

# What is Ionization Energy?

## Worksheet

Ionization energy (IE) is the energy needed to remove one electron from an atom:  $A(g) \rightarrow A^+(g) + e^-$ . Measured in kJ/mol or eV. Higher IE means electrons are harder to remove; lower IE means the atom is more likely to lose electrons and act as a reducing agent.

**IE = Energy required to remove electron**

## Questions

1. Ionization energy is defined as the energy required to
  - A) Add an electron to an atom
  - B) Remove an electron from an atom
  - C) Break a chemical bond
  - D) Form a covalent bond
2. Which element has the highest first ionization energy?
  - A) Helium (He)
  - B) Neon (Ne)
  - C) Fluorine (F)
  - D) Argon (Ar)
3. First ionization energy of Li is 520 kJ/mol. Second ionization energy is ~7300 kJ/mol. Why the jump?
  - A) The remaining electron is farther from the nucleus
  - B) Li has a noble gas configuration, very stable
  - C) The charge is now positive, weaker nuclear attraction
  - D) The second electron is in the 2s orbital
4. As you go down Group 1 (Li Na K), ionization energy
  - A) Increases (electrons held tighter)
  - B) Decreases (electrons farther away)
  - C) Stays constant
  - D) First increases, then decreases
5. The first ionization energy of hydrogen (H) is 1312 kJ/mol. How much energy is needed to ionize 0.5 mol of H atoms?
6. Compare first ionization energies: Na (496 kJ/mol) vs Mg (738 kJ/mol). Why is Mg higher?
7. The second ionization energy of Na is 4560 kJ/mol (much higher than IE = 496). Why?
8. Define: What is ionization energy?
9. Define: Unit of ionization energy?
10. Define: Why is second ionization energy always higher than first?

## Answer Key

1. B) Remove an electron from an atom - Ionization is the removal of an electron:  $A(g) \rightarrow A(g) + e$ .
2. A) Helium (He) - Helium - the smallest atom with a full 1s shell, electrons are closest and most tightly bound.
3. B) Li has a noble gas configuration, very stable - Li is [He], a stable noble gas configuration - removing the 2s electron is much harder.
4. B) Decreases (electrons farther away) - Valence electrons move to higher shells, farther from nucleus easier to remove lower IE.
5. Energy = IE moles Energy = 1312 kJ/mol 0.5 mol = 656 kJ
6. Mg has higher nuclear charge (12 vs 11 protons). Mg's outer electron is also in a filled subshell (3s), more stable. Both factors make Mg's electron harder to remove.
7. IE removes a 3s electron (valence). IE removes a 3p electron from Na. NA has a neon-like noble gas configuration [Ne], very stable. Energy jumps dramatically when removing from a stable inner shell.
8. The minimum energy required to remove one electron from a neutral atom in gas phase:  $A(g) \rightarrow A(g) + e$ .
9. Kilojoules per mole (kJ/mol) or electron volts (eV).
10. After removing one electron, the atom is positively charged (Na), which attracts the remaining electrons more strongly.

### **Bounlu**

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