九十二學年度 原子科學 系（所） 乙 組碩士班研究生招生考試

科目 普通化學 科號 3301 共 2 頁第 1 頁 *請在試卷【答案卷】內作答

1. Vitamin A has a molar mass of 286.4 g and has a general molecular formula of C_xH_yE, where E is an unknown element. If Vitamin A is 83.86% C and 10.56% H by mass, what is the molecular formula of vitamin A? (10%)

2. Consider the reaction $3O_2(g) \leftrightarrow 2O_3(g)$. At 175 °C and a pressure of 128 torr, an equilibrium mixture of O_2 and O_3 has a density of 0.168 g/L. Calculate K_p for the above reaction of 175 °C. (10%)

3. The solubility of benzoic acid is 0.34 g/100 mL in water at 25 °C and 10.0 g/100 mL in benzene (C_6H_6) at 25 °C. Rationalize this solubility behavior. For a 1.0 molal solution of benzoic acid in benzene, would the measured freezing-point depression be equal to, greater than, or less than 5.12 °C? (K_f = 5.12 °C kg/mol for benzene.) (10%)

4. Show the molecular structure of CH_4 and derive rigorously the bond angles in the CH_4. (10%)

5. When the Schrodinger equation for a one-electron atom is solved, a series of wave functions is obtained, each function corresponding to a particular energy. (a) Name the following orbitals with quantum numbers. (b) Explain the physical meaning of these wave functions and draw orbital shapes in three dimensional picture. (20%)

$$\Psi = \frac{1}{\sqrt{\pi}}\left(\frac{Z}{a_0}\right)^{3/2} e^{-\sigma}$$

$$\Psi = \frac{1}{4\sqrt{2\pi}}\left(\frac{Z}{a_0}\right)^{3/2} (2-\sigma) e^{-\sigma/2}$$

$$\Psi = \frac{1}{4\sqrt{2\pi}}\left(\frac{Z}{a_0}\right)^{3/2} \sigma e^{-\sigma/2} \sin\theta \sin\phi$$

$$\Psi = \frac{\sqrt{2}}{81\sqrt{\pi}}\left(\frac{Z}{a_0}\right)^{3/2} (6\sigma - \sigma^2) e^{-\sigma/3} \cos\theta$$

The wave functions can be written as the spherical polar coordinate system (r, θ, ϕ) where $\sigma = r/a_0$ and a_0 is the Bohr radius.

6. Carbon monoxide (CO) forms bonds to a variety of metals and metal ions. Its ability to bond to iron in hemoglobin is the reason that CO is so toxic. Use the MO model to predict which atom of carbon monoxide should form bonds to metals and explain that CO is a very strong ligand in the spectrochemical series. (10%)

7. Fruit flies are formidable pests that have the potential to seriously damage several important fruit crops. Because of this, there have been several widely publicized sprayings of residential areas in southern California with the pesticide malathion to try to control fruit flies. Now there may be a better way to kill fruit flies with a blend of two common dyes (red dye no. 28 and yellow dye no.8) which cause much less impacts than malathion on the environment. Discuss and explain. (10%)

8. Many biochemical reactions are catalyzed by large protein molecules called enzymes. A typical mechanism for the conversion of a biochemical substrate (S) to product (P) catalyzed by an enzyme (E) involves the following steps:

$E + S \rightarrow ES$ $\quad k_1$

$ES \rightarrow E + S$ $\quad k_{-1}$

$ES \rightarrow P$ $\quad k_2$

The rate-determining step is the decomposition of the intermediate enzyme-substrate complex (ES) to products (P). (a) Under these conditions, show that the overall rate of product formation is

$$Rate = \frac{d[P]}{dt} = \frac{k_2[E]_T[S]}{K_M + [S]}$$

where $[E]_T$ equals the total enzyme concentration and K_M is called the Michaelis-Menten constant. (b) Give expressions for K_M in terms of the rate constants used to define the mechanism. (c) Show the maximum rate, V_{max} in the Michaelis-Menten equation. (20%)