※ 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) 1^{st} law, 2^{nd} law and 3^{rd} law of thermodynamics using ONLY mathematical statement, no points will be given if the mathematical statement is not shown. (8 pts)
   (2) Clapeyron equation, both description and mathematical expression. (6 pts)
   (3) A H_2O barometer located in a room at 24℃ has a height of 11 m. What is the atmospheric pressure in kPa? (6 pts)

2. A 90 kg copper block initially at 90°C (ρ_{copper} = 8930 kg/m^3, $C_{coppeer}$ = 0.385 kJ/Kg·K) dropped into a adiabatic tank that contained 200 L of water at 25°C. Please determine: (15 pts)
   (1) the final equilibrium temperature? (7 pts)
   (2) the total entropy changes of this process? (8 pts)

3. A cylinder fitted with a piston has an initial volume of 0.5 m^3 and contains nitrogen at 200 kPa 27℃. The piston is moved, compressing the nitrogen until the pressure is 2 MPa and the temperature is 180℃. During this compression process heat is transferred from the nitrogen, and the work done on the nitrogen is 40 kJ. Determine the amount of heat transfer. (15 pts)

4. 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)

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5. If h = h(T, P) and s = s(T,P), please show that $dh = C_p dT + [v - T(\partial v/\partial T)_P]dP$. (10 pts)

6. Please develop an expression for the change in internal energy of a gas which follows the equation of state $P = \frac{RT}{v-b} - \frac{a}{v^2}$. (15 pts)