Chem 130, Eppley

KEY

Exam 1
Monday, Feb 27, 2017
100 pts

1. (16 pt total) Justify all parts of the following true statements. Some will be based on the Bohr model or quantum theory. **Be sure to state clearly which model you are using.** Choose your language and reasoning carefully and support your arguments with diagrams, tables, or calculations! (8 pt each)

   a. There are only 4 different orbitals in the 2nd principal quantum level but 16 in the 4th principal quantum level.

Orbitals are described by three quantum numbers n, l, and m_l. For the 2nd p.q.l, n=2, l can be 0 or 1, and so m_l can have the values indicated in the table for a total of 4 different orbitals. For n=4, l can be 0, 1, 2, or 3, so m_l can have the values indicated in the table for a total of 16 unique orbitals

n	l	m_l	
2	0	0	(2s)
2	1	-1	2p
2	1	0	4 orbitals
2	1	1	

n	l	m_l
4	0	0
4	1	-1
4	1	0
4	1	1
4	2	-2
4	2	-1
4	2	0
4	2	1
4	2	2
4	3	-3
4	3	-2
4	3	-1
4	3	0
4	3	1
4	3	2
4	3	3

   b. The wavelength of light emitted from a hydrogen atom when an electron moves from the n=4 to the n=2 level is 487 nm, and these photons have an energy of 246 kJ/mol.

E ↑ ① E_4 ↓ E_2 ΔE = (−)

$|\Delta E_{orb.it}| = E_{photon}$

$|-4.09\times10^{-19}\text{J}| = 4.09\times10^{-19}\text{J} = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\text{J·s}\times3\times10^{8}\text{m/s}}{\lambda}$

$4.09\times10^{-19}\text{J} = \frac{1.98\times10^{-25}\text{J·m}}{\lambda}$

$\lambda = 4.86\times10^{-7}\text{m}\times\frac{1\times10^{9}\text{nm}}{1\text{m}} = 486\text{nm}$

$\Delta E = E_2 - E_4$

$= -2.18\times10^{-18}\text{J}\left(\frac{1}{2^2}\right) - \left(-2.18\times10^{-18}\text{J}\left(\frac{1}{4^2}\right)\right)$

$= -5.45\times10^{-19}\text{J} + 1.36\times10^{-19}\text{J}$

$= -4.09\times10^{-19}\text{J}$

$\frac{4.09\times10^{-19}\text{J}}{\text{photon}}\times\frac{1\text{ kJ}}{1000\text{J}}\times\frac{6.02\times10^{23}\text{ photons}}{1\text{ mol}} = 246\text{ kJ/mol}$

2. Using your periodic table and other relevant information from this course, identify the following (3 pt each, 15 pt total):

   a. The term for the species that oxidizes something else in a redox reaction
      oxidizing agent

   b. Number of radial nodes in a 4p orbital
      $n-1 = l + \text{radial}$ $\quad 3 = 1 + \boxed{2}$

   c. The electron configuration for mercury
      $[Xe]\,6s^2 4f^{14} 5d^{10}$

   d. The **name** of the alkaline earth metal in the 5th period
      strontium

   e. The formula for an insoluble salt of iodide
      AgI

3. a. Write the formula for the following compounds. (5 pt)

i. hydrocyanic acid HCN

ii. potassium carbonate K_2CO_3

iii. manganese (II) acetate tetrahydrate $Mn(O_2C_2H_3)_2 \cdot 4H_2O$

iv. dinitrogen trioxide N_2O_3

v. plumbous chloride $PbCl_2$

b. Write the name for the following compounds. (5 pt)

i. $Na_2S_2O_3$ sodium thiosulfate

ii. $Cr_2(C_2O_4)_3$ chromium (III) oxalate

iii. H_2SO_3 sulfurous acid

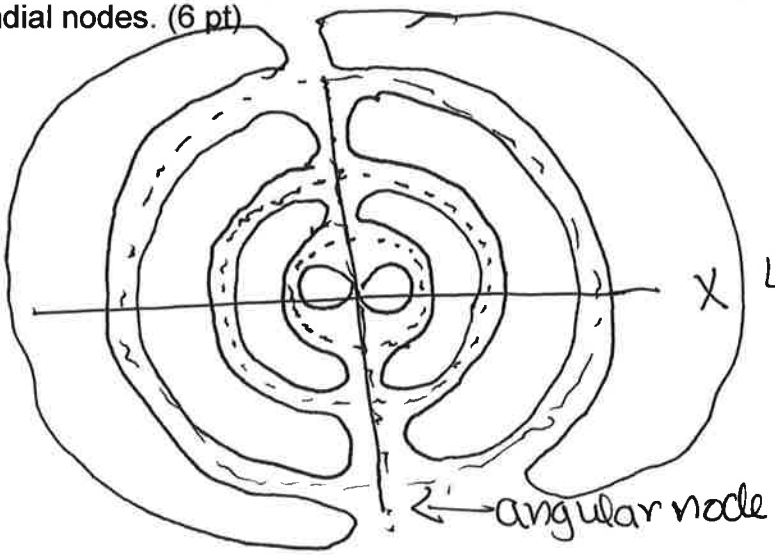
iv. AuCl gold (I) chloride

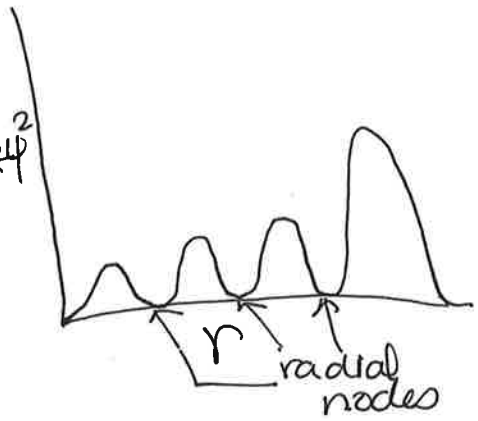
v. $Mg(ClO_4)_2 \cdot 6H_2O$ magnesium perchlorate hexahydrate

4. (13 pt total)

a. Draw a sketch of a $5p_x$ orbital, labeling the axes clearly. Label any angular and radial nodes. (6 pt)

5px
$\ell = 1$
$n = 5$
$4 = 1 + 3$





b. Draw a radial probability diagram for a $5p_x$ orbital next to your orbital above with axes and any nodes appropriately labeled. (4 pt)

c. What does the radial probability diagram show you (generally)? (3 pt)

size of orbital and how many radial nodes
probability of finding an e^- at a particular distance from ^{2} nucleus

5. (20 pt) For the following chemical reactions, give the requested information:

   a. Type of reaction (using the 4 types we discussed in class!) redox (3 pt)

   $$\overset{+3}{2\,FeCl_3\,(aq)} + \overset{0}{3\,Mg\,(s)} \rightarrow \overset{0}{2\,Fe\,(s)} + \overset{+2}{3\,MgCl_2\,(aq)}$$

   b. Predict the products, balance, and give the net ionic equation for the reaction of aqueous lead (II) nitrate with a solution of calcium chloride. (6 pt)

   $Pb(NO_3)_2(aq) + CaCl_2(aq) \rightarrow PbCl_2(s) + Ca(NO_3)_2(aq)$

   $Pb^{2+}(aq) + 2NO_3^-(aq) + Ca^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s) + Ca^{2+}(aq) + 2NO_3^-(aq)$

   $Pb^{2+}(aq) + 2Cl^-(aq) \rightarrow PbCl_2(s)$

   c. General term for **the role** of the underlined species in the reaction (3 pt)

   $$HClO_4 + \underline{PO_4^{3-}} \rightarrow ClO_4^- + HPO_4^{2-}$$

   base (Bronsted)

   d. Write the equation for the formation of a complex ion between aqueous chromium (III) and 6 chloride ions. (4 pt)

   $Cr^{3+}(aq) + 6Cl^-(aq) \rightarrow CrCl_6^{3-}(aq)$

   Lewis acid Lewis base

   e. In equation d above, identify the Lewis acid and Lewis base. (2 pt)

   f. What observations in the lab indicate a complexation reaction has happened? (2 pt)

   color change w/ no ppt

6. (7 pt total) An iridium-rich layer is found at the KT-boundary, the geological dividing line marking the extinction of the dinosaurs. The iridium is believed to be from a comet that struck the earth near the Yucatan peninsula.

   a. Give the electron configuration of the Ir (3 pt):

   $[Xe]\,6s^2 5d^7 4f^{14}$

   b. Based on your electron configuration, how many unpaired electrons would you expect Ir to have? (2 pt) ↑↓ ↑↓ ↑ ↑ ↑ (5d) 3

   c. Is it paramagnetic or diamagnetic? (2 pt)

   paramagnetic

7. (12 pt) Circle the correct answer(s) below.

a. Correct common charges for the elements below

Fe^{3+} Al^{3+} Sn^{3+} Au^{3+} Ag^{3+} As^{3-}

b. Circle the statement(s) about quantum theory that are true

- Electrons occupy circular orbits that can have only specific energies
- For a 3p orbital, l=0,1
- No two electrons in the same atom can have the same n, l, and m_l
- $(\Psi)^2$ describes the probability of finding an electron at a certain point in space
- Hund's rule is followed because half-filled orbitals are more stable than filled ones

c. Circle the elements that are in group IVA

Co Si Pb Br

d. Which classes of compounds typically form discrete (as opposed to extended) structures?

metals metalloids covalent compounds ionic compounds

8. (7 pt) Gamma ray astronomy is used to study the origins of the universe.

a. What is the energy of a mole of gamma rays with a frequency of 1×10^{10} GHz? (4 pt)

$1 \times 10^{10}\ GHz \times \frac{1 \times 10^{9}\ Hz}{1\ GHz} = 1 \times 10^{19}\ Hz = 1 \times 10^{19}\ s^{-1}$

$E = h\nu = 6.626 \times 10^{-34}\ J \cdot s\ (1 \times 10^{19}\ s^{-1}) = 6.626 \times 10^{-15}\ J$ / photon

$6.626 \times 10^{-15}\ J$ / photon $\times \frac{6.022 \times 10^{23}\ photons}{1\ mol} = 3.99 \times 10^{9}\ J/mol$

b. What is the wavelength of that light in nm? (3 pt)

$E = \frac{hc}{\lambda}$ $\lambda = \frac{6.626 \times 10^{-34}\ J \cdot s\ (3 \times 10^{8}\ m/s)}{6.626 \times 10^{-15}\ J}$

$\approx 3.0 \times 10^{-11}\ m \times \frac{1 \times 10^{9}\ nm}{1\ m} = 3.0 \times 10^{-2}\ nm$

BONUS: Share one thing you learned that I didn't include on this test.

lots of possibilities!