
Welcome!

This is a scripted chemistry lesson, covering *ions*.

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 we covered in the previous lesson on Atoms, Protons, Neutrons, and Electrons.

You should complete that lesson before working through this one.

The script for this lesson was written by Freelance-Teacher.

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1. Suppose a carbon atom has more electrons than protons.
Will the net charge of the atom be positive, negative, or neutral?

Answer:
From the previous lesson on Atoms, Protons, Neutrons, and Electrons,
you should know that
each proton has a +1 electric charge, and
each electron has a -1 electric charge.

The problem didn't tell us how many neutrons this particular carbon atom has,
but that will not be an issue
because each neutron has 0 electric charge.

Since the atom has more electrons than protons,
we conclude the net charge for this particular carbon atom will be *negative*.

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2. Suppose a carbon atom has fewer electrons than protons.
Will the net charge of the atom be positive, negative, or neutral?

Each proton has a +1 electric charge, and
each electron has a -1 electric charge.

Since the atom has fewer electrons than protons,
we conclude the net charge for this particular carbon atom will be *positive*.

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3. Suppose a carbon atom has equal numbers of electrons and protons.
Will the net charge of the atom be positive, negative, or neutral?

Each proton has a +1 electric charge, and
each electron has a -1 electric charge.

Since the atom has equal numbers of electrons and protons,
we conclude the net charge for this particular carbon atom will be *zero* (neutral).

In general, the word “net” means:
add up the individual things,
being careful to include a negative sign on each thing in the sum that is negative.

So the term “net charge” means:
add up all the individual charges,
being careful to include a negative sign on each charge that is negative.

To review,
when an atom has fewer electrons than protons, the atom’s net charge is positive;
when an atom has more electrons than protons, the atom’s net charge is negative;
when an atom has equal numbers of electrons and protons, the atom’s net charge is zero.

An *ion* is defined as:
an atom or group of atoms
with a positive or negative net electric charge.

For example, an atom with a net electric charge of -3 is an ion.

An atom with a net electric charge of +1 is also an ion.

An atom with a net electric charge of 0 is *not* an ion.

4. Suppose a neutral aluminum atom loses two electrons.
What will be the value of its new net electric charge?

Answer:
The new net electric charge for the aluminum atom will be +2.

Solution:
The aluminum atom begins with a net charge of 0.
Then the atom *loses* two electrons.

Each electron has a -1 electric charge.
So the atom begins with 0 charge, and then *loses* two -1 charges.

So we can calculate
new net charge = 0 - 2(-1)
So, new net charge = 0 - (-2)
So, new net charge = 0 + 2
So, new net charge = +2

In the previous example, we generated an aluminum atom with a +2 net electric charge.

Therefore, this aluminum atom is referred to as an *ion*.
The symbol for this ion is Al^{2+}.

5. Suppose a neutral chlorine atom gains three electrons.
What will be the value of its new net electric charge?
What is the symbol for this ion?

Answer:
The net electric charge for the chlorine ion will be -3.
The symbol for this ion is Cl^{3-}.

Solution:
The chlorine atom begins with a net charge of 0.
Then the atom *gains* three electrons.

Each electron has a –1 electric charge.
So the atom begins with 0 charge, and then *gains* three –1 charges.

So we can calculate
new net charge = 0 + 3(–1)
So, new net charge = 0 + (–3)
So, new net charge = –3

In this example we generated a chlorine atom with a –3 net electric charge.

Therefore, this chlorine atom is referred to as an *ion*.
The symbol for this ion is Cl^{3-}.

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6. Suppose a neutral calcium atom loses one electron.
What will be the value of its new net electric charge?
What is the symbol for this ion?

Answer:
The net electric charge for the calcium ion will be +1.
The symbol for this ion is Ca^{+}.

Solution:
The calcium atom begins with a net charge of 0.
Then the atom *loses* one electron.

Each electron has a –1 electric charge.
So the atom begins with 0 charge, and then *loses* one –1 charge.

So we can calculate
new net charge = 0 – 1(–1)
So, new net charge = 0 – (–1)
So, new net charge = 0 + 1
So, new net charge = +1

The symbol for this ion is Ca^{+}.

For simplicity, in the rest of this lesson,
instead of referring to “net electric charge”
we will just say “electric charge”, or simply “charge”.

For example, instead of saying that a calcium atom that loses an electron will have a +1 net electric charge,
we will simply say that a calcium atom that loses an electron will have a +1 charge.

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7. True or False.
In order for an atom to be neutral, it must have equal numbers of protons and electrons.

Answer:
True

If there are more protons than electrons, then the atom will be positively charged;
if there are fewer protons than electrons, then the atom will be negatively charged.

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8. How many electrons does a neutral sodium atom have?

Answer:
A neutral sodium atom has 11 electrons.

Solution:
Find sodium (Na) in the periodic table,
and notice that sodium has an atomic number of 11.

Recall from a previous lesson that:
atomic number = number of protons

So we know that any sodium atom has 11 protons.

The problem tells us that this particular sodium atom is neutral.

We know that, in order to be neutral,
the number of electrons must equal the number of protons.

So we know that this particular sodium atom must have 11 electrons.

Please take a look at your periodic table.
The elements in the last column of the periodic table (the rightmost column)
are called the noble gases.

So the noble gases are:
helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), and radon (Rn).

You should be able to see that
neutral helium has 2 electrons,
neutral neon has 10 electrons,
neutral argon has 18 electrons,
neutral krypton has 36 electrons,
neutral xenon has 54 electrons, and
neutral radon has 86 electrons.

These numbers of electrons are unusually “favorable”.

We say that the noble gases have unusually favorable “electron configurations”.

Therefore, neutral neon is unlikely to either gain or lose electrons,
because it already has an extremely favorable electron configuration.

The same thing could be said of any of the other noble gases.
(They’re called “noble” because they’re too proud to change.)

Now think about all the *other* elements in the periodic table,
besides the noble gases.

All of these other elements have *unfavorable* electron configurations when their atoms are neutral.

In order to achieve a favorable electron configuration,
each of these neutral atoms would like to either gain or lose electrons,
in order to achieve the same number of electrons as the “nearest” noble gas in the periodic table.

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9. Is a neutral sulfur likely to gain or lose electrons?
How many electrons is a neutral sulfur likely to gain or lose?

Answer:
Sulfur is likely to *gain two electrons*.
The symbol for this ion is S^{2-}.

Analysis:
In the periodic table, the nearest noble gas to sulfur (S) is argon.

In the periodic table, argon is two steps to the right of sulfur.

Therefore, in order to achieve the same electron configuration as argon,
sulfur will need to gain 2 electrons.
(That will take sulfur from 16 electrons to 18 electrons, like argon.)

So sulfur is likely to gain 2 electrons.

So sulfur is likely to form a -2 ion.
The symbol for this ion is S^{2-}.

As you can see, it's important to have your periodic table in front of you when you're doing chemistry!

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10. Is a neutral potassium likely to gain or lose electrons?
How many electrons is a neutral potassium likely to gain or lose?
What is the symbol for the ion that will be formed?

Answer:
Neutral potassium is likely to *lose one electron*.
This will form a K^+ ion.

Analysis:
In the periodic table, the nearest noble gas to potassium (K) is argon.
In the table, argon is one step to the left of potassium.
(Imagine that, when we "step" leftward from the leftmost column of the table,
we "wrap around" and end up in the rightmost column of the table.)
Therefore, in order to achieve the same electron configuration as argon, potassium will need to lose 1 electron. (That will take potassium from 19 electrons to 18 electrons, like argon.)
So potassium is likely to lose 1 electron.
So potassium is likely to form a +1 ion.
The symbol for this ion is K^+.

(It would also be correct to write the symbol as K^{1+},
but K^+ is more conventional.)

11. Is a neutral aluminum likely to gain or lose electrons?
How many electrons is a neutral aluminum likely to gain or lose?
What is the symbol for the ion that will be formed?

Answer:
Neutral aluminum is likely to *lose three electrons*.
This will form an Al^{3+} ion.

Analysis:
In the periodic table, aluminum is three steps from neon,
and aluminum is five steps from argon.

So the *nearest* noble gas to aluminum (Al) is *neon*.

In the table, neon is three steps to the *left* of aluminum.
(Imagine that, when we "step" leftward from the leftmost column of the table,
we "wrap around" and end up in the rightmost column of the table.)

Therefore, in order to achieve the same electron configuration as neon,
aluminum will need to *lose* 3 electrons.
(That will take aluminum from 13 electrons to 10 electrons, like neon.)

So aluminum is likely to lose 3 electrons.

So aluminum is likely to form a +3 ion.
The symbol for this ion is Al^{3+}.

12. Write the symbol for the ion that is likely to be formed by iodine.

Answer:
Iodine is likely to form an I^- ion.

Analysis:

In the periodic table, the nearest noble gas to iodine (I) is xenon (Xe).
In the table, xenon is one step to the right of iodine.
Therefore, in order to achieve the same electron configuration as xenon,
iodine will need to gain 1 electron.

So iodine is likely to form a −1 ion.
The symbol for this ion is I^-.

(It would also be correct to write the symbol as I^{1-},
but I^- is more conventional.)

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13. Write the symbol for the ion that is likely to be formed by nitrogen.

Answer:
Nitrogen is likely to form an N^{3-} ion.

Analysis:
In the periodic table, the nearest noble gas to nitrogen (N) is neon (Ne).
In the table, neon is three steps to the right of nitrogen.
Therefore, in order to achieve the same electron configuration as neon,
nitrogen will need to gain 3 electrons.

So nitrogen is likely to form a −3 ion.
The symbol for this ion is N^{3-}.

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13. Write the symbol for the ion that is likely to be formed by calcium.

Answer: Calcium is likely to form a Ca^{2+} ion.

Analysis:
In the periodic table, the nearest noble gas to calcium (Ca) is argon.
In the table, argon is two steps to the left of calcium.
Therefore, in order to achieve the same electron configuration as argon,
neutral calcium would need to lose 2 electrons.

So a neutral calcium atom is likely to lose 2 electrons.
So calcium is likely to form a +2 ion.
So the correct answer is Ca^{2+}.

To review,
14. What is the definition of an ion?

An ion is defined as:
an atom or group of atoms
with a positive or negative electric charge.

Now let's move on to a new concept.

A *cation* is defined as:
a positively charged ion

The word "cation" is pronounced "CAT-eye-on".

An *anion* is defined as:
a negatively charged ion

Here are some memory aids to help you remember these definitions.

In the word "anion", we can imagine that the letter "n" stands for "negative".

So we can imagine that the letters of the word "A-N-ION" spell out "A Negative ION".

In the word "cation", the letter "t" looks a little like a + symbol.

So we can imagine that the last five letters of the word "c a-t-ion" spell "a + ion";
i.e., "a positive ion".

15. What is the definition of an anion?

The definition of an anion is:
a negative ion

16. What do we call a positive ion?

A positive ion is called a *cation*.

17. Write the symbol for the ion likely to be formed by rubidium (Rb).
Is it a cation or an anion?

Answer:
Rb^+ cation

Analysis:
The closest noble gas to rubidium in the periodic table is krypton (Kr).

Krypton is one step to the left of rubidium in the table.
Therefore, in order to obtain an electron configuration similar to krypton,
rubidium wants to lose one electron,
resulting in an Rb^+ cation.

18. Write the symbol for the ion likely to be formed by oxygen.
Is it a cation or an anion?

Answer:
O^{2-} anion

Analysis:
The closest noble gas to oxygen in the periodic table is neon (Ne).

Neon is two steps to the right of oxygen in the table.
Therefore, in order to obtain an electron configuration similar to neon,
oxygen wants to gain two electrons,
resulting in an O^{2-} anion.

Let’s review the material we’ve covered in this lesson.

19. What is the definition of an ion?

An ion is defined as:
an atom or group of atoms
with a positive or negative electric charge.

In this lesson, we have discussed ions consisting of a single atom;
these are called *monatomic* ions.

In a future lesson, we will discuss ions that consist of a group of atoms.
(These are called *polyatomic* ions.)

20. What is the definition of a cation?

The definition of a cation is:
a positive ion

Memory aid:
In the word “cation”, the letter “t” looks a little like a + symbol.
So we can imagine that the last five letters of the word “c a-t-ion” spell “a + ion”;
i.e., “a positive ion”.

21. What is the name for a negative ion?

A negative ion is called an *anion*.

Memory aid:
In the word “anion”, we can suppose that the letter “n” stands for “negative”.
So we can imagine that the letters of the word “A-N-ION” spell “A Negative ION”.

22. True or False. If false, how would you rewrite the statement so that it is true?
The noble gases have unusually favorable electron configurations.

True.

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23. Fill in the blank:
In order to achieve a favorable electron configuration, any neutral atom would like to either gain or lose electrons, in order to _____.

In order to achieve a favorable electron configuration, any neutral atom would like to either gain or lose electrons, in order to *achieve the same number of electrons as the "nearest" noble gas in the periodic table*.

Exception:
The noble gases themselves already have favorable electron configurations,
so a noble gas is unlikely to either gain or lose electrons.

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24. Write the symbol for the ion likely to be formed by aluminum.
Is it a cation or an anion?

Answer:
Al^{3+} cation

Analysis:
The closest noble gas to aluminum in the periodic table is neon.

Neon is three steps to the left of aluminum in the table.
(We are imagining that, when you step to the left of the leftmost column, you "wrap around" and end up in the rightmost column.)

Therefore, in order to obtain an electron configuration similar to neon,
aluminum wants to lose three electrons,
resulting in an Al^{3+} cation.

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25. Write the symbol for the ion likely to be formed by strontium (Sr).
Is it a cation or an anion?

Answer:
Sr^{2+} cation

Analysis:
The closest noble gas to strontium in the periodic table is krypton (Kr).

Krypton is two steps to the left of strontium in the table.
(We are imagining that, when you step to the left of the leftmost column, you "wrap around" and end up in the rightmost column.)

Therefore, in order to obtain an electron configuration similar to krypton,
strontium wants to lose two electrons,
resulting in an Sr^{2+} cation.

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26. Write the symbol for the ion likely to be formed by lithium.
Is it a cation or an anion?

Answer:
Li^{+} cation

Analysis:
The closest noble gas to lithium in the periodic table is helium (He).

Helium is one step to the left of lithium in the table.
Therefore, in order to obtain an electron configuration similar to helium,
lithium wants to lose one electron,
resulting in an Li^{+} cation.

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27. Write the symbol for the ion likely to be formed by bromine.
Is it a cation or an anion?

Answer:
Br^- anion

Analysis:
The closest noble gas to bromine in the periodic table is krypton (Kr).

Krypton is one step to the right of bromine in the table.
Therefore, in order to obtain an electron configuration similar to krypton,
bromine wants to gain one electron,
resulting in a Br^- anion.

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28. Write the symbol for the ion likely to be formed by nitrogen.
Is it a cation or an anion?

Answer:
N^{3-} anion

Analysis:
The closest noble gas to nitrogen in the periodic table is neon (Ne).

Neon is three steps to the right of nitrogen in the table.
Therefore, in order to obtain an electron configuration similar to neon,
nitrogen wants to gain three electrons,
resulting in an N^{3-} anion.

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29. Write the symbol for the ion likely to be formed by sulfur.
Is it a cation or an anion?

Answer:
S^{2-} anion

Analysis:
The closest noble gas to sulfur in the periodic table is argon (Ar).

Argon is two steps to the right of sulfur in the table.
Therefore, in order to obtain an electron configuration similar to argon,
sulfur wants to gain two electrons,
resulting in an S^{2-} anion.

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30. What is a monatomic ion?

A monatomic ion is an ion consisting of a single atom.
For example, S^{2-}, or Na^{+}.

In a future lesson, we will discuss ions that consist of more than one atom.
(These are called *polyatomic* ions.)

You have completed the lesson.

You’re ready now to proceed to the next lesson for this chapter:
Ionic and Covalent Compounds