General Chemistry I NAME: Answer Key
Chem 111 Exam #2 November 8, 2013

Some Equations and Constants for your use:

$\lambda \times \nu = c \qquad E = h\nu \qquad E_n = \frac{-2.18 \times 10^{-18}\ J}{n^2} \qquad \lambda = \frac{h}{mv}$

$\Delta H^o_{rxn} = \sum \text{energies of bonds broken} - \sum \text{energies of bonds formed}$

$c = 3.00 \times 10^8\ m/s \qquad h = 6.626 \times 10^{-34}\ J \bullet s$

SHOW ALL WORK

1. Light and Energy

Consider electromagnetic radiation that delivers 2.00 x 10^{-19} J for each photon.

a. What is the frequency of the radiation, in Hz?

$\upsilon = E/h = 2.00 \times 10^{-19}\ J / 6.626 \times 10^{-34}\ Js =$ $3.02 \times 10^{14}\ s^{-1}$

b. What is the wavelength of this light, in nm?

$\lambda = c/\upsilon = 3.00 \times 10^8\ m/s / 3.02 \times 1014\ s^{-1} = 9.93 \times 10^{-7}\ m =$ 993 nm

c. Does 345 nm light have enough energy to break bonds that are 322 kJ/mol? Do the calculations to determine this.

$\upsilon = 3.00 \times 10^8\ m/s / 3.45 \times 10^{-7}\ m = 8.70 \times 10^{14}\ s^{-1}$

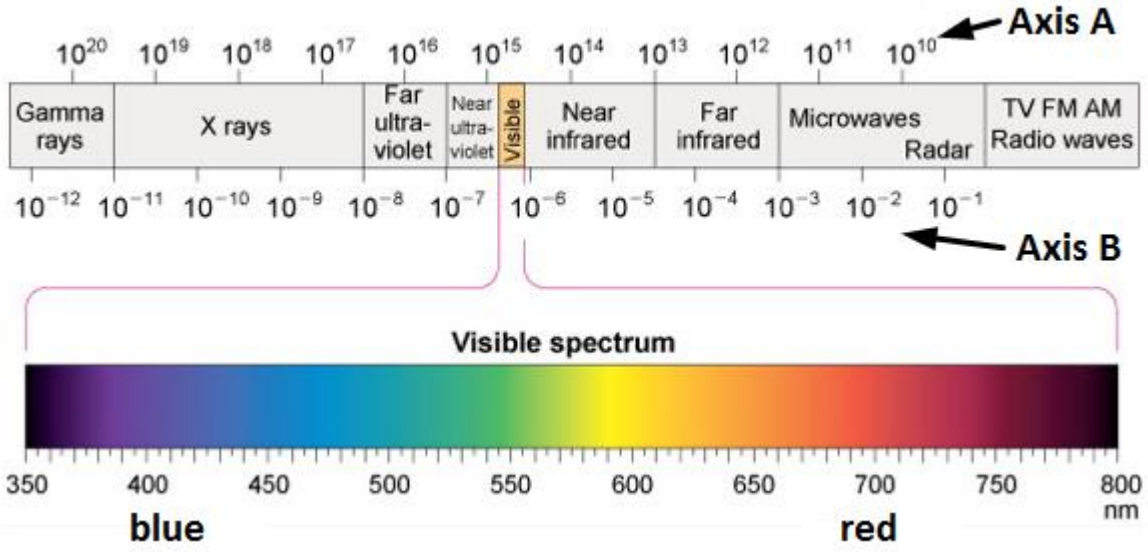
$E_{photon} = h\upsilon = 6.626 \times 10^{-34}\ Js \times 8.70 \times 10^{14}\ s^{-1} = 5.76 \times 10^{-19}\ J/photon$

Emol photons = 5.76 x 10^{-19} J/photon x 6.02 x 1023 photons/mol = 347000 J
=347 kJ/mol photons

Because the energy of the light is greater than the bond energy, the light can break the bonds.

2. Electromagnetic Spectrum

Consider the electromagnetic spectrum below.



a. Give the correct label for Axis A: **frequency (energy would be acceptable)**

b. Give the correct label for Axis B: **wavelength**

c. Which type of radiation has greater energy per photon? Radio or **IR**

d. Which type of radiation has greater frequency? **X-rays** or UV

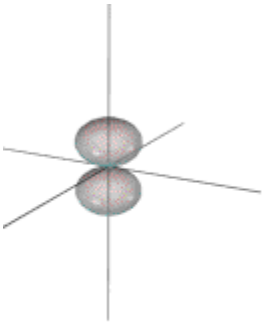
3.

Fill in the following chart regarding orbitals. Be careful to think about each one!

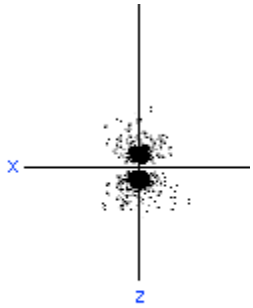
	number of orbitals	number of electrons that can be held
n = 3 shell	9	18
4p subshell	3	6
$3p_x$ orbital	1	2
2f subshell	0	0 (2f orbitals don't exist)
5g subshell	9	18

4. Orbital Shapes

Give the orbital designation for each orbital pictured. For example, 2s or $4p_x$.

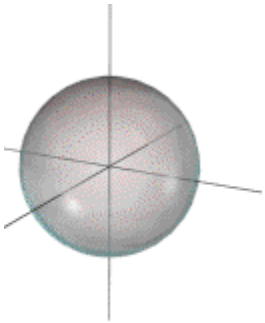


Boundary Surface

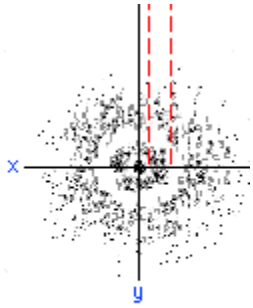


Dot Picture

$2p_z$



Boundary Surface



Dot Picture

3s

For the orbital above on the left: how many planar nodes? **1**

how many spherical nodes? **0**

Consider the wavefunction below. In what regions would it equal zero?

When x= 0, y = 0 or when r = 3

$$\psi = (3 - r)xy\, e^{-r}$$

How many planar nodes will it have? **2**

How may spherical nodes will it have? **1**

What orbital is this? Give a designation such as $2p_x$. **$4d_{xy}$**

5.

What is the driving force causing the formation of a covalent bond between two atoms? *Choose one.*

a. the ability to fill valence shells, usually with an octet of 8 electrons

b. the ability for electrons on one atom to be near the nucleus of another atom

c. the ability of electrons to "pair up" with other electrons from other atoms

d. the ability of two nuclei to be closer to each other, increasing the strong nuclear force

6. Electron Configurations

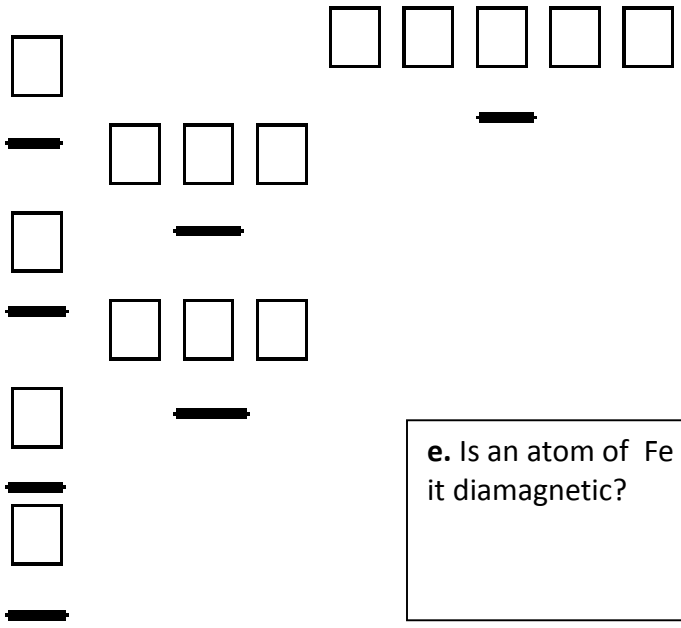
In any format you prefer, indicate the electron configurations for each of the following:

a. C $1s^2 2s^2 2p^2$

b. the Mn^{3+} ion $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$

c. The ion formed by O $1s^2 2s^2 2p^6$

d. Fill in the following charts to show the electron configuration of Fe. You need to fill in electron arrows and fill in the blanks below the boxes with what is appropriate to go there. That is, for each of the thick lines, you need to indicate what goes there in the diagram.



e. Is an atom of Fe **paramagnetic**, or is it diamagnetic?

7. Trends!

For *each pair*, indicate which is higher in energy:

a. the 2p orbitals of C or **the 3p orbitals of Si**

b. **the highest energy electron in Na** or the highest energy electron in Mg

For *each pair*, which bond is longer?

a. **C-C** or C-O

b. **C-C** or C=C

For each pair, indicate which is larger:

a. ionization energy of Li or **ionization energy of F**

b. radius of C or **radius of Si**

c. **radius of F^-** or radius of F^+

d. size of the ion made by Na or **size of the ion made by O**

For each, indicate which bond is more polar:

a. F – F or **H – F**

b. **O – H** or S – H

Summary of Trends: An atom has the following attributes:

a. it is smaller than P
b. it is smaller than B
c. it has lower energy orbitals than N
d. it does form chemical bonds
e. it is larger than F

What element is it? **Oxygen**

Explain your reasoning.

8. Lewis Structures

Draw Lewis Dot structures for the following:

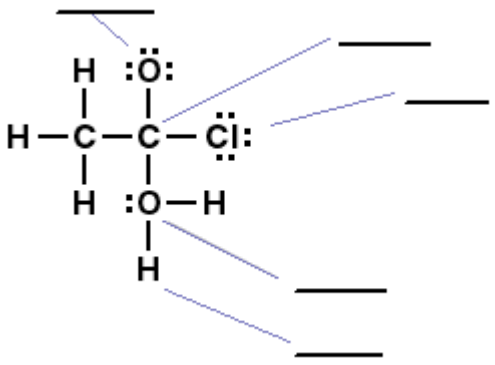
$CHCl_3$ (all atoms bonded to C)

SO_2 (draw all resonance structures)

$SeCl_4$

9. Formal Charge

Give the formal charge for each of the noted atoms in the following Lewis structure.



Top O = -1

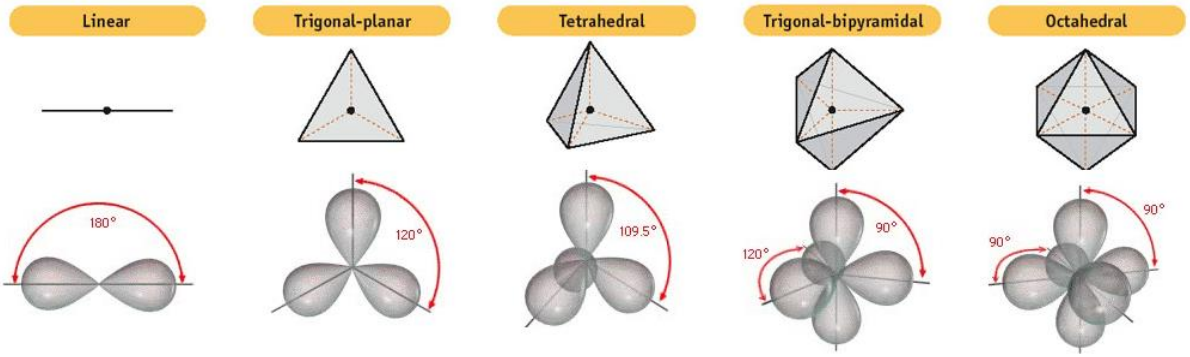
Cl = 0

C = 0

Bottom O = +1

H = 0

10.



For each of the following molecules, give the electron-pair geometry, the molecular geometry, the bond angles, and determine the molecular polarity. Space is given to show your work.

SO_2

electron-pair geometry: trigonal planar

molecular geometry: bent

bond angles: 120^o or a bit smaller

polar or nonpolar? polar

SO_3

electron-pair geometry: trigonal planar

molecular geometry: trigonal planar

bond angles: 120^o

polar or nonpolar? Nonpolar

SF_2

electron-pair geometry: tetrahedral

molecular geometry: bent

bond angles: 109^o or a bit smaller

polar or nonpolar? polar

11.
In the area below, sketch what the periodic table would look like if *all* orbital subshells could have exactly two orbitals instead of the way it really works (s = 1 orbital, p = 3 orbitals, d = 5 orbitals, etc.). Include just boxes in appropriate rows and columns, and do so for the first 4 periods of the periodic table. **Do not** put in element symbols. You're making a picture with a bunch of properly positioned boxes.

Each "block" uses 2 orbitals. Each block can therefore hold 4 electrons and the width of each block would be 4 elements wide. So, the periodic table would look that same except:

The s-block would expand from 2 elements wide to 4 elements wide.
The d-block contracts from 10 elements to 4 elements.
The p-block contracts from 6 elements to 4 elements.

12. Explain fully why F forms an anion and explain why its charge is -1 instead of -2.

F lies on the right side of the periodic table. It therefore has very low energy outermost orbitals. The reason for this: moving left-to-right across the periodic table, the number of protons in the nucleus increases. This increases attraction of electrons and lowers orbital energies. At the same time, electron-electron repulsions also increase, but to a lesser extent. So the overall effect is that effective nuclear charge increases moving to the right side of the table and orbital energies for those atoms are low.

Low energy orbitals with vacancies are good at attracting electrons, so F accepts electrons to form negatively charged ions.

Only vacancies in orbitals can be used to accept electrons, so the number of electrons that can be accepted equals the number of low energy vacancies. F has the electron configuration $1s^2 2s^2 2p^5$ so it has 1 low energy vacancy it can use. Therefore it accepts only 1 electron and form a -1 ion. To accept a 2^{nd} electron to make a -2 ion would require placing that 2^{nd} electron in a 3s orbital and that orbital is too high in energy to attract an electron from another element.