B1 · Electron transfer and redox

Completed notes | Notes 1/3

Follow the electrons, explain charge changes, write half-reactions and name what each agent makes possible.

1. One transfer and what it does to charge

Start with the moving electron

Redox is all about electrons moving from one particle to another. Here, one electron moves from A to B. A **loses** it and B **gains** it. A reaction that moves electrons like this is called an oxidation–reduction reaction, or redox for short.

Oxidation means loss of electrons, so A is oxidized. **Reduction** means gain of electrons, so B is reduced. The electron B gains is the same electron A lost, so the two changes always happen together.

On the diploma: decide loss or gain of electrons first. Then choose "oxidized" or "reduced". The letters A and B just label particles. They are not element symbols.

Watch: Reduction is gain, oxidation is loss (Tyler DeWitt, “Introduction to Oxidation Reduction (Redox) Reactions”, 0:41)

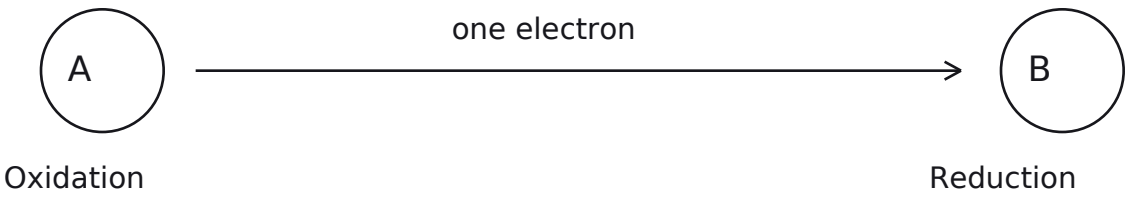
Why the charge changes

An electron carries **negative** charge. Adding a negative amount makes the charge value **decrease**. That is why gaining electrons is called reduction: the charge is reduced.

For example, 0 + (-1) = **-1**, and +3 + (-1) = **+2**. The +2 ion is still positive, but its charge went down. So a positive product can still be a reduction. Removing a negative electron makes the charge **increase**.

A neutral atom has equal positive and negative charge. The nucleus stays the same in these changes, so only the electrons move. When you are given particle counts, charge number = **proton count - electron count**.

Watch: Why gaining electrons is called reduction (Tyler DeWitt, “Introduction to Oxidation Reduction (Redox) Reactions”, 2:02)



A loses; B gains that same electron.

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2. Read the particles and the reaction

Particle words and notation

First, the words. An **atom** is a nucleus with electrons around it. An **ion** is a particle with a net charge, and it can be one atom or a bonded group. A **molecule** is a small bonded group of atoms. NaCl(s) is different: it builds a big ionic lattice, not separate molecules.

Now the symbols. A coefficient is the big number in front, and it counts **copies of a formula**. A subscript is the small lower number, and it counts **atoms within that formula**. A superscript is the small raised number, and it gives the **charge**. So $2Cl^-$ means **two chloride ions**, but Cl_2 is one neutral molecule with **two chlorine atoms**.

The letters in brackets tell you the state. (s) means **solid**, (l) means **liquid**, (g) means **gas**, and (aq) means **dissolved in water**.

On the diploma: read every number in a formula before you count anything. A coefficient, a subscript and a charge look alike but do three different jobs.

A simple shell model

Valence electrons are the ones in the **outer occupied shell**. We are given Na as 2,8,1 and Cl as 2,8,7. When Na gives one electron to Cl, Na^+ becomes **2,8** and Cl^- becomes **2,8,8**. The proton counts stay **unchanged**, because only electrons move.

Full outer shells help explain why Na^+ and Cl^- are common ions. But a full shell does not prove a reaction will happen. What matters is the energy change of the **complete reaction**.

Keep one real reaction in view

Take $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$. Sodium metal and chlorine gas start out neutral. Each Na gives away **one electron**. The Cl_2 molecule has two Cl atoms, and each takes one electron, so together they take in **two electrons in total**.

The Na^+ and Cl^- ions that form attract each other and build an ionic **lattice**, a repeating pattern of ions. Two +1 and two -1 balance, so the solid is neutral overall. The formula NaCl shows the **one-to-one ion ratio**. It does not mean a separate NaCl molecule exists.

On the diploma: always compare the particles before and after the reaction.

Watch: Sodium and chlorine make sodium chloride (Tyler DeWitt, “Introduction to Oxidation Reduction (Redox) Reactions”, 3:45)

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3. Half-reactions, agents and changed examples

Two halves of the same sodium/chlorine story

A half-reaction shows only one half of a redox reaction. Reduction: Cl_2 + **$2e^-$** → $2Cl^-$. The electrons go on the left because chlorine **takes them in**. Check it: two Cl on each side, and the total charge is **-2** on each side.

Oxidation: 2Na → $2Na^+$ + **$2e^-$**. The electrons go on the right because sodium **releases them**. The right side is +2 - 2 = **0**, which matches the neutral left side.

Now add the two halves. The same $2e^-$ sits on **opposite sides**, so it cancels. The electrons are not destroyed. They move from sodium to chlorine. What is left is 2Na + Cl_2 → $2Na^+$ + $2Cl^-$, and those ions form NaCl(s).

On the diploma: in a reduction half-reaction the electrons are reactants. In an oxidation half-reaction they are products.

Watch: Writing a half-reaction (Tyler DeWitt, “Introduction to Oxidation Reduction (Redox) Reactions”, 7:41)

Watch: Two half-reactions make the whole reaction (Tyler DeWitt, “Introduction to Oxidation Reduction (Redox) Reactions”, 10:45)

Watch: Oxidation and reduction always happen together (Tyler DeWitt, “Introduction to Oxidation Reduction (Redox) Reactions”, 11:14)

Agent names describe the partner’s change

An agent is a substance that makes a change happen in another substance. Na supplies the electrons, so chlorine can be **reduced**. That makes Na the **reducing agent**, even though Na itself is oxidized.

Cl_2 accepts the electrons, so sodium can be **oxidized**. That makes Cl_2 the **oxidizing agent**, even though Cl_2 itself is reduced. The two kinds of name answer two questions: what happens to this substance, and what does it do to its partner?

On the diploma: name the agents from the starting reactants, such as Cl_2, not from the product ions such as Cl^-. The reducing agent is the substance that is oxidized.

Watch: What an agent is (Tyler DeWitt, “Oxidizing Agents and Reducing Agents”, 0:57)

Watch: Which agent is which (Tyler DeWitt, “Oxidizing Agents and Reducing Agents”, 4:54)

Watch: Name the whole compound, not just one atom (Tyler DeWitt, “Oxidizing Agents and Reducing Agents”, 11:01)

Change one feature, keep the reasoning

Now start with NaCl that already exists. Solid NaCl already holds Na^+ and Cl^- ions. Dissolving it only separates ions that already have charges. Na stays +1 and Cl stays

-1, so no electrons move and this is **not redox**.

Seeing charge symbols in an equation does not mean redox. Compare each particle before and after, not just the charge marks.

Now try $Mg + Cu^{2+} \rightarrow Mg^{2+} + Cu$. Mg gives **two electrons** to **Cu^{2+}**. So Mg is the **reducing agent** and Cu^{2+} is the **oxidizing agent**. The oxidizing agent starts positive here, but the same loss and gain reasoning still works.

On the diploma: draw the electron arrow first. Then name the agents from the reactants, Mg and Cu^{2+}, not from the products.

Watch: Charges and ions do not make a reaction redox (Tyler DeWitt, “The Oxidation Reduction Question that Tricks Everyone!”, 0:21)

Watch: The charges never change, so no electrons move (Tyler DeWitt, “The Oxidation Reduction Question that Tricks Everyone!”, 1:22)

Watch: The same reaction starting neutral is redox (Tyler DeWitt, “The Oxidation Reduction Question that Tricks Everyone!”, 3:07)

Watch: Finding the agents in an equation (Tyler DeWitt, “Oxidizing Agents and Reducing Agents”, 6:21)

B1 · Worked practice

Electron transfer and redox | Questions 1-2 of 12

State symbols: (s) solid, (aq) dissolved in water, (l) liquid, (g) gas. Use the supplied reaction and conditions. B4 values name the Alberta Chemistry 30 Data Booklet table where used.

B1-P01 · Easy · A neutral magnesium atom has 12 protons and 12 electrons. It loses two electrons. How many electrons does it have now? What is its charge? Was it oxidized or reduced?

1. The protons do not change, so there are still 12. The electrons drop to 12 - 2 = 10. The charge is 12 - 10 = +2, so Mg^{2+} forms.

2. Losing electrons is oxidation. The charge is positive because negative electrons were removed, not because protons were added.

B1-P02 · Easy · A Cu^{2+} ion has 29 protons and 27 electrons. It gains two electrons. How many electrons does it have now? What is its charge? Was it oxidized or reduced?

1. Add the electrons: 27 + 2 = 29 electrons. With 29 protons, the net charge is 29 - 29 = 0.

2. Gaining electrons is reduction. The product is neutral Cu metal, not a negative copper ion.

B1 · Worked practice

Electron transfer and redox | Questions 3-4 of 12

B1-P03 · Easy · Complete $Fe^{2+} \rightarrow Fe^{3+} + ___$ with electrons. Is this an oxidation or a reduction? Check the charge on each side.

1. $Fe^{2+} \rightarrow Fe^{3+} + e^-$. Check the charge: the right side is +3 - 1 = +2, which matches the left side.

2. The electron is given off, so this is an oxidation. Do not change the charge written on Fe^{3+} to make it balance. Add the electron.

B1-P04 · Easy · Complete $Ag^+ + ___ \rightarrow Ag$ with electrons. Name the oxidizing agent and check the charge on each side.

1. $Ag^+ + e^- \rightarrow Ag$. The charge on the left is +1 - 1 = 0. The charge on the right is 0. They match.

2. Ag^+ takes the electron, so Ag^+ is reduced. Ag^+ is the oxidizing agent. Ag metal is the product, not the agent.

B1 · Worked practice

B1-P05 · Medium · Given $Mg(s) + Cu^{2+}(aq) \rightarrow Mg^{2+}(aq) + Cu(s)$, name what is oxidized, what is reduced, the reducing agent and the oxidizing agent. Explain the agent names.

1. Mg goes from 0 to +2 by losing two electrons, so Mg is oxidized. Cu^{2+} becomes Cu by gaining two electrons, so Cu^{2+} is reduced.

2. Mg is the reducing agent, because its electrons let the copper ions be reduced. Cu^{2+} is the oxidizing agent, because it takes those electrons and lets magnesium be oxidized.

B1-P06 · Medium · Given $Zn(s) + 2Ag^{+}(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$. Write the oxidation half-reaction and the reduction half-reaction for the amounts shown. Check that the electrons match.

1. $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$. Zinc is oxidized, so its two electrons are on the product side.

2. $2Ag^{+}(aq) + 2e^{-} \rightarrow 2Ag(s)$. Two silver ions each take one electron. Two electrons are lost and two are gained, so they match.

B1 · Worked practice

B1-P07 · Medium · Given $Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$. A student says this cannot be a reduction because the product is positive. Correct the student. Use the electron and the charge.

1. Reduction means gaining electrons. It does not mean the product is negative. Here Fe^{3+} gains one electron.

2. Its charge goes down from +3 to +2. Both are positive, but the charge went down and the electron is on the reactant side. So it is a reduction.

B1-P08 · Medium · Compare $KCl(s) \rightarrow K^+(aq) + Cl^-(aq)$ with $2K(s) + Cl_2(g) \rightarrow 2KCl(s)$. Which one is redox? Explain what happens to the charges in each.

1. Dissolving KCl only separates ions that were already K^+ and Cl^- in the solid. No ion changes its charge and no electrons move. So dissolving is not redox.

2. When KCl forms from K and Cl_2, each K atom (charge 0) becomes K^+ (+1). Each Cl atom (charge 0) becomes Cl^- (-1). Potassium loses electrons and chlorine gains them. So this reaction is redox.

B1 · Worked practice

B1-P09 · Challenging · A question says: three Cu^{2+} ions each gain two electrons. Aluminium atoms each lose three electrons to become Al^{3+}. How many Al atoms are needed? Write the balanced net equation and name both agents.

1. Three copper ions need 3 × 2 = 6 electrons. Each Al atom gives 3 electrons, so two Al atoms give 2 × 3 = 6 electrons.

2. $2Al(s) + 3Cu^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Cu(s)$. The charge is +6 on each side, and the atoms match too.

3. Al is the reducing agent and Cu^{2+} is the oxidizing agent. Coefficients count particles. They never change the charge of an ion.

B1-P10 · Challenging · A student writes the half-reaction $Zn \rightarrow Zn^{2+} + e^{-}$. Which check finds the mistake? Fix it. Explain why changing Zn^{2+} to Zn^{+} is not a correct fix.

1. The atoms match. But the charge is 0 on the left and +2 - 1 = +1 on the right. The charge check finds the mistake.

2. Use $Zn \rightarrow Zn^{2+} + 2e^{-}$. Now the charge is 0 on the left and +2 - 2 = 0 on the right. Zn^{2+} is the product that was given. Zn^{+} would be a different ion.

B1 · Worked practice

Electron transfer and redox | Questions 11-12 of 12

B1-P11 · Challenging · A beaker holds Fe^{2+} and Ag^{+}. The reaction $Fe^{2+} + Ag^{+} \rightarrow Fe^{3+} + Ag$ happens. Draw or describe the arrow that shows the electron moving. A student says “both are positive, so neither can give an electron”. Explain why that is wrong.

1. $Fe^{2+} \rightarrow Fe^{3+} + e^{-}$ gives one electron, and $Ag^{+} + e^{-} \rightarrow Ag$ takes it. Draw the arrow from Fe^{2+} to Ag^{+} and write “1 electron” on it.

2. A positive ion can still lose another electron. What matters is the change that happens, not whether the ion starts positive.

B1-P12 · Challenging · Zinc is put in blue copper(II) sulfate solution. A reddish solid forms on the zinc and the blue colour fades. Give one observation and one explanation in terms of particles. Use $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$ to explain both changes. What happens to the sulfate ion?

1. Observation: a reddish solid appears, or the blue colour fades. These are things we can see. They do not show electrons directly.

2. The equation tells us the solid is Cu. It forms when Cu^{2+} gains electrons. Zinc gives the electrons and becomes Zn^{2+} in the solution. Blue Cu^{2+} is used up, so the blue colour fades.

3. The sulfate ion does not change. It is a spectator ion, as in lesson NI. It is in the solution but takes no part in the reaction. It is not the oxidizing agent.