
Welcome!

This is a chemistry lesson, covering *atomic number and mass number*.

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

This lesson builds on the material in the previous lesson:
Atoms, Protons, Neutrons, and Electrons

You should complete that lesson before proceeding with this one.

This lesson was written by Freelance-Teacher.

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In the previous lesson we discussed the meaning of the “whole numbers” in the periodic table.

It would be convenient to have a name for these “whole numbers”.

Chemists have chosen to call the whole numbers in the periodic table
the *atomic numbers* of the elements.

So, the atomic number for hydrogen (H) is 1.
The atomic number for helium (He) is 2.
The atomic number for lithium (Li) is 3.
The atomic number for beryllium (Be) is 4.
The atomic number for boron (B) is 5.
The atomic number for carbon (C) is 6.
The atomic number for nitrogen (N) is 7.
Etc.

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1. What information does the atomic number give you about an element?

The atomic number is the name for the whole numbers in the periodic table.

But, in the previous lesson, we learned that these whole numbers tell you
the number of protons in one atom of each element.

So, atomic number = number of protons

The atomic number of an element tells you the number of protons in each atom of the element.

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2. What is the atomic number for potassium?
What information does this number give you about potassium?

Answer:
Looking in the periodic table,
we see that the atomic number for potassium (K) is 19.

We know that
atomic number = number of protons

So the atomic number tells us that any atom of potassium must contain 19 protons.

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3. Suppose you are told that the atomic number for some atom is 12.
What can you figure out about this atom?

We're told that the atomic number is 12.

atomic number = number of protons
So we know that this atom contains 12 protons.

We look for the number 12 in the periodic table
and we find that the element with 12 protons is magnesium (Mg).

Atomic number is a unitless concept.

The symbol for atomic number is *Z*.

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4. What have we learned about the whole numbers in the periodic table?

The whole numbers represent the number of protons for each element.

The whole number for each element is called the *atomic number* for that element.

What about the decimal numbers in the periodic table?

The decimal numbers in the periodic table
(e.g., 1.008, 4.003, 6.941, 9.012, 10.81, etc.)
are referred to as the *atomic masses*.

We will not be discussing the *meaning* of the concept of atomic mass any further in this lesson.
(We'll get to that in a future lesson, "Atomic Mass".)

For now, just be aware that the atomic masses are referenced by
the decimal numbers in the periodic table.

Now let's introduce the concept of *mass number*.

Here's the definition for mass number:
mass number = number of protons + number of neutrons

Please be aware that the "mass number" is a different concept from the "atomic mass".

On the previous page we learned that the decimal numbers in the periodic table tell you the atomic mass for each element;
but the periodic table does *not* tell you mass numbers.

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5. A particular atom of oxygen has 10 neutrons.
What is the mass number of this particular atom of oxygen?

Answer:
This particular atom of oxygen has a mass number of 18.

Analysis:
? = mass number

The problem tells us that this *particular* oxygen atom has 10 neutrons.

From the periodic table,
we know that *any* oxygen atom has an atomic number of 8.

atomic number = number of protons
So the oxygen atom has 8 protons.

mass number = number of protons + number of neutrons
So, for this particular oxygen atom,
mass number = 8 + 10
So, mass number = 18

So this particular oxygen atom has a mass number of 18.

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6. Suppose the mass number for a particular atom of chlorine is 37.
What can you figure out from that mass number?

Answer:
When we are told that the mass number for a particular atom of chlorine is 37,
we can conclude that this particular atom of chlorine consists of
17 protons (inside the nucleus),
and 20 neutrons (inside the nucleus).

Analysis:
mass number = number of protons + number of neutrons

Since we are told that the mass number for this particular atom of chlorine is 37,
we know that, for this particular chlorine atom,
number of protons + number of neutrons = 37

But we also know, from the periodic table, that the atomic number for any atom of chlorine is 17.

atomic number = number of protons
So we know that, for this particular atom of chlorine,
number of protons =17

So we can say that, for this particular chlorine atom,
17 + number of neutrons = 37
So, number of neutrons = 20

In summary, when we are told that the mass number for a particular atom of chlorine is 37,
we can conclude that this atom of chlorine consists of
17 protons (inside the nucleus), and
20 neutrons (inside the nucleus).

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7. You are told that a particular helium atom has a mass number of 3.
Figure out as much as you can from this information.

Answer:
When we are told that the mass number for a particular atom of helium is 3,
we can conclude that this atom of helium contains
2 protons, and
1 neutron.

Analysis:
mass number = number of protons + number of neutrons
Since we are told that the mass number for this particular atom of helium is 3,
we know that, for this particular helium atom,
number of protons + number of neutrons = 3

But we also know, from the periodic table, that the atomic number for any helium is 2.
atomic number = number of protons
So we know that, for this particular atom of helium,
number of protons = 2

So we can say that, for this particular helium atom,
2 + number of neutrons = 3
So, number of neutrons = 1

In summary, when we are told that the mass number for a particular atom of helium is 3,
we can conclude that this atom of helium consists of
2 protons (inside the nucleus), and
1 neutron (inside the nucleus).

In the previous problem,
how many *electrons* does the particular atom of helium contain?

The answer is that the number of electrons for this particular helium atom
cannot be determined from the information given.

Note:
Some textbooks follow the convention that the word “atom” is reserved for atoms in which the number of electrons equals the number of protons. (The word “ion” is used for atoms in which the number of electrons differs from the number of protons.) If you follow that convention, then you would say that the helium “atom” in the previous problem has 3 electrons.

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8. True or False? If false, rewrite the statement so that it is true.
Mass numbers can be either whole numbers (1, 2, 3, 4, 5, 6, etc.) or decimals (1.008, 4.003, 6.941, 9.012, 10.81, 12.01, etc).

False.
Mass numbers are always whole numbers, never decimals.

Analysis:
mass number = number of protons + number of neutrons

The number of protons is always a whole number, and
the number of neutrons is always a whole number,
so the mass number must always be a whole number, never a decimal.

Keep in mind that “mass number” is a separate concept from “atomic mass”.
Mass number is always a whole number,
while *atomic mass* is a decimal.

(We will not be discussing the *meaning* of the “atomic mass” in this lesson,
but we have learned that the atomic masses are referenced by the decimal numbers in the periodic table.)

Mass number is a unitless concept.

The symbol for mass number is *A*.

(Recall that we mentioned earlier that the symbol for atomic number is *Z*.)

The atomic symbol for a particular atom is sometimes written in the following format: ${}_{18}^{40}\mathrm{Ar}$

In this format,
the superscript represents the *mass number*, and
the subscript represents the *atomic number*.

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9. Consider the symbol ${}_{18}^{40}\mathbf{Ar}$.
What concept does the number 40 represent?
What concept does the number 18 represent?

In this format,
the superscript represents the *mass number*, and
the subscript represents the *atomic number*.

In the symbol ${}_{18}^{40}\mathrm{Ar}$
the superscript is 40, and
the subscript is 18.

So, for the symbol ${}_{18}^{40}\mathrm{Ar}$
40 represents the mass number, and
18 represents the atomic number.

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10. Consider the symbol $_{6}^{13}C$.
Figure out as much as you can about the atom represented by this symbol.

Answer:
From the symbol $_{6}^{13}C$,
we can figure out that, for this particular carbon atom,
atomic number = 6
mass number = 13
number of protons = 6
number of neutrons = 7

Analysis:
In this format,
the superscript represents the *mass number*, and
the subscript represents the *atomic number*.

In the symbol $_{6}^{13}C$
the superscript is 13, and
the subscript is 6.

So, for this particular atom of carbon,
the mass number is 13, and
the atomic number is 6.

atomic number = number of protons
So this carbon atom has 6 protons.

mass number = number of protons + number of neutrons
So, for this particular carbon atom,
13 = 6 + number of neutrons
So, number of neutrons = 7

So we can conclude that, for this particular carbon atom,
atomic number = 6
mass number = 13
number of protons = 6
number of neutrons = 7

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11. Consider the atom represented by the symbol $_{13}^{22}Al$.
Figure out as much as you can about this atom.

Answer:
From the symbol $_{13}^{22}Al$,
we can figure out that, for this particular aluminum atom,
atomic number = 13
mass number = 22
number of protons = 13
number of neutrons = 9

Analysis:
In this type of notation,
the superscript represents the *mass number*, and
the subscript represents the *atomic number*.

For the symbol $_{13}^{22}Al$,
the superscript is 22, and

the subscript is 13.

So, for this particular atom of aluminum,
the mass number is 22, and
the atomic number is 13.

atomic number = number of protons
So this aluminum atom has 13 protons.

mass number = number of protons + number of neutrons
So, for this aluminum atom,
22 = 13 + number of neutrons
So, number of neutrons = 9

So we can conclude that, for this particular aluminum atom,
atomic number = 13
mass number = 22
number of protons = 13
number of neutrons = 9

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12. Consider a sodium atom that contains 17 neutrons.
How would you write the symbol for this particular sodium atom?
Include a subscript and superscript.

Answer:
For this particular sodium atom, we can write its symbol as: $_{11}{}^{28}\mathrm{Na}$

Analysis:
From the periodic table, we know that the atomic number for sodium is 11.

atomic number = number of protons
So this sodium atom has 11 protons.

We are told that this particular sodium atom has 17 neutrons.

mass number = number of protons + number of neutrons
So, for this sodium atom,
mass number = 11 + 17
So: mass number = 28

In this notation,
the superscript represents the *mass number*, and
the subscript represents the *atomic number*.

Therefore, the symbol for this particular sodium atom is: $_{11}{}^{28}\mathrm{Na}$.

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13. True or false? If false, rewrite the statement so that it is true.
For a symbol like $_{29}{}^{65}\mathrm{Cu}$, the superscript represents the number of neutrons, and the subscript represents the number of protons.

False.

For a symbol like $_{29}{}^{65}\mathrm{Cu}$,
the superscript represents the *mass number*, not the number of neutrons;
the subscript does represent the number of protons.

Have you noticed that a symbol like $_{14}{}^{29}\mathrm{Si}$ actually contains “redundant” information?

The subscript, 14, is redundant information.
Do you see why?

Suppose the symbol was presented without a subscript, like so: $^{29}\mathrm{Si}$
Could you still figure out the atomic number of the atom?

Sure. If you look up Si (silicon) in the periodic table,
you will find that its atomic number is 14.
This demonstrates that, for this type of symbol, the subscript provides redundant information.

As a result, you will often see this type of symbol written *without* a subscript: $^{29}\mathrm{Si}$

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14. Consider the atom represented by the symbol ^{42}Ca. Figure out as much as you can about this atom.

Answer:
From the symbol ^{42}Ca,
we can figure out that, for this particular calcium atom,
atomic number = 20
mass number = 42
number of protons = 20
number of neutrons = 22

Analysis:
In this type of notation,
the superscript represents the mass number,
and there is no subscript shown.

For the symbol ^{42}Ca,
the superscript is 42,
and there is no subscript.

However, we can look up calcium (Ca) in the periodic table,
and see that its atomic number is 20.

So, for this particular atom of calcium,
the mass number is 42, and
the atomic number is 20.

atomic number = number of protons
So this calcium atom has 20 protons.

mass number = number of protons + number of neutrons
So, for this calcium atom,
42 = 20 + number of neutrons
So: number of neutrons = 22

So we can conclude that, for this particular calcium atom,
atomic number = 20
mass number = 42
number of protons = 20
number of neutrons = 22

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

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15. What is the definition of mass number?
What is the symbol for mass number?
What are the units for mass number?

Mass number = number of protons + number of neutrons

The symbol for mass number is *A*.

Mass number is a unitless concept.

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16. What is the definition of atomic number?
What is the symbol for atomic number?
What are the units for atomic number?

Atomic number = number of protons.

The symbol for atomic number is *Z*.

Atomic number is a unitless concept.

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17. In the notation $_{35}{}^{81}$Br, what do the numbers represent?

The superscript ^{81} represents the mass number, and
the subscript $_{35}$ represents the atomic number.

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18. Write the atomic symbol for a sulfur atom with 19 neutrons. Include both a subscript and a superscript.

Answer:
$_{16}{}^{35}S$

Analysis:
From the periodic table, we know that the atomic number for sulfur is 16.
So the number of protons for sulfur is 16.

mass number = number of protons + number of neutrons
So: mass number = 16 + 19
So: mass number = 35

The superscript represents the mass number, and
the subscript represents the atomic number.
So the correct symbol is: $_{16}{}^{35}S$

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19. True or False? And explain *why* the statement is true or false.
All atoms of the same element have the same atomic number.

True.
All atoms of the same element have the same atomic number,
because the atomic number represents the number of protons.

Different atoms of the same element must have the same number of protons,
because the number of protons is the fundamental thing that determines the identity of the element.

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20. True or False? And explain *why* the statement is true or false.
All atoms of the same element have the same mass number.

False.

mass number = number of protons + number of neutrons
Different atoms of the same element can have different mass numbers,
because they can have different numbers of neutrons.

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21. How do you determine the atomic number for an element from the periodic table?

The atomic number for each element
is the whole number associated with that element in the periodic table.

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22. How do you determine the mass number for an element from the periodic table?

Trick question.
You *cannot* determine the mass number for an element from the periodic table,
for two reasons.

Firstly, an “element” does not have one fixed mass number.
Different atoms of the same element can have different mass numbers.

For example, one particular atom of the element carbon might have 6 protons and 6 neutrons, resulting in a mass number of 12,
while another particular atom of the of the element carbon might have 6 protons and 7 neutrons,
resulting in a mass number of 13.

Secondly, the periodic table does not provide mass numbers.
Remember that the decimal numbers in the periodic table refer to “atomic masses”,
not mass numbers.

Notice that the second point above is a consequence of the first point.
It is impossible for the periodic table to provide the mass number for an element,
because an element does not have one fixed mass number.
Different atoms of the same element can have different mass numbers
(because they can have different numbers of neutrons).

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23. True or false? If false, rewrite the statement so that it is true.
For a symbol like $_{26}{}^{56}\mathrm{Fe}$, the superscript represents the number of neutrons, and the subscript represents the number of protons.

False.
For a symbol like $_{26}{}^{56}\mathrm{Fe}$,
the superscript represents the *mass number*, not the number of neutrons;
the subscript does represent the number of protons.

You have reached the end of the lesson.

You’re ready now to proceed to the next lesson for this chapter:
Isotopes