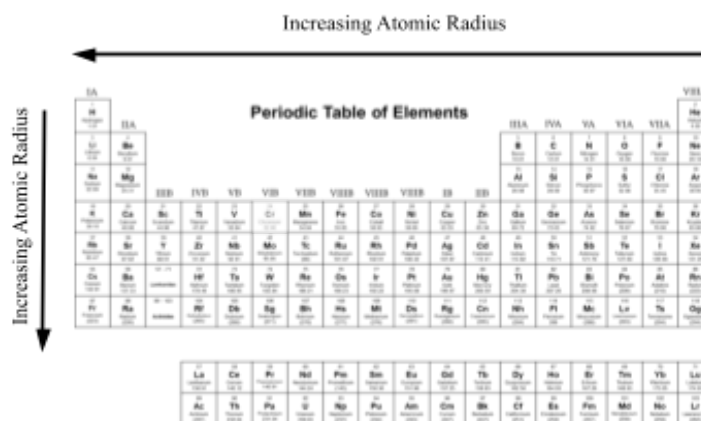


Unit 7: Periodicity (Periodic Properties)

Atomic and Ionic Radius

This worksheet will cover atomic and ionic radii and how they are affected by the gain or loss of electrons. Atoms are the building blocks of all matter and they each have different properties such as: size, charge, reactivity, etc. In chemistry, chemists organize these different atoms, or elements, into a table called the periodic table of elements.

Periodic trends regarding atomic radii can be summarized in the picture below:



Practice Problems:

1. Choose the element with the largest radius:

a. Lithium or Nickel:

b. Chlorine, Helium, or Boron:

c. Magnesium, Carbon, or Krypton:

d. Copper or Nickel: Explain.

e. Lithium, Oxygen, or Fluorine

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2. Fill in the blanks.

The atomic radius _____ as you go across the periodic table(left to right), and _____ as you go down the periodic table.

3. Does a chlorine atom have a greater radius than a chlorine ion with a negative charge? Explain.

5. Order the following from the largest atomic radii to the smallest:

- Phosphorus
- Sodium
- Fluorine
- Silicon

6. Is the radius of a Cl^- ion equal, greater, or less than a neon atom? Explain.

7. Order the following from the smallest atomic radii to the largest:

- Cl^- (Chlorine negative Ion)
- Co^{2+} (Cobalt Positive Ion)
- Fe^{2+} (Iron Positive Ion)
- Helium

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8. Challenge Question: Which ion is larger, Fe^{2+} or Fe^{3+} ? Explain.

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ANSWER KEY

1. Choose the element with the largest radius:

a. Lithium or Nickel:

Nickel because it has more electron shells. There are more electron shells because it is in a further down row on the table.

b. Chlorine, Helium, or Boron:

Chlorine because it has more electron shells.

c. Magnesium, Carbon, or Krypton:

Krypton because it has more electron shells.

d. Copper or Nickel:

Copper has a larger radius because it has fewer protons than nickel. According to Coulomb's law, the force attraction between the electrons and protons is proportionate to the charge and inversely proportional to the distance. Due to copper having fewer protons, its force on its electron shells is weaker. It does not have as tight of a hold on its electron shells compared to nickel. Nickel's nucleus pulls on its electron shells more due to the greater positive charge and thus results in a smaller radius compared to copper.

e. Lithium, Oxygen, or Fluorine

Lithium because it has fewer protons than fluorine and oxygen leading to a weaker pull on the electron shells.

2. Fill in the blanks.

The atomic radius **decreases** as you go across the periodic table (left to right), and **increases** as you go down the periodic table.

Atomic radius decreases as you go across a period because as you go across a period, the number of protons increases by one. However, the number of electron shells remains the same. According to Coulomb's law, the force between charged particles increases, as the magnitude of the charge increases. The presence of more protons pulls on the electrons shells making the radius smaller. Atomic radius increases as you go down a period because you gain additional electron shells which creates more space between the nucleus and electrons and thus increases the radius of the atom.

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3. Does the atom chlorine have a greater radius than a chlorine ion with a negative charge? Explain.

The negative chlorine atom has a larger radius due to it having an additional electron but the same number of protons, which then creates a weaker pull on the electrons from the nucleus. The protons have to exert an attractive force on more bodies, in this case electrons, so the overall pull is weaker as it has to pull in on more electrons. The weaker pull results in a larger radius.

4. Order the following from the largest atomic radii to the smallest:
- Phosphorus
 - Sodium
 - Fluorine
 - Silicon

Sodium, Silicon, Phosphorus, Fluorine
Sodium, Silicon and Phosphorus all have more electron shells than fluorine. Sodium has fewer protons than silicon and silicon has fewer protons than phosphorus. The fewer protons you have the weaker the pull on the electron shells.

5. Is the radius of a Cl^- ion equal, greater, or less than a neon atom? Explain.

Greater. In this case, both of them have the same number of electrons. However Cl^- has fewer protons than neon, Due to neon having more protons, it has a larger magnitude of charge. The stronger attractive force on the electrons results in the electrons being closer to the nucleus, resulting in a smaller radius.

6. Order the following from the smallest atomic radii to the largest:
- Cl^- (Chlorine negative ion)
 - Co^{2+} (Cobalt positive ion)
 - Fe^{2+} (Iron positive ion)
 - Helium

Helium, Cl^- , Co^{2+} , Fe^{2+}
Helium has the least amount of electron shells and chlorine has the second least. Co^{2+} and Fe^{2+} have the same number of electron shells but cobalt has more protons. This results in cobalt's nucleus exerting a greater force on the electrons, pulling them closer and

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thus making the radius smaller.

7. Challenge Question: Which Ion is larger, Fe^{2+} or Fe^{3+} ? Explain.

Fe^{2+} will have a larger radius due to the fact that the ion will have more electrons than Fe^{3+} , so the force of the protons in Fe^{2+} will be weaker than Fe^{3+} . Fe^{3+} lost 3 electrons while Fe^{2+} lost 2 electrons. Fe has 26 protons. These 26 protons will exert a greater force when pulling 23 electrons compared to 24. A greater force means the electrons are closer to the nucleus resulting in a smaller radius.