proof. (10)

b) For a steady state process involving an open system dmcv/dt = 0, i.e., mcv is constant. Is this always true for a closed system? Comment with suitable examples (if any). (10)

4. a) Obtain an expression for dh and du for a liquid in terms of cp, □p, □T, cv, dT and dP. Simplify the relations for an incompressible liquid. (10)

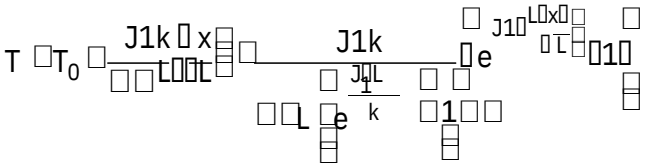
b) What is physical interpretation of cv and cp? (10)

5. Consider the metabolism of glucose in the human body. As we breathe in air, we transfer oxygen from our lungs into our bloodstream. That oxygen is transported to the cells of our tissues where it oxidizes glucose. Write down the stoichiometric reaction for the consumption of glucose (s) C6H12O6 by pure oxygen and by air. Determine : a) The amount of air required if 400% excess air is involved.

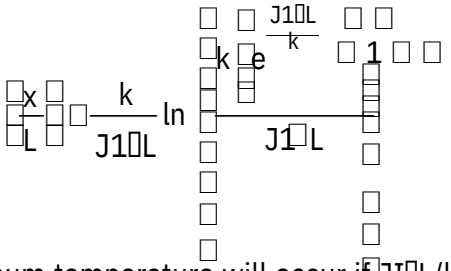
b) Express (A:F) in terms of the percentage of theoretical air and the equivalence ratio. c) Write the associated reaction equation. If the human breathing rate □□ 360 L(STP) hr–1. d) How much glucose is consumed per minute?

6. A steel casting weighing 20 kg is removed from a furnace at a temperature of 800°C and heat treated by quenching in a bath containing 500 kg water at 20°C Calculate the change in availability of the universe due to this operation. The specific heat of the water is 4.18 KJ/kg K, and that of steel is 0.42 KJ/kg K. Assume that the bath of water is rigid and perfectly insulated from the surroundings after the casting has been dropped in, and take the datum temperature and pressure as 20°C and 1 bar respectively. (20)

7. A thermal conductor of constant cross-sectional area connects two reservoirs which are both maintained at the same temperature, T0. An electric current is passed through the conductor, and heats it due to Joulean heating and the Thomson effect. Show that if the thermal and electrical conductivities, k and □, and the Thomson coefficient, □, are constant, the temperature in the conductor is given by



Show that the maximum temperature is achieved at a distance



Evaluate where the maximum temperature will occur if JI□L/k = 1, and explain why it is not in the centre of the bar. Show that the maximum temperature achieved by Joulean heating alone is in the centre of the conductor. (20)

8. Find the maximum work deliverable in a fuel cell by 1 kmole of H2 with O2 if it is isothermally reacted at 25°C and 1 bar to produce liquid water. Both reactants enter the cell separately. Determine the maximum voltage developed by the fuel cell. Consider also the scenario for the reaction of a stoichiometric amount of H2 with O2. What is the maximum possible fuel cell efficiency? Assume that □□h-1c = 285830 kJkmole. (20)

NOTE : Disclosure of Identity by writing Mobile No. or Marking of passing request on any paper of Answer Sheet will lead to UMC against the Student.