國立清華大學 103 學年度碩士班考試入學試題

系所班組別：生命科學院丙組

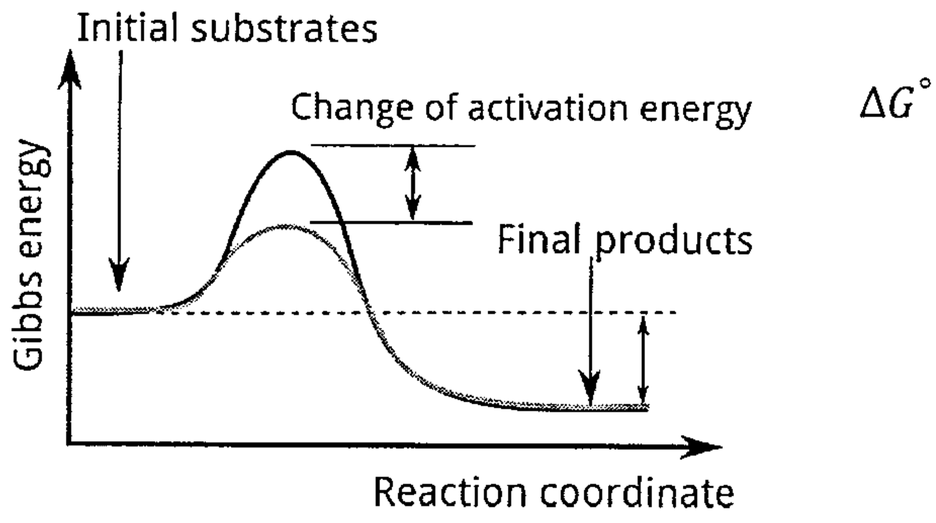
考試科目（代碼）：物理化學(0603)

1. (10%) After adding 0.01 M HCl to distilled water that is initially at pH 7, what is the final pH?

2. (10%) 3 mol of an ideal gas is adiabatically expanded against a constant external pressure of 1 bar. The initial temperature is 25°C. The initial and final pressure are 4 bar and 2 bar, respectively. Calculate the final temperature, q, w, ΔU and ΔH. (R = 8.314 J $mol^{-1}K^{-1}$)

3. (15%) 3 mol of an ideal gas, initially at 25°C and 1 bar, expand 3.5 fold in volume under three different conditions as follows. Calculate ΔS_{system}, ΔS_{total} and $\Delta S_{surroundings}$ and indicate if the process is spontaneous or not. (ln 3.5 = 1.25)
   a. Reversible and adiabatic.
   b. Reversible and isothermal.
   c. Isothermal expansion against zero external pressure, P_{ext} =0.

4. (5%) An enzyme decreases the activation energy of a reaction by 11.5 kJ/mol ($\Delta G^{\circ} = -11.5$ kJ). (i) Does this change increase or decrease the reaction rate? (2%) (ii) Assuming the temperature is 27.7°C (300.7 K)(R=8.315 J/(mol K), RT≈2500 J/mol), by how many orders of magnitude is the reaction rate changed due to the presence of enzyme? ($e^{2.3} \approx 10$). (3%)



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5. (10%) A tennis game is being played in a quantum-mechanical world. A player first hits the ball across the net. Her opponent runs the spot where the ball is expected to bounce and prepare to make a strike. Assume the uncertainty of the velocity of the ball is 50 nm s^{-1}, that it weighs 1.05 x 10^{-22} kg and that the racket has a diameter of 5 μm. (i) Based on Heisenberg's uncertainty principle, what is the uncertainty in the position of the ball? (ii) Can the opponent hit the ball? ($\hbar = 1.05 \times 10^{-34}$)

6. (10%) (i) What is the Heisenberg uncertainty principle? (ii) Based on (i), explain why a particle that is confined in a potential well always has a non-zero minimum energy (zero-point energy).

7. (10%) Consider electrons in a hydrogen atom

(i) The quantum states of the electrons can be described by three quantum numbers n, l and m_l. What physical properties does each of the three numbers correspond to? (6%)

(ii) Assuming an electron is at the state n=2 and its wavefunction is described by $\frac{1}{4\sqrt{2\pi}}\left(\frac{1}{a_0}\right)^{\frac{3}{2}}\left(\frac{r}{a_0}\right)e^{-\frac{r}{2a_0}}(\cos\theta)$

What are the values of l and m_l? $(a_0 = h^2\epsilon_0/\pi m e^2)$ (4%)

8. (15%) We are studying protein X in solution, however we don't know whether it's dimer, tetramer, hexamer or octamer. The diffusion coefficient D of monomeric protein X has been determined as 5 x 10^{-7} cm^2 s^{-1}. Under the same condition, the diffusion coefficient D of protein X oligomer is 2.5 x 10^{-7} cm^2 s^{-1}. If we assume that the shapes of the two protein states both are spheres.

(i) Please estimate the oligomerization state (dimer, tetramer or hexamer) of protein X by looking at hydrodynamic radius r from Stokes-Einstein equation:

$$D = \frac{kT}{6\pi\eta r}$$

where h is viscosity coefficient. (10%)

(ii) Please briefly describe another method to determine protein oligomerization state. (5%)

9. (5%) Fluorescence resonance energy transfer (FRET) can be use to measure distance between two chromophores of donor and acceptor (R_{DA}). The efficiency of energy transfer depends on the distance R_{DA}, according to the equation: efficiency = $R_0^6 / (R_0^6 + R_{DA}^6)$. We individually link fluorescence donor and acceptor to protein N- and C-terminal ends. If the corresponding value of R_0 = 6 nm. Under a condition, we found FRET efficiency = 0.5. Please estimate the apparent distance R_{DA} between donor and acceptor.

10. (10%) NADH and NAD^+ are important biological substances. They have equal absorption coefficients of A = 1.8 x 10^4 M^{-1} cm^{-1}, at 260 nm (as the isobestic point). However, at 340 nm, NAD^+ does not absorb but NADH has an absorption coefficient of 6.22 x 10^3 M^{-1} cm^{-1}. A solution containing both substances has an absorbance of A = 0.15 at 340 nm and 0.8 at 260 nm. Please calculate the concentration of each substance by using the Beer-Lambert law $A = \varepsilon C L$ (A: absorbance, C: concentration, L: pathlength).