UNIT8-DAY1-LaB11am

Wednesday, April 10, 2013
7:15 PM

Thinking Like a Chemist About Chemical Change

e^- on the move

UNIT8 DAY1

ke Spring 2013

IMPORTANT INFORMATION

LM33 due Tues 9 AM

big
lots of question
(no homework)

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What are we going to learn today?

Oxidation – Reduction Chemistry
Introduction
(Redox Chemistry)

Tracking the movement of electrons

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Principles of Chemistry II

Poll: Clicker Question 1

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

IF you do NOT study with a group outside of class, select A
A) Not Applicable
If you DO study with a group outside of class, indicate how true the statement is of you
B) NOT True of me at all
C) Somewhat NOT True of me
D) Somewhat true of me
E) Very True of Me

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How study groups matters…

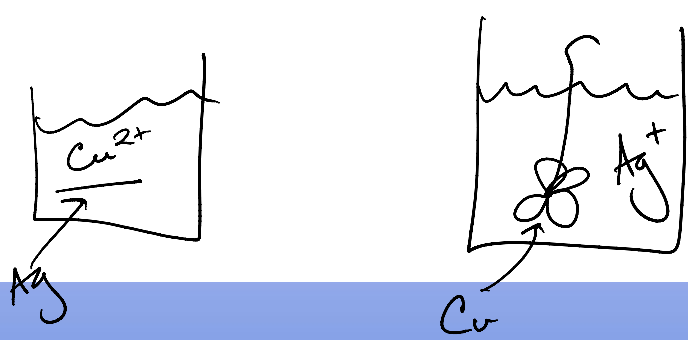
When 2 or more students engage in a common task, working jointly to solve the problem or develop understanding

- 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)

Macroscopic Look Chemical Change

Silver/Copper Ions and Copper/ Silver Ions



Poll: Clicker Question 2 e^- move from higher energy to lower energy from Cu to Ag

Microscopic Thought Chemical Change

The electrons are lower in energy in:

A) The Silver Metal — lower energy — more stable

B)The Copper Metal

Microscopic Thought Chemical Change

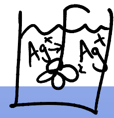
The electrons are lower in energy in:

Cu to Ag

A) The Silver Metal — lower energy — more stable
nothing happened with Ag metal in Cu^{2+} solution

B) The Copper Metal — Ag "wants" to be on Cu
Cu is lower in energy

C) They are the Same



Macroscopic Look Chemical Change

Aluminum/Copper Ions and Copper/Aluminum Ions

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

Al "dissolves"

Poll: Clicker Question 3

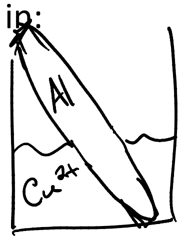
Microscopic Thought Chemical Change

The electrons are lower in energy in:

A) The Aluminum Metal

B) The Copper Metal

C) They are the Same



A) The Aluminum Metal

B) The Copper Metal

C) They are the Same

Poll: Clicker Question 4

model movement of electrons

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

The electrons are moving from where to where?

Is this reaction balanced?

A) YES

B) NO – must balance charge!

Poll: Clicker Question 5

model movement of electrons

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

The electrons are moving from where to where?

Is this reaction balanced?

A) YES

B) NO – must balance charge

Poll: Clicker Question 6

When will these reactions stop?

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

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

A) When the ion concentration goes to 0

B) When the metal disappears → How much??

C) When the systems come to equilibrium

D) It depends on the concentration of ions

"dead" battery has come to equilibrium

What is the equilibrium constant?

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

What is the equilibrium constant?

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

Product Favored

$$K > 1$$

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

$$2Al + 3Cu^{2+} \rightarrow 3Cu + 2Al^{3+}$$

$$K = \frac{[Al^{3+}]^{2}}{[Cu^{2+}]^{3}}$$

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

$$2Al + 3Cu^{2+} \rightarrow 2Al^{3+} + 3Cu$$

Product Favored

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

Reactant Favored

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

$\Delta G \propto K$

$\Delta G = -RT\ln K$

Can measure energy to get concentration

Activity Series for Predicting Change

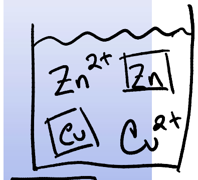
high energy e^-

most likely to undergo oxidation

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	$Co(s) \longrightarrow Co^{2+}(aq) + 2e^{-}$
Nickel	$Ni(s) \longrightarrow Ni^{2+}(aq) + 2e^{-}$
Tin	$Sn(s) \longrightarrow Sn^{2+}(aq) + 2e^{-}$
Lead	$Pb(s) \longrightarrow Pb^{2+}(aq) + 2e^{-}$
Hydrogen	$H_2(g) \longrightarrow 2H^{+}(aq) + 2e^{-}$

Ease of oxidation increases

oxidation loss of 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	$Co(s)$	$\longrightarrow$	$Co^{2+}(aq) + 2e^-$
Nickel	$Ni(s)$	$\longrightarrow$	$Ni^{2+}(aq) + 2e^-$
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	$Au(s)$	$\longrightarrow$	$Au^{3+}(aq) + 3e^-$

Ease of oxidation increases

least likely to undergo oxidation
least active
low energy e-

$\boxed{Cu}$ Cu^{2+}

$Cu^{2+} + Zn \rightarrow Zn^{2+} + Cu$

A) Product favored

B) Reactant favored

Based on the chart?

Mix Cu^{2+} ions/Cu metal and Zn^{2+} ions/Zn metal

Which will form solid metal from ions?

Please explain.

Poll: Clicker Question 7

How many electrons are moving in this reaction?

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

A) 0 2×3 = 6

B) 2

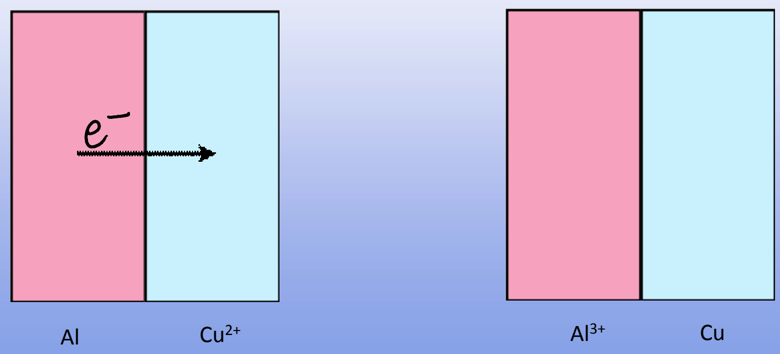
C) 3

D) 6

C) 3

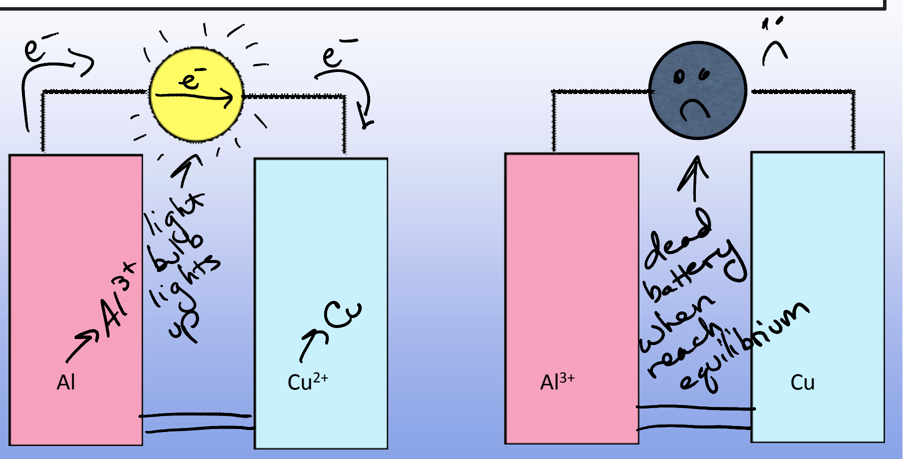
D) 6

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



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".



What is oxidized?

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

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

oxidized ↗ reduced

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

a) Al
b) Cu^{2+}
c) Cu
d) Al^{3+}

OXIDATION IS WHEN ATOM LOSES ELECTRONS:

$$(Al_{(s)} \rightarrow Al^{3+}_{(aq)} + 3e^-)\,2$$

Balance e^- flow & charge

REDUCTION IS WHEN ATOM GAINS ELECTRONS:

$$(2e^- + Cu^{2+}_{(aq)} \rightarrow Cu_{(s)})\,3$$

⇒ must be a reactant!

KEEP IT STRAIGHT

Oxidizing agent?
→ undergoes reduction

Reducing agent
– undergoes oxidation

OXIDATION IS WHEN ATOM LOSES ELECTRONS:

REDUCTION IS WHEN ATOM GAINS ELECTRONS:

OIL RIG Oxidation is Loss Reduction is Gain

LEO says GER Lose e^- Oxidation, Gain e^- Reduction

Just Remember It: Gain, Reduction, Oxidation Loss

JREMIT GROL

↳ Dr. Vanden Bout

Sometimes it is EASY to make ½ reactions

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

What is the oxidizing agent?
(get reduced)
(gains e-)
MUST be a reactant!

A) Al
B) Cu^{2+}
C) Cu
D) Al^{3+}

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Oxidation

$Al \longrightarrow Al^{3+} + 3e^-$ 3 electrons here x 2

Reduction

$Cu^{2+} + 2e^- \longrightarrow Cu$ 2 electrons here x 3

to balance we need equal number of electrons
easiest to stick with whole numbers

Thus we need
oxidation half reaction x 2
reduction half reaction x 3

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

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Sometimes it is NOT EASY to make ½ reactions

$\overset{0}{2Na(s)} + \overset{+1}{H_2}\overset{-2}{O}(l) \rightarrow \overset{+1}{Na}\overset{-2}{O}\overset{+1}{H}(aq) + \overset{0}{H_2}(g)$

neutral so all #'s must add up to zero

Na^+

OH^-

For this you must remember/assign oxidation #'s

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

neutral so all #'s must add up to zero Na^+ OH^-

For this you must remember/assign oxidation #'s

What is being oxidized?

A) Na
B) H_2O
C) Na^+
D) H_2

$Na \rightarrow Na^+ + 1e^-$

$2e^- + \overset{+1}{H_2}O \rightarrow \overset{0}{H_2}$

Still not balanced! Need more! LM

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Oxidation Numbers

1. The oxidation # of an uncombined element is 0.
2. The sum of the oxidation #'s of all the atoms in a species is equal to its total charge.
3. The oxidation # of H is +1 in combination with nonmetals and -1 in combination with metals.
4. The oxidation #'s of elements in Groups 1 and 2 is equal to their group number.
5. The oxidation # of the halogens is -1, unless it is in combination with oxygen or another halogen higher in the group. The oxidation number of fluorine is -1 in all its compounds.
6. The oxidation # of oxygen is -2 in most of its compounds. Exceptions are with fluorine, and as peroxide or superoxide.

Example: Assign oxidation numbers to SO_2 and SO_4^{2-} and 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

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