

國立臺灣大學102學年度轉學生招生考試試題

題號： 21

科目：普通化學(A)

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- (8 %) Draw the possible resonance structures for nitrous oxide N_2O . In your judgement, which structure is the most important one?
- (5 %) What is the definition of the Pauling's electronegativity scale?
- (12 %) Draw the density plots of the following atomic wave functions

$$\psi_1 \propto (r/a_0)^2 e^{-r/3a_0} \sin \theta \cos \theta \sin \phi$$

$$\psi_2 \propto (6r/a_0 - r^2/a_0^2) e^{-r/3a_0} \sin \theta \cos(\phi + \pi/4)$$

where (r, θ, ϕ) is the polar coordinate of the electron, and a_0 is the Bohr radius. Label the nodal surfaces on your plots. What are the angular quantum numbers l for these two states?

- (10 %) Draw the MO energy diagram for NO (assuming that σ_{2p_z} has a higher energy than π_{2p_z} and π_{2p_y}). Predict the magnetic properties of NO^+ , NO, NO^- .
- (10 %) (a) Write down the Lewis structure of $BeCl_2$ assuming the octet rule. (b) Is there other plausible structure if the octet rule is relaxed? Draw it.
- (8 %) A piece of aluminum is put into an excess aqueous solution of hydrochloric acid, where hydrogen gas is produced. Write down the balanced reaction. After some time, the mass of aluminum is reduced by 1.0g by this reaction. Calculate the volume occupied by the produced hydrogen gas at 1atm, 298K. (molecular weight $M = 26.98$ for Al, $R = 8.31 \text{ JK}^{-1}\text{mol}^{-1}$)
- (5 %) The IR spectrum of HCl vapor shows an absorption at frequency $8.63 \times 10^{13} \text{ Hz}$. Suppose that the bondings of DCl and HCl are the same, what will the frequency of the corresponding absorption of DCl? (molecular weights $H=1, D=2, Cl=35$)
- (10 %) A box of gas is in equilibrium. Let $f(u)du$ be the probability that the gas molecule has a speed within $(u, u + du)$. In terms of $f(u)$, what are the definitions of (a) average speed (b) most probable speed (c) root-mean-square speed? At the equilibrium, which one is the largest? Which one is the smallest?
- (6 %) Draw the qualitative phase diagrams of H_2O and CO_2 (two separate plots). Which one has the higher critical temperature? Why?
- (6 %) Consider the polar effect and the steric effect. Predict the relative acidities of alcohols CH_3OH , CH_3CH_2OH , and $CH_3(CH_2)_2OH$.
- (10 %) Acetic acid has $pK_a = 4.75$. Suppose that one prepares a buffer solution for $pH = 4.90$ where $[CH_3COO^-] = 0.020M$, and $[CH_3COOH] = 0.014M$. For 1L such buffer, how many gramme of $NaOH(s)$ can be added before pH exceeds 5.0?
- (10 %) A solution contains $[Ag^+] = 1.0 \times 10^{-6} M$ and $[Pb^{2+}] = 1.0 \times 10^{-2} M$. Given that $K_{sp} = 1.6 \times 10^{-10}$ for $AgCl(s)$ and $K_{sp} = 2.4 \times 10^{-4}$ for $PbCl_2(s)$. How much $[Cl^-]$ is needed to remove Ag^+ ion from the solution?

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