編號： 162

國立成功大學 109 學年度碩士班招生考試試題

系　　所：生物醫學工程學系

考試科目：熱力學

考試日期：0210，節次：1

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. Please describe the followings (20 pts)
   (1) The difference between Carnot efficiency and isentropic efficiency. (6 pts)
   (2) 1st law, 2nd law and 3rd law of thermodynamics using ONLY mathematical statement, no points will be given if the mathematical statement is not shown. (6 pts)
   (3) Based on Clausius inequality, please derive the entropy change of an irreversible process from two fixed states (ΔS_{irr}), considering ideal gas in a closed system. (8 pts)

2. A 10 kg piston in a cylinder with diameter of 200 mm is loaded with a linear spring and the outside atmospheric pressure of 100 kPa. The spring exerts no force on the piston when it is at the bottom of the cylinder, where the pressure is 500 kPa with volume 0.5 L. The valve is opened to let some air in, causing the piston to rise 3 cm. Find the new pressure. (10 pts)

3. Consider an actual heat engine with efficiency of η working between reservoirs at T_H and T_L. Please prove that: (15 pts)
   (1) If the heat engine is ideal then $\eta = 1 - \frac{T_L}{T_H}$ (7 pts)
   (2) If the heat engine is non-ideal then $\eta \leq \eta_{Carnot}$ (8 pts)

4. A drag force on a car, with frontal area A = 4 m^2, driving at 100 km/h in air at 25 °C with $F_d = 0.225 \cdot A \cdot \rho_{air} \cdot V^2$. How much power is needed and what is the traction force? (10 pts)

5. A silicon wafer of volume 0.2 L is heat treated at 200°C and now cooled in a 100-L closed air box initially at 25°C, 101 kPa. The box itself consists of 5 kg stainless 304 steel which has the same temperature as the air. Assuming no heat transfer with the surroundings, what is the final uniform temperature of all the masses? What is the final air pressure? C_{steel} = 0.46 kJ/kg·K, C_{si} = 0.7 kJ/kg·K, ρ_{si} = 2330 kg/m^3, $C_{V,air}$ = 0.717 kJ/kg ·K, R_{air} = 0.287 kJ/kg·K (15 pts)

6. If $u = u(T, v)$ and $s = s(T,v)$, please show that $du = C_v dT + \left[T\left(\frac{dP}{dT}\right)_v - P\right] dv$. (15 pts)

7. In a planned hydrogen storage facility an expander (turbine with heat transfer) brings 0.2 kg/s hydrogen gas from 1200 kPa, 600°C to 400 kPa. Assume the process is a polytropic process with n = 1.5. What are the (1) work? (2) heat transfer (3) Entropy generation in the expander? $C_{p,\,hydrogen}$ = 14.21 kJ/kg·K (15 pts)