
Welcome!

This is a chemistry lesson, covering *atoms, elements, protons, neutrons, and electrons*.

I will guide you step-by-step.

I will be asking you many questions along the way.

Each time I ask a question, **you should attempt to answer the question on your own**
before you scroll down to view my answer.

This is the first lesson in the chapter “Atoms, Molecules, and Compounds”,
which is the second chapter of the course, “Chemistry, Explained Step by Step”.

This lesson was written by Freelance-Teacher.

My website is:
http://www.freelance-teacher.com

You can support this project with a monthly pledge at my Patreon page:
https://www.patreon.com/freelanceteacher

Or you can make a one-time donation using the PayPal Donate link at my website.

I have videos available for many topics in chemistry, and other subjects, at my YouTube channel:
https://www.youtube.com/@freelanceteach

You can find a list of all the available lessons, in suggested order, at my website.
You can find AI-enhanced versions of all the lessons, which allow you to ask questions, and which can generate additional practice problems, at my website.
You can find a list of all the available videos, in suggested order, at my website.

I offer **tutoring** in chemistry, and a variety of other subjects.
For more information, go to my website.

In this chemistry course, we will study *matter*.

"Matter" is the "stuff" of the universe: cars, dogs, air, water, people, silverware, gasoline, umbrellas, and so on.

Chemists have discovered that matter is composed of *atoms*.
Atoms are tiny, tiny particles.
Each atom is far, far too small for you to see with the naked eye.
In fact, atoms are far too small to be seen even with an optical microscope.

There are approximately 118 different types of atoms.
These 118 atoms are listed in a special chart called the *periodic table*.

You will need to have a periodic table handy and in front of you during this lesson
(and during all of our lessons on chemistry),
so please find a copy of the periodic table in your textbook now.

You can usually find the periodic table on the inside front cover or back cover of a chemistry textbook.
Or you can Google for a periodic table.

From your periodic table, you can see that the types of atoms are
1 H (hydrogen)
2 He (helium)
3 Li (lithium)
4 Be (beryllium)
5 B (boron)
6 C (carbon)
7 N (nitrogen)
8 O (oxygen)
9 F (fluorine)
10 Ne (neon)
etc.

Each type of atom listed in the periodic table is called an *element*.
So we can say that there are approximately 118 different elements listed in the periodic table.
So, the elements are hydrogen, helium, lithium, beryllium, boron, carbon, nitrogen, etc.

Each element has its own *atomic symbol*.
The atomic symbols are listed in the periodic table.
For example, the atomic symbol for hydrogen is H,
the atomic symbol for helium is He,
the atomic symbol for lithium is Li,
the atomic symbol for beryllium is Be,
etc.

For your chemistry course, you will need to memorize the names that some of the atomic symbols represent.

Here are the names that you should memorize for now:
H = hydrogen
He = helium
Li = lithium
Be = beryllium
B = boron
C = carbon
N = nitrogen
O = oxygen
F = fluorine
Ne = neon
Na = sodium
Mg = magnesium
Al = aluminum
Si = silicon
P = phosphorus
S = sulfur
Cl = chlorine
Ar = argon
K = potassium
Ca = calcium
Br = bromine
I = iodine

If you are given any of the symbols in this list, you need to be able to provide the name of the element that the symbol represents.

No time like the present. Please memorize all the names in this list now.

Now take this quiz on the names that you memorized on the previous page.

What is the name for the element whose atomic symbol is Br?

Br is the symbol for *bromine*.

What is the name for the element whose atomic symbol is Mg?

Mg is the symbol for *magnesium*.

What is the name for the element whose atomic symbol is O?

O is the symbol for *oxygen*.

---”

What is the name for the element whose atomic symbol is Si?

Si is the symbol for silicon.

What is the name for the element whose atomic symbol is Ne?

Ne is the symbol for neon.

What is the name for the element whose atomic symbol is P?

P is the symbol for phosphorus.

What is the name for the element whose atomic symbol is B?

B is the symbol for boron.

What is the name for the element whose atomic symbol is S?

S is the symbol for sulfur.

What is the name for the element whose atomic symbol is Cl?

Cl is the symbol for chlorine.

What is the name for the element whose atomic symbol is Ca?

Ca is the symbol for calcium.

What is the name for the element whose atomic symbol is Li?

Li is the symbol for lithium.

What is the name for the element whose atomic symbol is I?

I is the symbol for iodine.

What is the name for the element whose atomic symbol is Be?

Be is the symbol for beryllium.

What is the name for the element whose atomic symbol is K?

K is the symbol for potassium.

What is the name for the element whose atomic symbol is N?

N is the symbol for nitrogen.

What is the name for the element whose atomic symbol is F?

F is the symbol for fluorine.

What is the name for the element whose atomic symbol is Na?

Na is the symbol for sodium.

What is the name for the element whose atomic symbol is C?

C is the symbol for carbon.

What is the name for the element whose atomic symbol is H?

H is the symbol for hydrogen.

What is the name for the element whose atomic symbol is Ar?

Ar is the symbol for argon.

What is the name for the element whose atomic symbol is He?

He is the symbol for helium.

What is the name for the element whose atomic symbol is Al?

Al is the symbol for aluminum.

Here are the atomic symbols you should memorize for now:
hydrogen = H
helium = He
lithium = Li
beryllium = Be
boron = B
carbon = C
nitrogen = N
oxygen = O
fluorine = F
neon = Ne
sodium = Na
magnesium = Mg
aluminum = Al
silicon = Si
phosphorus = P
sulfur = S
chlorine = Cl
argon = Ar
potassium = K
calcium = Ca
bromine = Br
iodine = I

If you are given the name of any of the element in this list, you need to be able to provide the atomic symbol for that element.

When writing these symbols, pay attention to correct capitalization.
For example, the correct symbol for is “C”, not “c”;
for another example, the symbol for helium is “He”, not “HE”.

Please memorize all the atomic symbols in this list now.

Take this quiz on the symbols.

Make sure you capitalize the letters for each symbol correctly.

What is the atomic symbol for phosphorus?

The atomic symbol for phosphorus is P.

What is the atomic symbol for sodium?

The atomic symbol for sodium is Na.

What is the atomic symbol for fluorine?

The atomic symbol for fluorine is F.

---”

What is the atomic symbol for magnesium?

The atomic symbol for magnesium is Mg.

What is the atomic symbol for bromine?

The atomic symbol for bromine is Br.

What is the atomic symbol for chlorine?

The atomic symbol for chlorine is Cl.

What is the atomic symbol for hydrogen?

The atomic symbol for hydrogen is H.

What is the atomic symbol for silicon?

The atomic symbol for silicon is Si.

What is the atomic symbol for iodine?

The atomic symbol for iodine is I.

What is the atomic symbol for argon?

The atomic symbol for argon is Ar.

What is the atomic symbol for nitrogen?

The atomic symbol for nitrogen is N.

What is the atomic symbol for boron?

The atomic symbol for boron is B.

What is the atomic symbol for sulfur?

The atomic symbol for sulfur is S.

What is the atomic symbol for neon?

The atomic symbol for neon is Ne.

What is the atomic symbol for lithium?

The atomic symbol for lithium is Li.

What is the atomic symbol for potassium?

The atomic symbol for potassium is K.

What is the atomic symbol for carbon?

The atomic symbol for carbon is C.

What is the atomic symbol for beryllium?

The atomic symbol for beryllium is Be.

What is the atomic symbol for oxygen?

The atomic symbol for oxygen is O.

What is the atomic symbol for helium?

The atomic symbol for helium is He.

What is the atomic symbol for aluminum?

The atomic symbol for aluminum is Al.

What is the atomic symbol for calcium?

The atomic symbol for calcium is Ca.

Take another look at your periodic table.
You should notice that each cell in the table contains two numbers:
a whole number (1, 2, 3, 4, 5, 6, 7, etc.)
and a decimal number (1.008, 4.003, 6.941, 9.012, 10.81, 12.01, 14.01, etc).

We will discuss these numbers further, later in the lesson.

What are atoms made of?

Chemists have discovered that atoms are composed *protons*, *neutrons*, and *electrons*.

Protons are tiny, tiny particles, even tinier than atoms.

Each proton carries a +1 electric charge.

Neutrons are tiny, tiny particles, approximately the same size as protons.

Each neutron carries 0 electric charge;
this can also be described as a “neutral” electric charge.

Electrons are tiny, tiny particles, roughly 1800 times less massive than even protons and neutrons.

Each electron carries a -1 electric charge.

Memorize this information.

Let’s review.

---

1. What is an atom composed of?

An atom is composed of protons, neutrons, and electrons.

---

2. What is the charge on a neutron?

A neutron has zero, or neutral, charge.

---

3. What is the charge on a proton?

A proton has +1 charge.

---

4. What is the charge on an electron?

An electron has -1 charge.

The protons and neutrons live in the center of the atom.
The center of the atom is called the *nucleus*.

So, we can say that the protons and neutrons live in the nucleus.

The electrons are located outside the nucleus.

The nucleus takes up only a tiny, tiny fraction of the entire space of the atom.
(To be more specific, the nucleus takes up roughly one quadrillionth of the space of the atom.)

---

5. In what part of the atom do neutrons live?

The neutrons live in the nucleus (the center of the atom).

---

6. In what part of the atom do electrons live?

The electrons are located outside the nucleus.

---

7. In what part of the atom do protons live?

The protons live in the nucleus.

---

8. List some elements.

The *elements* are the different types of atoms in the periodic table.

Some elements are hydrogen (H), helium (He), lithium (Li), beryllium (Be), boron (B), carbon (C), oxygen (O), nitrogen (N), fluorine (F), neon (Ne), etc.

What is the fundamental difference between different elements?

What is the fundamental difference between hydrogen and helium?
What is the fundamental difference between nitrogen and oxygen?
What is the fundamental difference between gold (Au) and lead (Pb)?

It turns out that the fundamental difference between different elements
is the *number of protons*.

A hydrogen atom has a different number of protons than a helium atom.
A nitrogen atom has a different number of protons than an oxygen atom.
A gold atom has a different number of protons than a lead atom.
Etc.

All hydrogen atoms have 1 proton (in the nucleus).
All helium atoms have 2 protons (in the nucleus).
All lithium atoms have 3 protons (in the nucleus).
All beryllium atoms have 4 protons (in the nucleus).
All boron atoms have 5 protons (in the nucleus).
All carbon atoms have 6 protons (in the nucleus).
All nitrogen atoms have 7 protons (in the nucleus).
All oxygen atoms have 8 protons (in the nucleus).
All fluorine atoms have 9 protons (in the nucleus).
All neon atoms have 10 protons (in the nucleus).
All gold (Au) atoms have 79 protons (in the nucleus).
All lead (Pb) atoms have 82 protons (in the nucleus).
Etc.

If two atoms have the same number of protons,
then those two atoms represent the same element.

If two atoms have different numbers of protons,
then those two atoms represent different elements.

If two atoms represent different elements,
then you know that they must have different number of protons.

If two atoms represent the same element,
then you know that they must have the same number of protons.

The fundamental difference between different elements is the number of protons!

All hydrogen atoms have 1 proton (in the nucleus).
All helium atoms have 2 protons (in the nucleus).
All lithium atoms have 3 protons (in the nucleus).
All beryllium atoms have 4 protons (in the nucleus).
All boron atoms have 5 protons (in the nucleus).
All carbon atoms have 6 protons (in the nucleus).
All nitrogen atoms have 7 protons (in the nucleus).
All oxygen atoms have 8 protons (in the nucleus).
All fluorine atoms have 9 protons (in the nucleus).
All neon atoms have 10 protons (in the nucleus).
All gold (Au) atoms have 79 protons (in the nucleus).
All lead (Pb) atoms have 82 protons (in the nucleus).

Did you notice that these numbers match the whole numbers associated with each element in the periodic table?
Take a moment now to look at your periodic table and confirm that this is true.

---

9. What information do the whole numbers in the periodic table represent?

From the above examples, it should be apparent to you
that the whole numbers in the periodic table
represent the *number of protons* contained in an atom of each element.

---

10. How many protons are there in an atom of calcium?

Look up calcium (Ca) in the periodic table and notice that it is associated with a whole number of 20.

So we know that there are *20 protons* in any atom of calcium.

---

11. An atom contains 17 protons. What element does the atom represent?
Or, is there not enough information to tell?

Answer: The atom represents the element chlorine (Cl).

Analysis:
The fundamental difference between different elements is the number of protons.
So, if you know the number of protons, there *is* enough information to identify the element.

We have learned that the whole numbers in the periodic table represent
the number of protons in an atom of each element.
So we look for the whole number 17 in the periodic table
and learn that the element chlorine (Cl) contains 17 protons.

So we know that an atom with 17 protons must represent the element chlorine.

We have learned that the whole numbers in the periodic table represent
the number of protons in an atom of each element.

What about the decimal numbers in the periodic table?
Well, we will learn what those decimal numbers represent in a later lesson (“Atomic Masses”).

---

12. True or False: All carbon atoms have the same number of protons.

Answer: True, all carbon atoms have 6 protons (in the nucleus).

The fundamental thing that makes an atom count as a carbon atom is that it has 6 protons!

What about neutrons?

It turns out that, for example, all carbon atoms do not need to have the same number of neutrons.
Some carbon atoms have 6 protons and 6 neutrons,
some carbon atoms have 6 protons and 7 neutrons,
and some carbon atoms have 6 protons and 8 neutrons.

The same thing is true for all elements.

For example, in the periodic table, the whole number associated with nitrogen is 7,
so we know that all nitrogen atoms have to have 7 protons.
However, different nitrogen atoms may have *different* numbers of *neutrons*.
Some nitrogen atoms have 7 protons and 7 neutrons (in the nucleus),
while other nitrogen atoms have 7 protons and 8 neutrons (in the nucleus).

---

13. True or false: All lithium atoms have the same number of neutrons.

Answer: False.
All lithium atoms have the same number of *protons* (3).
But we have learned that different atoms of the same element can have different numbers of neutrons.
So, different atoms of lithium can have different numbers of neutrons.

The fundamental thing that makes an atom count as a lithium atom is the number of protons (3),
not the number of neutrons!

What about electrons?

It turns out that, for example, all lithium atoms do not need to have the same number of electrons.
Some lithium atoms have 3 protons and 3 electrons,
some lithium atoms have 3 protons and 4 electrons,
some lithium atoms have 3 protons and 2 electrons,
some lithium atoms have 3 protons and 5 electrons,
etc.

The same thing is true for all elements.

For example, in the periodic table, magnesium is associated with the whole number 12,
so we know that all magnesium atoms have to have 12 protons.
However, different magnesium atoms may have _different_ numbers of _electrons_.
Some magnesium atoms have 12 protons (in the nucleus) and 12 electrons (outside the nucleus),
while other magnesium atoms have 12 protons (in the nucleus) and 11 electrons (outside the nucleus),
while other magnesium atoms have 12 (in the nucleus) protons and 10 electrons (outside the nucleus),
while other magnesium atoms have 12 (in the nucleus) protons and 13 electrons (outside the nucleus),
etc.

The fundamental thing that make an atom count as a magnesium atom is the number of protons (12),
not the number of electrons or neutrons!

---

14. True or False? All oxygen atoms have the same number of neutrons.

False. Different atoms of a particular element can have different numbers of neutrons.

---

15. True or False: All oxygen atoms have the same number of protons.

True. All atoms of a particular element must have the same number of protons.

The fundamental thing that makes an atom count as an oxygen atom is the number of protons (8).

---

16. True or False: All oxygen atoms have the same number of electrons.

Answer:
False. Different atoms of a particular element can have different numbers of electrons.

Note:
Some textbooks follow the convention that the word “atom” is reserved for atoms that contain the same number of protons as electrons; atoms that contain different numbers of electrons and protons are referred to as “ions”, rather than as “atoms”. If we were to follow that convention, then we would say that all oxygen “atoms” do have the same number of electrons (8), while oxygen “ions” can have different numbers of electrons (any number other than 8).

---

17. An atom has 53 neutrons. What element does the atom represent?
Or is there not enough information to tell?

Answer:
An atom of one element can have the same number of neutrons as an atom of a different element, so there is *not enough information to tell* what element the atom represents.

---

18. An atom has 53 protons. What element does the atom represent?
Or is there not enough information to tell?

Answer:
The atom represents the element iodine (I).

Analysis:
An atom of one element *cannot* have the same number of protons as an atom of another element. So once we know the number of protons, we should be able to figure out which element the atom represents.

We know that the whole numbers in the periodic table represent the number of protons for each element.
We're told that this particular atom has 53 protons.
Looking in the periodic table, we find the whole number 53 in cell for iodine (I).
So we know that an atom with 53 protons *must* represent the element iodine.

The fundamental thing that determines the identity of an element
is the number of protons in each atom of that element!

---

19. An atom has 53 electrons. What element does the atom represent?
Or is there not enough information to tell?

Answer:
An atom of one element can have the same number of electrons as an atom of a different element, so there is *not enough information to tell* what element the atom represents.

Note:
Some textbooks follow the convention that the word “atom” is reserved for atoms that contain the same number of protons as electrons; atoms that contain different numbers of electrons and protons are referred to as “ions”, rather than as “atoms”. If we were to follow this convention, then we would say that an “atom” with 53 electrons must represent iodine, but that there’s not enough information to tell what element an “ion” with 53 electrons would represent.

Let’s review the material we discussed in this lesson.

---

20. Define the term *elements.*

The elements are the different types of atoms.

---

21. List some elements.

Hydrogen, helium, lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, neon, etc.

The elements are all listed in the periodic table.

---

22. What are the symbols for each of the following elements:
beryllium
boron
bromine
calcium
carbon
chlorine
hydrogen
helium
magnesium
nitrogen
neon
phosphorus
potassium
silicon
sodium
sulfur

---

beryllium = Be
boron = B
bromine = Br
calcium = Ca
carbon = C
chlorine = Cl
hydrogen = H
helium = He
magnesium = Mg
nitrogen = N
neon = Ne
phosphorus = P
potassium = K
silicon = Si
sodium = Na
sulfur = S

---

23. What elements do each of the following symbols represent:
Al
Ar
F
I
Li
O

Al = aluminum
Ar = argon
F = fluorine
I = iodine
Li = lithium
O = oxygen

---

24. What are the components of an atom?
What is the electric charge on each component?
Where in the atom is each component located?

The components of an atom are
protons, neutrons, and electrons.

Each proton
has an electric charge of +1, and
is located in the nucleus (the center of the atom)

Each neutron
has an electric charge of 0 (neutral), and
is located in the nucleus.

Each electron
has an electric charge of -1, and
is located outside the nucleus.

---

25. Fill in the blank:
All atoms of the same element have the same number of _____s.

All atoms of the same element have the same number of *protons*.

The number of protons is the fundamental thing that determines the identity of the element.

---

26. Consider a particular phosphorus atom.
How many protons does this particular phosphorus atom have, or is there not enough information to tell?
How many neutrons does this particular phosphorus atom have, or is there not enough information to tell?
How many electrons does this particular phosphorus atom have, or is there not enough information to tell?

Answer:
The phosphorus atom contains 15 protons.
We don't have enough information to tell how many neutrons or electrons this particular phosphorus atom contains.

Analysis:
The number of protons is the same for all phosphorus atoms.
The number of protons for each type of element is given by the whole number in the periodic table.
The whole number for phosphorus is 15, so any atom of phosphorus contains *15 protons*.

Different phosphorus atoms can contain different numbers of neutrons,
so there's not enough information for us to tell how many neutrons this particular phosphorus atom has.

Different phosphorus atoms can contain different numbers of electrons,
so there's not enough information for us to tell how many electrons this particular phosphorus atom has.

Note:
Some textbooks follow the convention that the word "atom" is reserved for atoms that contain the same number of protons as electrons; atoms that contain different numbers of electrons and protons are referred to as "ions", rather than as "atoms". If we were to follow that convention, then we would say that a phosphorus "atom" must contain 15 electrons, while a phosphorus "ion" could contain any number of electrons other than 15.

You have reached the end of the lesson.

You are ready now to move on to the next lesson for this chapter:
Atomic Number and Mass Number