Unit 1 Review for Midterms

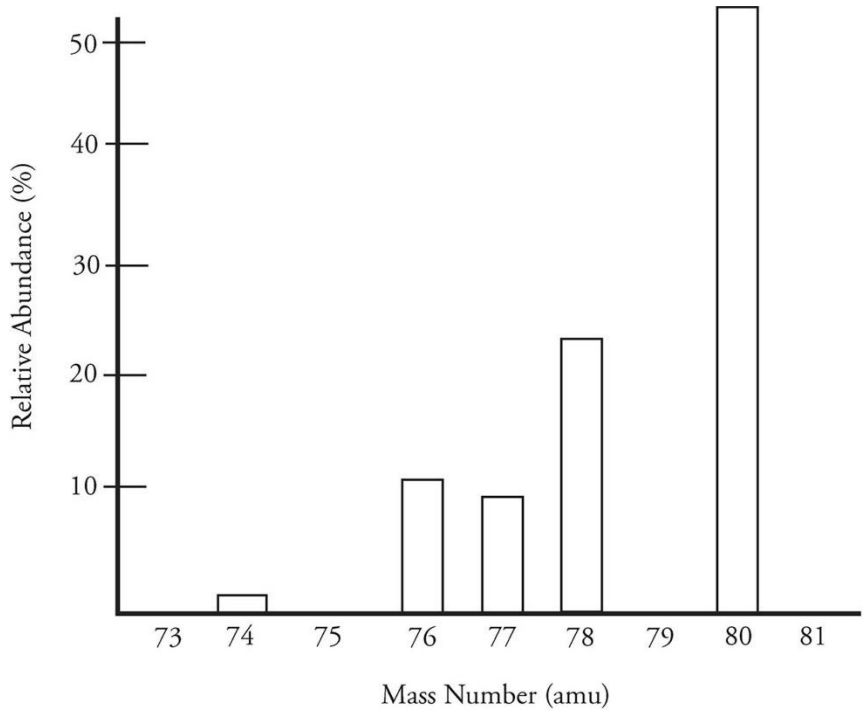
Atomic structure and properties

You should be able to:

- Convert between moles, grams, particles using Avogadro's number or molar mass where appropriate
- Explain the relationship between an element's mass spectrum and the masses of its isotopes
- Determine an average atomic mass using information from the mass spectrum
- Understand the law of definite proportions (same compound, same ratio of masses)
- Know the differences between a pure substance and a mixture
- Determine the empirical and molecular formulas from a compound given percent composition
- Determine the empirical formula from combustion analysis
- Understand the relationship between attractive/repulsive force, charge, and distance in Coulomb's law
- Write electron configurations for elements
- Know the difference between valence electrons and core electrons
- Understand the relationship between ionization energy of an electron and its position in the atom and electron shielding
- Explain the relationship between the photoelectron spectrum of an atom/ion and its electron configuration and the interactions between the electrons and nucleus
- Explain the relationship between ionization energy, atomic and ionic radii, electron affinity, and electronegativity trends
- Know what analogous compounds are and why they are analogous
- Understand why ions have a specific charge

1. Perform the following calculations:
   a. Calculate the percent by mass composition of ethylene glycol, $C_2H_6O_2$ (used in anti-freeze).
   b. Ascorbic acid (vitamin C) contains 40.92% C, 4.58% H, and 54.50% O by mass. It has a molar mass of 176.12 g/mol. Determine both the empirical formula and molecular formula of ascorbic acid.
   c. Ethyl butyrate, a compound that gives pineapple its characteristic odor, is composed of carbon, hydrogen, and oxygen. When a 2.78 g sample of ethyl butyrate is combusted, 6.32 g of carbon dioxide and 2.58 g of water are produced. Calculate the empirical formula of ethyl butyrate.
   d. A 5.250 g sample of nicotine was combusted, producing 14.242 g of carbon dioxide and 4.083 g of water. Nicotine contains carbon, hydrogen, and nitrogen. What is the empirical formula for nicotine? If nicotine has a molar mass of approximately 160 g/mol, what is its molecular formula?

2. Answer the following questions about the mass spectrum below:



   a. What does the mass spectrum tell us?
   b. Estimate (no calculator or calculations) the average atomic mass of the element.
   c. Calculate the average atomic mass of the element (with calculator).
   d. Identify the element using the periodic table.

3. Answer the following questions about periodic trends:
   a. As you go down a column on the periodic table, what happens to atomic radius? Why? Include Coulomb's law, electron shells, and electron shielding in your answer where appropriate.
   b. As you go across a row on the periodic table, what happens to atomic radius? Why? Include Coulomb's law, electron shells, nuclear charge, and electron shielding in your answer where appropriate.
   c. Describe the trends in ionization energy, including appropriate explanations.
   d. Describe the trends in electron affinity, including appropriate explanations.
   e. Describe the trends in electronegativity, including appropriate explanations.
   f. Explain the following variations in radii:
      i. $I^- > I > I^+$
      ii. $Ca^{2+} > Mg^{2+} > Be^{2+}$
   g. Write equations that show the processes that describe the first, second, and third ionization energies of an aluminum atom. Which would require the least amount of energy?

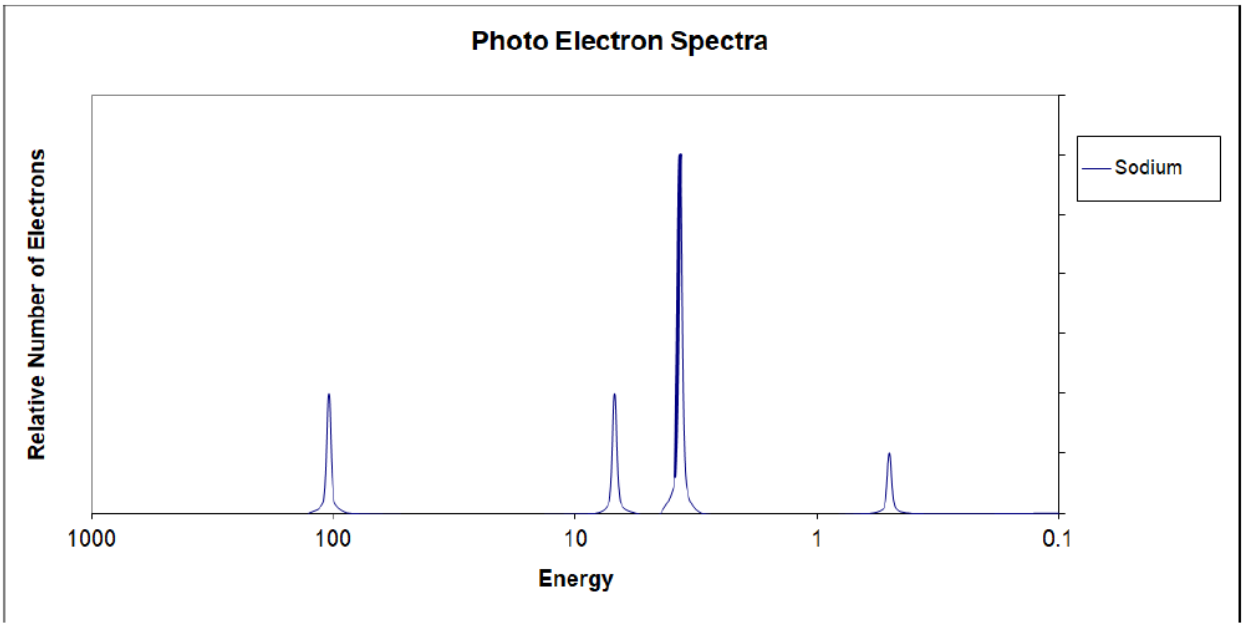
h. An element has the following ionization energies:

Ionisation energy number	Enthalpy / kJ mol^{-1}
1st	737.75
2nd	1450.68
3rd	7732.68
4th	10542.51

How many valence electrons are in an atom of this element? What group is this element in? Explain.

4. Answer the following questions about electron configurations:
   a. Write the full electron configurations for beryllium, selenium, and iron.
   b. Write the electron configurations for the fluoride ion, calcium ion, and zinc ion.
   c. Write the orbital diagrams for carbon and sodium.
   d. Use orbital diagrams to illustrate what happens when an oxygen atom gains two electrons.

5. For the following PES diagrams,
   a. Annotate each spectrum with a full electron configuration and orbital diagram.
   b. Explain the shift in peaks from sodium to silicon.



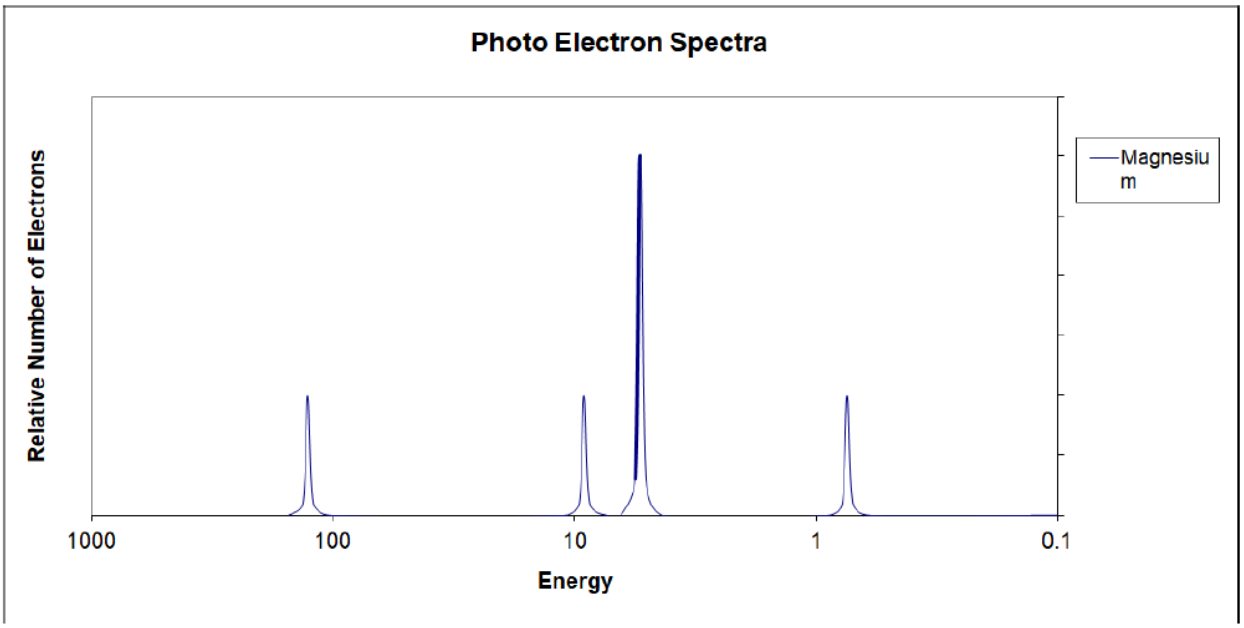


Photo Electron Spectra
Relative Number of Electrons
Magnesium
1000
100
10
1
0.1
Energy

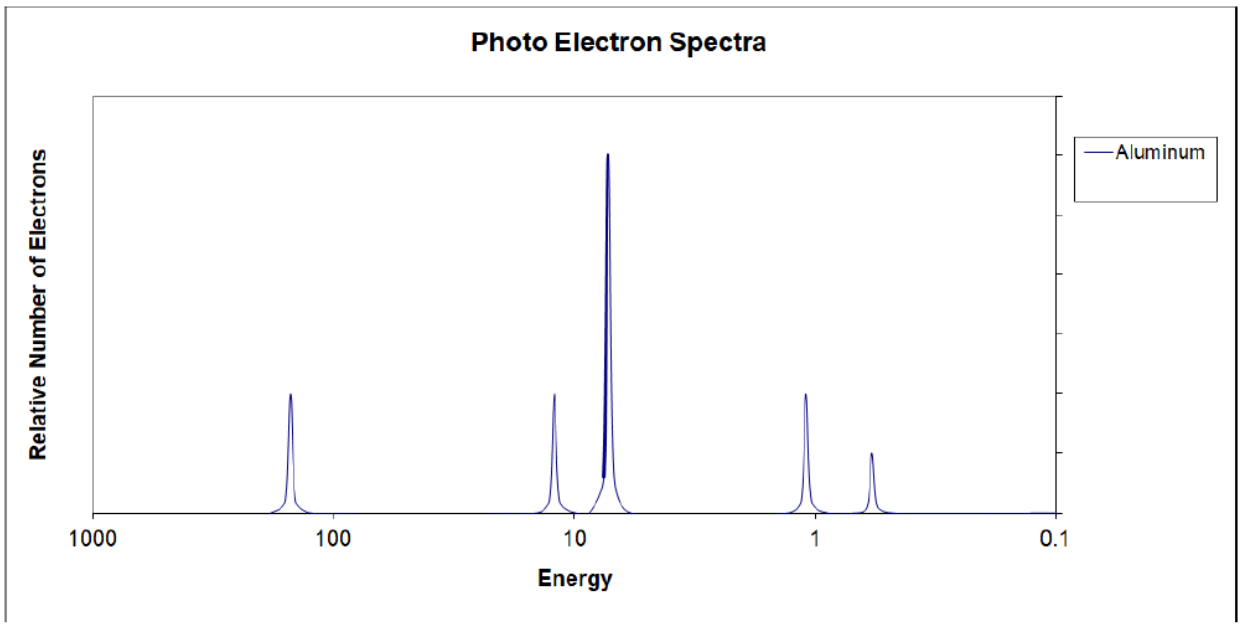


Photo Electron Spectra
Relative Number of Electrons
Aluminum
1000
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1
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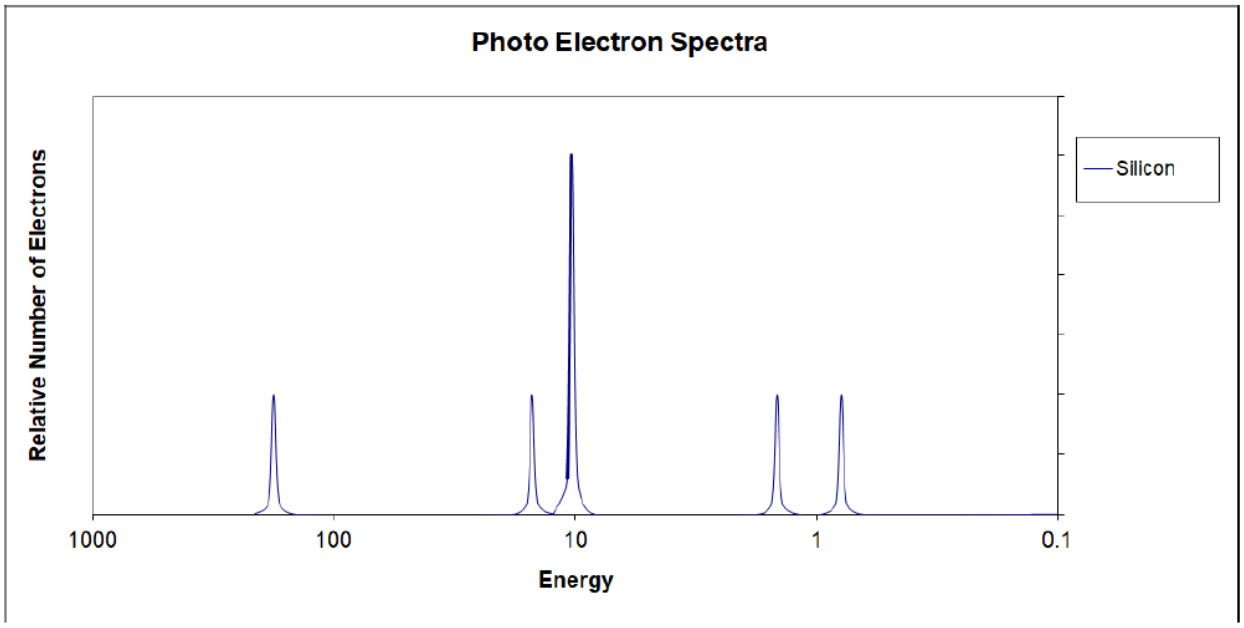
Energy



AP Questions

1. Answer the following questions that relate to the analysis of chemical compounds.

   a. A compound containing the elements C , H , N , and O is analyzed. When a 1.2359 g sample is burned in excess oxygen, 2.241 g of $CO_2(g)$ is formed. The combustion analysis also showed that the sample contained 0.0648 g of H.

      i. Determine the mass, in grams, of C in the 1.2359 g sample of the compound.

      ii. When the compound is analyzed for N content only, the mass percent of N is found to be 28.84 percent. Determine the mass, in grams, of N in the original 1.2359 g sample of the compound.

      iii. Determine the mass, in grams, of O in the original 1.2359 g sample of the compound.

      iv. Determine the empirical formula of the compound.

   b. A different compound, which has the empirical formula CH_2Br , has a vapor density of 6.00 g L^{-1} at 375 K and 0.983 atm. Using these data, determine the following.

      i. The molar mass of the compound

      ii. The molecular formula of the compound

Compound	Melting Point (°C)
LiI	449
KI	686
LiF	845
NaF	993

2. A student learns that ionic compounds have significant covalent character when a cation has a polarizing effect on a large anion. As a result, the student hypothesizes that salts composed of small cations and large anions should have relatively low melting points.
   a. Select two compounds from the table and explain how the data support the student's hypothesis.