UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

**End Semester Examination, December 2017**

**Program Name: M.Tech rotating Equipment** **Semester – I**
**Course Name : Advanced Thermodynamics and heat transfer** **Max. Marks : 100**
**Course Code : MERE-7002** **Duration : 3 Hrs**
**No. of page/s:**

**Note:**
**Steam table is allowed**

## Section- A (Attempt all of the following) (20)

1. Explain the throttling process for an ideal gas. (4)
2. Define fin effectiveness. When the use of fins is not justified. (4)
3. Explain the effect of temperature on the emissivity of surfaces. (4)
4. Define the terms irradiation and radiosity. Establish a relationship between them. (4)
5. Define absorptivity, reflectivity and transmissivity. (4)

## Section- B (Attempt all of the following) (40)

6. If a thin and long fin, insulated at its tip is used show that the heat transfer from the fin is given by $Q_{fin}= \sqrt{hpkA_c}\ (T_0 - T\infty)$ tanh ml. (5)
7. Derive the first and second Tds equation. (5)
8. Explain the concept of black body? What are its properties? Why does a cavity with a small hole behave as a black body? (5)
9. Water is to be heated at constant pressure from 25°c to 80°c .If the heat source is at constant temperature of 500°c and the ambient temperature is 20°c, what would be the gain in availability of water and effectiveness of the heating process. For water $c_p$=4.187kj/kgK. (5)

**10.** Explain the concept of reversible and useful work? Derive the expression for useful work for a closed system. (5)

**11.** A 1 m long, 5 cm diameter, cylinder placed in an atmosphere of $40^{o}C$ is provided with 12 longitudinal straight fins(**k =** 75 W/m.K), 0.75 mm thick. The fins protrudes 2.5 cm from the cylinder surface. The heat transfer coefficient is 23.3 $W/m^2$ .K. Calculate the rate of heat transfer, if the surface temperature of cylinder is at $150^{o}C$. (5)

**12.** A pressure vessel has a volume of 1 m3 and contains air at 1.4 MPa, 175°C. The air is cooled to 25°C by heat transfer to the surroundings at 25°C. Calculate the availability in the initial and final states and the irreversibility of this process. Take $P_0$= 100 kPa.

$C_p$ = 1.005 kJ/kg – K, $C_v$ = 0.718 kJ/kg – K; R = 0.287 kJ/kg – K (5)

**13.** A closed system contains 2 kg of air and during an adiabatic expansion process there occurs, a change in its pressure from 500KPa to 100KPa and in its temperature from 350 to 320K,if the volume doubles during the process ,make calculation for the maximum work ,the change in availability and irreversibility. $C_v$=0.718kj/kgK and R=0.287 kj/kgK, the surrounding conditions may be assumed to 10KPa and 300K. (5)

## Section -C (Attempt the following) (40)

**14.** (a) Discuss overall heat transfer coefficient. Obtain an expression for overall heat transfer coefficient based inner diameter of a hollow cylinder? (10)

(b) Two large parallel plates at temperature 1000 K and 600 K have emissivity of 0.5 and 0.8 respectively. A radiation shield having emissivity 0.1 on one side and 0.05 on the other side is placed between the plates. Calculate the heat transfer rate by radiation per square metre with and without radiation shield. (10)

**15.** (a) An aluminium block (*cp* = 400 J/kg K) with a mass of 5 kg is initially at 40°C in room air at 20°C. It is cooled reversibly by transferring heat to a completely reversible cyclic

heat engine until the block reaches 20°C. The 20°C room air serves as a constant temperature sink for the engine. Compute (i) the change in entropy for the block, (ii) the change in entropy for the room air, (iii) the work done by the engine. If the aluminium block is allowed to cool by natural convection to room air, compute (i) the change in entropy for the block, (ii) the change in entropy for the room air (iii) the net the change in entropy for the universe..
(10)

(b) A long rod of radius 50 cm with thermal conductivity of 10 W/m. K contains radioactive material, which generates heat uniformly within the cylinder at a rate of $0.3x10^5$ W/m$^3$. The rod is cooled by convection from its cylindrical surface at T∞ = 50$^o$ C with a heat transfer coefficient of 60 W/m$^2$. K. Determine the temperature at the centre and outer surface of the cylindrical rod. (10)

**OR**

(c) Consider a thorium (**k =** 54 W/m.K) fuel rod, 20 mm in diameter has a thin aluminium (**k** = 237 W/m.K) cladding 2 mm in thickness. The aluminium losses its mechanical strength above temperature 427$^o$C. If the rod is exposed to a fluid at 90$^o$C with h= 6000W/m$^2$.K. Is the system safe, if the heat generation rate in the thorium rod is $4x10^8$ W/m$^3$ ? (10)