

General Chemistry

- (1)(a)What is biological oxygen demand (BOD)?
 (b)What is the effect of excess nutrients in a lake? (10%)
- (2)Draw a molecular orbital energy diagram for NO, and determine the bond order for NO and NO⁻. (10%)
- (3)Identify the structure of each of the following species:
 (a)ClNO (N is the central atom), (b)PF₅, (c)SO₄⁻². (9%)
- (4)What work is done when 1.0 mole of solid CaCO₃ (volume= 34.2 ml) decomposes at 25 °C and 1.0 atm to give solid CaO (volume= 16.9 ml) and CO₂(g)? (Assume the gaseous CO₂ exhibit ideal gas behavior). (8%)
- (5)The rate equation for a reaction $A + 2 B \rightleftharpoons C$ is $v = d[C]/dt = k[A][B]$, where the initial concentration of A and B are [A]₀ and [B]₀, respectively. Show that $(1/([B]_0 - 2[A]_0)) \ln([A]_0[B]/[A][B]_0) = kt$. (10%)
- (6)When an electron in an excited molybdenum atom falls from the L to the K shell, an X-ray is emitted. These X-rays are diffracted at an angle of 7.75° by planes with a separation of 2.64 Å. What is the difference in energy, in an unit of kcal/mol, between the K and L shell in molybdenum. (Planck constant $h = 6.63 \times 10^{-34}$ J sec) (8%)
- (7)A cubic unit cell contains manganese (Mn) ions at the corners and fluoride ions at the center of each edge.
 (a)What is the empirical formula of this compound? Explain your answer.
 (b)Calculate the edge length of the unit cell if the radius of Mn⁺³ is 0.65 Å. (10%)
- (8)Calculate the enthalpy change, ΔH, of the reaction
 $CO(g) + 2 H_2(g) \rightleftharpoons CH_3OH(g)$
 from the bond energy data: C≡O, 1080; C-H, 415; O-H, 464; H-H, 436; C-O, 350 KJ/mol. (10%)
- (9)A buffer solution is made up of equal volumes of 0.100 M acetic acid and 0.500 M sodium acetate.
 (a)What is the pH of this solution?
 (b)What is the pH that results from adding 1.00 ml of 0.100 M HCl to 0.200 L of the buffer solution? (K_a of CH₃COOH is 1.8×10⁻⁵.) (10%)
- (10)(a)Use the following data to calculate the equilibrium constant at 798 °K and 1.0 atm for the reaction $CuS(s) + H_2(g) \rightleftharpoons Cu(s) + H_2S(g)$.
- | | ΔG _f ⁰ (kJ/mol) | ΔH _f ⁰ (kJ/mol) |
|---------------------|---------------------------------------|---------------------------------------|
| CuS(s) | -53.6 | -53.1 |
| H ₂ (g) | 0.0 | 0.0 |
| Cu(s) | 0.0 | 0.0 |
| H ₂ S(g) | -33.6 | -20.6 |
- (b)Explain why the reaction in (a) is spontaneous at low temperature but becomes spontaneous at high temperature. (15%)