國立中央大學八十八學年度碩士班研究生入學試題卷

所別: 機械工程研究所 丙組 科目: 熱力學 共 2 頁 第 1 頁

1. Consider an equilibrium mixture of C_2H_6, O_2, CO, CO_2 and H_2O. Write down the chemical equations if we take C_2H_6 and CO_2 as independent variables. (10%)

2. For a vessel containing vapor H_2O and liquid H_2O, assume that $T_f = T_g = 100$ °C, $p_r = 0.1013$ Mpa, $p_g = 0.07$ Mpa: Is the system in equilibrium? If not, will more vapor H_2O be condensed or more liquid H_2O be vaporized, why? [For saturated H_2O at 100 °C: $p_{sat} = 0.1013$ Mpa, $h_f = 419$ kJ/kg, $s_f = 1.3071$ kJ/(kg·K); For superheated H_2O at 100 °C and 0.07 Mpa: h = 2680 kJ/kg, s = 7.5341 kJ/(kg·K)] (10%)

3. Consider the entropy of a substance in its three phases.. (10%)
   (a) In which phase, the entropy is highest? In which phase, the entropy is lowest?
   (b) Give an explanation of your answers in part (a).

4. One important method to achieve low temperatures is by means of the Joule-Thomson expansion. (15%)
   (a) Define the Joule-Thomson coefficient, μ_{JT}.
   (b) To be able to lower the temperature, should μ_{JT} of the working fluid be positive or negative?
   (c) Show that the Joule-Thomson coefficient of an ideal gas equals to zero. Therefore, we cannot lower the temperature of an ideal gas by use of the Joule-Thomson expansion.

5. A combined cycle involves a gas power cycle topping a vapor power cycle. Show that the thermal efficiency of a combined gas-steam power plant η_{cc} can be expressed as

$$\eta_{cc} = \eta_g + \eta_s - \eta_g \eta_s ,$$

where $\eta_g = W_g/Q_{in}$ and $\eta_s = W_s/Q_{g,out}$ are the thermal efficiencies of the gas and the steam cycles, respectively. (5%)

6. Plate glass at 500 °C is cooled by passing air over its surfaces such that the convection heat transfer coefficient is h = 10 W/m²-K. To prevent cracking, it is known that the temperature gradient must not exceed 15 °C/mm at any point in the glass during the cooling process. If the thermal conductivity of the glass is 1.4 W/m-K and its surface emissivity is 0.8, what is the lowest temperature of the air that can be initially used for the cooling? Assume that the temperature of the air equals that of the surroundings. (10%)

7. A long cylinder of radius 10 cm consists of a nuclear reacting material (k = 0.5 W/m-K) generating 24,000 W/m^3 uniformly throughout its volume. This rod is encapsulated within another cylinder having an outer radius of 20 cm and a thermal conductivity of 4 W/m-K. The outer surface is surrounded by a fluid at 50 °C, and the convection coefficient between the surface and the fluid is 20 W/m^2-K. Find the temperature at the interface between the two cylinders and at the outer surface. (15%)

8. It is popular to apply Dittus-Boelter equation, $Nu = 0.023Re_D^{0.8}Pr^n$, for estimating in-tube heat transfer coefficient. Please explain why the Prandtl number exponent n = 0.3 for cooling and n = 0.4 for heating of fluid. (10%)

9. You are requested to design a test facility to determine the local heat transfer coefficient of uniform air flow over a flat plate.

   (a) Sketch a complete schematic diagram of the test facilities. Describe all of the components of the system and what data will be taken. (10%)

   (b) Write down all data reduction equations for obtaining the local heat transfer coefficient from the original data you measured. (5%)

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