本試題是否可以使用計算機：☑可使用 ， □不可使用　（請命題老師勾選）

1. Suppose that a refrigerator cools to 0℃, discharges heat at 25℃, and operates with 25% efficiency (compared to the ideal refrigerator). (a) How much work would be required to freeze 1 kg of water ($\Delta_f H = -6.02 kJ mol^{-1}$)? (b) How much heat would be discharged during the process? (10%)

2. A liter of water at 20℃ (density $= 0.998 g\ cm^{-3}$) is broken up into a spray. The surface tension of water at 20℃ is $7.27 \times 10^{-2}\ Nm^{-1}$. (a) If the ratio between the vapor pressure of the droplet and the vapor pressure of water at a plane surface is 4, what is the average radius of droplets? (b) Calculate the Gibbs energy change when the droplets are formed. (10%)

3. Calculate the absolute entropy of $SO_2(g)$ at 300 K and 1 bar according to the following data:
$S°(15.0K) = 1.26 JK^{-1}mol^{-1}$, $C_{p,m}(s) = 32.65 JK^{-1}mol^{-1}$, $T_{fus} = 197.64K$, $\Delta_{fus}H° = 7402 Jmol^{-1}$,
$C_{p,m}(l) = 87.20 JK^{-1}mol^{-1}$, $T_b = 263.08K$, $\Delta_{vap}H° = 24937 Jmol^{-1}$, $C_{p,m}(g) = 39.88 JK^{-1}mol^{-1}$.
(10%)

4. For molecular oxygen at 300 K and 1 bar, calculate (a) the average (mean) speed, (b) the most probable speed, and (c) the root-mean-square speed. (9%)

5. $dG = -SdT + VdP$, show that this equation is also valid for the partial molar properties:
$dG_i = -S_i dT + V_i dP$　　　　(10%)

6. Predict the signs of the entropy changes in the following reactions when they occur in aqueous solution: (Give the reasons!)
   (a) hydrolysis of urea:　$H_2NCONH_2 + H_2O \rightarrow CO_2 + 2\ NH_3$
   (b) $H^+ + OH^- \rightarrow H_2O$
   (c) $CH_3COOH \rightarrow CH_3COO^- + H^+$
   (d) $CH_2BrCOOCH_3 + S_2O_3^{2-} \rightarrow CH_2(S_2O_3^-)COOCH_3 + Br^-$　　　　(12%)

7. The cell potential of the following concentration cell is caused by the concentration gradient between the two chloride solutions in the cell
   $$Ag\,|\,AgCl(s)\,|\,Cl^-(0.01\ mol\ kg^{-1})\ ::Cl^-(0.10\ mol\ kg^{-1})\,|\,AgCl(s)\,|\,Ag$$
   where :: denotes the salt bridge
   (a) Write the half-cell reactions and the cell reaction.
   (b) Calculate the electromotive force of the concentration cell at 25℃, assuming zero junction potention for the salt bridge and the activity coefficients are unity.
   (c) Which is the positive electrode?　　　　(12%)

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8. For a reversible reaction　　　$A \underset{k_{-1}}{\overset{k_1}{\Longleftrightarrow}} Y + Z$

The rate constants k_1 and k_{-1} can be measured by the T-jump technique. Show that the relaxation time is　　　$t^* = \dfrac{1}{k_1 + 2k_{-1}x_e}$

where x_e is the concentration of Y and Z at equilibrium.　　　(12%)

9. Describe the following terms or answer the questions:

(a) Estimate the residual entropy of CO at $0\ K$ based on the statistic probability.　(3%)

(b) chemical potential (3%)

(c) Nernst potentials　(3%)

(d) autocatalysis　(3%)

(e) For a gas system from state 1 to state 2, the expansion work done on the surroundings through an irreversible process is smaller than that through a reversible process. Where does the lost work go?　(3%)