In-Class Quantum Review 2019!

1a. Write the electron configuration for each of these. * don't abbreviate for Mg or Mg ion.

chloride ion

Cobalt (II) ion

*magnesium atom

*magnesium ion

Molybdenum atom (Note: Mo doesn't follow the "rules")

Molybdenum (IV) ion

Gold (Au). Note: Gold doesn't quite "follow the rules."

b. How many **valence** electrons are in each of these?

chloride ion   Mg atom   Mo atom   Gold atom   Bismuth (Bi) atom

2. Consider electron is 1s, 2s, 3s, and 4s orbitals.
a. Which of these orbitals is the "highest energy" orbital and which is the "lowest energy" orbital?

b. Explain why the electrons in the "highest energy" orbital have more energy… why is this a higher energy orbital?

c. How does this relate to ionization energy, for example,
Which has higher ionization energy: magnesium or calcium. Why?

3. Photoelectric effect.
a. Explain the process of the photoelectric effect.

b. The photoelectric effect displays the _________-like properties of light. (wave or particle?)

Consider the work function values of 4.34×10^{-19} J, 7.73×10^{-19} J, and 1.09×10^{-18} J.
These below to the elements gold, iodine, and calcium (not in order though.)
c. What is the meaning of the work function?

d. Which periodic trend is the work function more similar to: electron affinity or ionization energy?

e. How do metals compare to nonmetals in terms of their work function?

f. Which work function (above) corresponds to iodine?

g. Calcium is higher on the metal activity series than gold.
Determine which work function belongs to Ca and which belongs to Au.

Suppose gold is hit with monochromatic light from a 10 Watt bulb with a wavelength of 211 nm.
h. Determine the maximum kinetic energy of the ejected electrons.

i. What is the min/max (which is it?) wavelength that will be effective in causing the photoelectric effect in gold?

3j. How will the <u>number</u> of electrons ejected and the <u>kinetic energy</u> of the ejected electrons change (relative to the 10 Watt bulb with 211 nanometers), in each case? Assume the distance to the bulb is constant.

	Number e- ejected	KE of ejected e-
10 W and 280 nm	_______________	_______________
10 W and 230 nm	_______________	_______________
10 W and 150 nm	_______________	_______________
20 W and 211 nm	_______________	_______________
20 W and 280 nm	_______________	_______________
20 W and 150 nm	_______________	_______________

4a. Consider these values for bromine: -324 kJ/mole, 2.8, 1140 kJ/mole
Which value corresponds to the ionization energy? the electron affininity? the electronegativity?
Define each term as part of your answer.

Ionization energy:

Electron affinity:

Electronegativity:

b. What "reaction" corresponds to the first ionization energy of bromine?
Write a balanced "reaction" that shows what is happening, including phase subscripts and the energy term.

c. What "reaction" corresponds to the electron affinity of bromine?
Write a balanced "reaction" that shows what is happening, including phase subscripts and the energy term.

5a. For each pair, circle the atom or ion with the larger radius!

Ca	or	Br	F^{-1}	or	Cl^{-1}
Fe	or	Fe^{+2}	Ca	or	Li
Te	or	Te^{-2}			
Cl^{-1}	or	Ca^{+2}			
P	or	As			
Fe^{+3}	or	Mn^{+2}			

c. For each pair, circle the atom or ion with the higher ionization energy:

P	or	As	Ca	or	Br	Fe^{+2}	or	Fe^{+3}	Ca^{+2}	or	Ca

6. a. Out of Silicon and Chlorine, which element would you expect to have a higher first ionization energy? Justify your choice; explain why the element you chose should have a higher ionization energy.

b. Out of Magnesium and Strontium, which element would you expect to have a higher first ionization energy? Justify your choice; explain why the element you chose should have a higher ionization energy.

bb. Out of Mg and Sr, which is more metallic?

c. Explain why arsenic(As) has a higher first ionization energy than selenium (Se).
d. Explain why Cadmium (Cd) has a higher first ionization energy than Indium (In).

7. a. The process of breaking a covalent bond into two separate atoms is always _______ thermic.

b. The process of forming a covalent bond from two separate atoms is always _______ thermic.

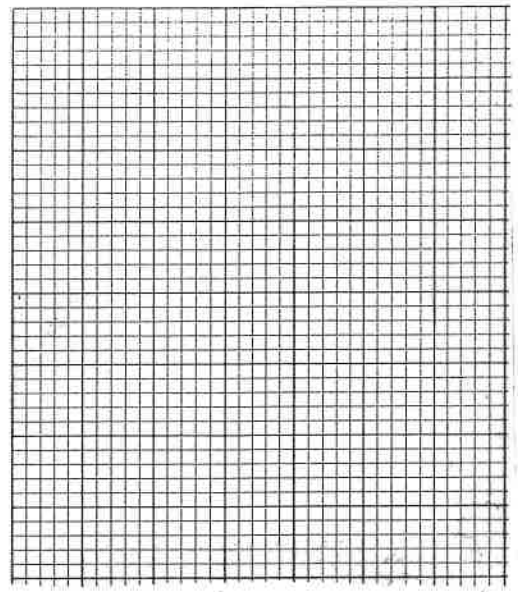
c. What type(s) of EM radiation is most commonly absorbed/released in (a) and (b)?____________________

d. What type(s) of EM radiation is most commonly associated with vibration of bonds? ____________________

e. What type(s) of EM radiation is most commonly associated with rotation of molecules?____________________

f. When a valence electron is removed from an atom (in ionization), what type of EM radiation does this require?

____



g. Visible light is most commonly absorbed/released as ______.

x. "hydrogen bonds" form or "break"
y. an atom or molecule is ionized to form a cation
z. electrons transition between nondegenerate d-orbitals.

8. In HCl, the H-Cl bond length is 0.127 nm, and the bond energy is 431 kJ/mole.

a. What does the bond energy of 431 kJ/mole mean?

b. Sketch a graph showing potential energy vs internuclear distance for a H-Cl bond.

c. When the H and Cl start out very far apart (at say, 10 nm), and then bond together at a distance of 0.127 nm, is energy absorbed or released? WHY?

d. If the H and Cl are bonded together at a distance of 0.127 nm, and they get closer together (say, at 0.10 nm), is energy absorbed or released? WHY?

8e. Convert the 431 kJ/mole (the bond energy of the H—Cl bond) to a photon energy. (Joules per photon).

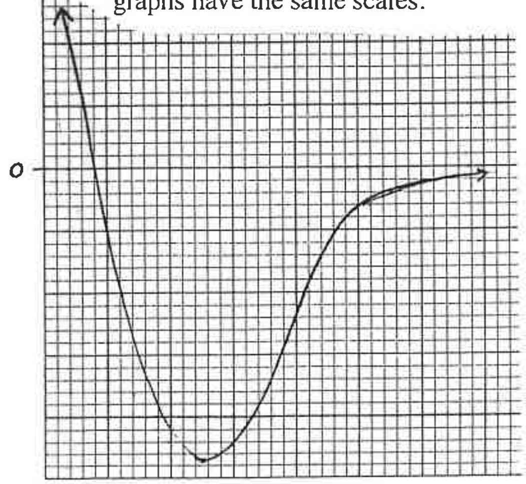
f. Find the wavelength (in nm) that corresponds to this photon energy.

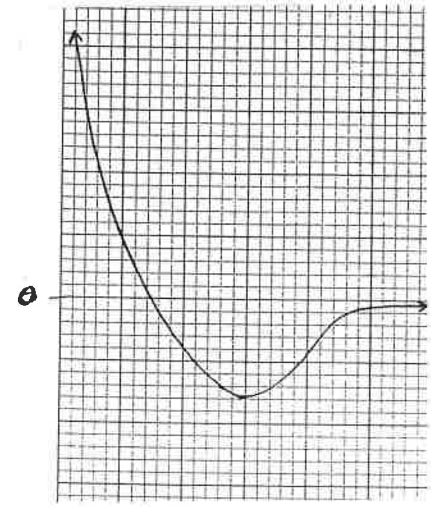
g. Breaking bonds usually requires photons in the ultraviolet range (and a few hundred kJ/mole). Removing valence electrons also requires photons in the ultraviolet range. (and 100's or 1000's of kJ/mole) However, removing a CORE electron often requires X-rays! Explain why!

h. Removing a "1s" electron from a sulfur atom requires x-rays with a wavelength of 0.501 nm (or shorter). Calculate the photon energy of these x-rays.

i. Convert the photon energy into kilojoules per mole.

J. The graphs below show potential energy vs internuclear distance for a N-N single bond and a N-N double bond. Which is the single bond, and which is the double bond? Explain in two different ways how you know. Assume the graphs have the same scales.





9. Names to Know: (What they did, their atomic models (if applicable), and roughly when.)

Dalton,

Thomson,

Einstein,

Rutherford,

Bohr,

de Broglie,

Schrodinger

Heisenberg

(Chadwick- actually you don't need to know Chadwick. but FYI he discovered the neutron in 1932)

10 a. Spectrophotometry, Beer's Law, Complementary Colors:
(What is spectrophotometry? What does Beer's Law Say? What are complementary colors and what do they have to do with spectrophotometry?)

b. Which of these would you expect to be colored?

Fe^{+2} Ti^{+2} Ti^{+4} Ca^{+2} Cr^{+3} Zn^{+2}

An experiment is done to measure the absorbance of a solution of $Fe(NO_3)_3$, which is orange.
c. What type of wavelength of light (what color) should be used in the spectrophotometer? Why?

d. A student creates a ferric nitrate solution by dissolving 10.0 grams of ferric nitrate into a total solution volume of 250.0 mL (in a volumetric flask) and then mixing the solution thoroughly. They then fill a clean, dry cuvette about halfway up with the ferric nitrate solution, wipe the cuvette to remove any fingerprints, and then correctly measure the absorbance.
How would the reported absorbance change (increase, decrease, or no change?) if the student did the following things?

____________They dissolved the 10.0 grams into a 500.0 mL flask instead of a 250. mL flask (and filled it to the line)

____________ They didn't wipe off the cuvette, so it had fingerprints on it.

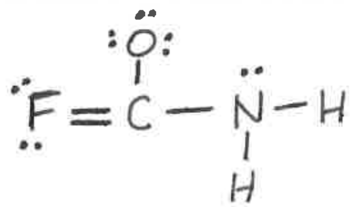
____________ They filled the cuvette ¾ of the way, instead of ½ of the way.

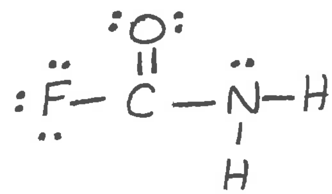
____________ Right before adding the ferric nitrate solution, they rinsed the cuvette with distilled water, and did not dry it.

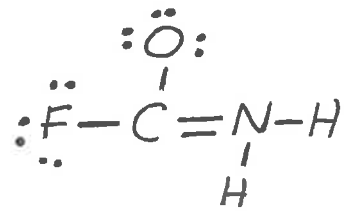
____________ They dissolved 20.0 grams of ferric nitrate instead of 10.0 grams, and 500.0 mL instead of 250.0 mL (and filled it to the line).

____________ After pouring the ferric nitrate solution into the cuvette, they waited a day before testing it in the spectrophotometer. (It was a hot day, so 10% of the liquid evaporated)

11. Three possible dot structures for a compound are shown below.
a. Determine the formal charge for each atom in each structure.
b. Which dot structure is best? (which one has the lowest potential energy?)
c. Which dot structure is worst? (which one has the highest potential energy?)







12. Which of these molecules/ions have resonance? Draw the dot structure of each to tell.

NO_3^{-1} PF_5 NO_2^{-1} HNO_2 CS_2

SO_3^{-2} SO_3 CH_2O (C is central) CF_4 IBr_2^{-1} PO_2^{-1}

13a. Draw the dot structures or the carbonate ion (CO_3^{-2}), and carbonic acid (H_2CO_3). Which of these have resonance?

b. There should be 3 different C—O bond lengths (total) in the structures you drew.
Indicate which C—O bond is expected to be the shortest, and which is expected to be the longest.

c. There should be 3 different C—O bond strengths (total) in the structures you drew.
Indicate which C—O bond should be the strongest, and which should be the weakest.
Also, which C—O bond should have the highest "bond energy", and which is expected to be the lowest "bond energy"?

d. Determine all bond angles in carbonate ion and in carbonic acid.
(If they are more or less than the ideal bond angles, you will need to estimate the actual angles.)

14. Do the following for NF_3, BCl_3, CH_2S (C is the central atom), PF_5, SO_2, ICl_4^{-1}, CS_2, and IF_5

a. Lewis Dot structure

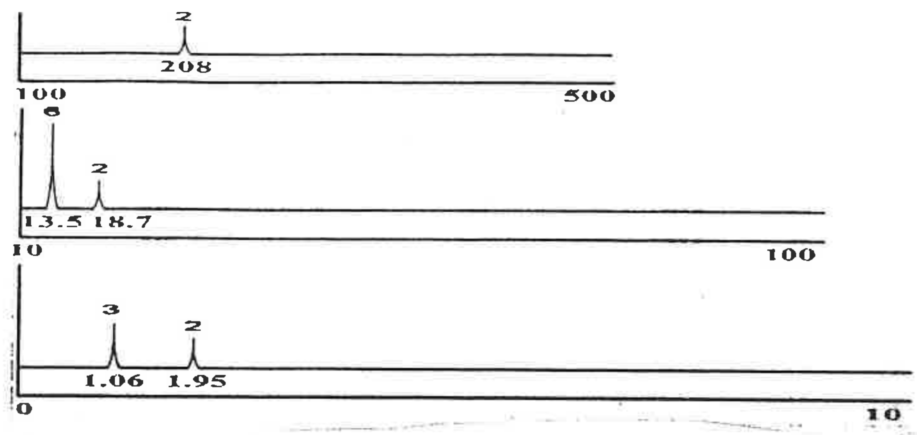
b. Identify VSEPR shape name(s) and bond angles, and sketch it
(If the bond angles are not the "ideal" angles, you'll need to estimate what the angles would be.)

c. Is it polar? If so, draw the net polarity arrow. (Don't worry about the polarity of the ion...)
(all the bonds have at least a 0.5 ΔEN except those in CH_2S)

d. Determine the hybridization of the central atom, unless it has an expanded octet (more than 8 v.e.).

e. Draw the orbital filling diagram for the central atom in NF_3, BCl_3, CH_2S, SO_2 and CS_2 before and after hybridization.

f. Which of the molecules have at least 1 pi bond? Is/are the pi bond(s) localized or delocalized?



15. Consider this spectrum acquired by doing photoelectron spectroscopy with Phosphorus.
a. Label each axis. Assume that the energy units are MJ/mole.
b. Label each peak – which electrons correspond to which peak?
c. How do the peak heights correspond to the orbitals/configuration/electrons? explain.

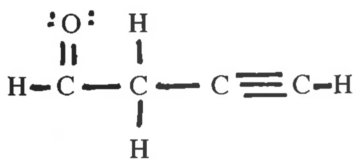
d. What is the IE1 (first ionization energy) of phosphorus, in kJ/mole?

e. Write the chemical equation that corresponds to IE1 of phosphorus, including the energy term.

f. In the PES spectrum for Sulfur, the highest binding energy peak is at 239 MJ/mole.
What orbital does this correspond to? _______
Explain why the maximum B.E. for sulfur (239 MJ) is greater than the maximum B.E. for phosphorus (208 MJ).

g. Sulfur's lowest energy peak is at 1.00 MJ/mole. What orbital does this correspond to? _______
Explain why this B.E. (1.00 MJ) is less than the value for phosphorus's B.E. (1.06), even though these correspond to the same type of orbital.

16. How many total sigma and pi bonds in this?
What is the hybridization of each carbon?
What is the ideal bond angle at each carbon?
Does this molecule have resonance?
Draw the orbital diagram for an unhybridized carbon atom.
For the first three carbons, draw the orbital diagram after hybridization.



17a. Consider the species SO_3^{-2} and SO_3. Which one(s) of these exhibit resonance?
b. Another way I could have asked (a), is, which one(s) of these have a ________________________________?
c. Explain your answers to (a) and (b).
d. How do the S-O bond strengths compare in the above two things?
e. Identify the hybridization of the sulfur in the each species in (a).

18a. If an electron in a hydrogen atom "jumps" from n = 5 to n =2, what will be the change in energy?

b. Will the atom *absorb* or *release* energy as this change occurs? (which one?) why?

Suppose an electron in a hydrogen atom starts at n =1, and then leaves the atom.
This means that the final n-level is essentially ∞ !

c. How much energy must the atom absorb to do this, in Joules?

d. Find the frequency and wavelength of the photon that the atom must absorb (starting with the energy from part(c)).

e. What type of light is this? (What part of the EM spectrum)?
(hint, it is the same type of EM radiation that is typically required to ionize an atom!)

f. Convert the energy required to kJ/mole.