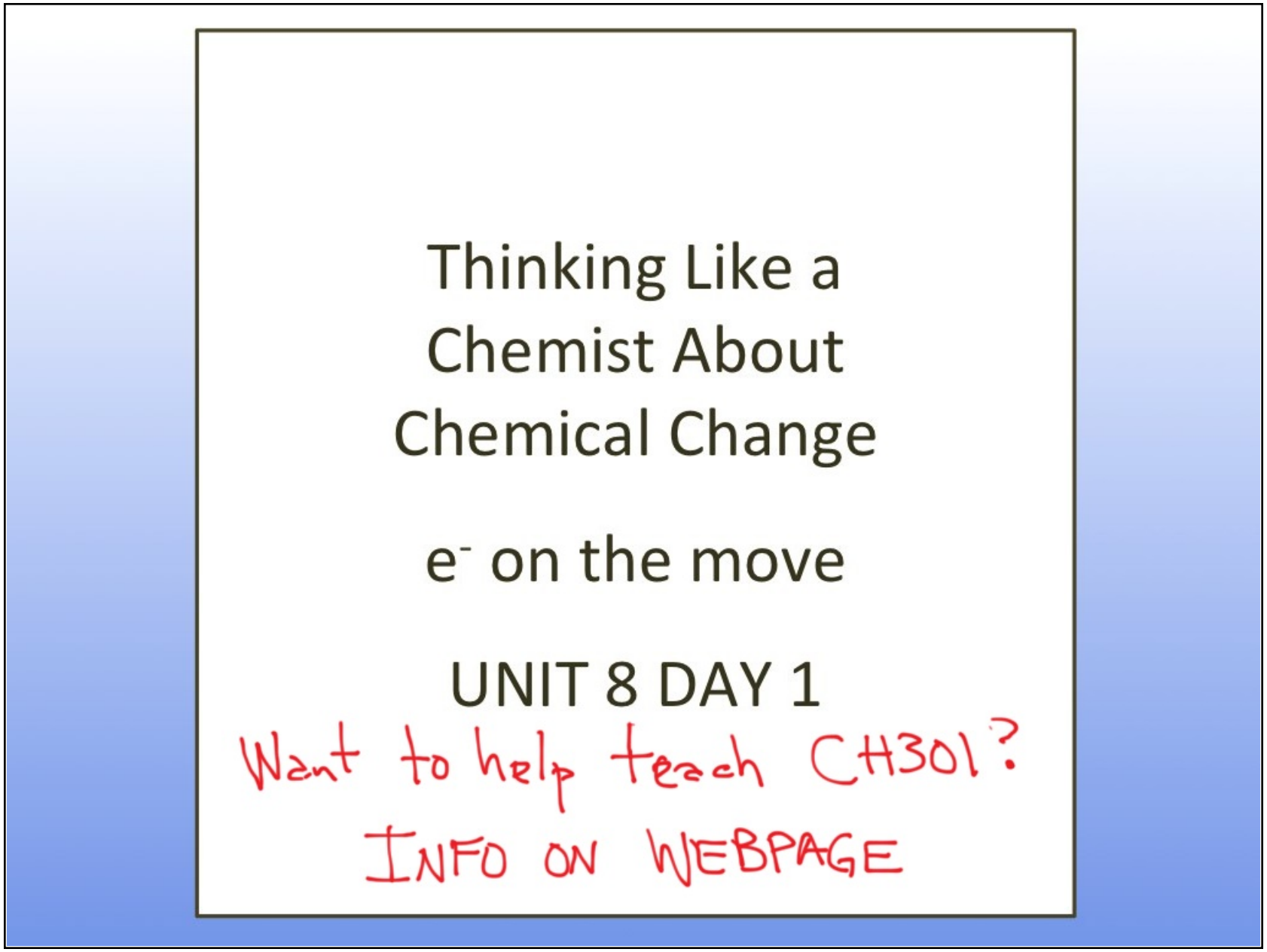
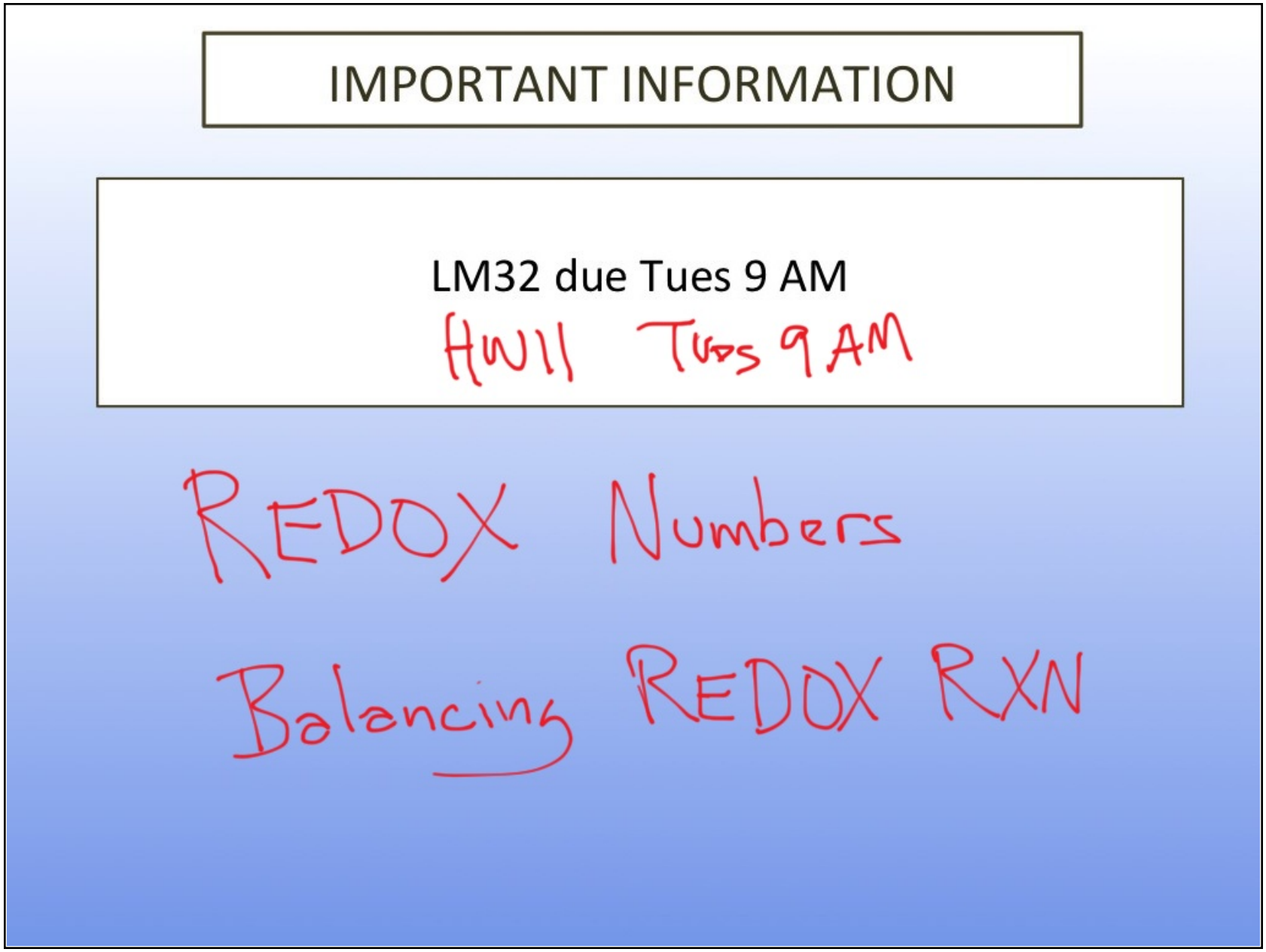
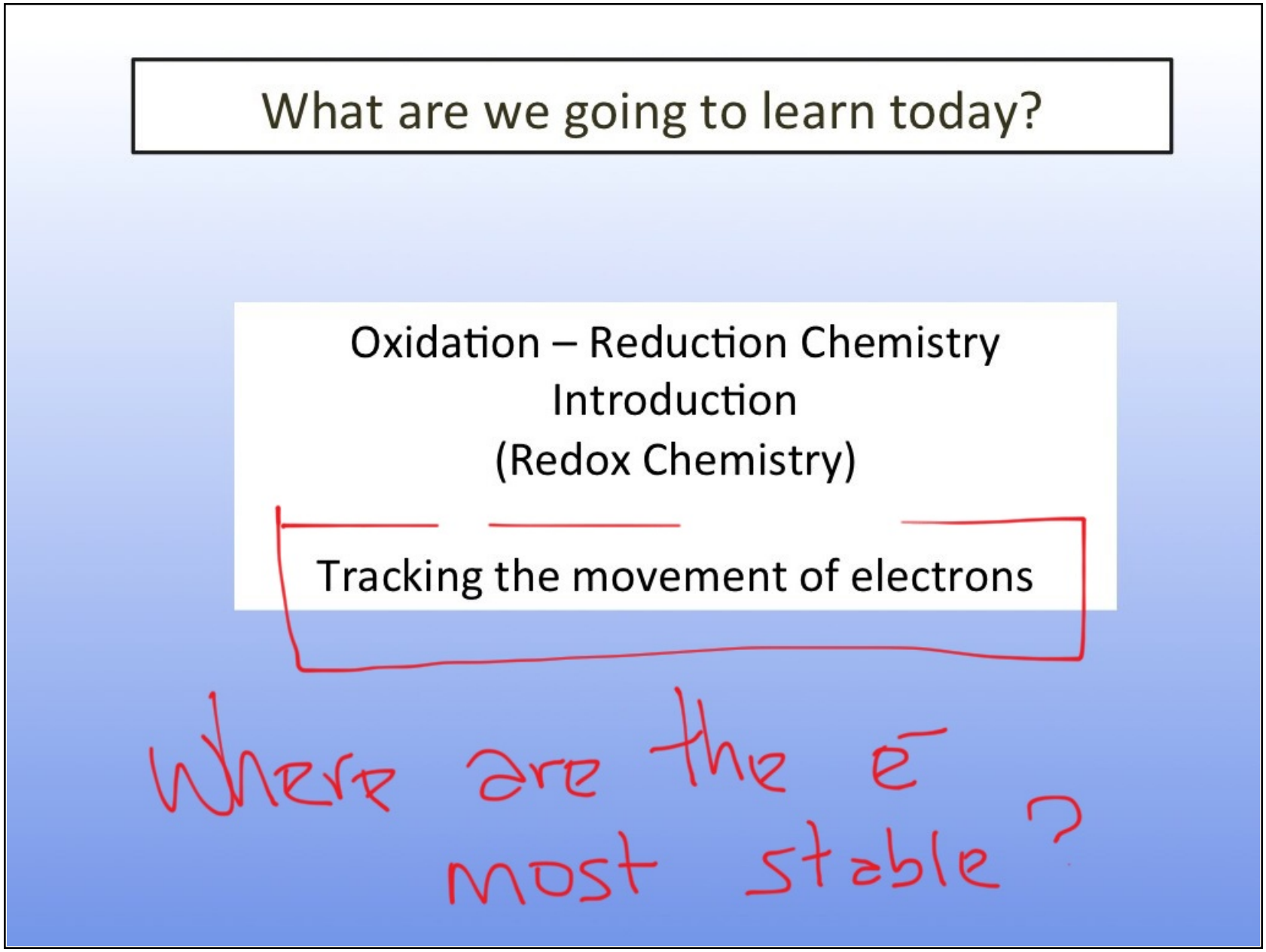

Thinking Like a
Chemist About
Chemical Change
e- on the move
UNIT 8 DAY 1
Want to help teach CH301?
INFO ON WEBPAGE


IMPORTANT INFORMATION
LM32 due Tues 9 AM
HW11 Tues 9 AM
REDOX Numbers
Balancing REDOX RXN


What are we going to learn today?
Oxidation – Reduction Chemistry
Introduction
(Redox Chemistry)
Tracking the movement of electrons
Where are the e⁻ most stable?

Poll: Clicker Question

Studying chemistry with other students outside of class is helping me learn the material.

A. Not Applicable (Pick this choice if you do NOT study with a group outside of class.)

B. NOT True of me at all

C. Somewhat NOT True of me

D. Somewhat true of me

E. Very True of Me

Best for long term memory

How study groups matters...

When 2 or more students engage in a common task, working jointly to solve the problem or develop understanding

- Students who learn via collaboration (study groups) or peer tutoring outperformed those learning individually.
- Exposes you to different perspective and negotiate with one another to achieve mutual understanding.
- Those students who engaged in constructive dialogue were found to retain their knowledge longer.

(Ding & Harskamp, 2011)

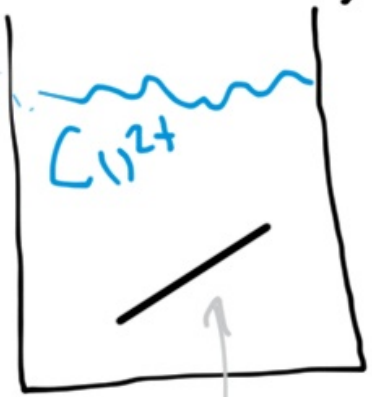
SCIENCE!

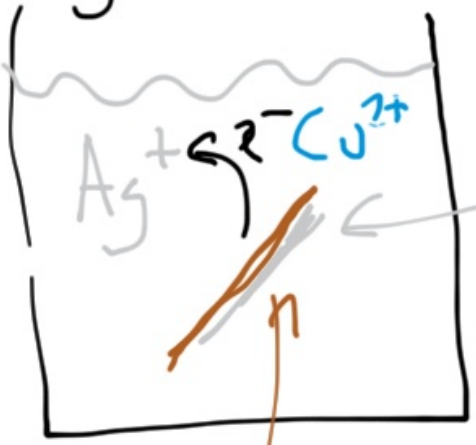
Macroscopic Look Chemical Change

Silver/Copper Ions and Copper/ Silver Ions

$Cu^{2+} + Ag \not\rightarrow$

$Ag^{+} + Cu \longrightarrow Ag + Cu^{2+}$





Ag wire

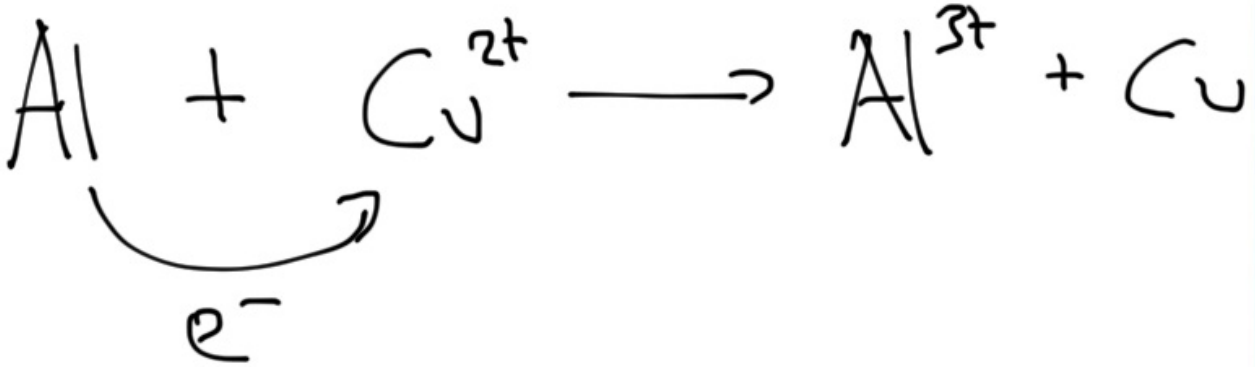
NO CHEM

Cu wire

REACTION

Macroscopic Look Chemical Change

Aluminum/Copper Ions and Copper/Aluminum Ions



e⁻ move from Al to Cu2+

Poll: Clicker Question

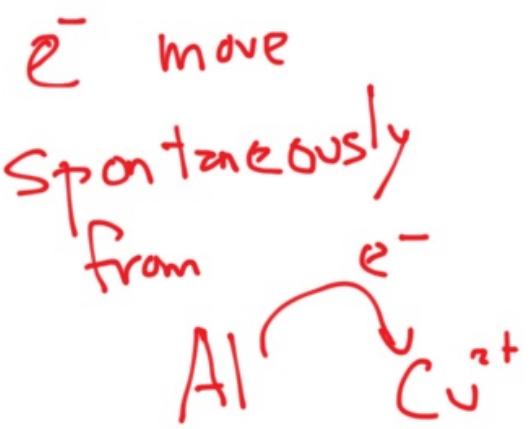
Microscopic Thought Chemical Change

The electrons are lower in energy in:

A) The Aluminum Metal

B)The Copper Metal

C)They are the Same



Poll: Clicker Question

Model movement of electrons

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

$-2e^{-}$

$+2e^{-}$

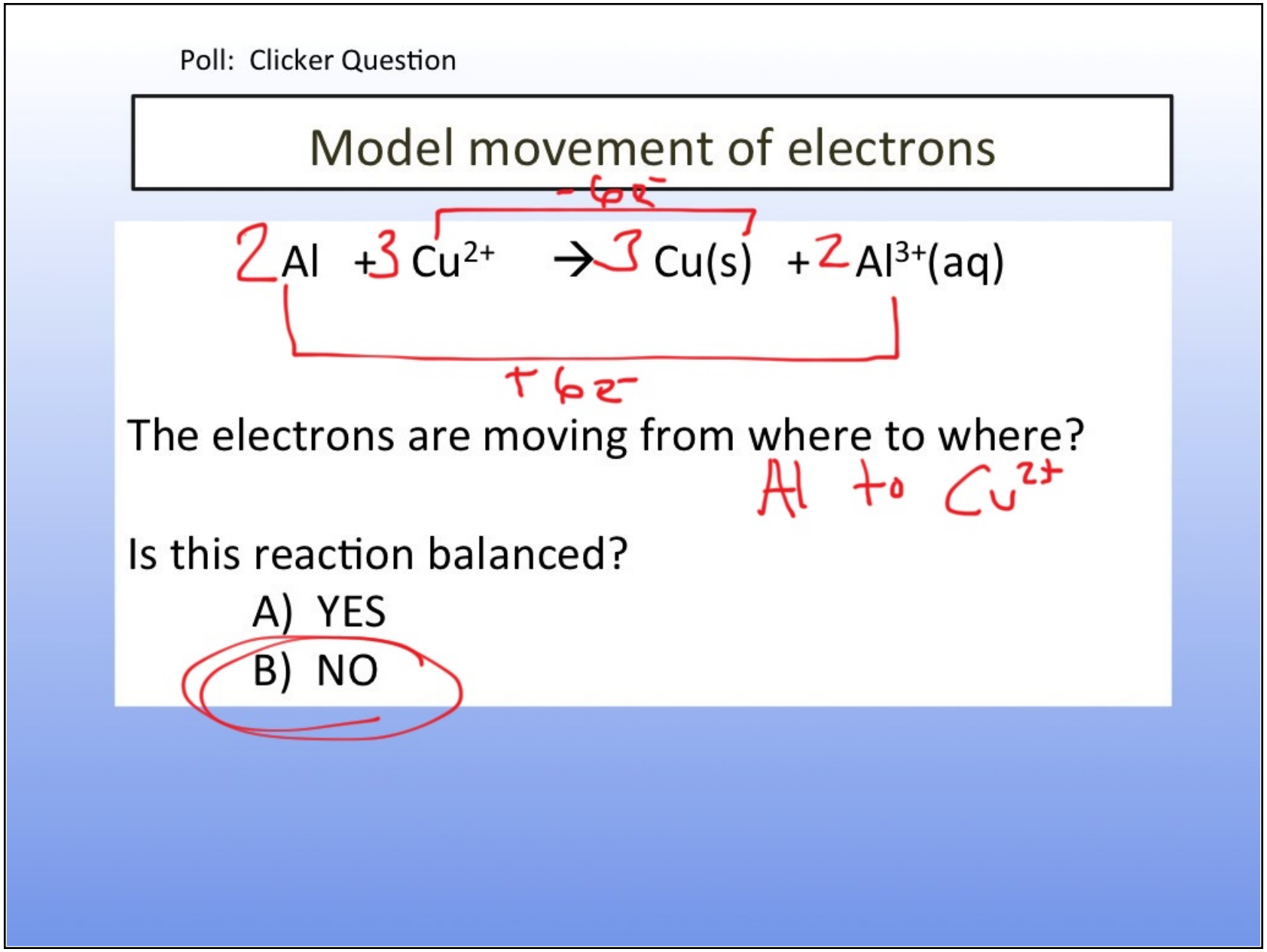
The electrons are moving from where to where?

Is this reaction balanced?

A) YES

B) NO

CHARGE isn't balanced


Poll: Clicker Question
Model movement of electrons
2 Al + 3 Cu2+ → 3 Cu(s) + 2 Al3+(aq)
- 6e-
+ 6e-
The electrons are moving from where to where?
Al to Cu2+
Is this reaction balanced?
A) YES
B) NO

Poll: Clicker Question

When will these reactions stop?

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

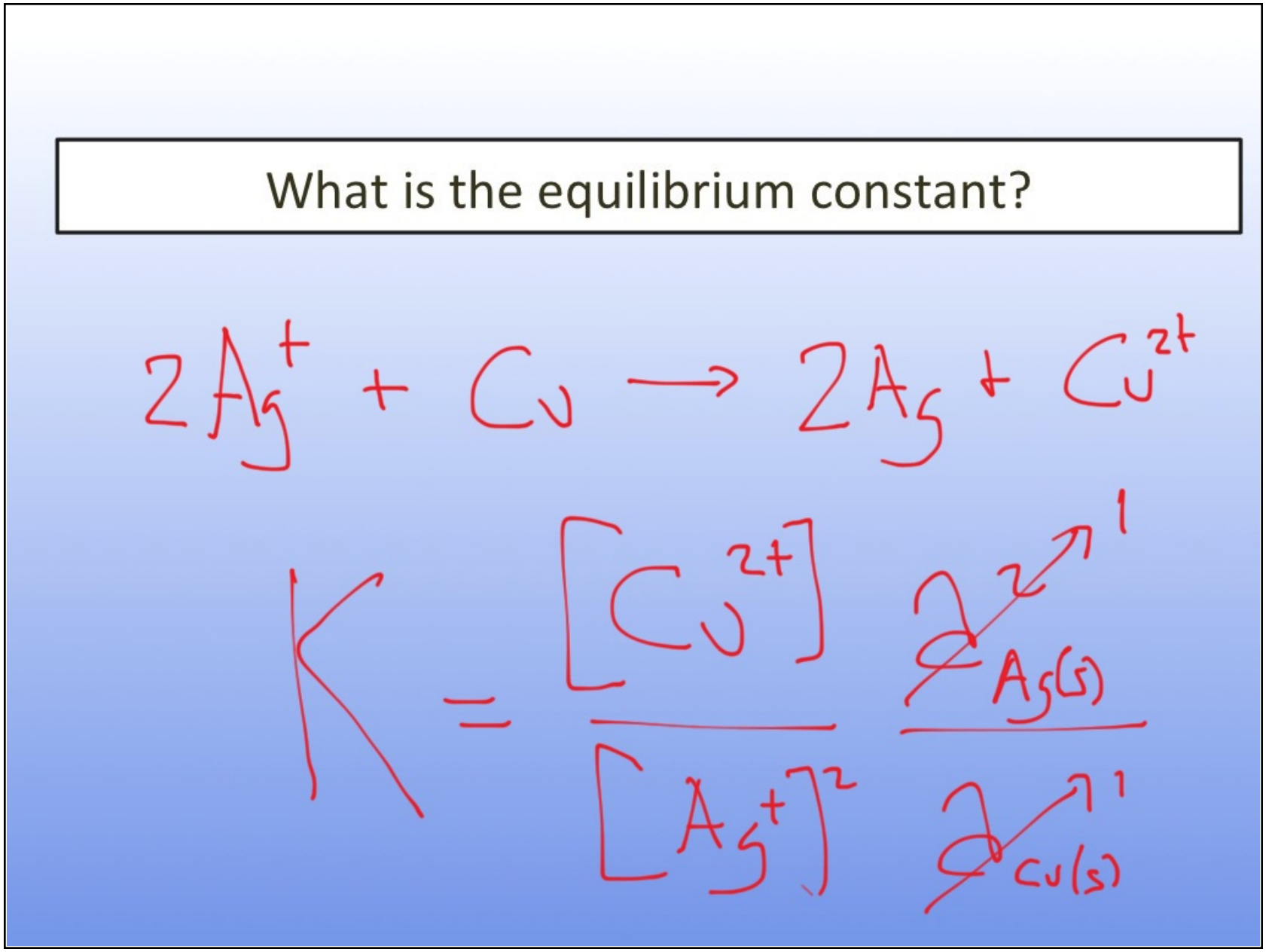
$$Al + Cu^{2+} \rightarrow Cu(s) + Al^{3+}(aq)$$

A) When the ion concentration goes to 0

B) When the metal disappears ← might happen before equil.

C) When the systems come to equilibrium

D) It depends on the concentration of ions ← final equil depends on concs

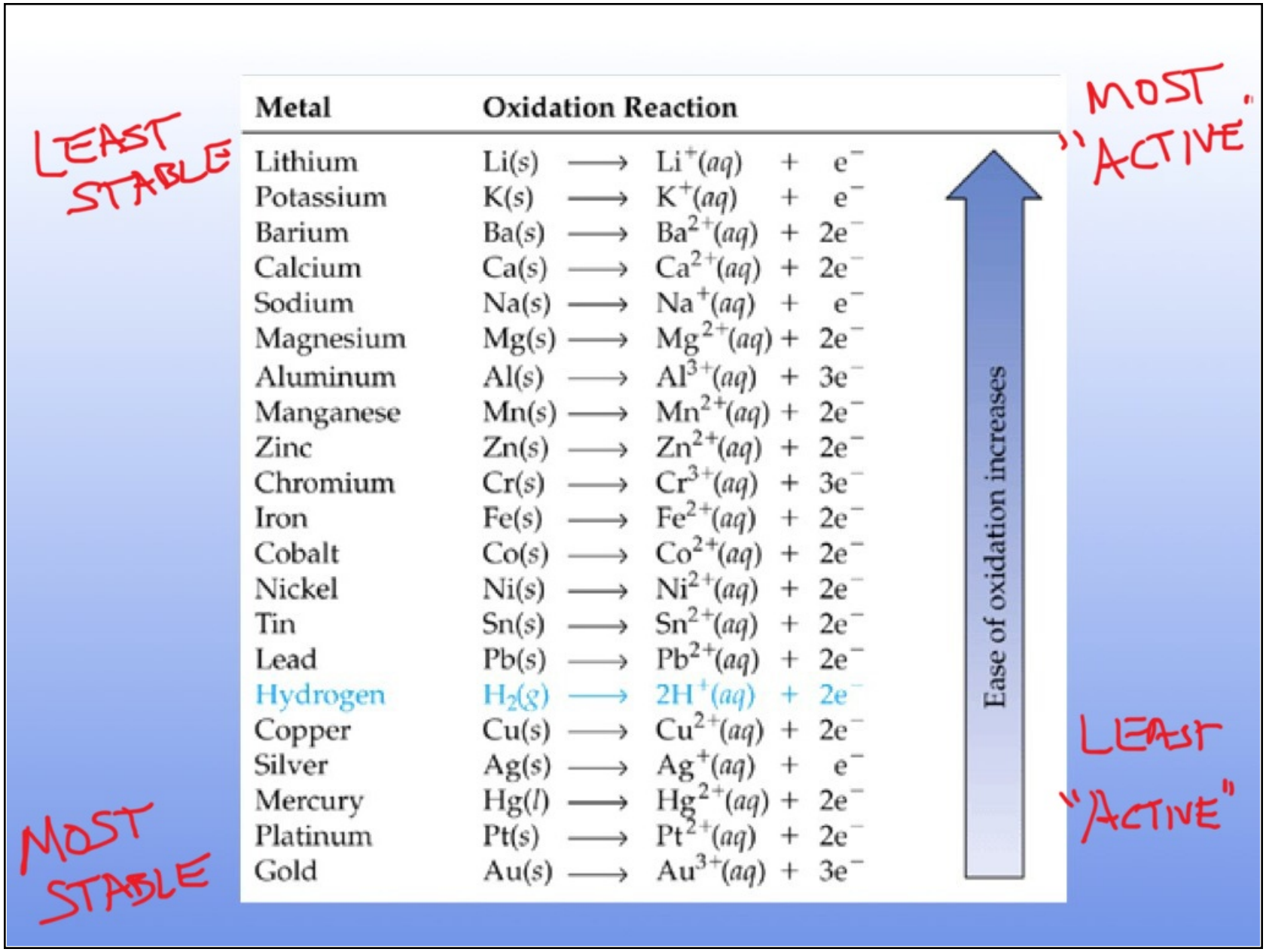

What is the equilibrium constant?
$2Ag^+ + Cu \rightarrow 2Ag + Cu^{2+}$
$K = \frac{[Cu^{2+}]}{[Ag^+]^2}$
$\frac{2^1}{2^1}$
$A_{g(s)}$
$Cu_{(s)}$

Could you have predicted which of the reactions favor reactants and which favor products?

$$K = \frac{[Cu^{2+}]}{[Ag^{+}]^2} \gg 1$$

What about one that we didn't do... silver + aluminum ion?

We saw it. Favors products



Metal	Oxidation Reaction
Lithium	$Li(s) \longrightarrow Li^+(aq) + e^-$
Potassium	$K(s) \longrightarrow K^+(aq) + e^-$
Barium	$Ba(s) \longrightarrow Ba^{2+}(aq) + 2e^-$
Calcium	$Ca(s) \longrightarrow Ca^{2+}(aq) + 2e^-$
Sodium	$Na(s) \longrightarrow Na^+(aq) + e^-$
Magnesium	$Mg(s) \longrightarrow Mg^{2+}(aq) + 2e^-$
Aluminum	$Al(s) \longrightarrow Al^{3+}(aq) + 3e^-$
Manganese	$Mn(s) \longrightarrow Mn^{2+}(aq) + 2e^-$
Zinc	$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$
Chromium	$Cr(s) \longrightarrow Cr^{3+}(aq) + 3e^-$
Iron	$Fe(s) \longrightarrow Fe^{2+}(aq) + 2e^-$
Cobalt	$Co(s) \longrightarrow Co^{2+}(aq) + 2e^-$
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Tin	$Sn(s) \longrightarrow Sn^{2+}(aq) + 2e^-$
Lead	$Pb(s) \longrightarrow Pb^{2+}(aq) + 2e^-$
Hydrogen	$H_2(g) \longrightarrow 2H^+(aq) + 2e^-$
Copper	$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
Silver	$Ag(s) \longrightarrow Ag^+(aq) + e^-$
Mercury	$Hg(l) \longrightarrow Hg^{2+}(aq) + 2e^-$
Platinum	$Pt(s) \longrightarrow Pt^{2+}(aq) + 2e^-$
Gold	$Au(s) \longrightarrow Au^{3+}(aq) + 3e^-$

Poll: Clicker Question

Consider a mixture which contains Cu^{2+} ions, Cu metal, Zn^{2+} ions, and Zn metal.

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

Which side of the reaction is favored?

A) Left

B) Right

more stable than Zn

Metal	Oxidation Reaction
Lithium	$Li(s) \longrightarrow Li^+(aq) + e^-$
Potassium	$K(s) \longrightarrow K^+(aq) + e^-$
Barium	$Ba(s) \longrightarrow Ba^{2+}(aq) + 2e^-$
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Platinum	$Pt(s) \longrightarrow Pt^{2+}(aq) + 2e^-$
Gold	$Au(s) \longrightarrow Au^{3+}(aq) + 3e^-$

Ease of oxidation increases

Poll: Clicker Question

Consider a mixture of Cu^{2+} ions/Cu metal and Zn^{2+} ions/Zn metal.

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

Which will form solid metal from ions?

A) Cu

B) Zn

Metal	Oxidation Reaction
Lithium	$Li(s) \longrightarrow Li^+(aq) + e^-$
Potassium	$K(s) \longrightarrow K^+(aq) + e^-$
Barium	$Ba(s) \longrightarrow Ba^{2+}(aq) + 2e^-$
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Sodium	$Na(s) \longrightarrow Na^+(aq) + e^-$
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Zinc	$Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$
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Lead	$Pb(s) \longrightarrow Pb^{2+}(aq) + 2e^-$
Hydrogen	$H_2(g) \longrightarrow 2H^+(aq) + 2e^-$
Copper	$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$
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Mercury	$Hg(l) \longrightarrow Hg^{2+}(aq) + 2e^-$
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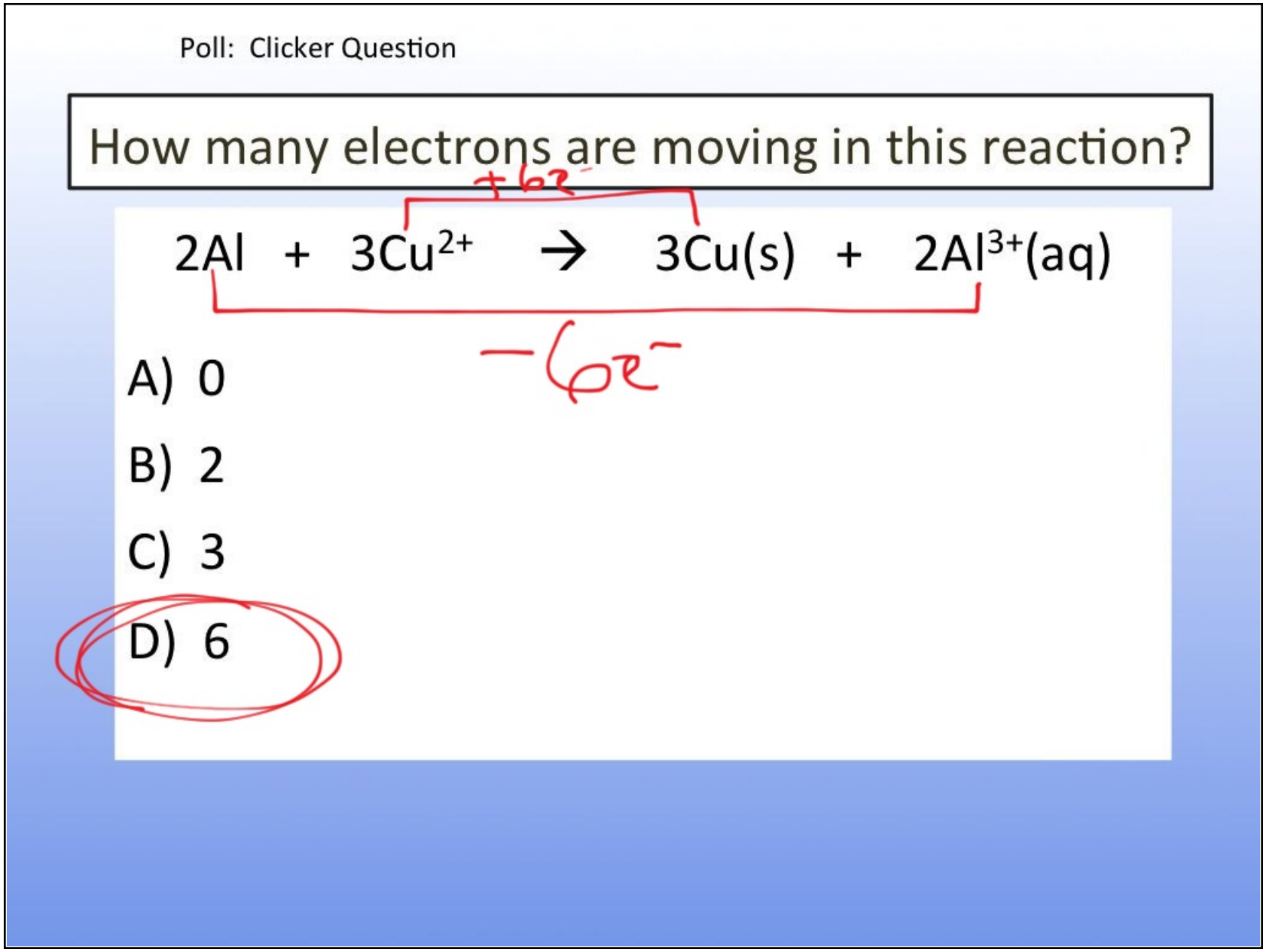
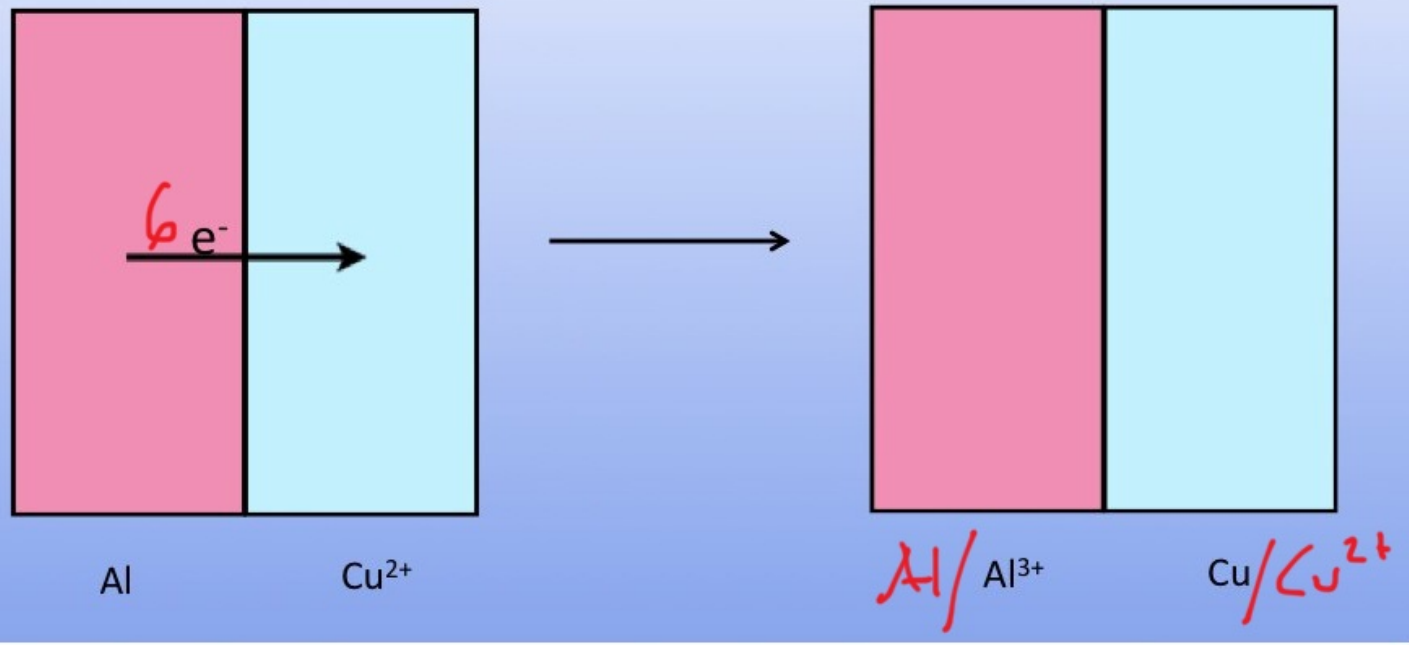
Gold	$Au(s) \longrightarrow Au^{3+}(aq) + 3e^-$

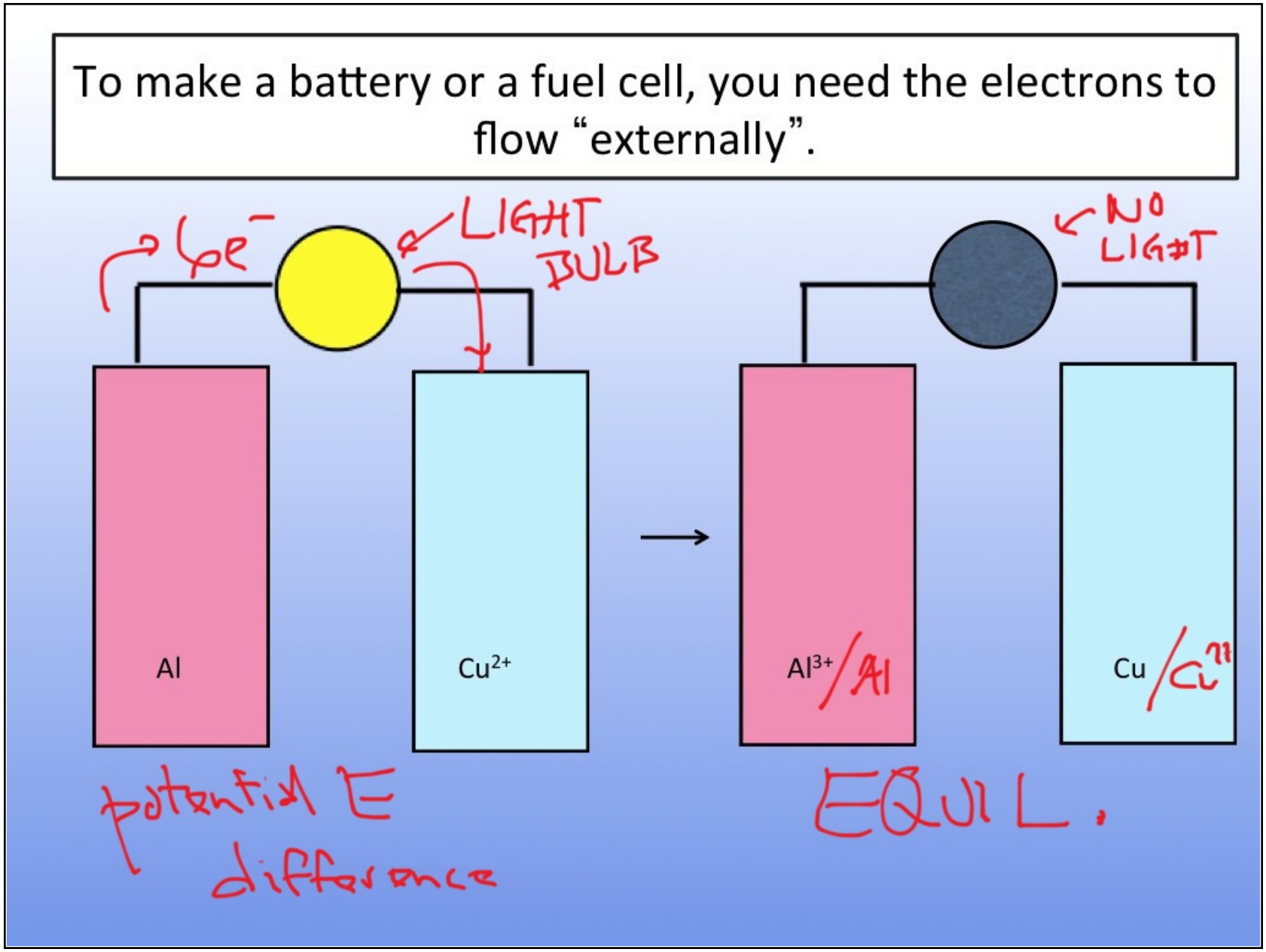
Ease of oxidation increases


Poll: Clicker Question
How many electrons are moving in this reaction?
+6e⁻
2Al + 3Cu2+ → 3Cu(s) + 2Al3+(aq)
−6e⁻
A) 0
B) 2
C) 3
D) 6

Free energy of $2Al + 3Cu^{2+} \rightarrow 3Cu + 2Al^{3+}$



We can make use of the electrons moving between reactants if you can physically separate the reactants.


To make a battery or a fuel cell, you need the electrons to flow "externally".
6e⁻
LIGHT BULB
NO LIGHT
Al
Cu2+
Al3+/Al
Cu/Cu11
potential difference
EQUIL.

Sometimes it is EASY to make ½ reactions

Use a model to show the separation of the redox reaction:

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

That is, write the oxidation ½ reaction and the reduction ½ reaction

OXIDATION IS WHEN ATOM LOSES ELECTRONS:

$$Al \longrightarrow Al^{3+} + 3e^-$$

REDUCTION IS WHEN ATOM GAINS ELECTRONS:

$$Cu^{2+} + 2e^- \longrightarrow Cu$$

KEEP IT STRAIGHT

OXIDATION IS WHEN ATOM LOSES ELECTRONS:

REDUCTION IS WHEN ATOM GAINS ELECTRONS:

OIL RIG

Oxidation is loss
reduction is gain

LEO says GER

lose electrons oxidation
gain electrons reduction

JREMIT GROL

JUST REMEMBER IT

GAIN REDUCTION
OXIDATION LOSS

Poll: Clicker Question

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

this "does" oxidizing

What is the oxidizing agent?

A. Al

B. Cu^{2+}

C. Cu

D. Al^{3+}

aluminum metal is oxidized by the oxidizing agent Cu^{2+}

Poll: Clicker Question

Sometimes it is NOT EASY to make ½ reactions

$2Na(s) + H_2O(l) \rightarrow NaOH(aq) + H_2(g)$

For this you must remember and assign oxidation #'s

What is being oxidized?

A.Na

B.H_2O

C.Na^+

D.H_2

$Na \longrightarrow Na^{+1} + e^-$

Oxidation Numbers LEARN

1. The sum of all the oxidation numbers in a chemical species must equal the charge on the chemical species.
2. The oxidation number of an atom in its neutral elemental state is zero.
3. The oxidation number for a monatomic ion is its charge.
4. In compounds, hydrogen is given the oxidation number of +1. Unless it is bonded to a metal in which case it is -1.
5. Oxygen is given the oxidation number of -2. Unless it is bonded to another in a peroxide bond (oxygen-oxygen single bond). Then it is -1.
6. The most electronegative element is assigned its charge as an ion.

Examples: Assign oxidation numbers SO_2, SO_4^{2-}, P_4O_6 and $KMnO_4$

Learning Outcomes

Identify an oxidation – reduction (redox) reaction based on changes in oxidation numbers across the chemical change.

Identify oxidizing/reducing agents in chemical reaction.

Balance a net redox reaction using the ½ reaction method in acidic or basic solution.

Recognize degrees of reactivity based on an activity series table or a standard reduction potential table.

Apply standard reduction potential data to determine the relative strength of oxidizing/reducing agents

Poll: Clicker Question

Consider a mixture which contains Cu^{2+} ions, Cu metal, Zn^{2+} ions, and Zn metal.

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

Which side of the reaction is favored?

A) Left

B) Right

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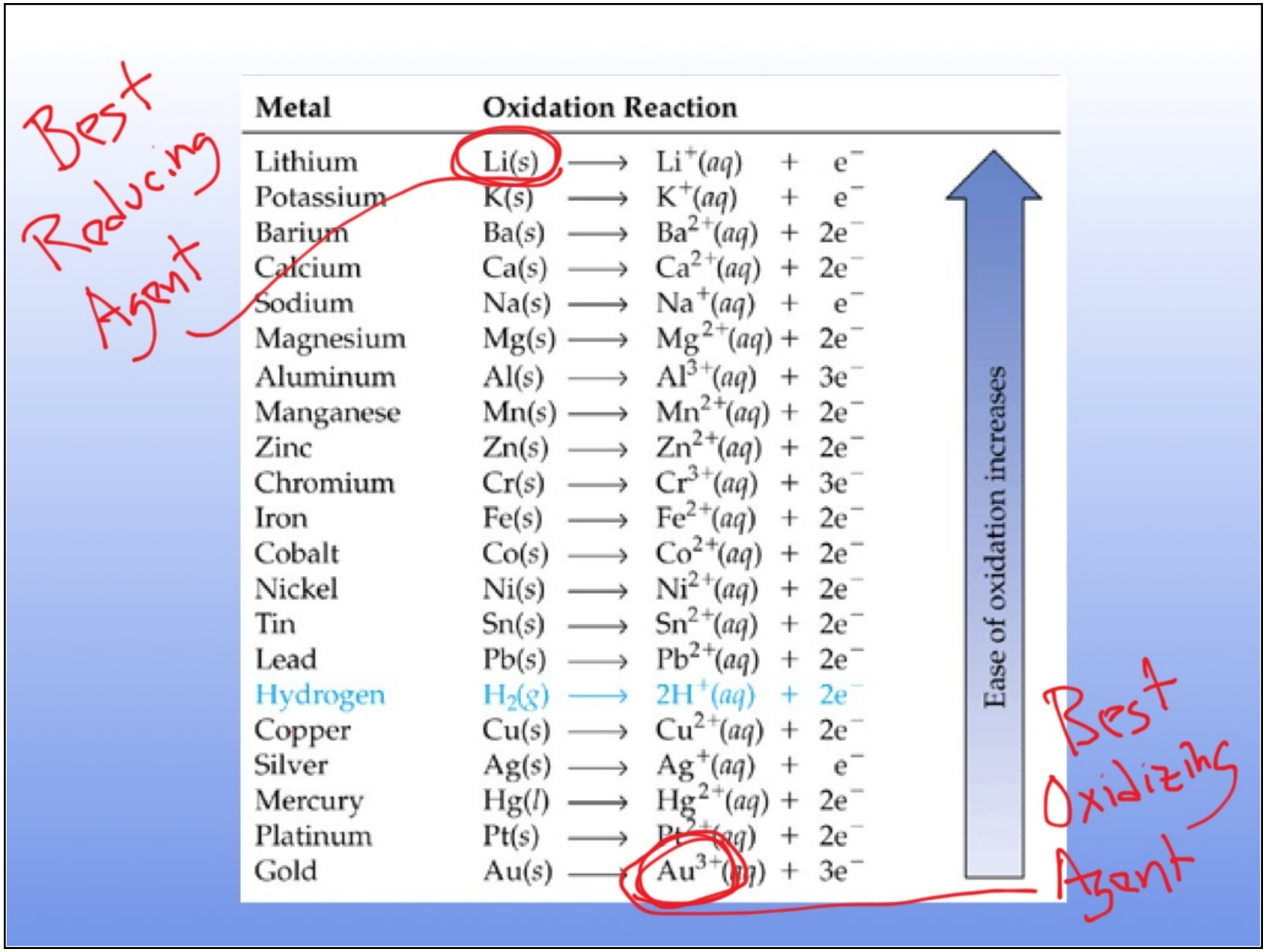
Gold	$Au(s) \longrightarrow Au^{3+}(aq) + 3e^-$

Ease of oxidation increases


Best Reducing Agent
Metal
Oxidation Reaction
Lithium Li(s) ⟶ Li+(aq) + e−
Potassium K(s) ⟶ K+(aq) + e−
Barium Ba(s) ⟶ Ba2+(aq) + 2e−
Calcium Ca(s) ⟶ Ca2+(aq) + 2e−
Sodium Na(s) ⟶ Na+(aq) + e−
Magnesium Mg(s) ⟶ Mg2+(aq) + 2e−
Aluminum Al(s) ⟶ Al3+(aq) + 3e−
Manganese Mn(s) ⟶ Mn2+(aq) + 2e−
Zinc Zn(s) ⟶ Zn2+(aq) + 2e−
Chromium Cr(s) ⟶ Cr3+(aq) + 3e−
Iron Fe(s) ⟶ Fe2+(aq) + 2e−
Cobalt Co(s) ⟶ Co2+(aq) + 2e−
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Platinum Pt(s) ⟶ Pt2+(aq) + 2e−
Gold Au(s) ⟶ Au3+(aq) + 3e−
Ease of oxidation increases
Best Oxidizing Agent