Essential Question

What actually changes in a single replacement reaction?

Single Replacement Review

- An element replaces part of a compound
- Check the activity series first
- The replaced part becomes an element

A + BC → AC + B

$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$

zinc replaces copper

Free Elements Stay Together

Split (aq)

soluble ionic compounds

strong acids

$CuSO_4(aq) \rightarrow Cu^{2+} + SO_4^{2-}$

Don't Split

free elements

solids, liquids, gases

$Zn(s)$, $Cu(s)$, $H_2(g)$, $H_2O(l)$

A free element is neutral, not an ion

Complete Ionic Equation

- Start with the balanced equation
- Split every (aq) compound
- Keep free elements together

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

$$Zn(s) + Cu^{2+}(aq) + SO_4^{2-}(aq) \rightarrow Zn^{2+}(aq) + SO_4^{2-}(aq) + Cu(s)$$

Finding the Spectators

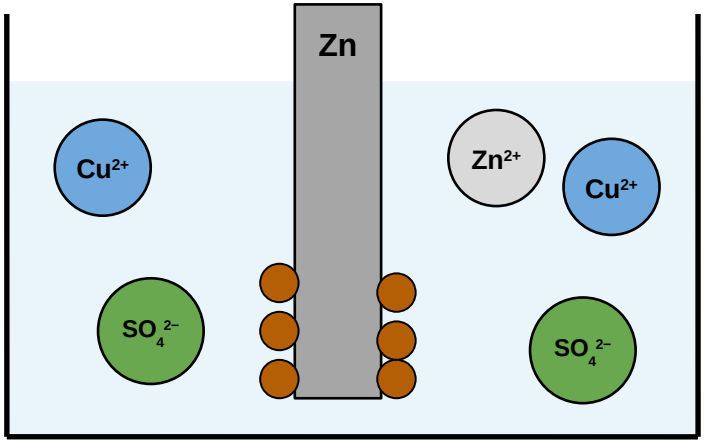
- Look for ions that match exactly
- Sulfate is the only spectator here
- Zinc and copper both change

$$Zn(s) + Cu^{2+}(aq) + \cancel{SO_4^{2-}(aq)} \rightarrow$$
$$Zn^{2+}(aq) + \cancel{SO_4^{2-}(aq)} + Cu(s)$$

crossed out = spectator ion

Net Ionic Equation

- Write only what's left
- An atom becomes an ion
- An ion becomes an atom



zinc strip in $CuSO_4(aq)$

$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$

Electrons Move

- Zinc atoms lose 2 electrons
- Copper ions gain 2 electrons
- Electrons move from Zn to Cu^{2+}

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$

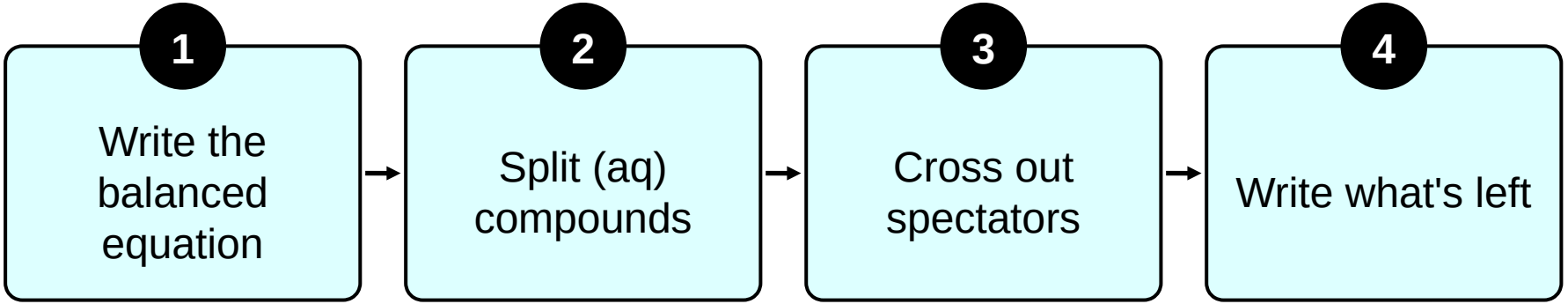
zinc loses electrons

$$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$$

copper(II) ion gains electrons

electron transfer = a redox reaction

Steps: Writing a Net Ionic Equation



$Mg + 2HCl \rightarrow MgCl_2 + H_2(g)$	**$Mg + 2H^+ + 2Cl^- \rightarrow Mg^{2+} + 2Cl^- + H_2(g)$**	**spectator: Cl^-**	**$Mg + 2H^+ \rightarrow Mg^{2+} + H_2(g)$**

Example: Mg(s) + HCl(aq)

Check the Charges

- Atoms must balance
- Total charge must balance too
- Add up the charges on each side

$2Al(s) + 3Cu^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Cu(s)$

from $2Al + 3CuCl_2 \rightarrow 2AlCl_3 + 3Cu$

$3 \times (+2) = +6$

left side

$2 \times (+3) = +6$

right side

+6 = +6, so charge is balanced

Nonmetals Can Replace Too

- A halogen replaces a halide ion
- Higher halogens replace lower ones
- The metal ion is the spectator

$$Cl_2(g) + 2KI(aq) \rightarrow 2KCl(aq) + I_2(s)$$

$$Cl_2(g) + \cancel{2K^+} + 2I^- \rightarrow \cancel{2K^+} + 2Cl^- + I_2(s)$$

$$Cl_2(g) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(s)$$

When There's No Reaction

- Check the activity series first
- A lower element can't replace a higher one
- No reaction means no net ionic equation

more active

Na
Mg
Al
Zn
Fe
Pb
H
Cu
Ag

less active

$Cu(s) + ZnSO_4(aq) \rightarrow NR$

Cu is below Zn

Example: Copper and Silver

Write the balanced molecular, complete ionic, and net ionic equations. If there is no reaction, write NR.

$$Cu(s) + AgNO_3(aq) \rightarrow$$

Example: A Metal and an Acid

Write the balanced molecular, complete ionic, and net ionic equations. If there is no reaction, write NR.

Al(s) + HCl(aq) →

Example: A Halogen Replacement

Write the balanced molecular, complete ionic, and net ionic equations. If there is no reaction, write NR.

$$Br_2(l) + NaI(aq) \rightarrow$$

Example: No Spectators

Write the balanced molecular, complete ionic, and net ionic equations. If there is no reaction, write NR.

$$Na(s) + H_2O(l) \rightarrow$$

Example: Check the Activity Series

Write the balanced molecular, complete ionic, and net ionic equations. If there is no reaction, write NR.

$$Ag(s) + Cu(NO_3)_2(aq) \rightarrow$$

Net Ionic Equations (Single)

Big Ideas

- Free elements never split
- Spectators match on both sides
- Atoms and charges must balance
- Lower element means NR

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

metal replaces a metal ion

$$Cl_2(g) + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2(s)$$

halogen replaces a halide ion