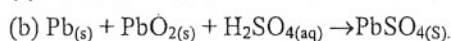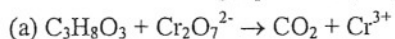1. Consider the isothermal expansion of 1.00 mole of ideal gas at 27℃. the volume increases from 30.0 to 40.0 L. calculate q, w, ΔE, ΔH, ΔS, and ΔG for two situations. (a) a free expansion (b) a reversible expansion. (10 points)
   [Note: ln2 = 0.693, ln3 = 1.099, R = 8.314 J/K mol.]

2. Given the K_a and K_b values of 5.6×10^{-10} and 1.6×10^{-5} for NH_4^+ and CN^-, respectively, calculate the pH of a 0.100 M NH_4CN solution. (10 points)

3. Calculate the concentration of Ag^+, $Ag(S_2O_3)^-$, and $Ag(S_2O_3)_2^{3-}$ in a solution prepared by mixing 150 mL of 0.001 M $AgNO_3$ with 200 mL of 5.00 M $Na_2S_2O_3$. The stepwise formation equilibrium constants for $Ag(S_2O_3)^-$ and $Ag(S_2O_3)_2^{3-}$ are 7.4×10^8 and 3.9×10^4, respectively. (10 points)

4. Balance the following equations. (10 points, 5 points each)
   (a) $C_3H_8O_3 + Cr_2O_7^{2-} \rightarrow CO_2 + Cr^{3+}$
   (b) $Pb_{(s)} + PbO_{2(s)} + H_2SO_{4(aq)} \rightarrow PbSO_{4(S)}$
   [Note that you might need to add H_2O or H^+ to balance these equations.]

5. (a) At a given temperature, what is the ratio of the root-mean-square (rms) speed of the atoms of Ar gas to the rms speed of H_2 gas? (the atomic weights of Ar and H are 39.95 and 1, respectively.) (b) how does the rms speed and kinetic energy of these gaseous atoms and molecules vary quantitatively with temperature? (c) Draw a diagram to show the distribution of speed of Ar and H_2 gas at a given temperature (300 K, for example). (10 points)

6 Name 5 types of chemical bonding and describe their characteristic properties briefly. (10 points)

7 Draw the shape of the five d orbitals (5 points) and explain how we know the shape of the d orbitals. (5 points)

8 Titanium metal has a body-centered cubic unit cell. The density of titanium is 4.5 g/cm³. Calculate the edge length of the unit cell and a value for the atomic radius of titanium. (10 points)
   [Hint: in a body-centered arrangement of spheres, the spheres touch along the body diagonal.]

注意：背面有試題

9　When an aqueous solution of KCN is added to a solution containing Ni^{+2} ions, a precipitate forms, which redissolves upon addition of more KCN solution.　No precipitate forms when H_2S is bubbled into this solution.　Write reactions describing what happens in this solution. (10 points)

[Hint: CN⁻ is a Bronsted-Lowry base ($K_b \sim 10^{-5}$) and a Lewis base.]

10　Complete the following reactions. (10 points, 2 points each)