國立臺北科技大學

100學年度研究所碩士在職專班入學考試

化學工程研究所

乙組：物理化學試題

填准考證號碼

注意事項：

1. 本試題共 6 題，配分共 100 分。
2. 請按順序標明題號作答，不必抄題。
3. 全部答案均須答在試卷答案欄內，否則不予計分。

1. An ideal gas undergoes a single-stage expansion against a constant external pressure $P_{external} = P_f$ at constant temperature from T, P_i, V_i to T, P_f, V_f.
   a. What is the largest mass m that can be lifted through the height h in this expansion ? (6%).
   b. The system is restored to its initial state in a single-stage compression. What is the smallest mass m' that must fall through the height h to restore the system to its initial state ? (6%)
   c. If 1.50 moles ideal gas is at $h = 10.0$ cm, $P_i = 2.50 \times 10^6$ Pa, $P_f = 0.750 \times 10^6$ Pa, and $T = 300$ K, calculate the values of the masses in parts (a) and (b) ? (8%)

2. Someone observed that a hard-working horse can lift a 330 lb weight 100 ft in 1 minute. Assuming the horse generates energy to accomplish this work by metabolizing glucose:

$$C_6H_{12}O_6(s) + 6\,O_2(g) \rightarrow 6\,H_2O(l) + 6\,CO_2(g)$$

   Calculate how much glucose a horse must metabolize to sustain this rate of work for 1 hour at 25 °C ? (15%)

3. A sample of sucrose, $C_{12}H_{22}O_{11}$, weighing 0.1265 g is burned in a bomb calorimeter at 25℃, and 2082.3 J of heat was evolved (after correction for standard conditions).
   a. Calculate $\Delta_c U°$ and $\Delta_c H°$ for the combustion of 1 mole of sucrose ? (10%)
   b. Using the data $\Delta_f H°(H_2O(l)) = -285.83$ kJ mol^{-1}, $\Delta_f H°(CO_2(g)) = -393.51$ kJ mol^{-1} and your answer to (a), calculate the enthalpy of formation for sucrose $\Delta_f H°(C_{12}H_{22}O_{11}(s))$? (5%)
   c. The rise in temperature of the calorimeter and its contents as a result of the reaction is 1.743 K. Calculate the heat capacity of the calorimeter and its contents. (5%)

4. The densities of pure water and ethanol are 997 and 789 kg m^{-3}, respectively. The partial molar volumes of ethanol and water are 55.2 and 17.8 × 10^{-3} L mol^{-1}, respectively. Calculate the change in volume relative to the pure components when 2.50 L of a solution with $x_{ethanol} = 0.35$ is prepared. (15%)

5. Between 0 °C and 90 °C, the potential of the cell

$$Pt(s) \mid H_2(g, f = 1\text{ bar}) \mid HCl(aq, m = 0.100) \mid AgCl(s) \mid Ag(s)$$

   is described by the equation

$$E(\text{V}) = 0.35510 - 0.3422 \times 10^{-4}\, t - 3.2347 \times 10^{-6}\, t^2 + 6.314 \times 10^{-9}\, t^3$$

   where t is the temperature on the Celsius scale. Write the cell reaction and calculate ΔG, ΔH, and ΔS for the cell reaction at 30 °C. (15%)

6. Using the steady-state treatment, derive the predicted rate law expression for the following mechanism: (15%)

$$A_2 \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} 2A$$

$$A + B \xrightarrow{k_2} P$$