國立臺灣大學 103 學年度碩士班招生考試試題

1. The work function for Fe is 434 kJ/mol. What is the maximum wavelength of an incident light for the generation of photoelectron from iron electrode? (6 points)

2. Calculate the de Broglie wavelength of a hydrogen atom moving with a velocity 10 % of the speed of light. (6 points)

3. Rationalize the following lattice energy values: (6 points)

Compound	Lattice energy (kJ/mol)
NaBr	-747
LiF	-1007
CaF_2	-2613
CaO	-3513

4. Given the ionic radius of Na^+(95 pm) and Cl^- (181 pm), please calculate the density of sodium chloride. (NaCl = 58.44 g/mol) (6 points)

5. Calculate the osmotic pressure of a 0.15 M NaCl aqueous solution at 25 °C. (6 points)

6. Please define the ideal gas and ideal solution. (6 points)

7. Carbon monoxide, CO, possesses similar molecular orbital ordering to N_2. Please draw the molecular orbital energy-level diagram of CO (both A.O. and M.O. are required). (10 points)

A.O. of carbon　　M.O. of CO　　A.O. of oxygen

8. Calculate the bond order of CO^+ and CO^{2-}. (6 points)

9. The diffusion rate of methane was found to be 1.41 times faster than that of an unknown gas molecule at room temperature. Question: What is the density of the unknown gas molecule under STP condition? (CH_4 = 16.04 g/mol) (6 points)

10. 100 mL of 1.0 M H_2SO_4 solution was added to 1 L of buffer solution, which was prepared from 1.50 M acetic acid ($K_a = 1.8 \times 10^{-5}$ M) and 1.50 M of sodium acetate. Please calculate the pH value *before* and *after* the addition of sulfuric acid. (12 points)

11. Gas molecule A undergoes photolysis under the irradiation of UV light. The change in concentration of A is shown below. Question: If the initial concentration of A is 0.75 M, how long does it take to consume 75 % of molecule? (6 points)

Time (h)	[A] (M)
0	0.200
1	0.160
2	0.133
4	0.100
6	0.080
8	0.067
10	0.057
12	0.050

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12. Please calculate the ΔH_{vap} and predict the normal boiling point of an unknown solvent with the vapor pressure data given below. (12 points)

T (°C)	P (torr)
-74.3	1
-48.1	10
-27.7	40
-11.5	100
17.9	400

13. Given $\sigma = (Z\,r/a_0)$ and $a_0 = 0.529$ Å. Please calculate the radial nodal locations of the $R_{2,0}$ and $R_{3,1}$ orbitals of He^+. (12 points)

Radial Part $R_{nl}(r)$

$$R_{1s} = 2\left(\frac{Z}{a_0}\right)^{3/2} \exp(-\sigma)$$

$$R_{2s} = \frac{1}{2\sqrt{2}}\left(\frac{Z}{a_0}\right)^{3/2} (2-\sigma)\exp(-\sigma/2)$$

$$R_{3s} = \frac{2}{81\sqrt{3}}\left(\frac{Z}{a_0}\right)^{3/2} (27-18\sigma+2\sigma^2)\exp(-\sigma/3)$$

$$R_{2p} = \frac{1}{2\sqrt{6}}\left(\frac{Z}{a_0}\right)^{3/2} \sigma\exp(-\sigma/2)$$

$$R_{3p} = \frac{4}{81\sqrt{6}}\left(\frac{Z}{a_0}\right)^{3/2} (6\sigma-\sigma^2)\exp(-\sigma/3)$$

$$R_{3d} = \frac{4}{81\sqrt{30}}\left(\frac{Z}{a_0}\right)^{3/2} \sigma^2\exp(-\sigma/3)$$

Speed of light	3×10^{8} m s^{-1}
Planck constant	6.626×10^{-34} J s
Boltzmann constant	1.38×10^{-23} J K^{-1}
Electron mass	9.11×10^{-31} kg
Proton mass	1.67×10^{-27} kg
Avogadro constant	6.02×10^{23} mol^{-1}
Universal gas constant	0.082 L atm K^{-1} mol^{-1} 8.314 J K^{-1} mol^{-1}

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