Ionization Energy

Unit: Periodicity

MA Curriculum Frameworks (2016): HS-PS1-1

Mastery Objective(s): (Students will be able to…)

- Rank elements according to ionization energy based on their location on the periodic table.

Success Criteria:

- Rankings account for size and effective nuclear charge.

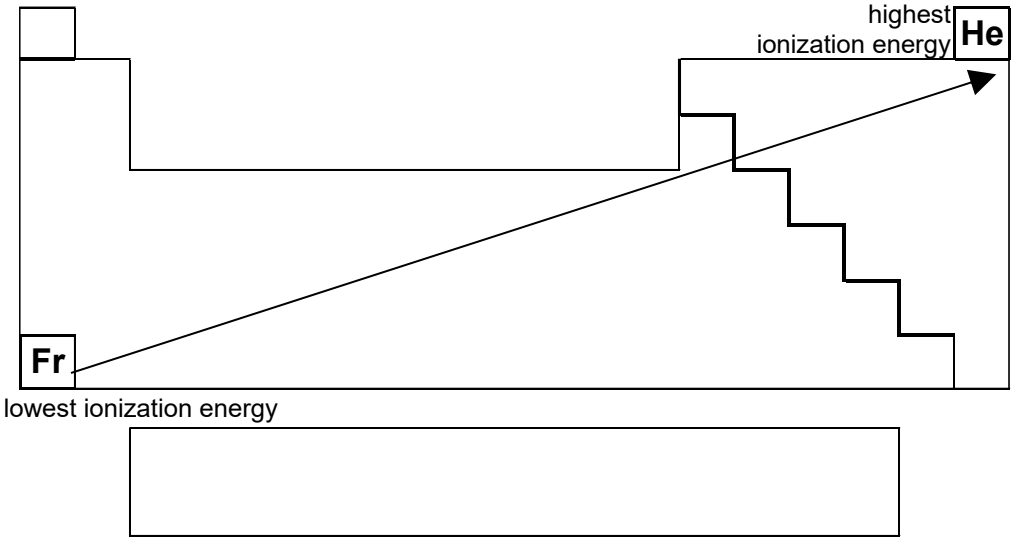
Tier 2 Vocabulary: ionization

Language Objectives:

- Explain why ionization energy increases as you go up and to the right on the periodic table.

Notes:

ionization energy: the amount of energy that it takes to remove an electron from an atom. (This makes it an ion. Ionization energy is literally the amount of energy it takes to make an atom into an ion.) Ionization energy is a measure of how tightly an element holds onto its electrons.



Use this space for summary and/or additional notes:

Ionization Energy

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The more an element "wants" to gain electrons (meaning the more energetically favorable it is), the more tightly it will hold onto its own electrons, and the higher the ionization energies.

- Atoms of elements farther to the right hold on to electrons more tightly, because obtaining a full valent shell by gaining electrons is more stable than obtaining a full valent shell by losing them. Similarly, elements farther to the left are more stable if they attain a full valent shell by losing electrons than by gaining them.
- Atoms of elements higher up within a group hold on to electrons more tightly because they have fewer energy levels & sublevels to spread the electrons over. Also, because the atom has fewer levels, the electrons are closer to the nucleus, which means the force of attraction by the positive charge is stronger.
- Noble gases *and ions that have the same electron configuration as a noble gas* have the highest ionization energies, because they have the most stable electron configurations.
- Helium has the highest ionization energy. Francium has the lowest.

Ionization energy is calculated by measuring how much heat it takes to get an element to lose an electron and become a positive ion.

1st ionization energy: the amount of energy it takes to remove one electron from a neutral atom, to make a +1 ion.

2nd ionization energy: the amount of energy it takes to remove a second electron to make a +2 ion from a +1 ion.

3rd, 4th ionization energy, *etc.*: the amount of energy it takes to remove a third electron to make a +3 ion from a +2 ion, to remove a fourth electron to make a +4 ion, *etc.*

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Consider the following table of ionization energies.

Element	1st Ionization Energy (kJ/mol)	2nd Ionization Energy (kJ/mol)	3rd Ionization Energy (kJ/mol)
	(neutral atom)	(+1 ion)	(+2 ion)
Ne	2081	3952	6122
Na	496	4562	6912
Mg	738	1451	7733

Notice that there is a large jump in the ionization energy once the atom or ion has a full valent shell (the same electron configuration as a noble gas, or a "noble gas core").

In the above table, neon (Ne) has the largest 1st ionization energy, because it is a noble gas and it already has a full valent shell.

Sodium (Na) has the smallest 1st ionization energy. This is because removing one electron will give it a "noble gas core". However, sodium has the largest 2nd ionization energy, because the +1 ion has a full valent shell, and is therefore more stable.

Magnesium (Mg) has the lowest 2nd ionization energy, because removing that second electron will give it a noble gas core. However, because the +2 ion has a noble gas core, Mg has the largest 3rd ionization energy.

First ionization energies for all elements are listed in your Chemistry Reference Tables in "Table Z. Selected Properties of the Elements," which begins on page 516.

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Homework Problems

For each pair of elements:

- Answer the question about which element has the higher or lower ionization energy.
- State the direction(s) on the periodic table (up *vs.* down and/or left *vs.* right) that you based your choice on.
- Explain *why* moving that direction (up *vs.* down and/or left *vs.* right) caused the difference in ionization energy.

1. Which element has a *higher* first ionization energy: Na or Al ?
   Direction(s):
   Explanation:

2. Which element has a *higher* first ionization energy: Mg or Ca ?
   Direction(s):
   Explanation:

3. Which element has a *lower* second ionization energy: K or Ca ?
   Direction(s):
   Explanation:

4. Which element has a *lower* second ionization energy: Sr or Ba ?
   Direction(s):
   Explanation:

5. Which element has a *higher* first ionization energy: K or B ?
   Direction(s):
   Explanation:

6. Which element has a *lower* first ionization energy: Rb or P ?
   Direction(s):
   Explanation:

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