國立成功大學

115學年度碩士班招生考試試題

編　號：106

系　所：生物醫學工程學系

科　目：熱力學

日　期：0203

節　次：第 1 節

注　意：1.可使用計算機
2.請於答案卷(卡)作答，於試題上作答，不予計分。

1. If $h = h(T, P)$ and $s = s(T,P)$, please show that $dh = C_p dT + [v - T(\partial v/\partial T)_P]dP$. (15 pts)

2. Consider a rigid and evacuated container (bottle) of volume $\forall$, as in below figure left, that is surrounded by the atmosphere (T_0, P_0). At some point in time, the neck valve of the bottle opens, and atmospheric air gradually flows in. The wall of the bottle is thin and conductive enough so that the trapped air and the atmosphere eventually reach thermal equilibrium. At the end, the trapped air and the atmosphere are also in mechanical equilibrium because the neck valve remains open. (25 pts)
   (1) Please determine the net heat transfer interaction, in terms of T_0, P_0 or $\forall$ that take place through the wall of the bottle during the entire filling process. Points will not be given if mathematical derivation is not shown. (15 pts)
   (2) Consider the same rigid tank contains ideal gas of unit mass in the beginning, with the temperature equals to the atmosphere ($T = T_0$), but pressure equals to P. The atmospheric conditions are T_0 and P_0. Please derive the equation of availability, in terms of T_0, P_0, P and gas constant R. (10 pts)

3. A 100 kg copper block initially at 95°C (ρ_{copper} = 8930 kg/m^3, C_{copper} = 0.385 kJ/Kg·K) dropped into a adiabatic tank that contained 200 L of water at 25°C. Please determine: (10 pts)
   (1) the final equilibrium temperature? (5 pts)
   (2) the total entropy changes of this process? (5 pts)

4. In a planned hydrogen storage facility an expander (turbine with heat transfer) brings 0.5 kg/s hydrogen gas from 1200 kPa, 600^{o}C to 400 kPa. Assume the process is a polytropic process with n = 1.5, $C_{p,\,hydrogen}$ = 14.21 kJ/kg·K Please determine: (15 pts)
   (1) work and heat transfer? (10 pts)
   (2) Entropy generation in the expander? (5 pts)

5. Prove that $C_p - C_v = R$ using the thermodynamic relations. (15 pts)

6. During a cardiac surgery, an extracorporeal blood-warming device is used to bring the patient's blood from room temperature to near body temperature before it is returned to the circulation. The device can be modeled as a steady-flow heater. Blood can be approximated as an incompressible fluid with constant specific heat C_p = 4.0 kJ/kg·K. The blood enters the device at 20°C and leaves at 36°C. The mass flow rate of blood is 0.25 kg/s. The operating room temperature is 25°C and can be taken as the ambient temperature T_0. Kinetic and potential energy changes can be neglected. (20 pts)
   (1) Determine the required rate of heat transfer to the blood (in kW). (5 pts)
   (2) Determine the rate of entropy change of the blood as it flows through the device (in kW/K). (5 pts)
   (3) Assuming the heater is electrically powered and perfectly insulated from the surroundings (i.e., no heat loss to the room air), determine the rate of entropy generation and the rate of exergy destruction associated with this process. Comment briefly on the thermodynamic irreversibility of this medical device. (10 pts)