國立中山大學102學年度碩士暨碩士專班招生考試試題

科目名稱：熱力學【材光系碩士班乙組】　　題號：439006

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

（請依序作答，標示題號，並注意單位）

1. Methane is delivered at 298 K to a glass factory, which operates a melting furnace at 1600 K. The fuel is mixed with a quantity of air, also at 298 K, which is 10% in excess of the amount theoretically needed for complete combustion. (Air is approximately 21% O_2 and 79% N_2).
   (a) Assuming complete combustion, what is the composition of the flue gas (the gas following combustion)? (10%)
   (b) What is the temperature of the gas, assuming no heat loss? (10%)

Data	For	ΔH_{298} [kcal/(g.mole)]	Cp [cal/mole.K]
	CH_4	-17.89	16
	CO_2	-94.05	13.7
	H_2O	-57.80	11.9
	N_2		8.2
	O_2		8.2

2. Metals exhibit some interesting properties when they are rapidly solidified from the liquid state. An apparatus for the rapid solidification of copper is cooled by water. In the apparatus, liquid copper at its melting point (1356 K) is sprayed on a cooling surface, where it solidifies and cools to 400 K. The copper is supplied to the apparatus at the rate of one kilogram per minute. Cooling water is available at 20 °C, and is not allowed to rise above 80 °C. What is the minimum flow rate of water in the apparatus, in cubic meter per minute? Clearly state the system and basis for your calculation. (20%)

Data		
	For water:	Cp = 1 cal/g.K
		Density = 1 g/cm^3
	For copper:	molecular weight = 63.54 g/mol
		Cp (solid) = 5.4 cal/(mol.K)
		Heat of fusion = 3120 cal/mol

3. A great deal of effort has been expended to find "high temperature superconductors": materials that are superconductors at temperatures higher than the boiling point of liquid nitrogen (77 K). Most of the older superconductors had to be operated with liquid helium (boiling point 4.2 K) as the cooling fluid. To estimate the savings possible in operating costs through the use of the "high temperature" superconductors, calculate the minimum work needed to compensate for a heat leak of 1 kJ into the superconductor for both "high temperature" superconductors and the older ones. Assume that the ambient temperature is 300 K. (20%)

4. An alloy composed of 30 wt% Zirconium and 70 wt% Columbium is being slowly cooled from 2400 °C during processing. Equilibrium is maintained at each temperature. Use the accompanying Cb-Zr phase diagram to answer parts (a) ~(c)
   (a) At what temperature does the first solid form and what is the composition of the solid? (5%)
   (b) At what temperature does the last liquid solidify, and what is the composition of the last liquid? (5%)
   (c) Plot the molar Gibbs free energy of mixing (ΔG_{mix}) of each phase and show their relationships with equilibrium phase compositions at 2000 °C and 800 °C respectively. (30%)

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