SNC2D CHEMISTRY

CHEMICAL REACTIONS

- Atoms & Ions (P.157-158)

Atoms & Ions

Marathon runners can become dizzy after drinking too much water during a race. Taking in water is necessary, but drinking too much causes the level of sodium in the blood to fall dangerously low. You lose sodium when you sweat during strenuous activity.

Atoms & Ions

When scientists refer to sodium in the blood, they do not mean the shiny metal element. Rather, they are referring to sodium ions. Sports drinks contain several types of ions, including sodium ions. These drinks are designed to replace ions lost from the body.

Atoms & Ions

*Recall that protons have a positive charge and electrons have a negative charge. An atom has an overall charge of zero since it always has the same number of protons and electrons. An **ion** is formed when an atom (or group of atoms) gains or loses at least one electron. An atom that gains electrons becomes a negatively charged ion. An atom that loses electrons becomes a positively charged ion.*

ION

- a charged particle that results when an atom gains or loses one or more electrons (i.e. # protons ≠ # electrons)
- gains electrons ☞ – charge
- loses electrons ☞ + charge

Activity: Testing for Ions (2DCHEM-ASG2)

INSTRUCTIONS

A. Read the activity "2DCHEM - ASG2 (Testing for Ions)".
B. Follow the instructions given (i.e. procedure 1 to 8).
C. Answer the questions given (i.e. conclusion and analysis 1 to 5).

NOTE!

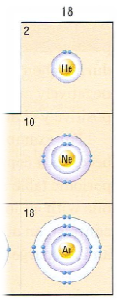
- This is a formal lab report. Be sure to use complete sentences, particularly when it asks you to explain, discuss, describe, …

How Atoms Form Ions

In general, atoms gain or lose enough electrons to have a full outer orbit. This arrangement of electrons is most stable.

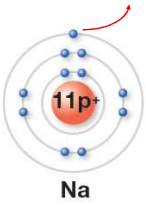
RECALL!

The elements in column 18 (i.e. the noble gases) are the most stable elements in the periodic table. In fact, they are so stable they rarely react with other elements. This is because their outer orbits are already full.



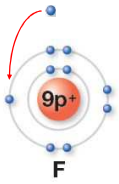
How Atoms Form Ions

For example, sodium has one electron in its outermost orbit. In order to form a stable ion, sodium loses this one electron to obtain a full outer orbit of eight electrons. This forms a sodium ion, Na^+.



How Atoms Form Ions

On the other hand, fluorine has seven electrons in its outermost orbit. In this case, fluorine gains one electron in order to obtain a full outer orbit. This forms a fluoride ion, F^-.



How Atoms Form Ions

*Because ions have unequal numbers of protons and electrons, they are no longer neutral. Instead, ions have either a positive or a negative ionic charge. The **ionic charge** is the sum of the ion's positive and negative charges.*

IONIC CHARGE

- the sum of the ion's + and – charges

How Atoms Form Ions

RECALL!

The sodium atom lost one electron in order to obtain a full outer orbit. As a result, the sodium ion has one more proton than it has electrons. Thus, its ionic charge is 1+. The fluorine atom gained one electron in order to obtain a full outer orbit. As a result, the fluoride ion has one more electron than it has protons. Thus, its ionic charge is 1–.

	Na^+	F^-
Positive Charges (protons)	11+	9+
Negative charges (electrons)	10-	10-
Ionic charge	1+	1-

How Atoms Form Ions

PRACTICE

1. The metal element cesium has one electron in its outer orbit. Will cesium atoms form positively charged or negatively charged ions? Predict their charge.

   loses 1 electron ☞ 1+

How Atoms Form Ions

PRACTICE

2. The non-metal element selenium has six electrons in its outer orbit. Will selenium atoms form positively charged or negatively charged ions? Predict their charge.

   gains 2 electrons ☞ 2–

Names & Symbols of Ions

Metals often form positively charged ions. A positively charged ion has the same name as the element. For example, the element sodium forms sodium ions. In contrast, non-metals often form negatively charged ions. To name a negative ion, add "ide" to the stem of the name. Fluorine becomes fluoride. Common non-metals include oxygen, chlorine, and nitrogen. Their negative ions are oxide, chloride, and nitride.

Names & Symbols of Ions

The chemical symbol for an ion contains both the symbol of the element and its charge. The charge is shown by a numeral and a plus or minus sign. For example, the symbol for the sodium ion is Na^+ and the symbol for the oxide ion is O^{2-}. When an ion has a charge of 1+ or 1–, the "1" is not included in the chemical symbol. Chloride is written as Cl^-, not Cl^{1-}.

Names & Symbols of Ions

NOTE!

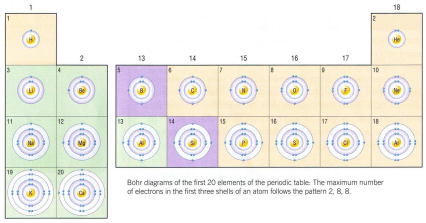
Not all atoms will form ions, and some atoms can form an ion in more than one way. Information on the periodic table shows the ion charge of ions that will form for each element.

Element	Ion Charge	Symbol	Name
sodium	1+	Na^+	sodium
calcium	2+	Ca^{2+}	calcium
aluminum	3+	Al^{3+}	aluminum
fluorine	1–	F^-	fluoride
oxygen	2–	O^{2-}	oxide
nickel	2+ 3+	Ni^{2+} Ni^{3+}	nickel (II) nickel (III)
lead	2+ 4+	Pd^{2+} Pb^{4+}	lead (II) lead (IV)
gold	3+ 1+	Au^{3+} Au^+	gold (III) gold (I)

Activity: Trends in Ionic Charge

INSTRUCTIONS

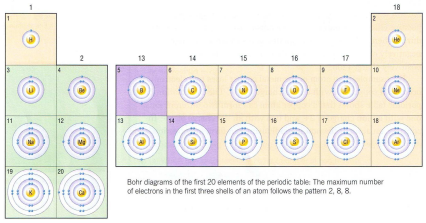
A. Look at the B-R diagrams and decide how many electrons the atoms need to lose or gain in order to gain a full outer orbit. Recall, this is the ionic charge of the atom.



Activity: Trends in Ionic Charge

INSTRUCTIONS

B. Describe the trend in ionic charge within a group (i.e. a column).



Trends in Ionic Charge

TRENDS IN IONIC CHARGE

- related to the # of electrons the atom needs to lose/gain in order to become stable (i.e. a full outer orbit)
- metals:
  - tend to lose electrons (1-3) to form positively charged ions
  - name does **not** change
- non-metals:
  - tend to gain electrons (1-3) to form negatively charged ions
  - add "ide" to the name

NOTE!

There are different ways to quickly determine the ionic charge of an atom:

① *It is indicated on the periodic table (upper right corner).*

② *Look at the column number and …*

Trends in Ionic Charge

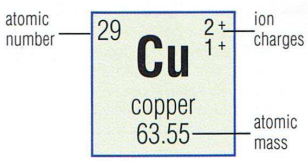
PRACTICE

3. Write the name and symbol of the ion formed by each of the following elements:

(a)	sodium	sodium	Na^+
(b)	chlorine	chloride	Cl^-
(c)	sulfur	sulfide	S^{2-}
(d)	phosphorus	phosphide	P^{3-}
(e)	aluminum	aluminum	Al^{3+}
(f)	lithium	lithium	Li^+
(g)	magnesium	magnesium	Mg^{2+}
(h)	nitrogen	nitride	N^{3-}

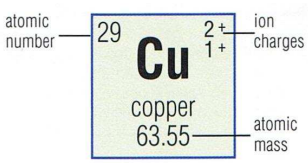
Multivalent Elements

When an element can form only one type of ion, such as calcium, the ion has the same name as the element. However, the atoms of many metals can form more than one type of ion. For example, an atom of copper can form one of two different ions, one with a charge of 1+ or one with a charge of 2+.



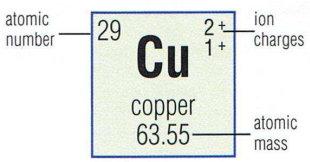
Multivalent Elements

*A **multivalent element** is an element that can form an ion in more than one way. Many metal elements are multivalent. The name of an ion of a multivalent element **always** contains a Roman numeral that indicates the ion charge.*



Multivalent Elements

For example, Cu^{1+} is named copper (I), which is read as "copper one". Similarly, Cu^{2+} is named copper (II), which is read "copper two". Copper (II) ions are found in the ionic compound copper (II) chloride.



Multivalent Elements

MULTIVALENT ELEMENT

- element that can form an ion in more than one way
- includes many metals
- name of ion contains a Roman numeral that indicates the ion charge
- for example,
  - Cu^{1+} = copper (I)
  - Cu^{2+} = copper (II)

Ions in the Human Body

Dissolved ions play a vital role in body functions. Ions of iron in red blood cells, for example, help carry inhaled oxygen throughout the body. Bones and teeth are made of compounds that contain calcium ions. Your nervous system relies on ions to function. The simple act of lifting a finger requires your brain to send nerve impulses to the muscles of the finger, telling them to move. These impulses are carried through the nerve cells by ions.

IONS IN THE HUMAN BODY

- play a vital role in body functions
  - carry oxygen in blood (iron)
  - make up bones and teeth (calcium)
  - …

Ions in the Human Body

PRACTICE

4. Many people consume "iron" pills if the level of iron in their blood is low. Do you think these pills contain atoms or ions of iron? Explain.

   ions – easier for the body to absorb

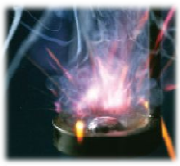
Ions in the Human Body

NOTE!

A normal healthy diet gives you all the ions your body needs. However, a diet high in sodium can raise your blood pressure. Prolonged high blood pressure greatly increases the risk for stroke, heart attack, and kidney failure. Diet is just one of many factors that can raise blood pressure. Others include stress and family history.

✔ Check Your Learning

1. Bananas are an excellent source of potassium. However, a sample of potassium atoms bursts into flames if it comes in contact with water. Bananas contain water.
   (a) What form of potassium (atom or ion) is in bananas?



   (a) ion

✔ Check Your Learning

1. Bananas are an excellent source of potassium. However, a sample of potassium atoms bursts into flames if it comes in contact with water. Bananas contain water.
   (b) What is its chemical symbol?

(b) K^+

✔ Check Your Learning

2. Atoms and ions are described as isoelectronic if they have the same number of electrons. Name the noble gas that is isoelectronic with each of the following stable ions:
   (a) Li^+ Helium
   (b) F^- Neon
   (c) Ca^{2+} Argon
   (d) S^{2-} Argon
   (e) Br^- Krypton
   (f) Rb^+ Krypton

✔ Check Your Learning

TEXTBOOK
P.158 Q.1,2

WIKI (CHEMISTRY)
✎.... 2DCHEM - ASG2 (Testing for Ions)