國立雲林科技大學 系所：化材系
101 學年度碩士班暨碩士在職專班招生考試試題 科目：化工熱力學

1. (20%)

YunTech Industry (YTI) has a novel idea to conserve wasted thermal energy in plants. They want to use a set of "state-of the-art" Carnoco heat engines. YTI claims it can generate enormous quantities of electric power by converting waste heat that would be released in cooling tower. In one particular application for Douliou (斗六) city, they claim that 1 MW of electric power can be produced from a 100 kg/s of hot process water available at 150℃ and 2 bar. Water is also available from the Zhuoshuixi(濁水) river basin which has a seasonal average temperature of 24℃. Describe what you think of the proposed process, and what is the maximum power output? You can assume that the following properties apply to water from the Zhuoshuixi river and from the plant (C_p=4000J/kg, density 1000= kg/m^3).

2. (15%)

First, please explain the physical meaning of excess Gibbs energy. The excess Gibbs energy for binary systems consisting of liquids with similar chemical nature may be represented a reasonable approximation by the following equation:

$$G^E/RT = Bx_1x_2,$$

where B is a function of temperature only. Under such binary systems, it is often observed that the ratio of the vapor pressures of the pure components is nearly constant over a considerable temperature range. Let this ratio to be k. and assume the vapor phase to be an ideal gas. If an azeotrope exists, show B to be a function of k. In addition, determine the range of values of B at k = 1.2 as no azeotrope can exist.

3. (15%)

There is a piston/cylinder instrument. An operator used it to compressed one kilogram of water with a specific volume = 1003 cm^3/kg at 25℃ and 200 bar in a mechanically reversible, isothermal process to 2000 bar. Please determine total heat (Q), the internal energy change (ΔU), the enthalpy change (ΔH), the entropy and change (ΔS) of the system as well as the work (W) from the surrounding. A satisfactory assumption is that volume is constant at its arithmetic average value. Given that the volume expansivity = 2.5×10^{-4} $K^{-1}$and the isothermal compressibility = 4.5×10^{-5} bar^{-1}.

國立雲林科技大學
101 學年度碩士班暨碩士在職專班招生考試試題

系所：化材系
科目：化工熱力學

4. (18%)

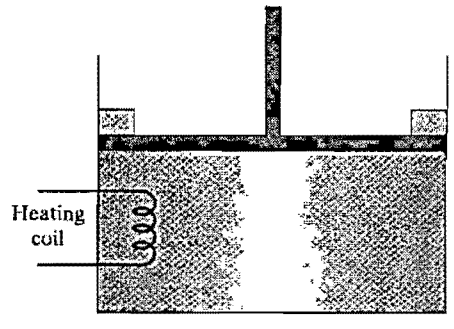
A rigid vessel of 0.06 m^3 volume contains an ideal gas (constant-volume heat capacity = (5/2)R, R is gas constant), at 500 K and 1 bar.

(a) If heat in the amount of 15000 J is transferred to the gas, determine its entropy change. (8%)

(b) If the vessel is fitted with a stirrer that is rotated by a shaft work so that work in the amount of 15000 J is done on the gas, what is the entropy change of the gas if the process is adiabatic? What is the total entropy change of the process? Justify the irreversible feature of the process? (10%)

5. (15%)

The frictionless piston-and-cylinder system shown is subjected to 1.013 bar external pressure. The piston mass is 200 kg and has an area of 0.15 m^2, and the initial volume of the entrapped ideal gas is 0.12 m^3. The piston and cylinder do not conduct heat, but heat can be added to the gas by a heating coil. The gas has a constant-volume heat capacity of 30.1 J/mol-K and an initial temperature of 298 K, and 10.5 kJ of energy are to be supplied to the gas through the heating coil. If stops placed at the initial equilibrium position of the piston prevent it from rising, what will be the final temperature and pressure of the gas?



6. (17%)

A chemical engineer is asked to estimate the solubility of gaseous nitrogen in liquid carbon tetrachloride at 25 °C and a partial pressure of nitrogen of 1 bar. Assume that the liquid nitrogen fugacity at 25 °C is 1000 bar.

(a) Calculate the mole fraction of nitrogen present in the liquid CCl_4 at equilibrium if the two species form an ideal solution. (7%)

(b) From the regular solution theory, it is estimated that

$$\ln \gamma_{N2} = 0.526(1 - X_{N2})^2$$ where γ: activity coefficient; X: mole fraction in liquid.

What is the equilibrium mole fraction of nitrogen in CCl_4 under these circumstances? (10%)