Chem 130, Eppley

KEY

Exam 1
Friday, September 21, 2017
100 pts

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

   i. dinitrogen trioxide N_2O_3

   ii. magnesium nitrate hexahydrate $Mg(NO_3)_2 \cdot 6H_2O$

   iii. titanium (IV) oxide TiO_2

   iv. stannous fluoride SnF_2

   v. chloric acid $HClO_3$

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

   i. HBr hydrobromic acid

   ii. $(NH_4)_2C_2O_4$ ammonium oxalate

   iii. $Fe(ClO_4)_2 \cdot 3H_2O$ iron (II) perchlorate trihydrate

   iv. SeF_4 selenium tetrafluoride

   v. KO_2 potassium superoxide

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

   a. The name for an area of an atomic orbital where there is 0% probability of finding the electron node

   b. The oxidation states of **all** of the elements in $Cd(ClO_4)_2$ Cd +2 Cl +7 O −2

   c. The electron configuration of Gd $[Xe]6s^2 5d^1 4f^7$

   d. The **name** of the halogen in the 4th period bromine

   e. The symbol of a main group element with a common charge of +3 Al, Ga etc.

3. (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. The Z_{eff} of an atom increases as you go across the periodic table but it stays approximately the same as you go down the periodic table.

As you go across the PT, # p increases, but the number of shielding e⁻ stays the same, so the charge felt by the outer e⁻ increases. As you go down the PT, # p increases, but the # of shielding inner e⁻ increases by the same amt, meaning Zeff stays about the same.

   b. There are 5 different d-orbitals in the 4th principal quantum level and each one can hold 2 e⁻. There is only 1 s-orbital in the 4th principal quantum level but it can also hold 2 e⁻.

$n=4$ d orbital $\Rightarrow l=2$

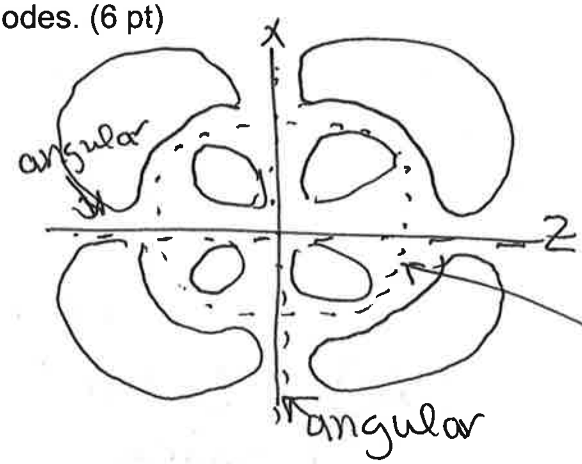
s orbital $\Rightarrow l=0$

For $l=0$ (s orbital) only one possible value exists for m_l because m_l can go from $-l$ to $+l$. There are 2e because m_s can be $+\frac{1}{2}$ or $-\frac{1}{2}$.

For $l=2$ (d orbital), m_l can have 5 different values, $(-2,-1,0,1,2)$ representing the 5 different d orbitals. Electrons can have $m_s=+\frac{1}{2}$ or $m_s=-\frac{1}{2}$, meaning 2 e⁻ can fit in each orbital.

4. (10 pt total)

   a. Draw a sketch of a $4d_{xz}$ orbital, labeling the axes clearly. Label all angular and radial nodes. (6 pt)

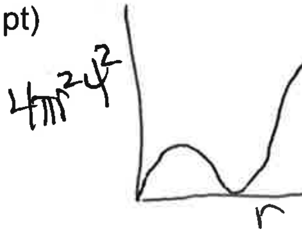


total nodes $= 3 = \overset{(l)}{2} +$ radial

n−1

$= 1$ radial node

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



5. (17 pt total) a. Turn the following description into a series of **(unbalanced)** chemical equations including states of matter: Iron metal is added to a solution of hydrochloric acid. It reacts to form hydrogen gas and aqueous iron (III). When an excess of the sodium hydroxide is added, iron (III) hydroxide precipitates from solution. When a solution of potassium thiocyanate is added to this mixture, a blood red complex ion consisting of one thiocyanate with one iron (III) ion is formed. (6 pt)

redox $Fe(s) + HCl(aq) \longrightarrow H_2(g) + Fe^{3+}(aq) + Cl^-(aq)$

precip. $3NaOH(aq) + Fe^{3+}(aq) \longrightarrow Fe(OH)_3(s) + 3Na^+(aq)$

Complex. $KSCN(aq) + Fe(OH)_3(s) \longrightarrow Fe(SCN)^{2+}(aq)$
$3OH^-(aq) + K^+(aq)$

b. Classify each of the 3 reactions above according to the 4 types we used. (3 pt)

c. For one of the reactions above (clearly indicate which one!) balance and write the net ionic equation. (4 pt)

all but redox are balanced

$3OH^-(aq) + Fe^{3+}(aq) \rightarrow Fe(OH)_3(s)$

$SCN^-(aq) + Fe(OH)_3(s) \rightarrow Fe(SCN)^{2+}(aq) + 3OH^-(aq)$ net ionic

(1 pt each) Identify a substance in the reactions above that is a:

d. Base NaOH (though not acting as a base here!)

e. Complex ion $Fe(SCN)^{2+}(aq)$

f. Oxidizing agent HCl

6. (12 pt) Circle the correct answer(s) below.

a. Circle elements that are metals:

antimony [✓ platinum] [✓ strontium] [✓ beryllium] [✓ mercury]

b. Circle the terms for a proton acceptor and an electron pair acceptor, respectively.

Lewis acid, Base Acid, Lewis Acid Base, Lewis Base Acid, Lewis base [✓ Base, Lewis Acid]

c. Circle the elements that have unpaired electrons

[✓ Na] [✓ Se] Ne [✓ Fe] Ca

d. Circle the salts that are insoluble

$MgCl_2$ [✓ $Ca_3(PO_4)_2$] $Hg(NO_3)_2$ Na_2CO_3

7. (11 pt total) a. If an electron moves from the n=3 level of a H atom to the ground state (n=1), is the sign of the energy change positive or negative? (2 pt)

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b. What is the frequency of the light associated with that transition in GHz (give it in other units if you are not sure how to convert!)? (6 pt)

$2.92 \times 10^{15}\ \text{Hz} \times \frac{1\ \text{Gz}}{1 \times 10^{9}\ \text{Hz}} = \boxed{2.92 \times 10^{6}\ \text{GHz}}$

$$\Delta E = E_1 - E_3$$

$$= -2.18 \times 10^{-18}\text{J}\left(\frac{1}{1^2}\right) - \left(-2.18 \times 10^{-18}\text{J}\left(\frac{1}{3^2}\right)\right)$$

$$= -1.937 \times 10^{-18}\text{J}$$

$$E_{photon} = |\Delta E| = +1.937 \times 10^{-18} = h\nu = (6.626 \times 10^{-34}\text{J}\cdot\text{s})\nu$$

$$\nu = 2.92 \times 10^{15} = \text{Hz}$$

c. Calculate the energy of that transition for 1 mol of electrons in units of kJ/mol. (3 pt)

$$\frac{-1.937 \times 10^{-18}\text{J}}{\text{photon}} \times \frac{1\ \text{kJ}}{1000\ \text{J}} \times \frac{6.022 \times 10^{23}\ \text{photons}}{1\ \text{mol}} =$$

$$\boxed{1166\ \text{kJ/mol}}$$

8. When you put electrons into orbitals in multi-electron atoms, you populate the orbitals using three different rules: Hund's rule, the Aufbau principle, and the Pauli Exclusion Principle. Explain two of these rules and why you follow them! (4 pt)

Hund's rule:
minimize
e^- repulsions

$\underline{\uparrow}\ \underline{\uparrow}\ \underline{\ \ }$
2p
put 1 e^- in
each degenerate
orbital

Aufbau
populate
orbitals from
lowest to
highest energy
$\underline{\ \ }\ \underline{\ \ }\ \underline{\ \ }$ 2p
$\underline{\ \ }$ 2s
$\underline{\uparrow\downarrow}$ 1s

Pauli
Exclusion
Principle
each orbital
has unique
combin.
of n, l, m_l
each e^- unique
combin of
n, l, m_l, m_s
(two e^- in
each orbital)