

2003B.7 – Trends

2006.8 – e- config, trends, solubility

2006B.7 – Trends, emission spectrum

2007B.2 – Abundance, mole conv., $c = \lambda\nu$, $E = h\nu$, energy

2007B.6 – Trends, e- config, ox #, trends

2008.5 – Trends (IE)

2015B.6 – $E = h\nu$, e⁻ config

2016B.5 – e⁻ config, Trend (IE), $c = \lambda\nu$, $E = h\nu$

2017B.7 – e⁻ config, Trend (IE), Mass Spec,

2003B.7

Account for the following observations using principles of atomic structure and/or chemical bonding. In each part, your answer must include specific information about both substances.

- (a) The Ca^{2+} and Cl^- ions are isoelectronic, but their radii are not the same. Which ion has the larger radius? Explain.
- (b) **REMOVED**
- (c) Compounds containing Kr have been synthesized, but there are no known compounds that contain He.
- (d) The first ionization energy of Be is 900 kJ mol^{-1} , but the first ionization energy of B is 800 kJ mol^{-1} .

Suppose that a stable element with atomic number 119, symbol Q, has been discovered.

- (a) Write the ground-state electron configuration for Q, showing only the valence-shell electrons.
- (b) Would Q be a metal or a nonmetal? Explain in terms of electron configuration.
- (c) On the basis of periodic trends, would Q have the largest atomic radius in its group or would it have the smallest? Explain in terms of electronic structure.
- (d) What would be the most likely charge of the Q ion in stable ionic compounds?
- (e) **REMOVED**
- (f) Assume that Q reacts to form a carbonate compound.
 - (i) Write the formula for the compound formed between Q and the carbonate ion, CO_3^{2-} .
 - (ii) Predict whether or not the compound would be soluble in water. Explain your reasoning.

2006B.7

Account for each of the following observations in terms of atomic theory and/or quantum theory.

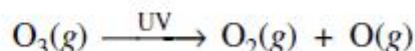
- (a) Atomic size decreases from Na to Cl in the periodic table.
- (b) **REMOVED**
- (c) The first ionization energy of K is less than that of Na.
- (d) Each element displays a unique gas-phase emission spectrum.

Answer the following problems about gases.

- (a) The average atomic mass of naturally occurring neon is 20.18 amu. There are two common isotopes of naturally occurring neon as indicated in the table below.

Isotope	Mass (amu)
Ne-20	19.99
Ne-22	21.99

- (i) Using the information above, calculate the percent abundance of each isotope.
- (ii) Calculate the number of Ne-22 atoms in a 12.55 g sample of naturally occurring neon.
- (b) A major line in the emission spectrum of neon corresponds to a frequency of $4.34 \times 10^{14} \text{ s}^{-1}$. Calculate the wavelength, in nanometers, of light that corresponds to this line.
- (c) In the upper atmosphere, ozone molecules decompose as they absorb ultraviolet (UV) radiation, as shown by the equation below. Ozone serves to block harmful ultraviolet radiation that comes from the Sun.



A molecule of $\text{O}_3(g)$ absorbs a photon with a frequency of $1.00 \times 10^{15} \text{ s}^{-1}$.

- (i) How much energy, in joules, does the $\text{O}_3(g)$ molecule absorb per photon?
- (ii) The minimum energy needed to break an oxygen-oxygen bond in ozone is 387 kJ mol^{-1} . Does a photon with a frequency of $1.00 \times 10^{15} \text{ s}^{-1}$ have enough energy to break this bond? Support your answer with a calculation.

	First Ionization Energy (kJ mol ⁻¹)	Second Ionization Energy (kJ mol ⁻¹)	Third Ionization Energy (kJ mol ⁻¹)
Element 1	1,251	2,300	3,820
Element 2	496	4,560	6,910
Element 3	738	1,450	7,730
Element 4	1,000	2,250	3,360

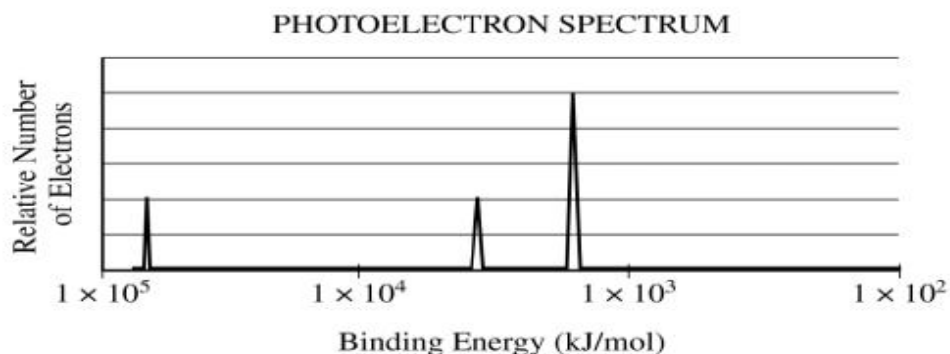
The table above shows the first three ionization energies for atoms of four elements from the third period of the periodic table. The elements are numbered randomly. Use the information in the table to answer the following questions.

- (a) Which element is most metallic in character? Explain your reasoning.
- (b) Identify element 3. Explain your reasoning.
- (c) Write the complete electron configuration for an atom of element 3.
- (d) What is the expected oxidation state for the most common ion of element 2 ?
- (e) What is the chemical symbol for element 2 ?
- (f) A neutral atom of which of the four elements has the smallest radius?

Using principles of atomic and molecular structure and the information in the table below, answer the following questions about atomic fluorine, oxygen, and xenon, as well as some of their compounds.

Atom	First Ionization Energy (kJ mol ⁻¹)
F	1,681.0
O	1,313.9
Xe	?

- (a) Write the equation for the ionization of atomic fluorine that requires 1,681.0 kJ mol⁻¹.
- (b) Account for the fact that the first ionization energy of atomic fluorine is greater than that of atomic oxygen. (You must discuss both atoms in your response.)
- (c) Predict whether the first ionization energy of atomic xenon is greater than, less than, or equal to the first ionization energy of atomic fluorine. Justify your prediction.



Peak 1	Peak 2	Peak 3
6.72×10^4 kJ/mol	3.88×10^3 kJ/mol	1.68×10^3 kJ/mol

The complete photoelectron spectrum of an unknown element is shown above. The frequency ranges of different regions of the electromagnetic spectrum are given in the table below.

Region of Electromagnetic Spectrum	Frequency Range (s^{-1})
Infrared (IR)	1×10^{12} to 4×10^{14}
Ultraviolet/visible (UV/vis)	4×10^{14} to 5×10^{16}
X-rays	5×10^{16} to 1×10^{19}
Gamma rays	$> 1 \times 10^{19}$

- (a) To generate the spectrum above, a source capable of producing electromagnetic radiation with an energy of 7×10^4 kJ per mole of photons was used. Such radiation is from which region of the electromagnetic spectrum? Justify your answer with a calculation.
- (b) A student examines the spectrum and proposes that the second ionization energy of the element is 3.88×10^3 kJ/mol. To refute the proposed interpretation of the spectrum, identify the following.
- The subshell from which an electron is removed in the second ionization of an atom of the element
 - The subshell that corresponds to the second peak of the photoelectron spectrum above

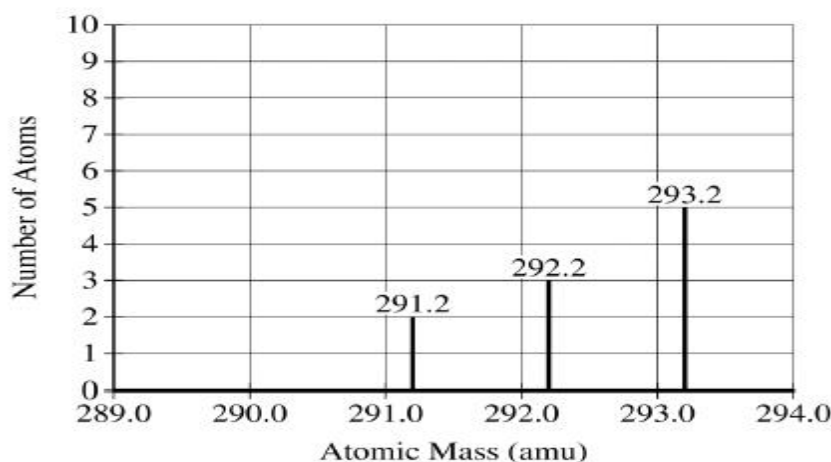
Element	First Ionization Energy (J/mol)
Na	4.95×10^5
K	4.19×10^5

The first ionization energies for Na and K are given in the table above. Na metal reacts vigorously with water to form hydrogen gas and a metal hydroxide. K metal reacts vigorously as well, but it bursts into a violet-colored flame.

- Write the electron configuration for a K^+ ion.
- Based on principles of atomic structure, explain why the first ionization energy of K is lower than the first ionization energy of Na.
- A student hypothesizes that the flame is violet colored because violet light consists of photons that have the energy needed to ionize K atoms. The wavelength of the violet light is measured to be 423 nm.
 - Calculate the energy, in J, of one photon of violet light with a wavelength of 423 nm.
 - Is the energy of one photon of the violet light sufficient to cause the ionization of a K atom? Justify your answer.

A new element with atomic number 116 was discovered in 2000. In 2012 it was named livermorium, Lv. Although Lv is radioactive and short-lived, its chemical properties and reactivity should follow periodic trends.

- Write the electron configuration for the valence electrons of Lv in the ground state.
- According to periodic properties, what would be the most likely formula for the product obtained when Lv reacts with $\text{H}_2(\text{g})$?
- The first ionization energy of polonium, Po, is 812 kJ/mol. Is the first ionization energy of Lv expected to be greater than, less than, or equal to that of Po? Justify your answer in terms of Coulomb's law.
- Shown below is a hypothetical mass spectrum for a sample of Lv containing 10 atoms.



Using the information in the graph, determine the average atomic mass of Lv in the sample to four significant figures.