※ 考生請注意：本試題 ☑可，☐不可 使用計算機

1. Judge the following statements are correct (O) or incorrect (×): (10%)
   (a) All spontaneous (natural) processes are irreversible.
   (b) Considering the universe as an isolated system, its entropy remained constant because no heat was input or released.
   (c) It is impossible to convert heat to work completely for any cyclic processes.
   (d) Entropy (S) is a state function, so $\oint dS = 0$ for all reversible and irreversible processes.
   (e) At 1 atm and 120℃, the Gibbs energy of liquid water is smaller than the Gibbs energy of water vapor.
2. Calculate the most probable speed, root-mean-square speed, mean free path, collision frequency, and collision density of nitrogen molecules at 300K and 1 bar based on the assumption of ideal gas. (*i.e.* collision diameter of $N_2 = 3.74\times10^{-10}$ m) (15%)
3. Suppose that the reaction A + B = Y + Z is believed to occur according to the mechanism

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

$$X + B \xrightarrow{k_2} Y + Z$$

   Apply the steady-state treatment to obtain an expression for the reaction rate. (15%)
4. The pH may be measured with a hydrogen electrode connected with a calomel electrode through a salt bridge. If the cell expression is

   $$Pt, H_2(1bar) \,|\, H^+(a_{H^+}) :: Cl^-(saturated) \,|\, Hg_2Cl_2(s) \,|\, Hg$$

   and $E° = 0.2412\,V$ for the calomel electrode $Cl^-(saturated) \,|\, Hg_2Cl_2(s) \,|\, Hg$ at 25℃ (a) Write the half-cell reactions and cell reaction. (b) Derive the relationship between pH and E, ignoring the liquid junction potential. (15%)
5. One mole of ideal gas was compressed isothermally at 300 K from 1 bar to 10 bar against a constant pressure of 10 bar. Calculate the $q_m, w_m, \Delta S_m, \Delta A_m, \Delta G_m$. (15%)
6. Determine the number of degrees of freedom for the following systems?
   (a) $CaCO_3$(s) in equilibrium with CaO(s) and CO_2(g). (3%)
   (b) NH_4Cl(s) is allowed to dissociate to NH_3(g) and HCl(g) until equilibrium is reached. (3%)
   (c) A solution of potassium chloride and sodium chloride at 298 K and 1 atm. (3%)
   (d) The region between the bubble point surface and the dew point surface in the P-T-composition diagram for a two-component system. (3%)
   (e) CO(g), CO_2(g), H_2(g), and CH_4(g) in equilibrium in the gas phase. (5%)
7. Describe the following terms or answer the questions:
   (a) Is the vapor pressure of a spherical droplet larger or smaller than that of a planar liquid? Why? (3%)
   (b) The molar conductivity of hydrogen ions in water is much higher than other ions. Why? (3%)
   (c) Retrograde condensation (3%)
   (d) When the pressure is reduced, the b.p. and m.p. of water increase or decrease? Explain them according to a plot of Gibbs energy vs. temperature. (4%)