

國立嘉義大學 99 學年度

應用化學系碩士班 (甲組) 招生考試試題

科目：綜合化學 II

一、物理化學 (計算題及問答題 50 分)

說明：1. 請標明題號並依序作答。

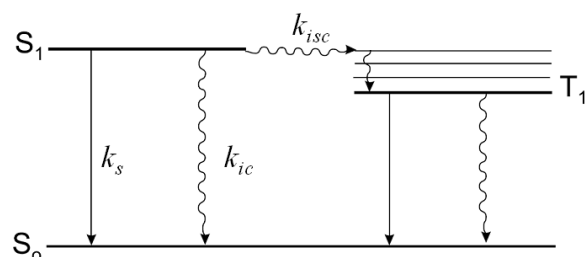
2. 填充題的答案必須要寫在答卷上；計算題必須寫出計算過程，只寫答案不給分。

3. $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$, $h = 6.626 \times 10^{-34} \text{ Js}$, $c \approx 3.0 \times 10^8 \text{ ms}^{-1}$,

$$N_A = 6.02 \times 10^{23}, e \approx 1.6 \times 10^{-19} \text{ C}, \int_0^{\infty} x^n e^{-ax} dx = \frac{n!}{a^{n+1}}$$

1. The 1s orbital of hydrogen atom is $\psi_{1s} = Ce^{-r/a_0}$ where C is a constant. (a) Find the value of C that normalizes the 1s orbital. (b) Find $\left\langle \frac{1}{r} \right\rangle_{1s}$. (10 points)

2. The rate constants for the various processes were denoted as follows



k_r : rate constant for radiative deactivation $S_1 \rightarrow S_0$ with emission of fluorescence.

k_{ic} : rate constant for internal conversion $S_1 \rightarrow S_0$.

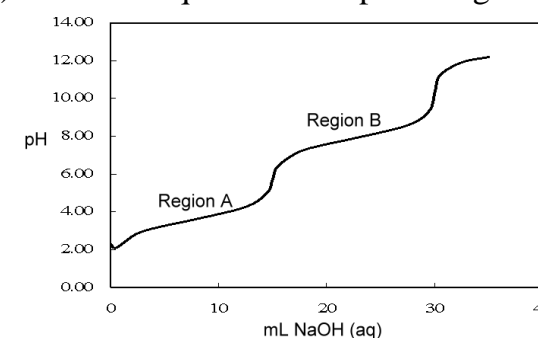
k_{isc} : rate constant for intersystem crossing.

Assume that k_r , k_{ic} , and k_{isc} of a molecule are 10^8 , 5×10^8 , and $4 \times 10^8 \text{ s}^{-1}$, respectively. (a) What is the lifetime of S_1 state of that molecule? (b) What is the fluorescence quantum yield? (8 points)

3. The C_{3v} group has the following classes: E , $2 C_3$, and $3 \sigma_v$. (a) How many irreducible representations does this group have and (b) what is the dimensionality of each? (6 points)
4. A 4-level system, which has the energy, 0, ϵ , 2ϵ and 3ϵ for each level, contains 6 indistinguishable particles. If this system has the total energy of 4ϵ , (a) how many configurations does this system have? and (b) what is the most probable configuration? (6 points)
5. Explain the following terms briefly. (20 points)
- Joule-Thomson coefficient
 - Rate-determining step
 - Maxwell-Boltzmann distribution
 - Franck-Condens principle
 - Anti-Stokes Raman scattering

二、分析化學 (50 分)

1. The pK_a values of a diprotic acid H_2A are $pK_{a1} = 3.56$, $pK_{a2} = 7.88$
- When 30.0 mL of 0.100 M H_2A was titrated with 0.200 M NaOH. The titration curve is shown as below. Give the ways to determine the first equivalent point and the pK_{a2} value, and locate them in the figure (Copy the figure to the answer sheet by yourself). (4 points)
 - Write the equations that pH in regions A and B could be obtained. (4 points)



- Explain standard addition method. (4 points)
 - What condition you should use it instead of external standard method? Explain. (3 points)
3. Suppose you are an instrument constructor, please sketch a double-beam UV/vis spectrophotometer with all necessary components, such as D_2 lamp, mirrors, and grating, etc. All components you need are available. (8 points)
- How do ion-selective electrodes work? (3 points)
 - State the commercial combination ion-selective electrode used for pH measurement. (3 points)
 - Write the relationship between potential and activity of a divalent cation, M^{2+} . (2 points)
5. Three amino acids, A, B, and C, have similar sizes and their isoelectric points (pI values) are 8.35, 6.10, and 6.88, respectively. Separation of these amino acids can be achieved by cation-exchange chromatography.
- To reach this goal, how should the pH of the mobile phase be controlled? Why? (3 points)
 - Give the elution order of these amino acids. Explain briefly. (4 points)
6. A solution containing 8.11 ppm of compound A (FW: 292.2 g/mol) has an absorbance of 0.666 in a 2.00-cm cell at 480 nm. Calculate the molar absorptivity of compound A. (6 points)
7. The amount of Fe in a 0.882-g ore sample was determined by redox titration. The sample was dissolved in HCl, the iron was brought into Fe^{2+} , then the solution was diluted to 100-mL. A 25.0 mL aliquot was titrated with 15.05 mL of 0.0112M $K_2Cr_2O_7$ to reach the diphenylamine sulfonic acid end point. Report the iron content of the ore as % w/w Fe_2O_3 (159.7 g/mol). (6 points)