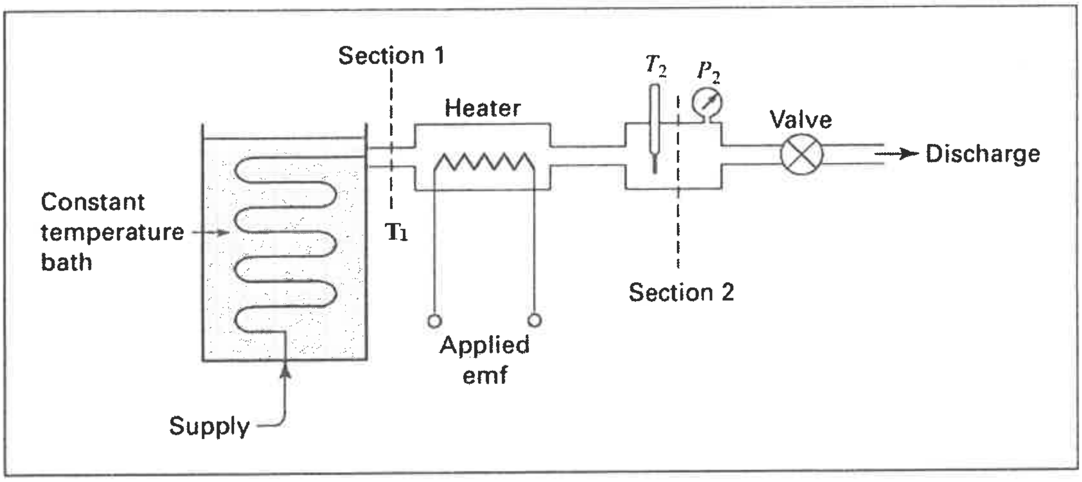
國立雲林科技大學 108 學年度 碩士班招生考試試題

系所：化材系
科目：化工熱力學

1. [9%]

A simple flow calorimeter is illustrated schematically in the figure below.



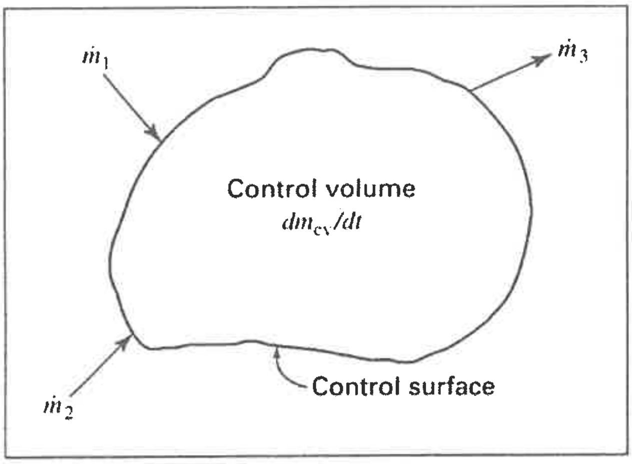

(1) What is the function for the flow calorimeter? [3%]

(2) Write the energy balance equation for the process, assuming that both kinetic- and potential energy are negligible and there is no shaft work. [3%]

(3) If the test fluid is water, flow rate = 4.15 g $s^{-1}$, $T_1$ = 0 ℃, $T_2$ = 300 ℃, $P_2$ = 3 bar, rate of heat addition from resistance heater = 12,740 W. The water is completely vaporized in the process. Calculate the enthalpy of steam at 300 ℃，3 bar based on H = 0 for $H_2O(l)$ at 0 ℃. [3%]

2. [18%]

According to the schematic representation of a control volume for an open system,



(1) What is the *continuity equation* for the mass balance? The expression should include $\frac{dm_{cv}}{dt}$ and $u$(velocity), $A$(cross-sectional area), $\rho$(density). [3%]

(2) What is the mathematical condition for a steady-state based on the equation given in (1)? [3%]

(3) Write the complete energy balance with a mathematical expression, including $\frac{d(mU)_{cv}}{dt}$, $\dot{m}$ , enthalpy change( $\Delta$ H), $\dot{Q}$, and $\dot{W}$ (Assume potential energy and kinetic energy are negligible). [3%]

(4) What is the mathematical condition for a steady-state, steady-flow process based on the equation given in (3)? [3%]

(5) Write an energy balance equation for a steady-state, steady-flow process based on (3) if kinetic- and potential energy are negligible and the mechanical work is $W_s$ only. [3%]

(6) Derive the expression for a closed system starting from (5). [3%]

3. 【9%】

Air flows at a steady rate through a horizontal pipe to a partly closed valve. The pipe leaving the valve is enough larger than the entrance pipe that the kinetic-energy change of the air as it flows through the valve is negligible. The valve and connecting pipes are well insulated. The conditions of the air upstream from the valve are 20℃(293.15 K) and 6 bar, and the downstream pressure is 3 bar. If air is regarded as an ideal gas, and the system is insulated, making Q negligible. The potential –energy and kinetic-energy changes are negligible.

(1) What is ΔH value for this process? [3%]

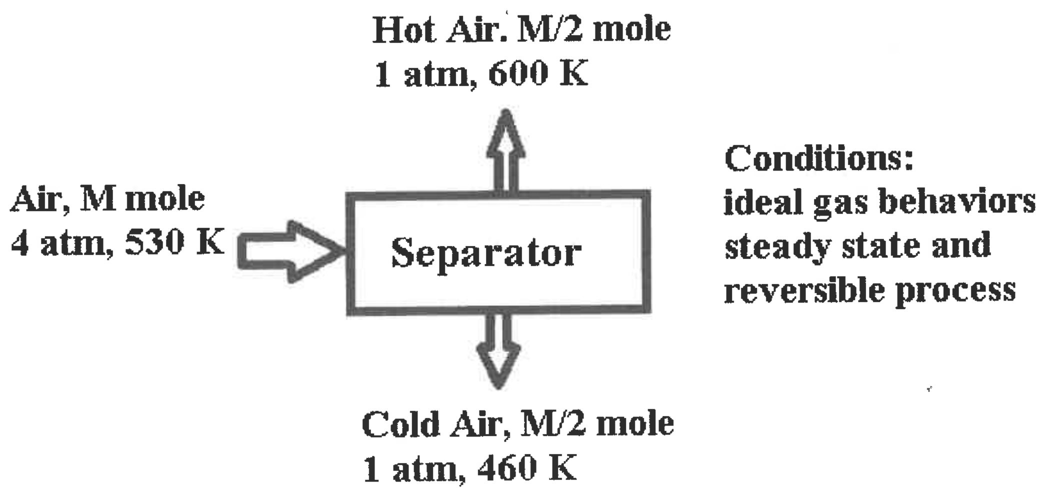
(2) What is the temperature of the air some distance downstream from the valve?

[3%]

(3) What is such a process called in chemical industrial application? [3%]

4. [9%]

The following illustrates one mole (M=1 mole) of gas separation process through a separating device and the conditions for the whole process. Assume Cp=(7/2)R, adiabatic and no shaft work. Please answer the following question.



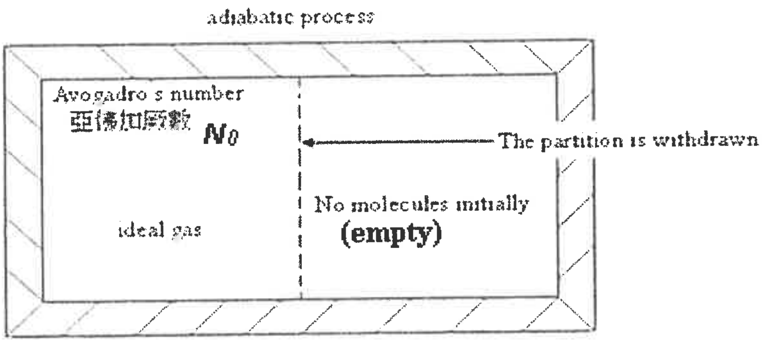

(1) What is the value of $\Delta S_1$ for the process to the hot air? [3%]

(2) What is the value of $\Delta S_2$ for the process to the cold air? [3%]

(3) Calculate $\Delta S_{total}$ for the whole process. Whether the whole process is possible? [3%]

5. [5%]

Suppose an insulated container, partitioned into two equal volumes, contains Avogadro's number $N_0$ of ideal-gas molecules in one section and no molecules in the other. When the partition is withdrawn, the molecules quickly distribute themselves uniformly throughout the total volume. The process is an adiabatic expression that accomplishes no work.




(1) What is the ΔT for this process? [2%]

(2) What is the ΔS for this process? [3%]

6. [25%]

For the binary system 1 and 2, the following Antoine equations provide vapor pressures:

$\ln P_1^{sat} = 14.28 - \dfrac{2943.3}{T/^oC + 223}$ ; $\ln P_2^{sat} = 14.21 - \dfrac{2975.5}{T/^oC + 210}$ ; where T is in kelvins and the vapor pressures are in kPa. Assume the validity of Rault's law,

(1) Prepare a graph showing p (pressure) vs. $x_1$ and p vs $y_2$ for a temperature of 76°C. [10%]

(2) Prepare a graph showing T (temperature) vs $x_1$ and T vs $y_2$ for a pressure of 72 kPa. [10%]

(3) Please address the bubble line, dew line, and phases in the graphs (1) and (2). [5%]

7. [10%]

For thermodynamic property M, we can know nM = M(T, P, $n_1$,$n_2$, ..$n_i$…), and $\overline{Mi}$ a generic partial property. Please show us how to obtain M= $\sum x_i \overline{M_i}$ and $\sum x_i d\overline{M_i}$ =0 at constant T and P.

8. [15%]

(1) Please explain what physical meanings of fugacity, fugacity coefficient, activity, and activity coefficient are, respectively? [8%]

(2) Please show how to gain the activity coefficient is a function of Poynting factor as a vapor mixture and a solution coexist in equilibrium. [7%]