2.1: The Elements

Exercises

1. Which of the following substances are elements?
   a. sodium
   b. milk
   c. gold
   d. water
   e. air
   f. liquefied nitrogen

2. Which of the following substances are elements?
   a. paper
   b. electricity
   c. neon
   d. carbon
   e. wood
   f. concrete

3. Write the chemical symbol for each element.
   a. silver
   b. sulfur
   c. nitrogen
   d. neon

4. Write the chemical symbol for each element.
   a. bromine
   b. oxygen
   c. lithium
   d. boron

5. Explain why it is improper to write CO as the chemical symbol for cobalt.

6. Explain why it is improper to write NO as the chemical symbol for nobelium.

7. Complete the following table.
8. Complete the following table.

<table>
<thead>
<tr>
<th>Element Symbol</th>
<th>Element Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Cr</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element Symbol</th>
<th>Element Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg</td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td></td>
</tr>
<tr>
<td>Cl</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td></td>
</tr>
<tr>
<td>Pt</td>
<td></td>
</tr>
</tbody>
</table>

Answers

1. a. element  
   b. not an element  
   c. element  
   d. not an element  
   e. not an element  
   f. element

3. a. Ag  
   b. S  
   c. N  
   d. Ne

5. By convention, the second letter in an element’s symbol is always lowercase.
7. | Element Symbol | Element Name   |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>fluorine</td>
</tr>
<tr>
<td>Fe</td>
<td>iron</td>
</tr>
<tr>
<td>I</td>
<td>iodine</td>
</tr>
<tr>
<td>Cr</td>
<td>chromium</td>
</tr>
<tr>
<td>C</td>
<td>carbon</td>
</tr>
<tr>
<td>P</td>
<td>phosphorus</td>
</tr>
</tbody>
</table>

2.2: Atomic Theory

Exercises

1. Which of the following elements exist as diatomic molecules?
   a. helium
   b. hydrogen
   c. iodine
   d. gold

2. Which of the following elements exist as diatomic molecules?
   a. chlorine
   b. potassium
   c. silver
   d. oxygen

3. Why is it proper to represent the elemental form of helium as He but improper to represent the elemental form of hydrogen as H?

4. Why is it proper to represent the elemental form of chlorine as Cl\(_2\) but improper to represent the elemental form of calcium as Ca\(_2\)?

Answers

1. a. no
   b. yes
   c. yes
3. Hydrogen exists as a diatomic molecule in its elemental form; helium does not exist as a diatomic molecule.

### 2.3: The Structure of Atoms

#### Exercises

1. Which is smaller—an electron or a helium atom?

2. Which is larger—a proton or an atom of lead?

3. Which subatomic particle has a positive charge? Which subatomic particle has a negative charge?

4. Which subatomic particle is electrically neutral? Does it exist inside or outside the nucleus?

5. Protons are among the (most, least) massive subatomic particles, and they are found (inside, outside) the nucleus.

6. Electrons are among the (most, least) massive subatomic particles, and they are found (inside, outside) the nucleus.

7. Describe why Rutherford used the term *planetary model* to describe his model of atomic structure.

8. Why is the planetary model not an appropriate way to describe the structure of an atom?

9. What happened to most of the alpha particles in Rutherford’s experiment? Explain why that happened.

10. Electrons account for the (majority, minority) of the (mass, volume) of an atom.

#### Answers

1. An electron is smaller.

3. proton; electron

5. most; inside

7. Electrons are in orbit about the nucleus.

9. Most of the alpha particles went through the metal sheet because atoms are mostly empty space.

### 2.4: Nuclei of Atoms
Exercises

1. How many protons are in the nucleus of each element?
   a. radon
   b. tungsten
   c. chromium
   d. beryllium

2. How many protons are in the nucleus of each element?
   a. sulfur
   b. uranium
   c. calcium
   d. lithium

3. What are the atomic numbers of the elements in Exercise 1?

4. What are the atomic numbers of the elements in Exercise 2?

5. How many electrons are in neutral atoms of the elements in Exercise 1?

6. How many electrons are in neutral atoms of the elements in Exercise 2?

7. Complete the following table.

<table>
<thead>
<tr>
<th>Number of Protons</th>
<th>Number of Neutrons</th>
<th>Element Name</th>
<th>Isotope Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>120</td>
<td></td>
<td>(\text{^{55}_{26}Fe})</td>
</tr>
<tr>
<td>2</td>
<td>hydrogen</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. Complete the following table.

<table>
<thead>
<tr>
<th>Number of Protons</th>
<th>Number of Neutrons</th>
<th>Element Name</th>
<th>Isotope Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>153</td>
<td></td>
<td>(\text{^{3}_{2}He})</td>
</tr>
<tr>
<td>21</td>
<td>potassium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. State the number of protons, neutrons, and electrons in neutral atoms of each isotope.
   a. \(^{131}\text{I}\)
   b. \(^{40}\text{K}\)
   c. \(^{201}\text{Hg}\)
10. State the number of protons, neutrons, and electrons in neutral atoms of each isotope.
   a. \(^3\)H
   b. \(^{133}\)Cs
   c. \(^{56}\)Fe
   d. \(^{207}\)Pb

11. What is the mass number of a gallium atom that has 38 neutrons in it?

12. What is the mass number of a uranium atom that has 143 neutrons in it?

13. Complete each sentence.
   a. \(^{48}\)Ti has _____ neutrons.
   b. \(^{40}\)Ar has _____ neutrons.
   c. \(^3\)H has _____ neutrons.

14. Complete each sentence.
   a. \(^{18}\)O has _____ neutrons.
   b. \(^{60}\)Ni has _____ neutrons.
   c. \(^{127}\)I has _____ neutrons.

#### Answers

1. a. 86
   b. 74
   c. 24
   d. 4

3. 86, 74, 24, and 4

5. 86, 74, 24, and 4

7. | Number of Protons | Number of Neutrons | Element Name | Isotope Symbol |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>120</td>
<td>mercury</td>
<td>(^{200})Hg</td>
</tr>
<tr>
<td>26</td>
<td>29</td>
<td>iron</td>
<td>(^{55})Fe</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>hydrogen</td>
<td>(^{3})H</td>
</tr>
</tbody>
</table>

9. a. protons: 53; neutrons: 78; electrons: 53
b. protons: 19; neutrons: 21; electrons: 19

11. 69

c. protons: 80; neutrons: 121; electrons: 80

d. protons: 9; neutrons: 10; electrons: 9

13. a. 26
    b. 22
    c. 2

2.5: Atomic Masses

Exercises

1. What is the atomic mass of zinc in atomic mass units?

2. What is the atomic mass of barium in atomic mass units?

3. What is the average mass of a single magnesium atom in grams?

4. What is the average mass of a single calcium atom in grams?

5. What is the mass of $1.00 \times 10^{24}$ aluminum atoms in grams?

6. What is the mass of $5.00 \times 10^{23}$ carbon atoms in grams?

7. Which has more mass—1 tungsten atom or 11 oxygen atoms?

8. Which has more mass—1 magnesium atom or 6 helium atoms?

Answers

1. 65.4 u

3. $4.04 \times 10^{-23}$ g

5. 44.8 g

7. 1 tungsten atom
2.6: Arrangements of Electrons

1. What is the maximum number of electrons that can fit in an s subshell? Does it matter what shell the s subshell is in?

2. What is the maximum number of electrons that can fit in a p subshell? Does it matter what shell the p subshell is in?

3. What is the maximum number of electrons that can fit in a d subshell? Does it matter what shell the d subshell is in?

4. What is the maximum number of electrons that can fit in an f subshell? Does it matter what shell the f subshell is in?

5. What is the electron configuration of a carbon atom?

6. What is the electron configuration of a sulfur atom?

7. What is the valence shell electron configuration of a calcium atom?

8. What is the valence shell electron configuration of a selenium atom?

9. What atom has the electron configuration 1s^22s^22p^5?

10. What atom has the electron configuration 1s^22s^22p^63s^23p^3?

11. Draw a representation of the electronic structure of an oxygen atom.


13. A potassium atom has ____ core electrons and ____ valence electrons.

14. A silicon atom has ____ core electrons and ____ valence electrons.

Answers

1. 2; no

3. 10; no

5. 1s^22s^22p^2

7. 4s^2

9. fluorine
2.7: The Periodic Table

Exercises

1. Which elements have chemical properties similar to those of magnesium?
   a. sodium
   b. fluorine
   c. calcium
   d. barium
   e. selenium

2. Which elements have chemical properties similar to those of lithium?
   a. sodium
   b. calcium
   c. beryllium
   d. barium
   e. potassium

3. Which elements have chemical properties similar to those of chlorine?
   a. sodium
   b. fluorine
c. calcium
d. iodine
e. sulfur

4. Which elements have chemical properties similar to those of carbon?
   a. silicon
   b. oxygen
   c. germanium
   d. barium
   e. argon

5. Which elements are alkali metals?
   a. sodium
   b. magnesium
   c. aluminum
   d. potassium
   e. calcium

6. Which elements are alkaline earth metals?
   a. sodium
   b. magnesium
   c. aluminum
   d. potassium
   e. calcium

7. Which elements are halogens?
   a. oxygen
   b. fluorine
   c. chlorine
   d. sulfur
   e. carbon

8. Which elements are noble gases?
   a. helium
   b. hydrogen
   c. oxygen
   d. neon
   e. chlorine

9. Which pairs of elements are located in the same period?
   a. H and Li
b. H and He  
c. Na and S  
d. Na and Rb

10. Which pairs of elements are located in the same period?
   a. V and Nb  
b. K and Br  
c. Na and P  
d. Li and Mg

11. In each pair of atoms, which atom has the greater atomic radius?
   a. H and Li  
b. N and P  
c. Cl and Ar  
d. Al and Cl

12. In each pair of atoms, which atom has the greater atomic radius?
   a. H and He  
b. N and F  
c. Cl and Br  
d. Al and B

13. Scandium is a (metal, nonmetal, semimetal) and is a member of the (main group elements, transition metals).

14. Silicon is a (metal, nonmetal, semimetal) and is a member of the (main group elements, transition metals).

---

Answers

1. a. no  
b. no  
c. yes  
d. yes  
e. no

3. a. no  
b. yes  
c. no  
d. yes  
e. no

5. a. yes  
b. no
2.8: Chapter Summary

Q2.1.1

Which of the following substances are elements?

1. sodium
2. milk
3. gold
4. water
5. air
6. liquefied nitrogen

Hint: what is the definition of an element?

Answer:

1. element
2. not an element
3. element
4. not an element
5. not an element
6. element

Solution:

At first we need to know the definition of an element: a chemical element is a **pure** chemical substance consisting of a **single** type of atom. Also, we need to know the compositions of these substances. The substances that can be represented with a **single** chemical symbol (maybe with subscript or superscript).

1. Sodium is Na → an element
2. Milk is an organic solution containing lipids, proteins, salts minerals, vitamins, carbohydrates and other miscellaneous compounds → not an element
3. Gold is Au → an element
4. Water is H_2O → not an element
5. Air is composed of many gases such O_2, N_2 → not an element
6. Liquefied nitrogen is still N_2 → an element.

Q2.1.2

Which of the following substances are elements?

1. paper
2. electricity
3. neon
4. carbon
5. wood
6. concrete

Hint: what is the definition of an element?

Answer:

1. not an element
2. not an element
3. element
4. element
5. not an element
6. not an element element

Solution:

At first we need to know the definition of an element: a chemical element is a **pure** chemical substance consisting
of a **SINGLE** type of atom. Also, we need to know the compositions of these substances. The substances that can be represented with a **SINGLE** chemical symbol (can have subscript or superscript).

1. Paper is mostly cellulose composed of carbon, hydrogen and oxygen \((C_6H_{10}O_5)_n\) → not an element
2. Electricity is a form of energy not atoms → not an element
3. Neon is a noble gas with chemical symbol Ne → an element
4. Carbon is C → an element
5. Wood is majorly composed with cellulose and lignin → not an element
6. Concrete is composed of water and coarse granular material → not an element.

---

**Q2.1.3**

Write the chemical symbol for each element.

1. silver
2. sulfur
3. nitrogen
4. neon

**Hint:** what is the first or first two letters of the name of the element? Sometimes it's the Latin name of the element. However, sometimes it's not the first 2 letters.

**Answer:**

1. Ag
2. S
3. N
4. Ne

**Solution:**

Usually, the chemical symbol of an element is the first or first 2 letters of the English name or Latin name of the element with the **first letter ALWAYS in uppercase and the second ALWAYS letter in lowercase**. However, that's not always the case, such as Tin (Stannum in Latin) is Sn. This is the time a [Periodic Table](#) comes in handy.

---

**Q2.1.4**

Write the chemical symbol for each element.

1. bromine
2. oxygen
3. lithium
4. boron
Hint: what is the first or first two letters of the name of the element? Sometimes it's the Latin name of the element. However, sometimes it's not the first 2 letters.

Answer:

1. Br
2. O
3. Li
4. B

Solution:

Usually, the chemical symbol of an element is the first or first 2 letters of the English name or Latin name of the element with the first letter ALWAYS in uppercase and the second letter ALWAYS in lowercase. However, that's not always the case, such as Tin (Stannum in Latin) is Sn. This is the time a Periodic Table comes in handy.

Q2.1.5

Explain why it is improper to write CO as the chemical symbol for cobalt.

Hint: How would this notation confuse the readers?

Answer: If "CO" was written as the chemical symbol for cobalt, it would be the same as the chemical formula for carbon monoxide. This ambiguity would create a lot of problems such as in labeling and might lead to life-threatening danger.

Solution:

The chemical symbol is ALWAYS written with the first letter in uppercase and the second letter in lowercase.

Q2.1.6

Explain why it is improper to write NO as the chemical symbol for nobelium.

Hint: How would this notation confuse the readers?

Answer: If "NO" was written as the chemical symbol for cobalt, it would be the same as the chemical formula for nitrogen monoxide. This ambiguity would create a lot of problems such as in labeling and might lead to life-threatening danger.

Solution:

The chemical symbol is ALWAYS written with the first letter in uppercase and the second letter in lowercase.

Q2.1.7

Complete the following table.
<table>
<thead>
<tr>
<th>Element Symbol</th>
<th>Element Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>fluorine</td>
</tr>
<tr>
<td>Fe</td>
<td>iron</td>
</tr>
<tr>
<td>I</td>
<td>iodine</td>
</tr>
<tr>
<td>Cr</td>
<td>chromium</td>
</tr>
<tr>
<td>C</td>
<td>carbon</td>
</tr>
<tr>
<td>P</td>
<td>phosphorus</td>
</tr>
</tbody>
</table>

**Hint:** The element symbols are usually the first or first two letters of the element names.

**Answer:**

<table>
<thead>
<tr>
<th>Element Symbol</th>
<th>Element Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
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</tr>
<tr>
<td>Fe</td>
<td>iron</td>
</tr>
<tr>
<td>I</td>
<td>iodine</td>
</tr>
<tr>
<td>Cr</td>
<td>chromium</td>
</tr>
<tr>
<td>C</td>
<td>carbon</td>
</tr>
<tr>
<td>P</td>
<td>phosphorus</td>
</tr>
</tbody>
</table>

**Solution:**

Usually, the chemical symbol of an element is the first or first 2 letters of the English name or Latin name of the element. Also, metals tend to end in -ium; halogens gases (group 17 gases) end in -ine; noble gases except helium end in -on; gases other than halogens and noble gases tend to end in -gen. However, that's not always the case, such as Tin (Stannum in Latin) is Sn. This is the time a [Periodic Table](#) comes in handy.

---

**Q2.1.8**

Complete the following table.

<table>
<thead>
<tr>
<th>Element Symbol</th>
<th>Element Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg</td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td></td>
</tr>
<tr>
<td>Element Symbol</td>
<td>Element Name</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Cl</td>
<td>Chlorine</td>
</tr>
<tr>
<td>K</td>
<td>Potassium</td>
</tr>
<tr>
<td>Pt</td>
<td>Platinum</td>
</tr>
</tbody>
</table>

**Hint:** The element symbols are usually the first or first two letters of the element names.

**Answer:**

<table>
<thead>
<tr>
<th>Element Symbol</th>
<th>Element Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg</td>
<td>Magnesium</td>
</tr>
<tr>
<td>Mn</td>
<td>Manganese</td>
</tr>
<tr>
<td>Ca</td>
<td>Calcium</td>
</tr>
<tr>
<td>Cl</td>
<td>Chlorine</td>
</tr>
<tr>
<td>K</td>
<td>Potassium</td>
</tr>
<tr>
<td>Pt</td>
<td>Platinum</td>
</tr>
</tbody>
</table>

**Solution:**

Usually, the chemical symbol of an element is the first or first 2 letters of the English name or Latin name of the element. Also, metals tend to end in -ium; halogens gases (group 17 gases) end in -ine; noble gases except helium end in -on; gases other than halogens and noble gases tend to end in -gen. However, that's not always the case, such as Tin (Stannum in Latin) is Sn. This is the time a Periodic Table comes in handy.

---

**Q2.2.1**

Which of the following elements exist as diatomic molecules?

a. helium  
b. hydrogen  
c. iodine  
d. gold

**Hint:** Which atoms don't have an octet?

**Answer:**

a. No
Solution:

Diatomic molecules are molecules composed of only two atoms. If an atom has full valence shell, the atom is very stable and hardly react with other atoms. When an atom doesn't have a complete valence shell, it wants to pair up the unpaired electrons in valence shell to reach a stabler status. So, if an atom has unpaired valence electrons, it will form one or more covalent bonds with another atom which also has unpaired valence electrons to form an octet. Metal atoms form metallic bonds and exist as large continuous lattice structure.

a. Helium is in the first period and has 2 valence electrons, so its valence shell is full → monatomic
b. Hydrogen is also in the first period but has only 1 valence electrons, so it has an unpaired electron in the valence shell. 2 Hydrogen atoms form 1 covalent bond → diatomic
c. Iodine is in group VII so it has 7 valence electrons leaving one valence electron unpaired. 2 Iodine atoms form 1 covalent bond → diatomic
d. First of all, gold is metal. Second, gold is a transition metal so it has more than one unpaired valence electron → not diatomic

Q2.2.2

Which of the following elements exist as diatomic molecules?

a. chlorine  
b. potassium  
c. silver  
d. oxygen

**Hint:** Which atoms don't have an octet?

**Answer:**

a. Yes  
b. No  
c. No  
d. Yes

**Solution:**

Diatomic molecules are molecules composed of only two atoms. If an atom has full valence shell, the atom is very stable and hardly react with other atoms. When an atom doesn't have a complete valence shell, it wants to pair up the unpaired electrons in valence shell to reach a stabler status. So, if an atom has unpaired valence electrons, it will form one or more covalent bonds with another atom which also has unpaired valence electrons to form an octet. Metal atoms form metallic
bonds and exist as large continuous lattice structure.

- Chlorine is in group VII so it has 7 valence electrons leaving one valence electron unpaired. 2 Chlorine atoms form 1 covalent bond → diatomic
- Potassium is in group I so it has 1 unpaired valence electron. However, even 2 potassium atoms pair up, they cannot form an octet → not diatomic
- Silver is a transition metal so it has more than one unpaired valence electron → not diatomic
- Oxygen is in group VI so it has 6 valence electrons so it has 2 unpaired valence electron. 2 Chlorine atoms form 2 covalent bonds → diatomic

Q2.1.3

Why is it proper to represent the elemental form of helium as He but improper to represent the elemental form of hydrogen as H?

**Hint:** How many atoms are there in these 2 gas molecules?

**Answer:** Because Hydrogen molecules are diatomic while Helium molecules are monatomic.

**Solution:** If an atom has unpaired valence electrons, it will form one or more covalent bonds with another atom which also has unpaired valence electrons to form an octet. Hydrogen is a group I element, so it has 1 valence electron. Therefore, it wants to form one covalent bond with, in this case, another hydrogen atom to complete its duet (since hydrogen only has the first shell). On the other hand, Helium already has a complete valence shell so it is stable and exist in a monatomic form.

Q2.1.4

Why is it proper to represent the elemental form of chlorine as Cl2 but improper to represent the elemental form of calcium as Ca2?

**Hint:** How many atoms are there in these 2 gas molecules?

**Answer:** Because Chlorine molecules are diatomic while Calcium molecules exist as large continuous lattice structure.

**Solution:** If an atom has unpaired valence electrons, it will form one or more covalent bonds with another atom which also has unpaired valence electrons to form an octet. Chlorine is a group VII element, so it has 7 valence electrons. Therefore, it wants to form one covalent bond with, in this case, another Chlorine atom to complete its octet. Calcium is a group II element, but it's metal. So, calcium atoms form metallic bonds and exist in a vast network structure called lattice system.