1M $CuSO_4$

64g 32g

16*4

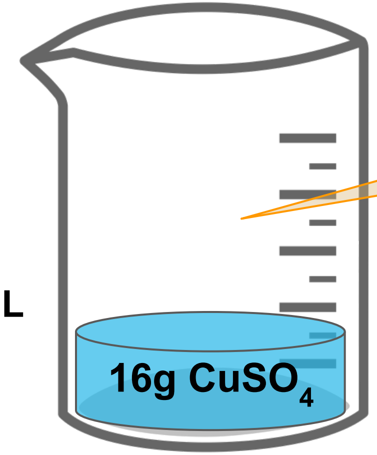
$CuSO_4(aq)$

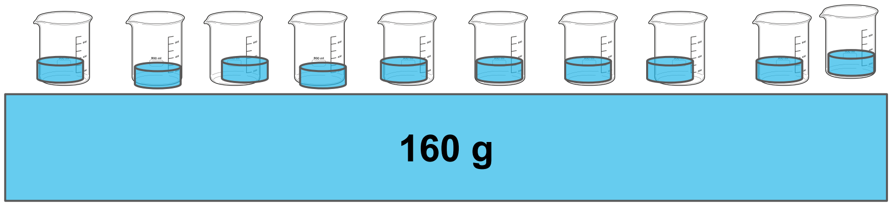
1000mL

1M $CuSO_4$

How much copper is in here that can react and exchange places with iron?

100mL





0.5M $CuSO_4$

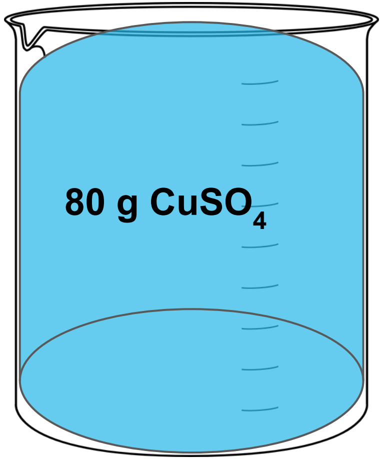
64g 32g

16*4

$CuSO_4(aq)$

160g*0.5 = 80g

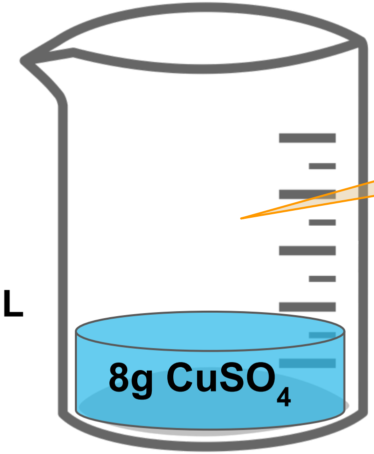
1000mL

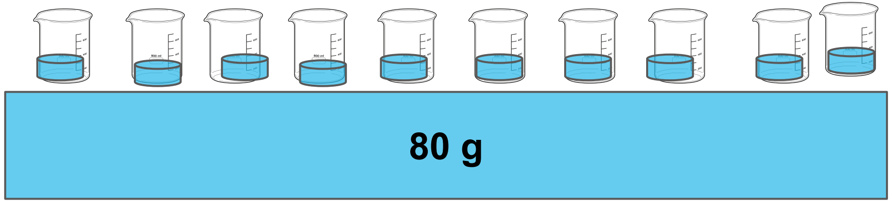


0.5M $CuSO_4$

How much copper is in here that can react and exchange places with iron?

100mL



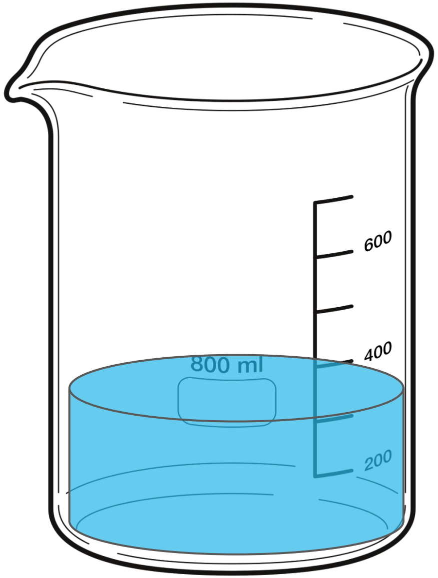


1.0M $CuSO_4$

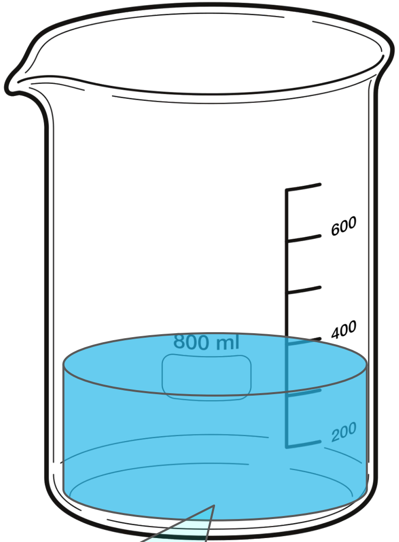
- 160g $CuSO_4$ in 1000 mL of water
- 200ml of 1M has 32g $CuSO_4$
- 100ml of 1M has 16g $CuSO_4$

0.5M $CuSO_4$

- 80g $CuSO_4$ in 1000 mL of water
- 200ml of 0.5M has 16g $CuSO_4$
- 100ml of 0.5M has 8g $CuSO_4$

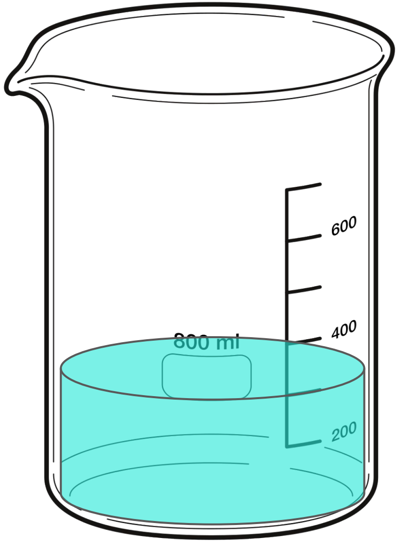


2 g Fe

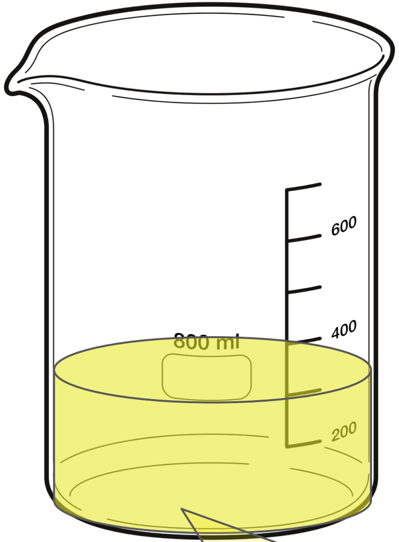


Iron was the limiting reactant because the solution is blue (still copper in solution)

4 g Fe



6 g Fe



CuSO4 was the limiting reactant because the solution is NOT blue but Yellow- Proof that all the copper was taken out of the solution and now is a solid.

What is the difference between Fe^{+2} and Fe^{+3}

Solution

Fe^{2+}	Fe^{3+}
Iron(Fe) loses its two electrons from the valence shell to form $Fe^{2+}$and hence showing +2 Oxidation state.	Iron(Fe) loses its two electrons from the valence shell to form Fe^{3+} and hence showing +3 Oxidation state.
The ion formed is called Ferrous ion.	The ion formed is called a Ferric ion.
Usually, they are paramagnetic in nature but all the electrons are paired in low spin complexes which may show diamagnetic behavior.	They always show the paramagnetic behavior because of lone pair of electrons
The general electronic configuration: $1s^22s^22p^63s^23d^6$	The general electronic configuration: $1s^22s^22p^63s^23d^5$
They are unstable in nature.	Due to its half-filled subshell it is more stable, than Fe^{2+}
Ferrous ion is of green color solution and turns to violet color when mixed with water.$(FeSO_4.7H_2O)$.	Ferric ions contain yellow brown solution $(FeCl_3.6H_2O)$.

What is the limiting reactant?

3 grams of Iron are mixed in a 200 mL solution of 0.5M copper sulfate. In 200 ml of CuSO4 solution there is 16g $CuSO_4$.

3g Fe	1 mol Fe	1 mol Cu	64g Cu	= 3.4 g Cu
	56g Fe	1 mol Fe	1 mol Cu	

16g $CuSO_4$	1 mol $CuSO_4$	1 mol Cu	64 Cu	= 6.4 g Cu
	160 $CuSO_4$	1 mol $CuSO_4$	1 mol Cu	

What is the limiting reactant?

3 grams of Iron are mixed in a 200 mL solution of 0.5M copper sulfate. In 200 ml of CuSO4 solution there is 16g $CuSO_4$.

$$\frac{3\text{g Fe}}{} \left| \frac{1\text{ mol Fe}}{56\text{g Fe}} \right| \frac{1\text{ mol Cu}}{1\text{ mol Fe}} \left| \frac{64\text{g Cu}}{1\text{ mol Cu}} \right. = 3.4\text{ g Cu}$$

This is the smallest so 3 grams of Fe limited the production of copper in this reaction

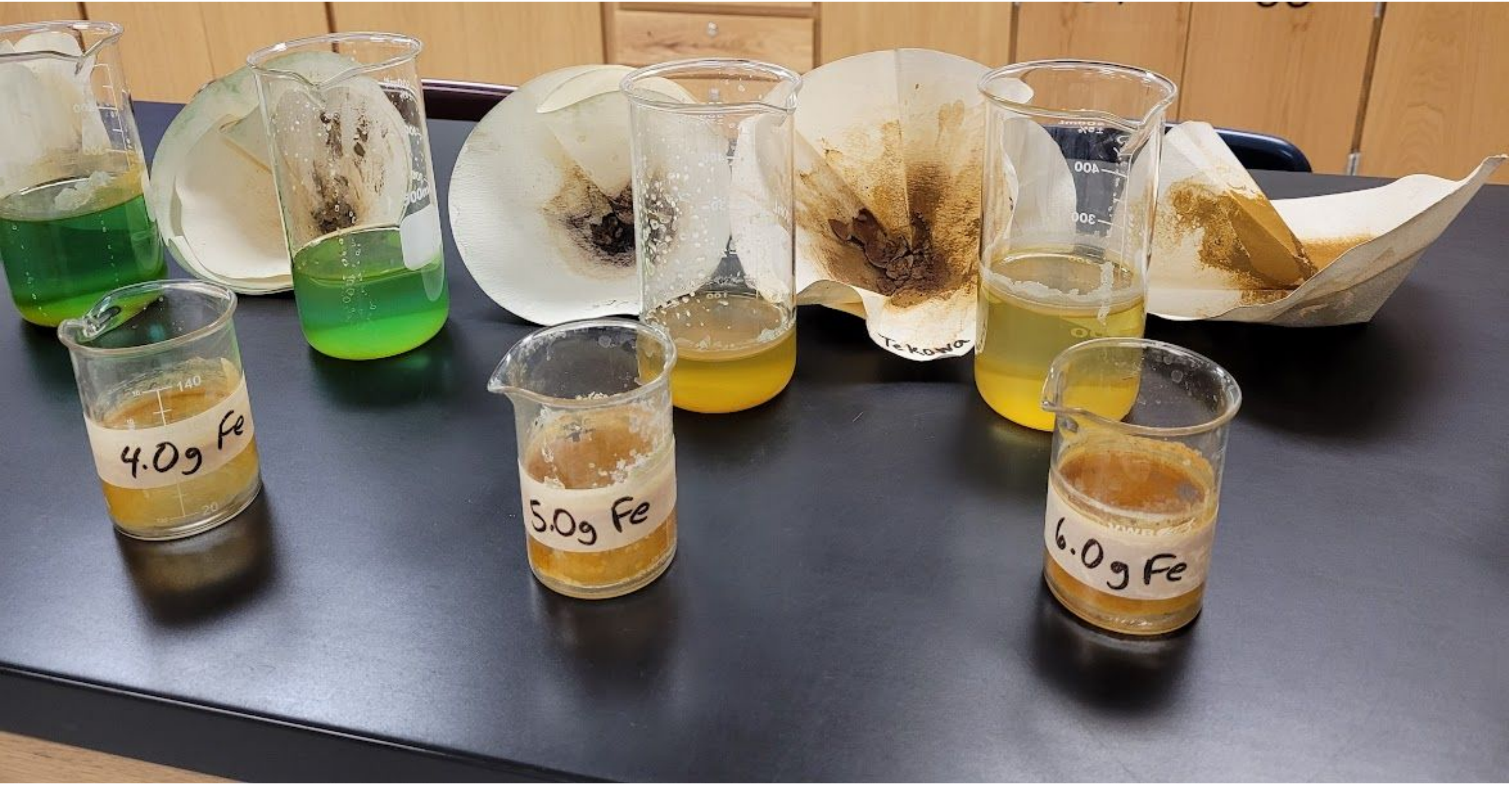
$$\frac{16\text{g } CuSO_4}{} \left| \frac{1\text{ mol } CuSO_4}{160\ CuSO_4} \right| \frac{1\text{ mol Cu}}{1\text{ mol } CuSO_4} \left| \frac{64\text{ Cu}}{1\text{ mol Cu}} \right. = 6.4\text{ g Cu}$$

What is the % Error of the amount of copper recovered?

Exact amount of copper that was supposed to be recovered = **3.4 g Cu**

Amount of copper recovered in the experiment = **3.6g Cu**

$$\% \text{ Error} = \frac{\text{Experimental- Actual}}{\text{Actual}} * 100 \quad \text{so,} \quad \frac{3.6 - 3.4}{3.4} * 100 = 5.9\% \text{ Error}$$



4.0g Fe
5.0g Fe
6.0g Fe
Tekowa

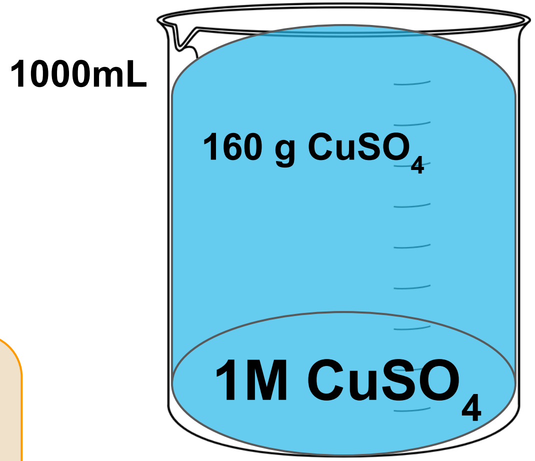
If 100mL of 1 M $CuSO_4$ reacts with 2.5 grams of Iron. How much copper can be produced?

Use Equation #1 AND #2

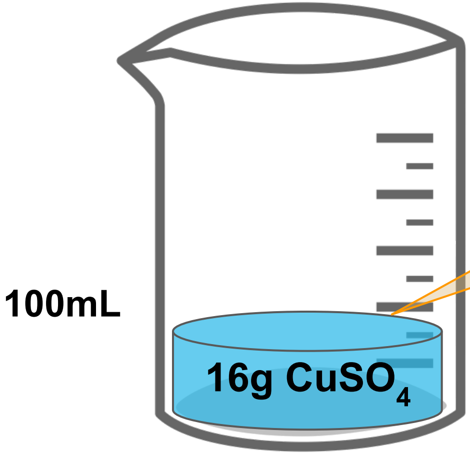
#1 $Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_3\ (aq)$

#2 $2Fe\ (s) + 3CuSO_4(aq) \rightarrow Fe_2(SO_4)_3(s) + 3Cu\ (s)$

If 100mL of 1 M $CuSO_4$ reacts with 2.5 grams of Iron. How much copper can be produced?



How much copper is in here that can react and exchange places with iron?

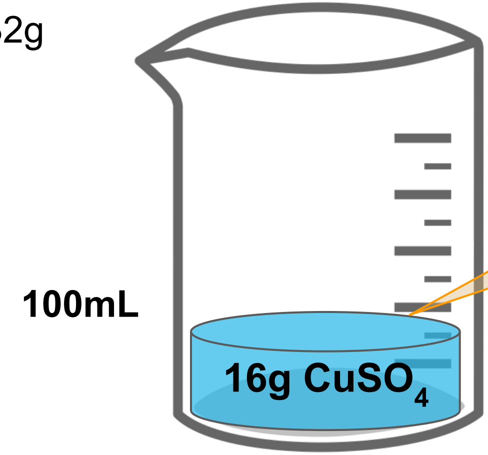


If 100mL of 1 M $CuSO_4$ reacts with 2.5 grams of Iron. How much copper can be produced?

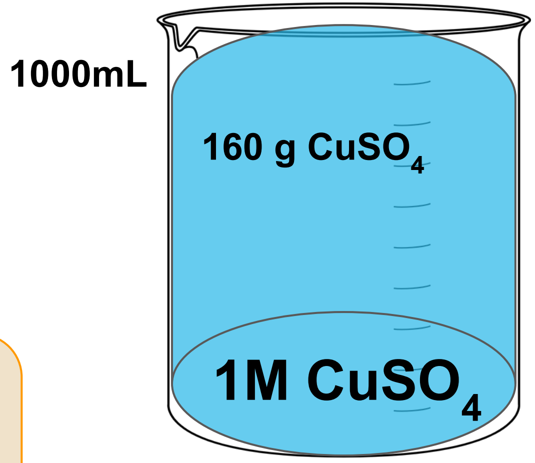
Equation #1

$$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_3\ (aq)$$

64g 32g 16*4

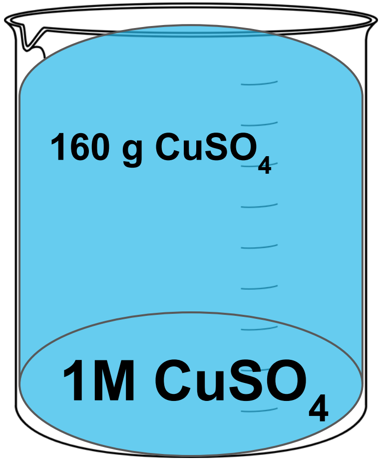


How much copper is in here that can react and exchange places with iron?



If 100mL of 1 M $CuSO_4$ reacts with 2.5 grams of Iron. How much copper can be produced?

1000mL



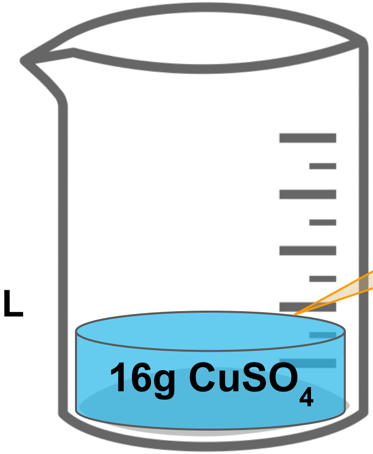
Equation #1

$$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_3\ (aq)$$

64g 32g 16*4

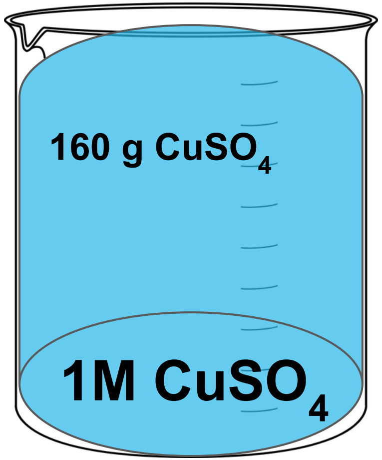
How much copper is in here that can react and exchange places with iron?

100mL



If 100mL of 1 M $CuSO_4$ reacts with 2.5 grams of Iron. How much copper can be produced?

1000mL



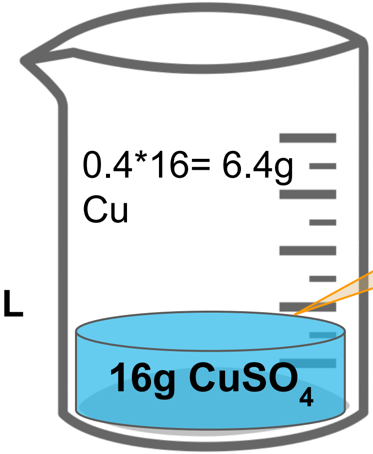
Equation #1

$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_3\ (aq)$

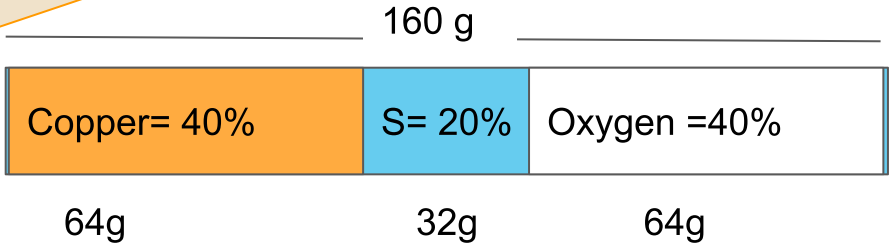
64g 32g 16*4

$$\frac{64g}{160\ g} = 0.4$$

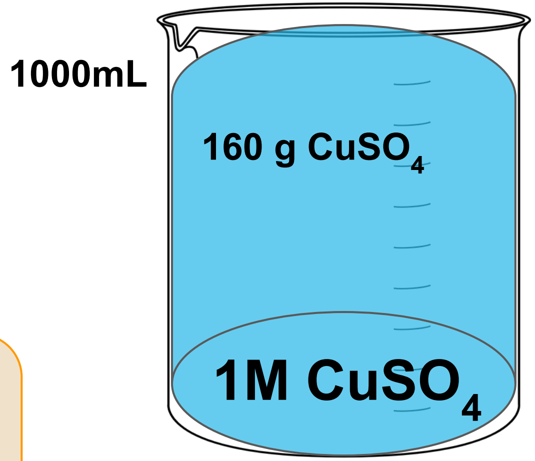
100mL



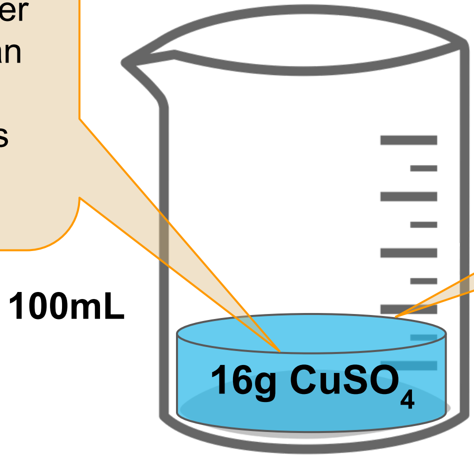
How much copper is in here that can react and exchange places with iron?



If 100mL of 1 M $CuSO_4$ reacts with 2.5 grams of Iron. How much copper can be produced?

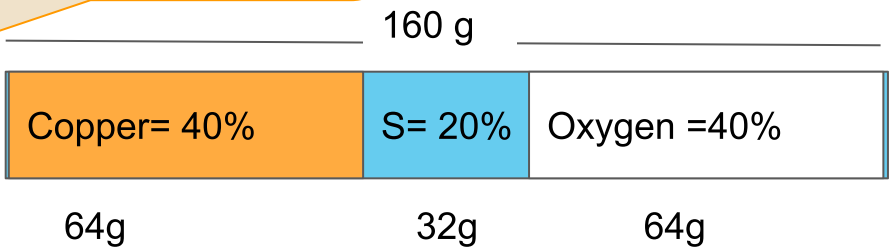


How much copper is in here that can react and exchange places with iron?

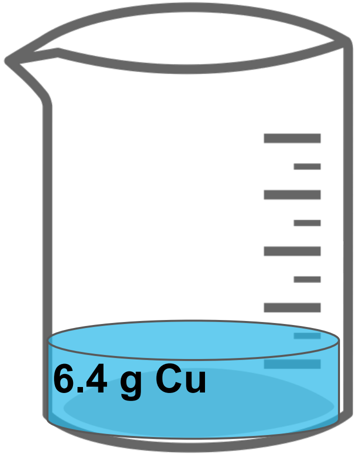


40% of 16 g CuSO4

So, **6.4 g of Cu**



If 100mL of 1 M $CuSO_4$ reacts with 2.5 grams of Iron. How much copper can be produced?



Equation #1

$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_3\ (aq)$

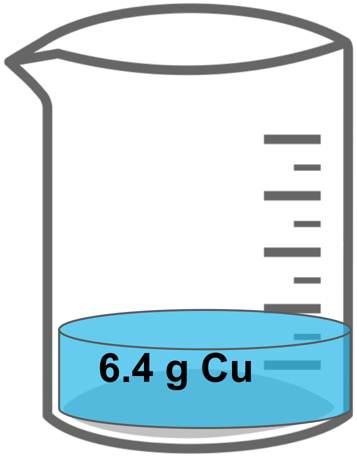
2.5 g Fe	1 mol Fe	1 mol Cu	64 g Cu
	56 g Fe	1 mol Fe	1 mol Cu

2.86 grams of Cu can be made from 2.5 grams of Iron

If 100mL of 1 M $CuSO_4$ reacts with 2.5 grams of Iron. How much copper can be produced?

Equation #2

$$2Fe\ (s) + 3CuSO_4(aq) \rightarrow Fe_2(SO_4)_3(s) + 3Cu\ (s)$$



2.5 g Fe	1 mol Fe	3 mol Cu	64 g Cu
	56 g Fe	2 mol Fe	1 mol Cu

4.29 g of Cu could be produced with this equation.

Graded: 10 points

You calculate:

Find **your** copper from your given iron amounts for BOTH equations:

Equation #1: 1Fe:1Cu ratio - $Fe\ (s) + CuSO_4(aq) \rightarrow Fe_2(SO_4)_3(s) + Cu\ (s)$

2.5 g Fe	1 mol Fe	1 mol Cu	64 g Cu
	56 g Fe	1 mol Fe	1 mol Cu

2.86 grams of Cu can be made from 2.5 grams of Iron

Equation #2: 2Fe:3Cu ratio - $2Fe\ (s) + 3CuSO_4(aq) \rightarrow Fe_2(SO_4)_3(s) + 3Cu\ (s)$

2.5 g Fe	1 mol Fe	3 mol Cu	64 g Cu
	56 g Fe	2 mol Fe	1 mol Cu

4.29 g of Cu could be produced with this equation.

Observations:

Record Observation for Fe 1g-11 g. Record color patterns, amounts, magnetisms etc.

Reaction of Fe with $CuSO_4$....

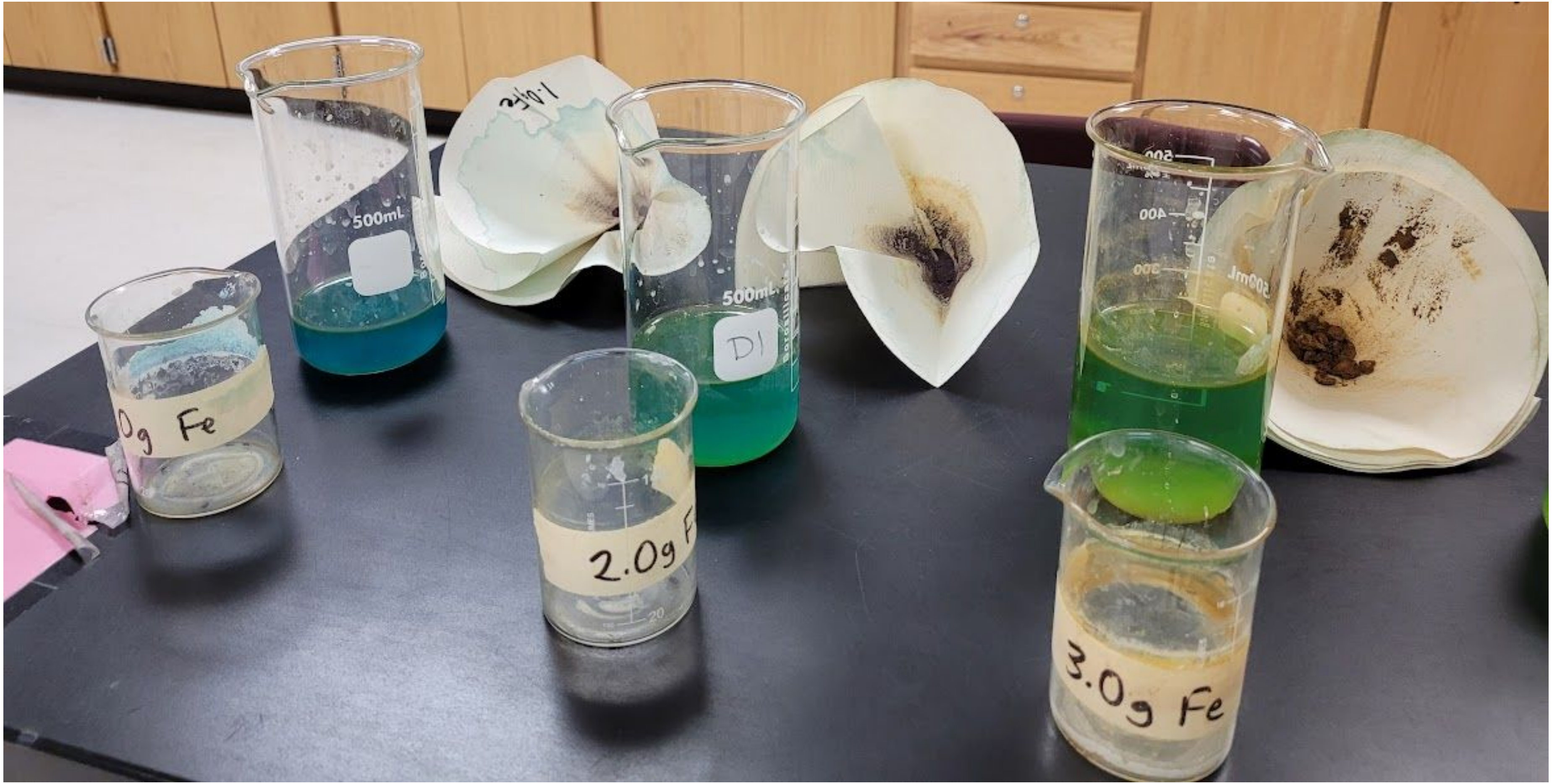
Observations: Details matter!

Graded: 15 points

Initial Iron (g)	Aqueous Solution (color, concentrations, particles)	Solids (color, texture, amounts)	Other: Magnetisms, jar, paper, etc.
1			
2			
3			
4			
5			
6			
7			
8			

Initial Iron (g)	Aqueous Solution (color, concentrations, particles)	Solids (color, texture, amounts)	Other: Magnetisms, jar, paper, etc.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

Initial Iron (g)	Aqueous Solution (color, concentrations, particles)	Solids (color, texture, amounts)	Other: Magnetisms, jar, paper, etc.
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			


500mL
0g Fe
DI
500mL
2.0g F
3.0g Fe


propack
FLEXIBLE
PLASTIC
STRAWS
CLEAR
400
2.6g
DI
500mL
8.0g Fe
9.0g Fe
10.0g Fe
11.0g Fe


500mL
400mL

	Equation 1 Balanced			Equation 2 Balanced	
	1 Mole of Fe	1 Mole of Cu		2 Moles of Fe	3 Moles of Cu
	Fe (g)	Cu (g) with excess CuSO4		Fe (g)	Cu (g) with excess CuSO4
No one	0		No one	0	
Tekowa	1		Tekowa	1	
Evan	2		Evan	2	
Kadin/Trenton	3		Kadin/Trenton	3	
Sarah/Julie	4		Sarah/Julie	4	
Allyn	5		Allyn	5	
Megan/Toby	6		Megan/Toby	6	
Collin	7		Collin	7	
Serina/Kamari	8		Serina/Kamari	8	
Kiki	9		Kiki	9	
Cooper/Denim	10		Cooper/Denim	10	
Sofie/Kaylene	11		Sofie/Kaylene	11	

Fill in your calculation for Equation 1 and 2 here.

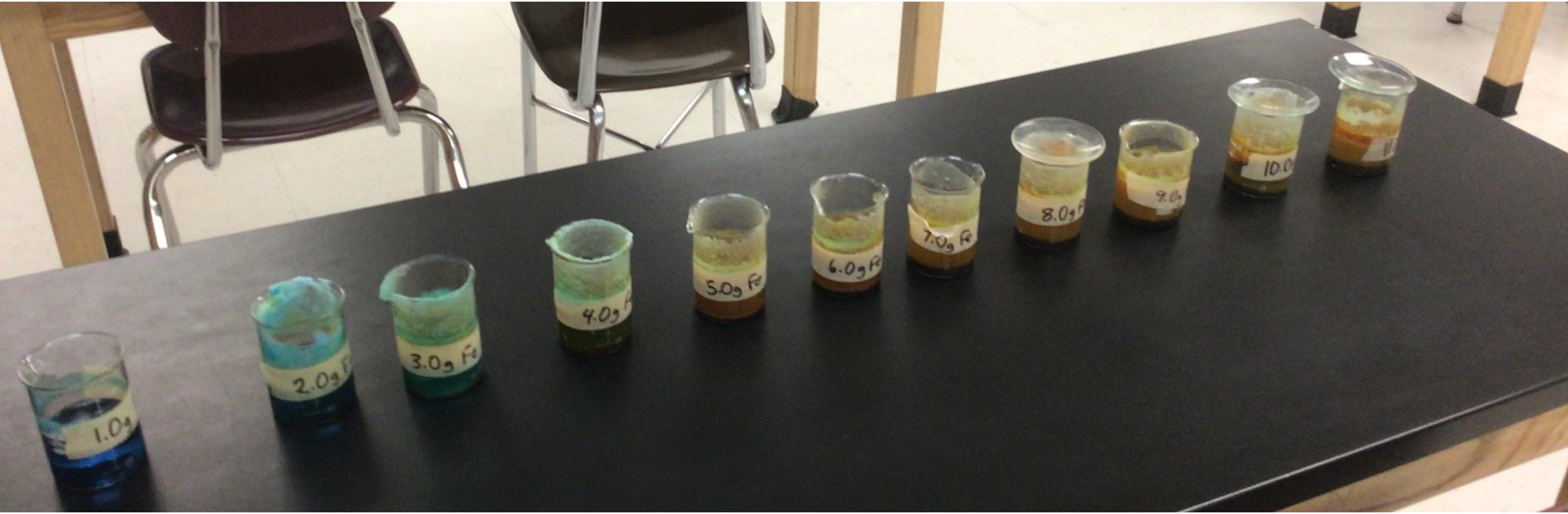
If Iron is +2

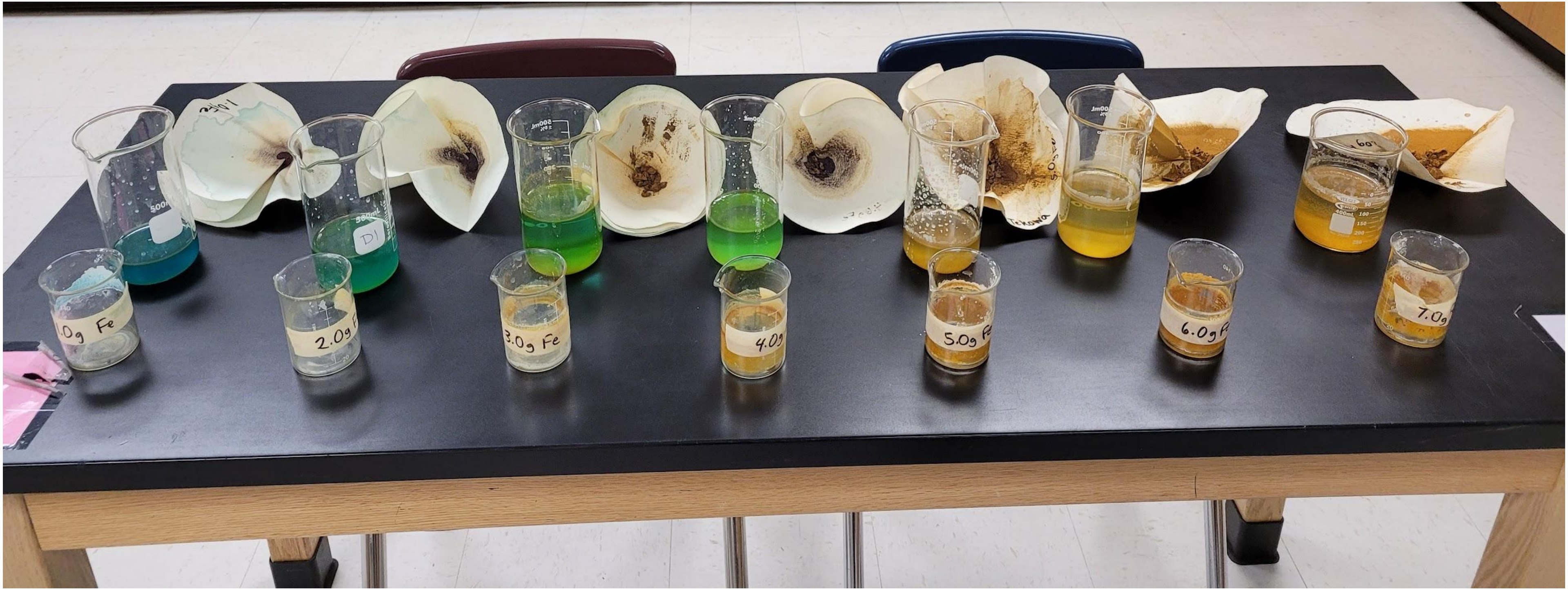
Fe (g)	Cu (g) with excess CuSO4	Cu Expected (g)
0.0	0.0	0.0
1.0	1.1	1.1
2.0	2.3	2.3
3.0	3.4	3.4
4.0	4.6	4.6
5.0	5.7	5.7
6.0	6.9	**6.4**
7.0	8.0	**6.4**
8.0	9.1	**6.4**
9.0	10.3	**6.4**
10.0	11.4	**6.4**
11.0	12.6	**6.4**

If Iron is +3

Fe (g)	Cu (g)	Cu Expected (g)
0.0	0.0	0.0
1.0	1.7	1.7
2.0	3.4	3.4
3.0	5.1	5.1
4.0	6.9	6.4
5.0	8.6	6.4
6.0	10.3	**6.4**
7.0	12.0	**6.4**
8.0	13.7	**6.4**
9.0	15.4	**6.4**
10.0	17.1	**6.4**
11.0	18.9	**6.4**

The Highlighted Areas show the predicted color of the aqueous solution for each reaction.


1.0g
2.0g Fe
3.0g Fe
4.0g Fe
5.0g Fe
6.0g Fe
7.0g Fe
8.0g Fe
9.0g
10.0g



DI
.0g Fe
2.0g F
3.0g Fe
4.0g
5.0g Fe
6.0g Fe
7.0g

You calculate:

Find your Iron amount on the counter and weigh the filter paper(s). Subtract the mass of the filter paper(s) and **record** the amount you have of copper or copper/iron solid mixture.

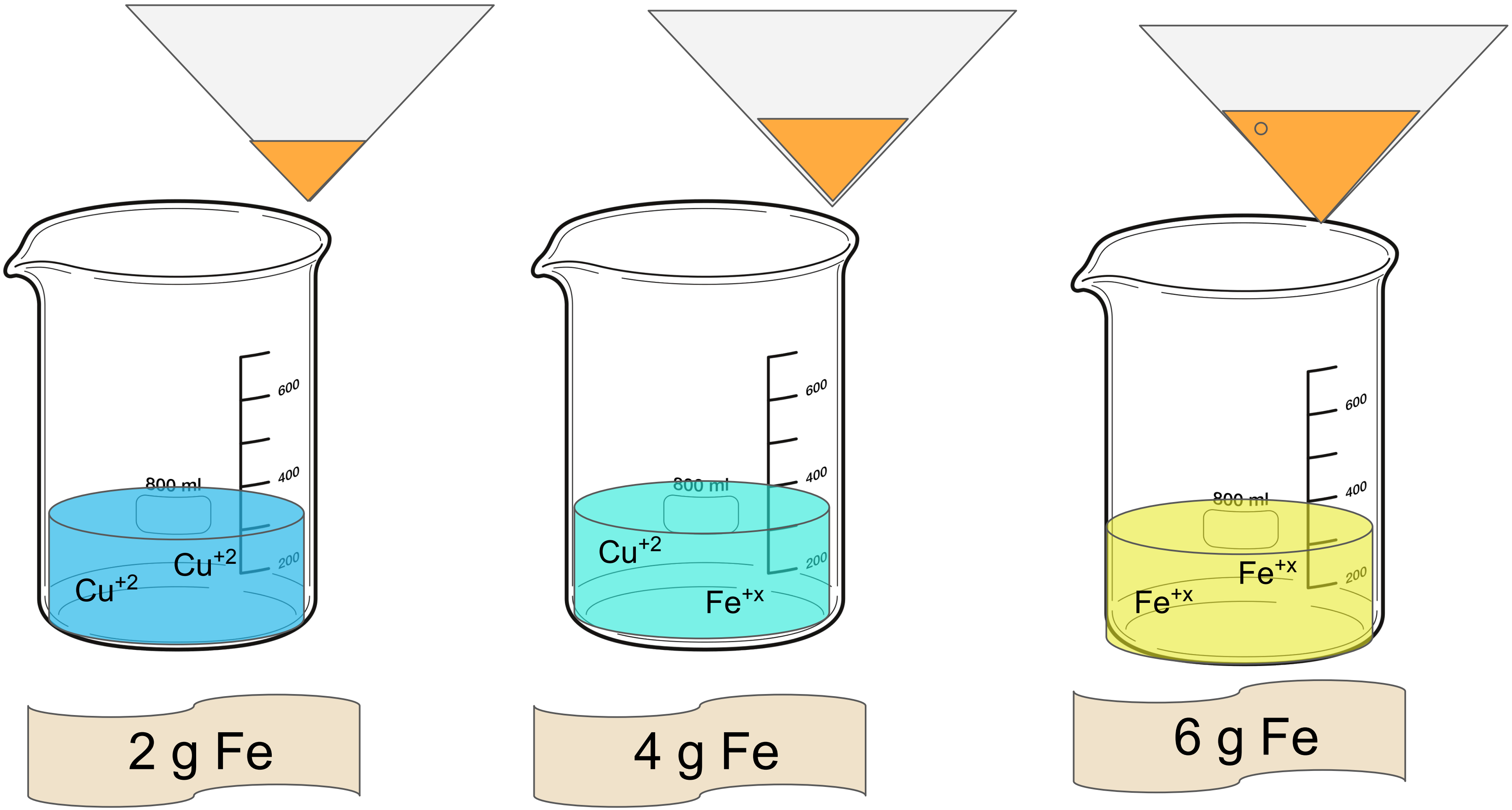
	Fe (g)	Cu (g) with excess CuSO4	Cu Expected (g)	Fe expected leftover	Total Expected Mass (g)	Actual Mass on Filter (g)	Fe (g) expected in FeSO4
No one	0						
Tekowa	1						
Evan	2						
Kadin/Trenton	3						
Sarah/Julie	4						
Allyn	5						
Megan/Toby	6						
Collin	7						
Sarina/Kamari	8						

Data from our class:
https://docs.google.com/spreadsheets/d/1GVQNHcEzWoU91I4FM7uFWdqBWJvx1tUuLM5XEU7pJ6k/edit?usp=sharing

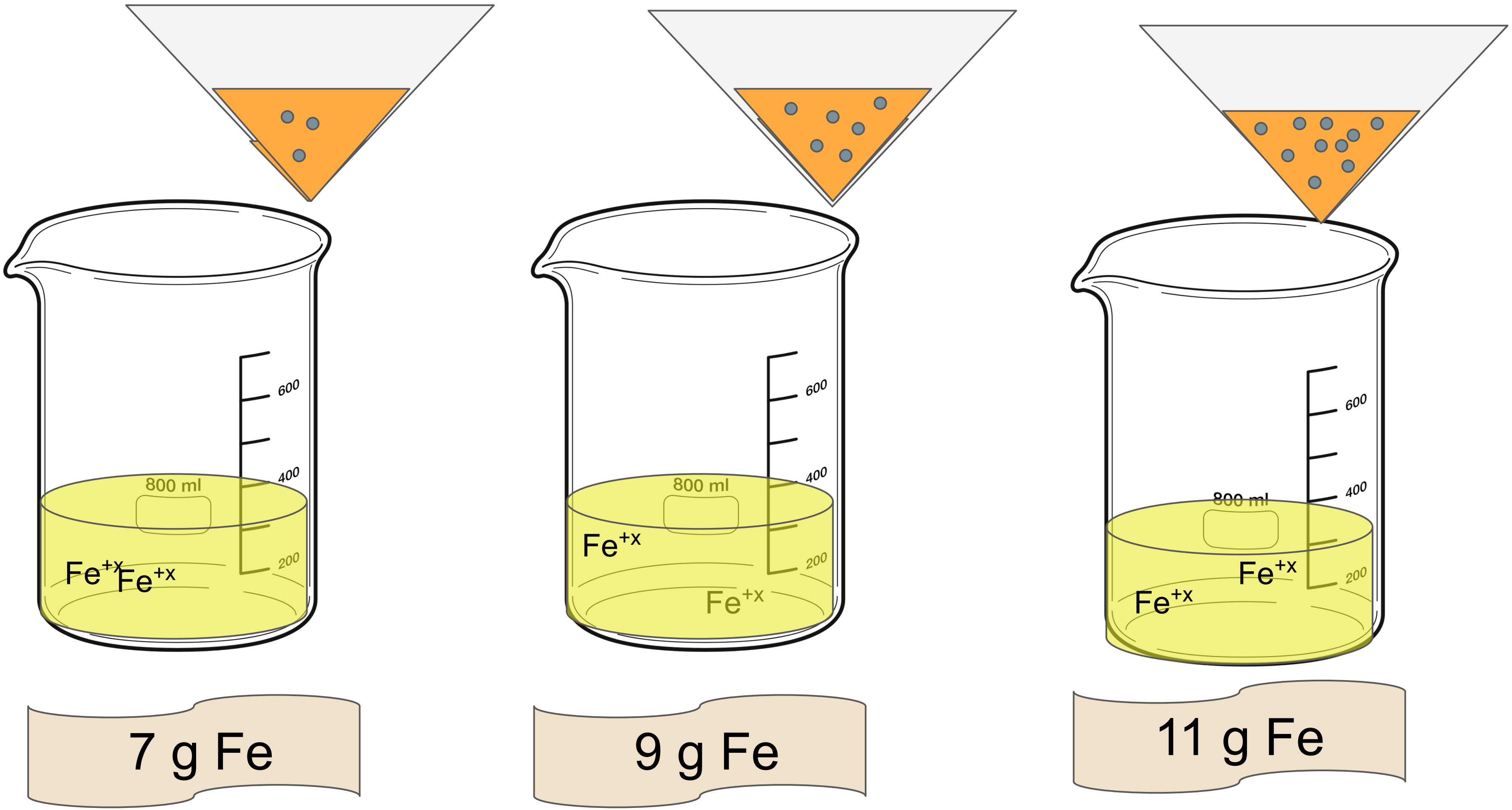
Graded: 15 points

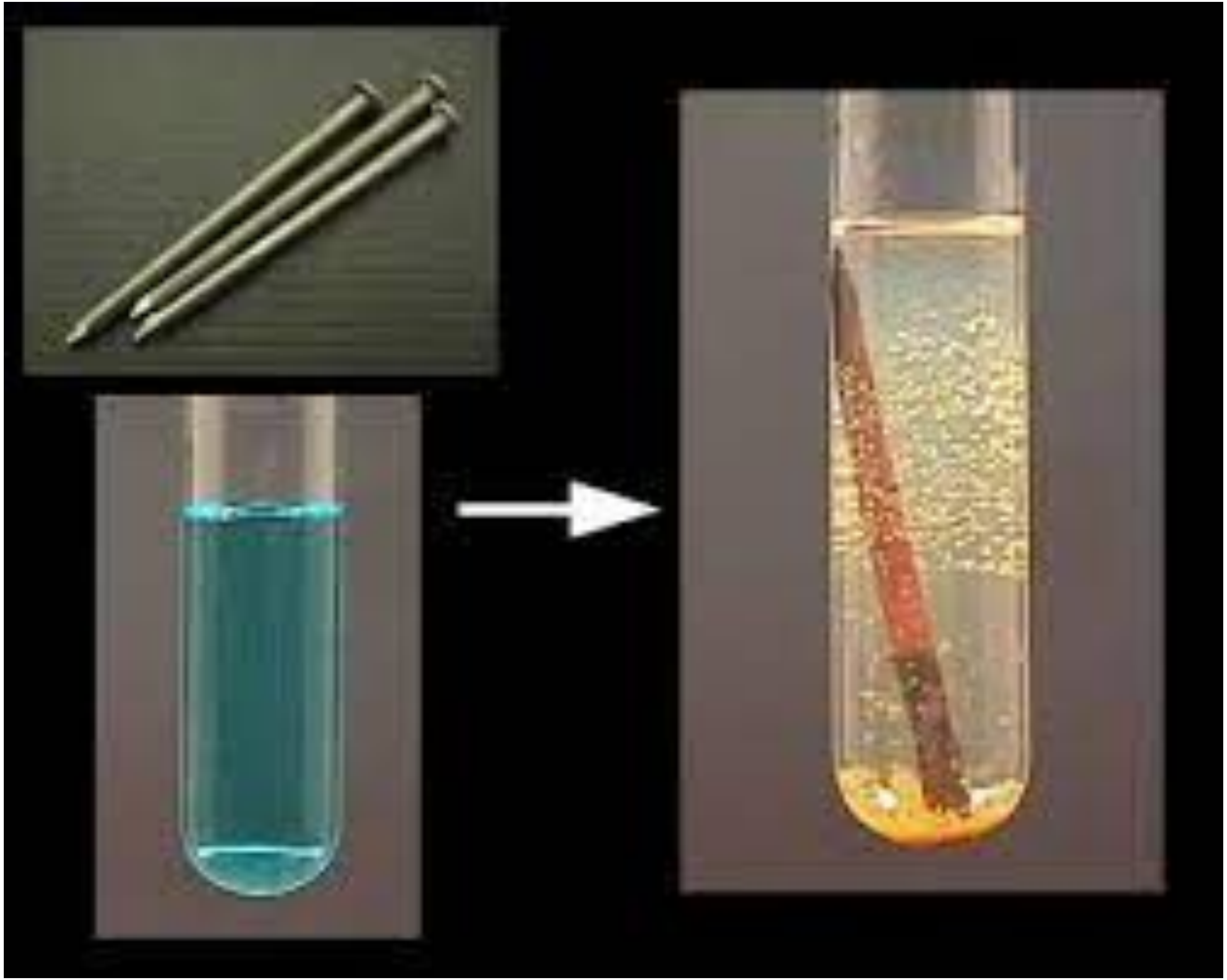
Fe (g)	Cu (g) with excess CuSO4	Cu Expected (g)	Fe expected leftover	Total Expected Mass (g)	Actual Mass on Filter (g)	Fe (g) expected in FeSO4
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						

Fe (g)	Cu (g) with excess CuSO4	Cu Expected (g)	Fe expected leftover	Total Expected Mass (g)	Actual Mass on Filter (g)	Fe (g) expected in FeSO4
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						



800 ml
600
400
200
Cu^{+2}
Cu^{+2}
2 g Fe
800 ml
600
400
200
Cu^{+2}
Fe^{+x}
4 g Fe
800 ml
600
400
200
Fe^{+x}
Fe^{+x}
6 g Fe


600
400
800 ml
200
Fe+x
Fe+x
7 g Fe
600
400
800 ml
200
Fe+x
Fe+x
9 g Fe
600
400
800 ml
200
Fe+x
Fe+x
11 g Fe

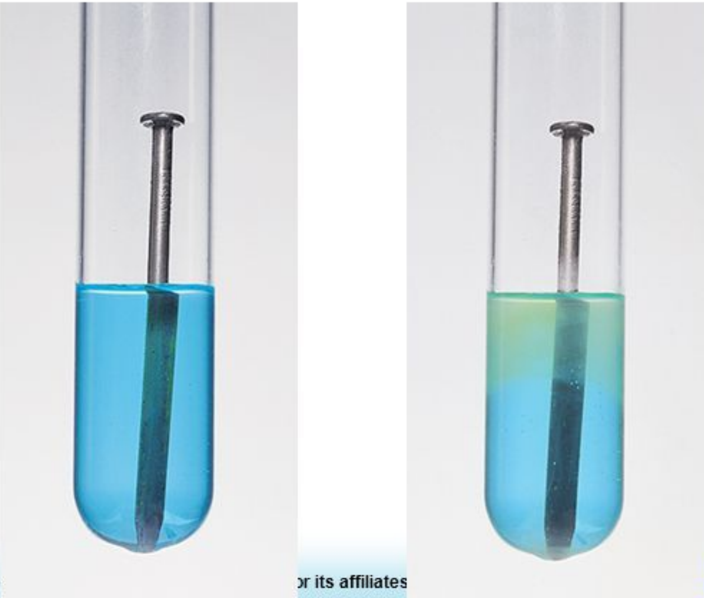


This figure illustrates a redox reaction that shows what occurs when a shiny iron nail is dipped into a solution of copper(II) sulfate.

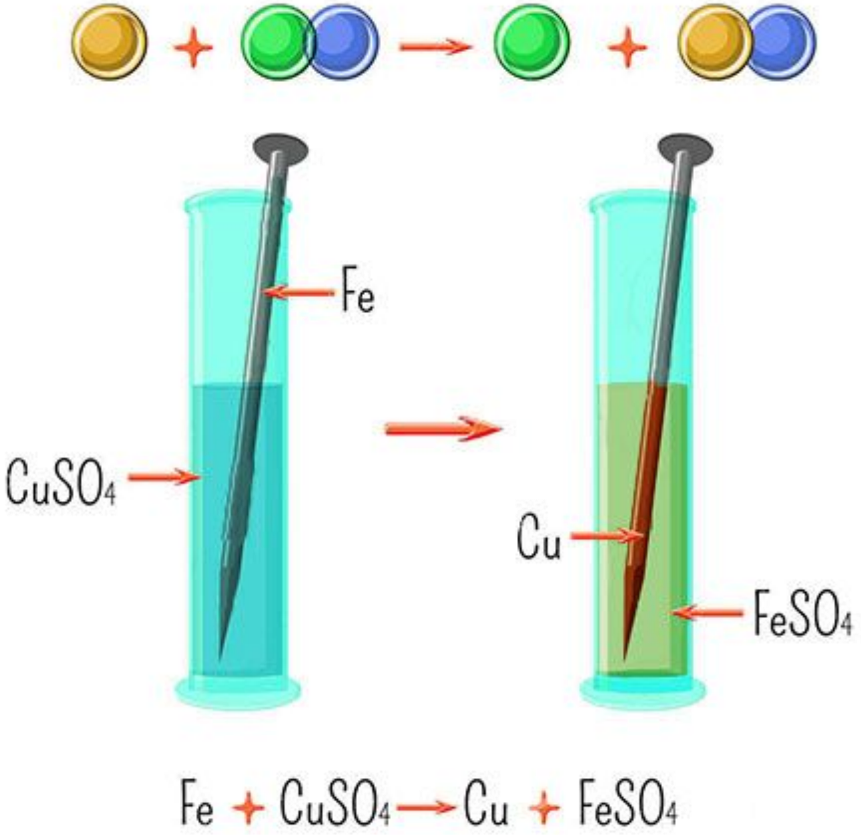
$$Cu^{2+}SO_4 + Fe \rightarrow Fe^{2+}SO_4 + Cu$$

- **The iron reduces Cu^{2+} ions in solution and is simultaneously oxidized to Fe^{2+}.**

- **The iron becomes coated with metallic copper.**



Single displacement reaction



$$Fe + CuSO_4 \rightarrow Cu + FeSO_4$$

Iron is oxidized and Copper is reduced

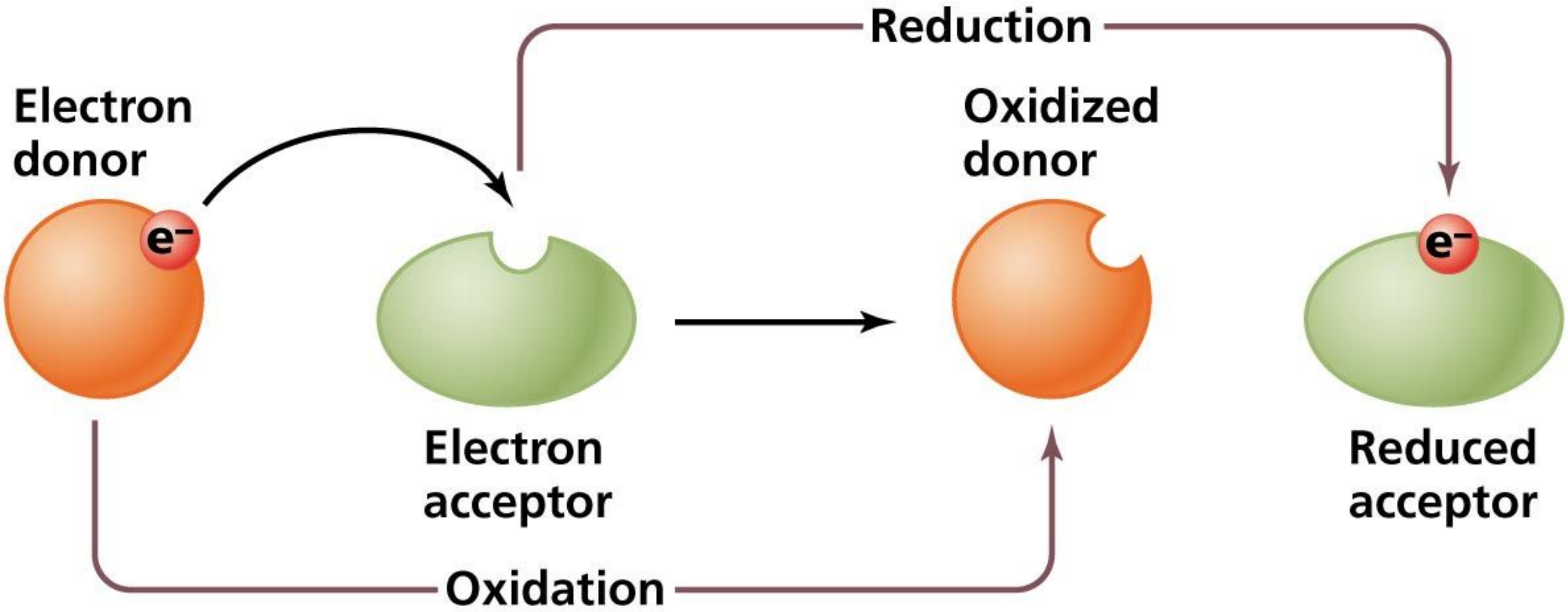
a. $Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_3\ (aq)$

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

b. $2Fe\ (s) + 3CuSO_4(aq) \rightarrow Fe_2(SO_4)_3(s) + 3Cu\ (s)$

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

Electron Transfer and Redox Reactions



“Oxidation-Reduction Reactions”

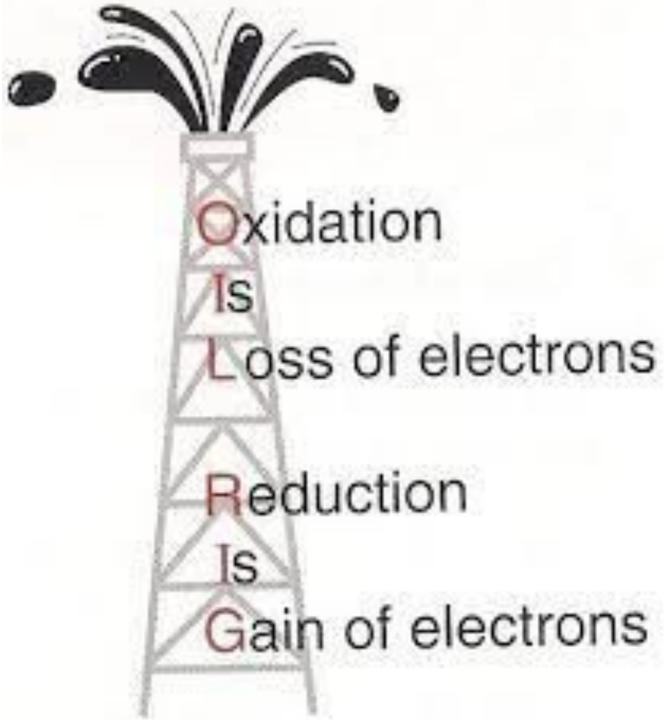
LEO SAYS GER

Lose electrons its oxidation

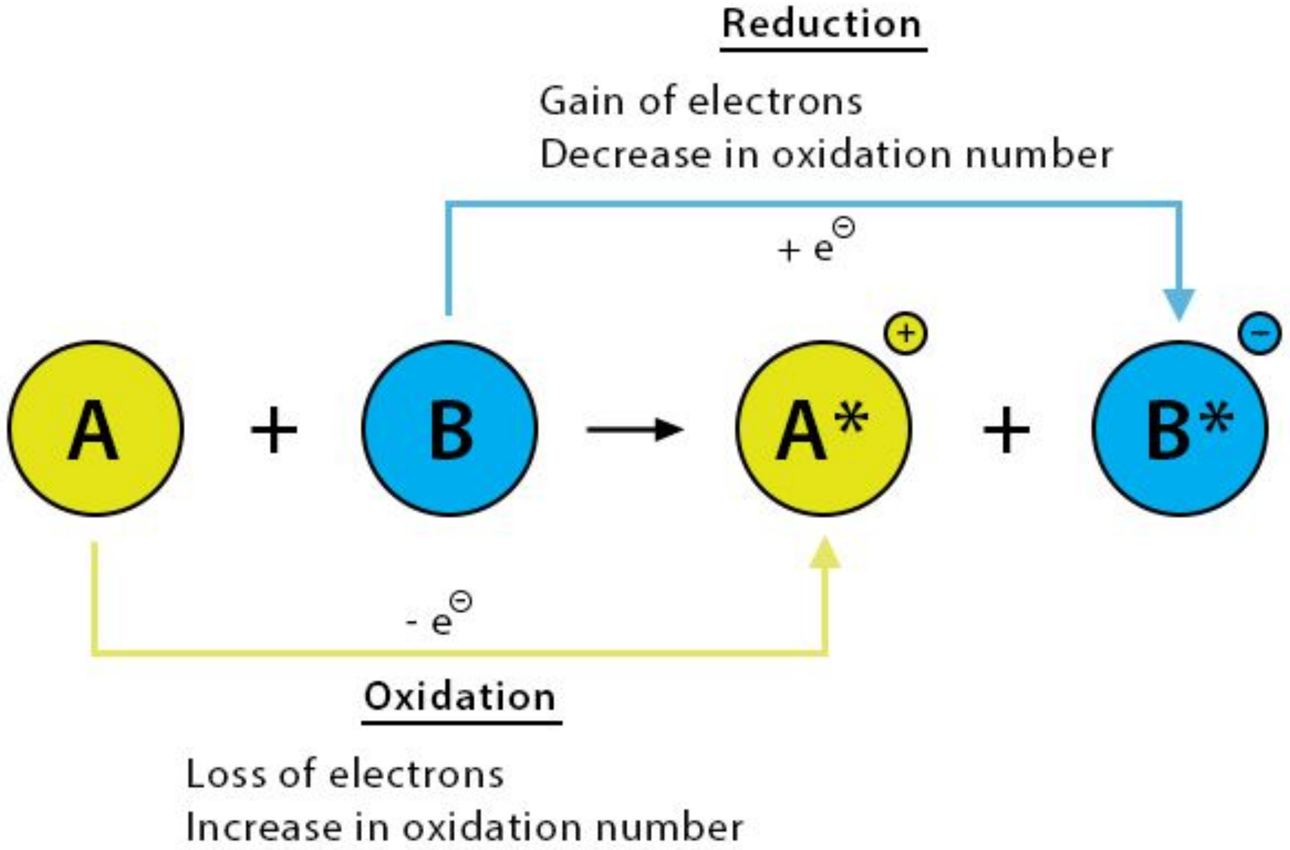
Gain electrons its reduction

O — Oxidation
I — is
L — Loss of electrons

R — Reduction
I — is
G — Gain of electrons

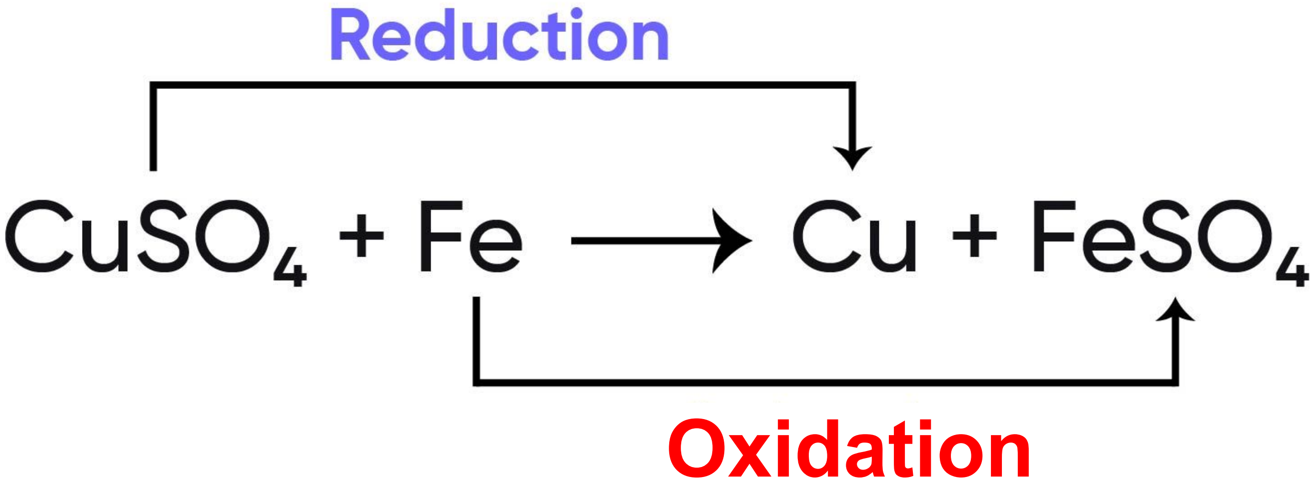


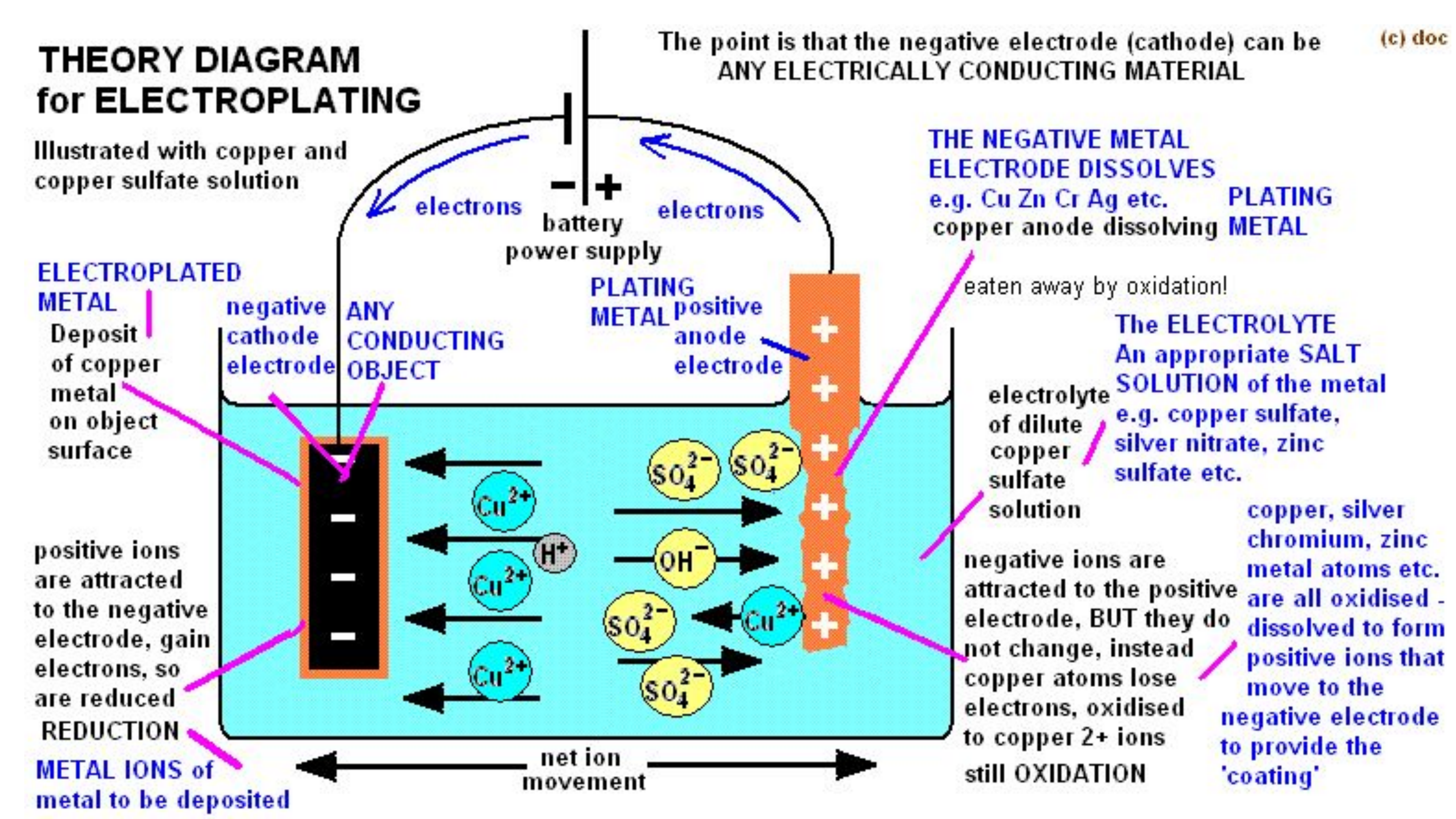
Redox Reaction



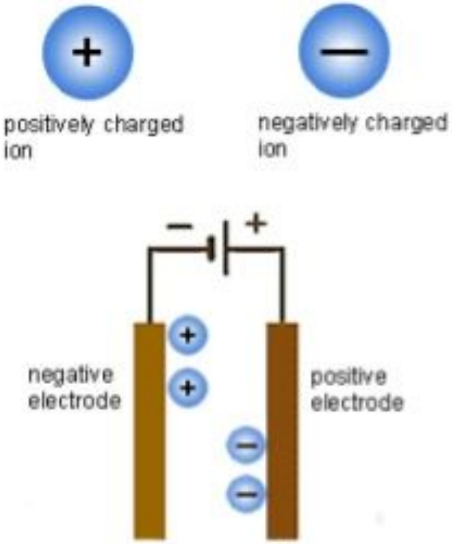
teachoo

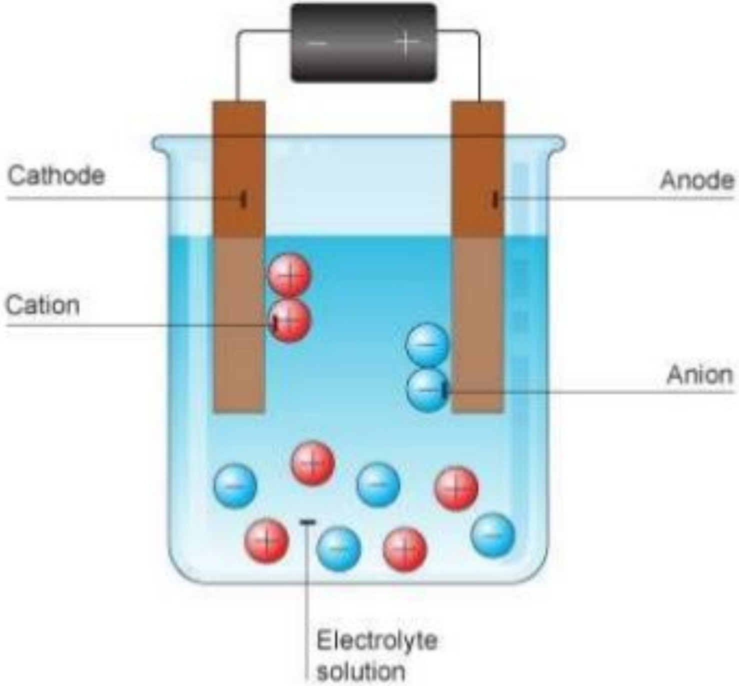
REACTION OF COPPER SULPHATE WITH IRON

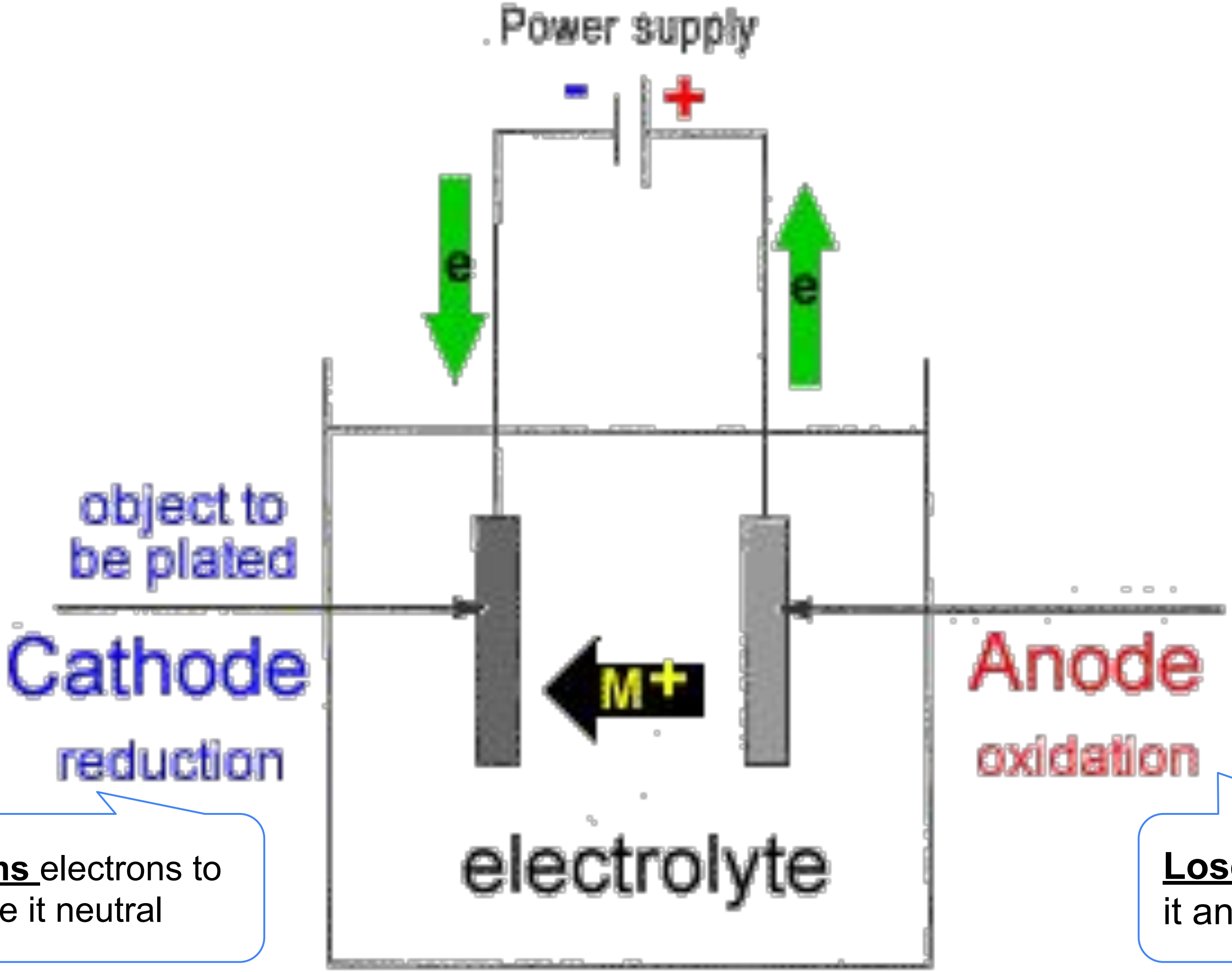



THEORY DIAGRAM for ELECTROPLATING
(c) doc
Illustrated with copper and copper sulfate solution
The point is that the negative electrode (cathode) can be ANY ELECTRICALLY CONDUCTING MATERIAL
electrons
electrons
- +
battery power supply
THE NEGATIVE METAL ELECTRODE DISSOLVES
e.g. Cu Zn Cr Ag etc.
copper anode dissolving
PLATING METAL
eaten away by oxidation!
ELECTROPLATED METAL
Deposit of copper metal on object surface
negative cathode electrode
ANY CONDUCTING OBJECT
PLATING METAL
positive anode electrode
The ELECTROLYTE
An appropriate SALT SOLUTION of the metal
e.g. copper sulfate, silver nitrate, zinc sulfate etc.
electrolyte of dilute copper sulfate solution
Cu2+
H+
OH-
SO42-
positive ions are attracted to the negative electrode, gain electrons, so are reduced
REDUCTION
METAL IONS of metal to be deposited
negative ions are attracted to the positive electrode, BUT they do not change, instead copper atoms lose electrons, oxidised to copper 2+ ions
still OXIDATION
copper, silver chromium, zinc metal atoms etc. are all oxidised - dissolved to form positive ions that move to the negative electrode to provide the 'coating'
net ion movement

Don't **PANIC** - **P**ositive is **A**node, **N**egative **I**s **C**athode.



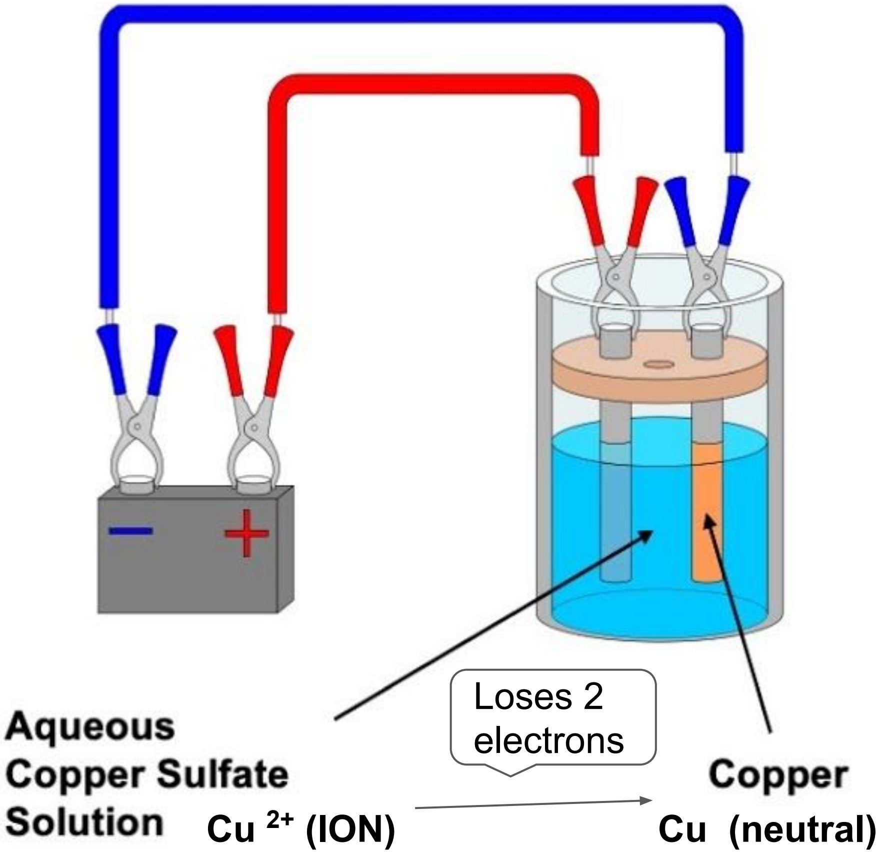




Gains electrons to make it neutral

Loses electrons to make it an ionic chemical

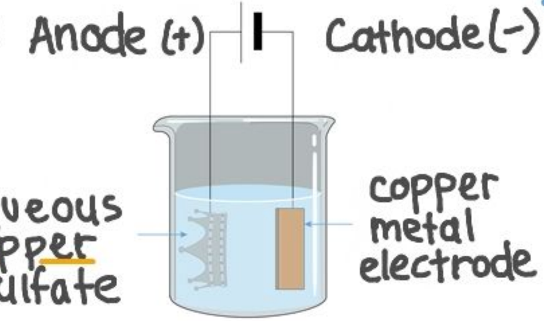
Electroplating



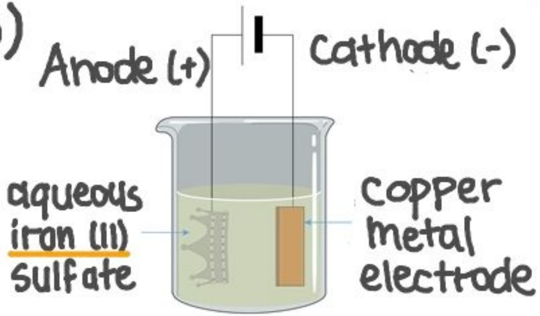
- Electroplating is the process of coating an object (usually made of metal) with a thin layer of a different metal by electrolysis.
- This is a useful way of protecting a metal from corrosion e.g. by plating steel (which easily rusts with a layer of nickel, chromium or gold).
- The process is also used to make a metal object more attractive.

Which diagram shows the appropriate apparatus to electroplate the iron crown with copper?

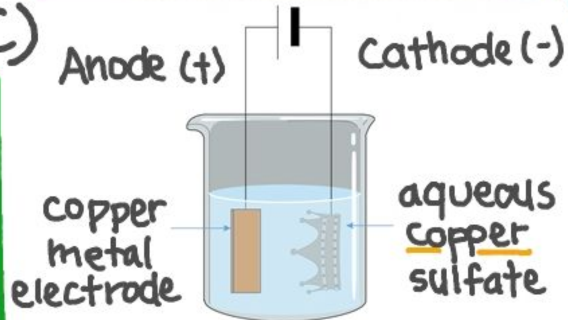
A)



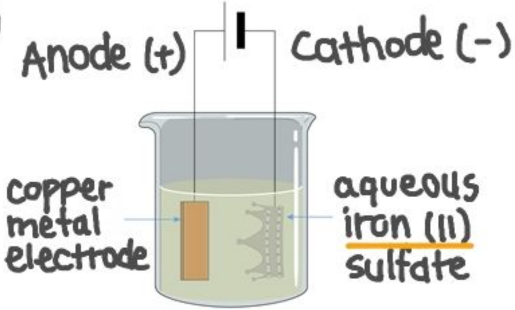
B)



C)

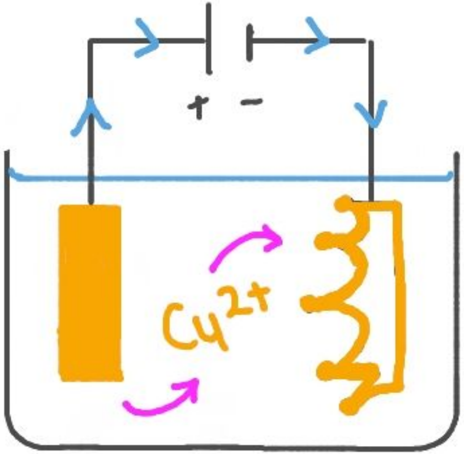


D)

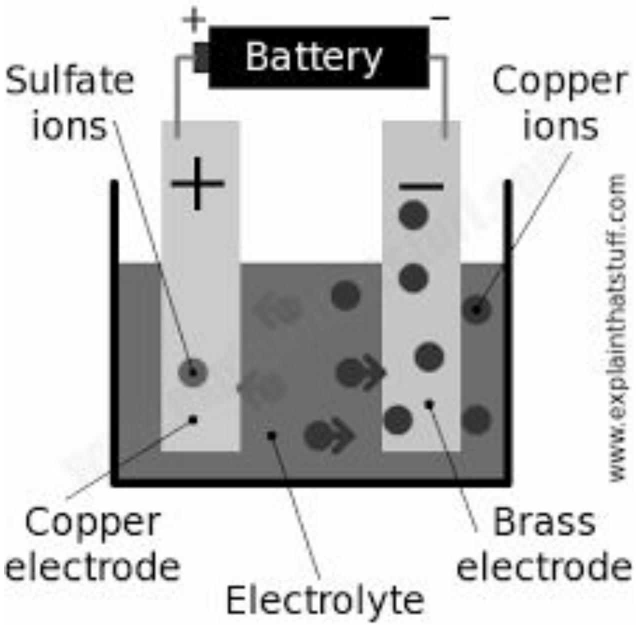


anode oxidation

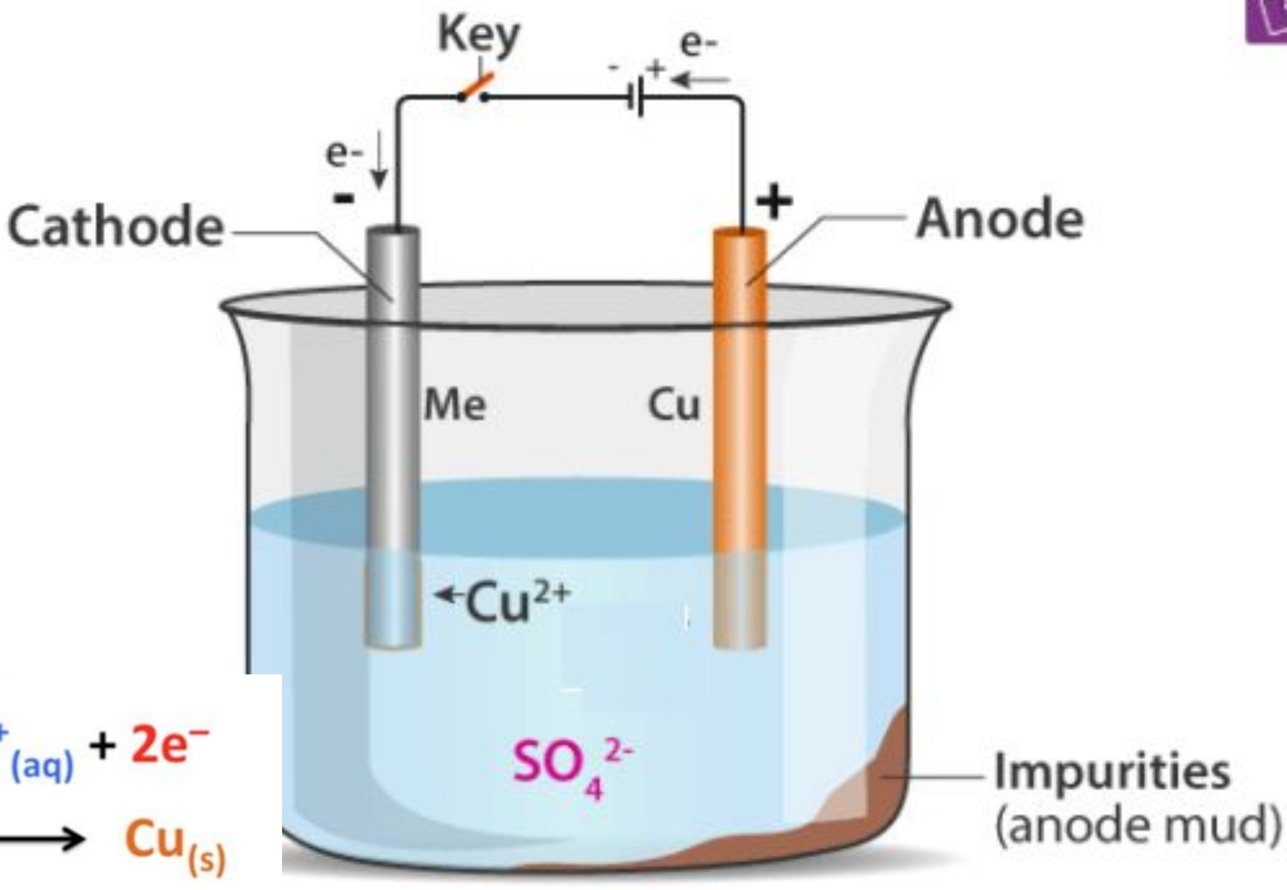
cathode reduction



electrolytic cell


Battery
+
−
Sulfate ions
Copper ions
+
−
www.explainthatstuff.com
Copper electrode
Electrolyte
Brass electrode

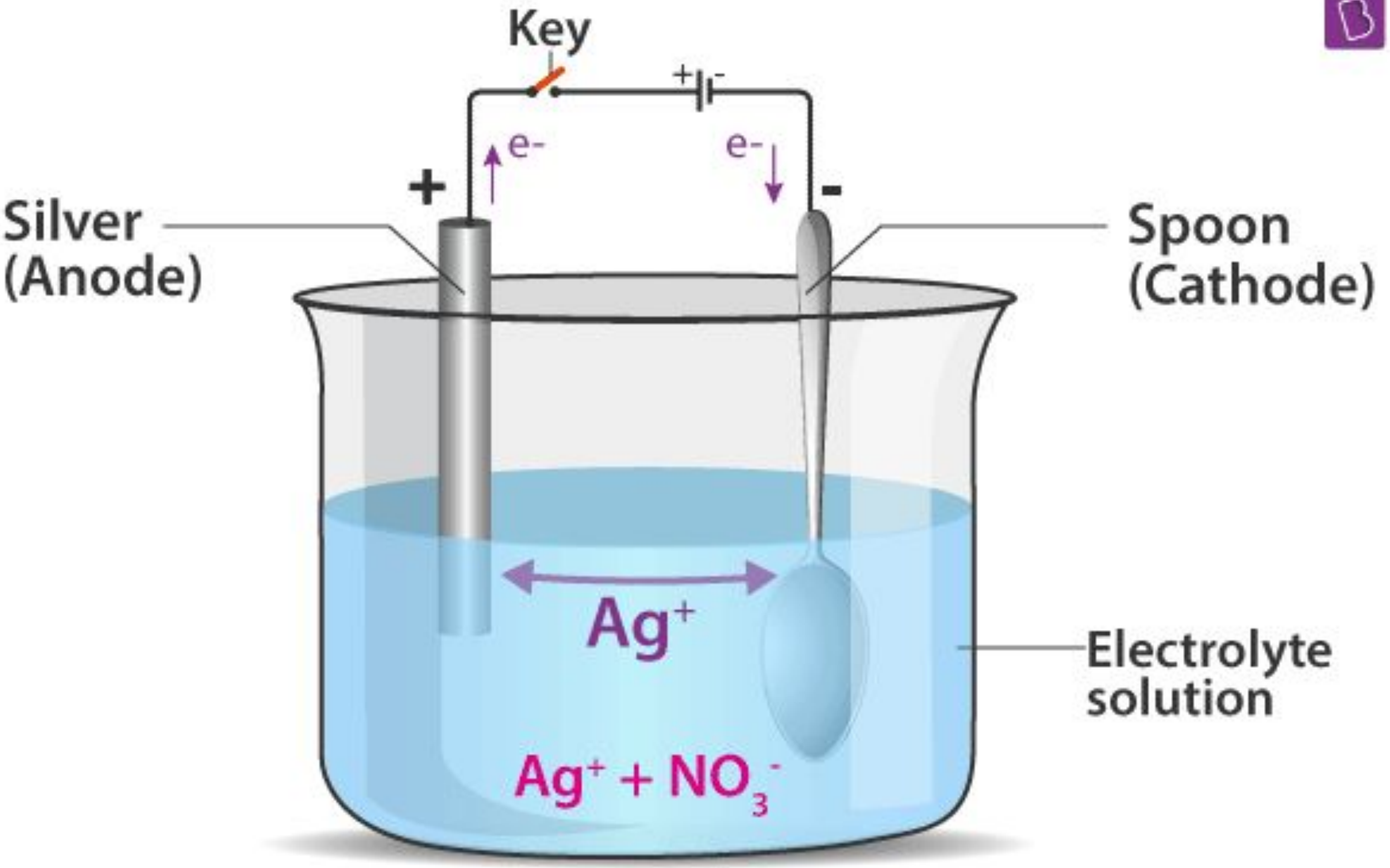
Copper become pure copper (no longer a +2 ion) and therefore gained 2 electrons.



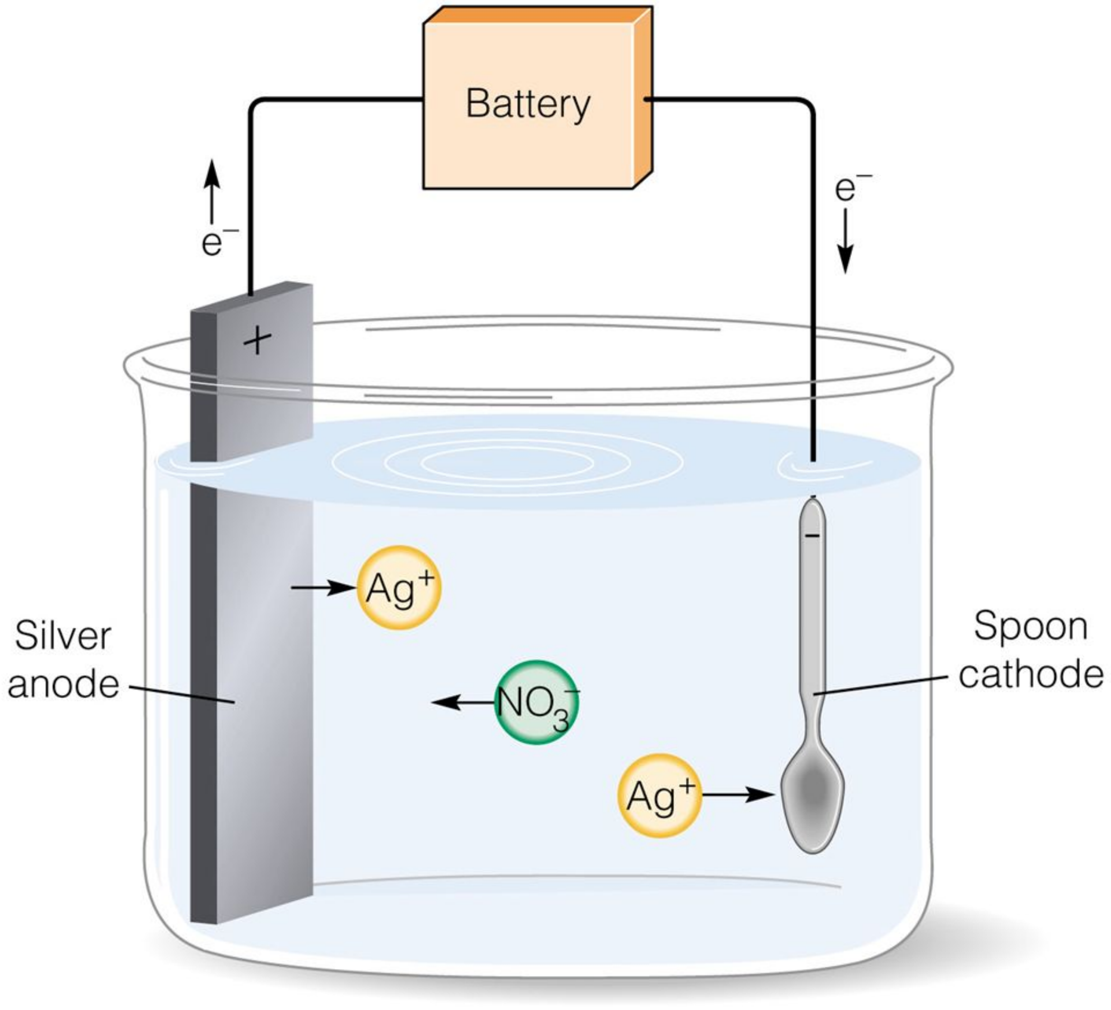
Copper Plating

Anode: $Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e^{-}$

Cathode: $Cu^{2+}_{(aq)} + 2e^{-} \longrightarrow Cu_{(s)}$

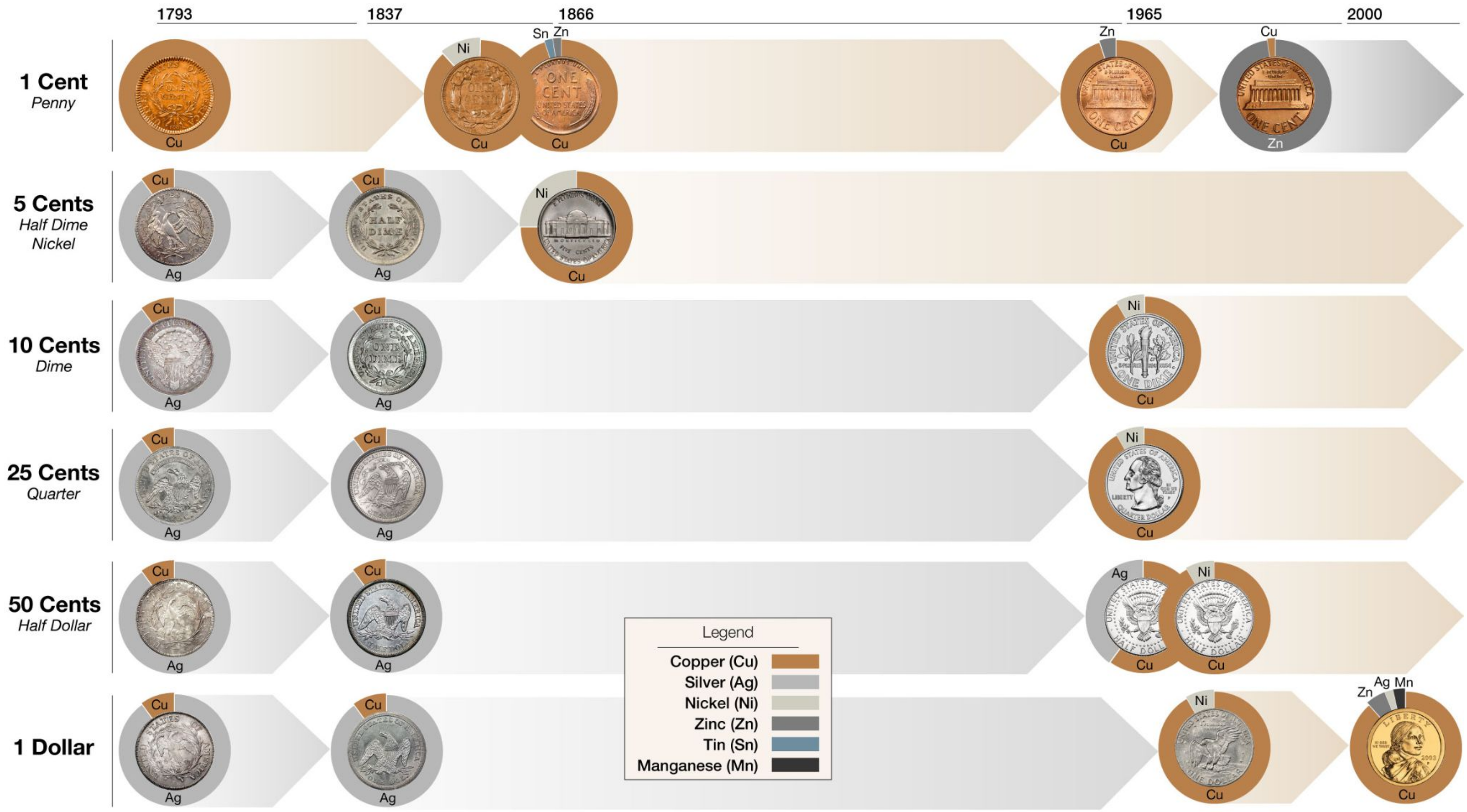


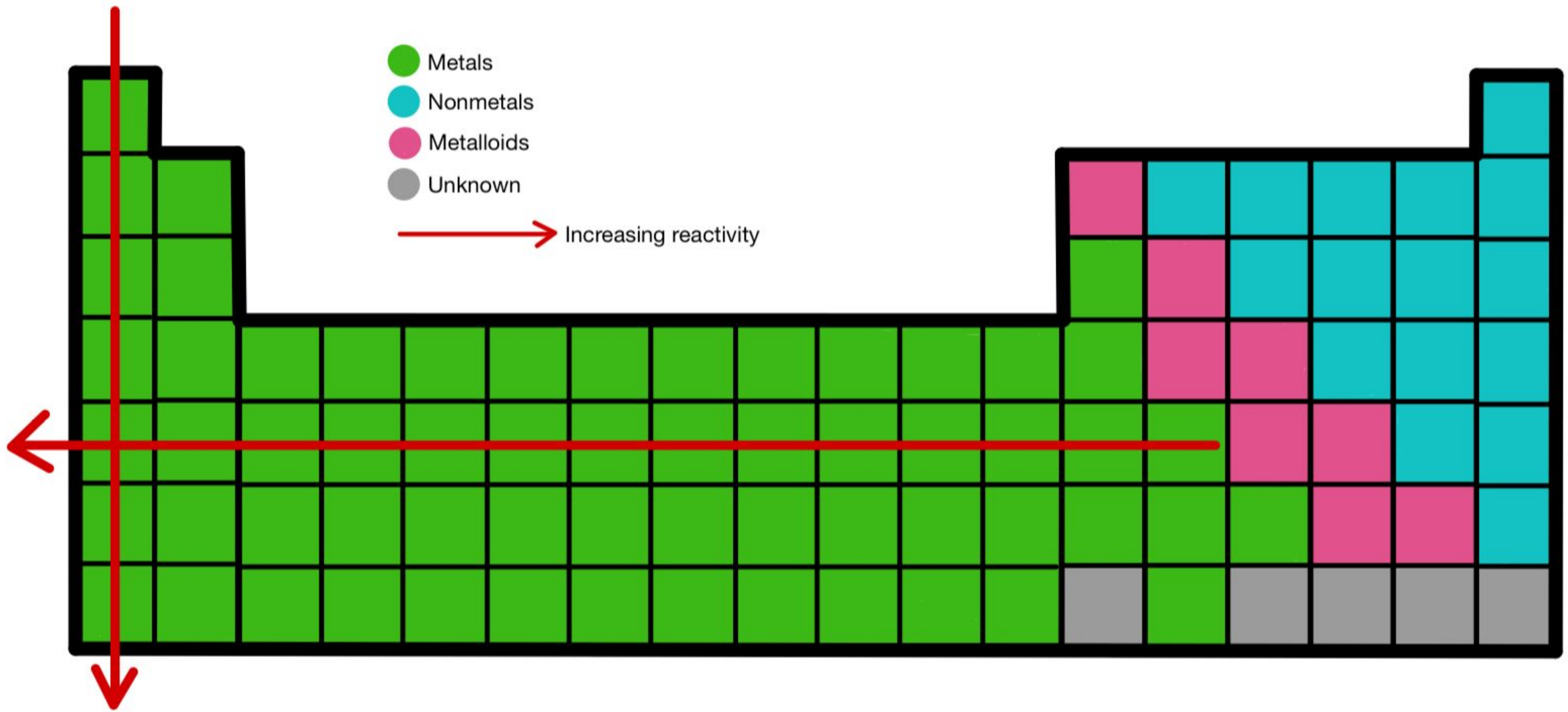
Silver Plating

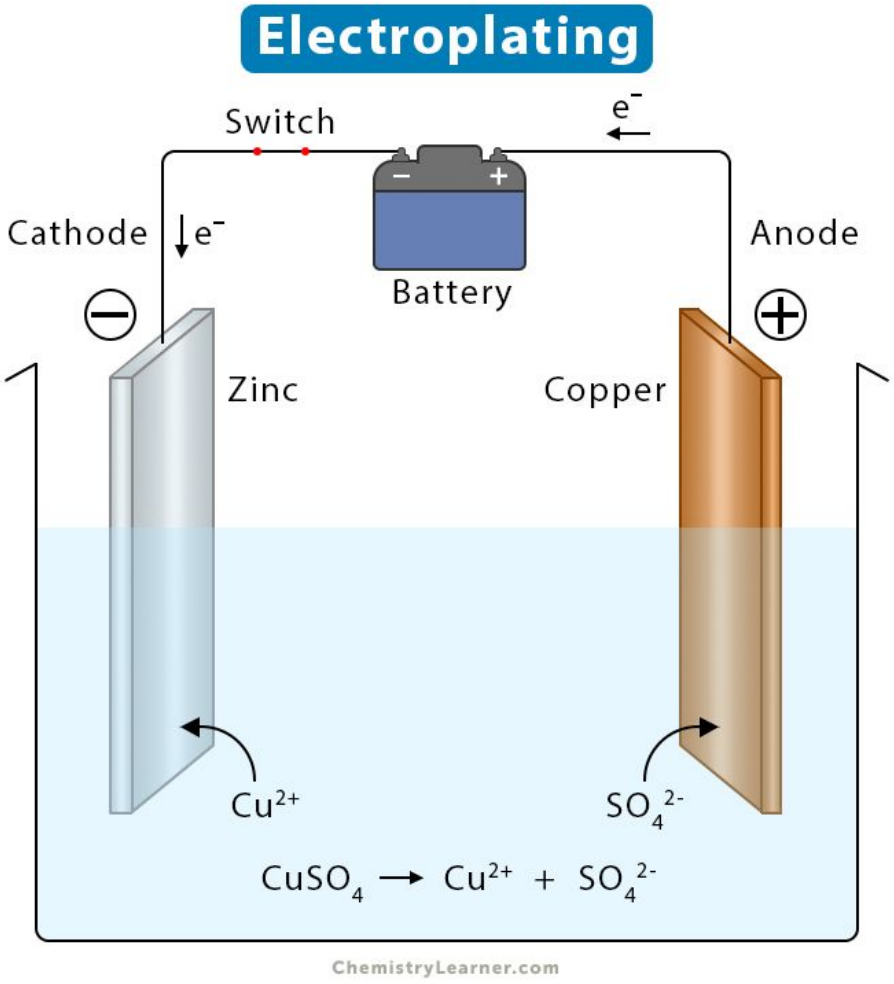

Battery
e⁻
e⁻
+
−
Ag⁺
NO_3^-
Ag⁺
Silver
anode
Spoon
cathode

UNITED STATES MINT

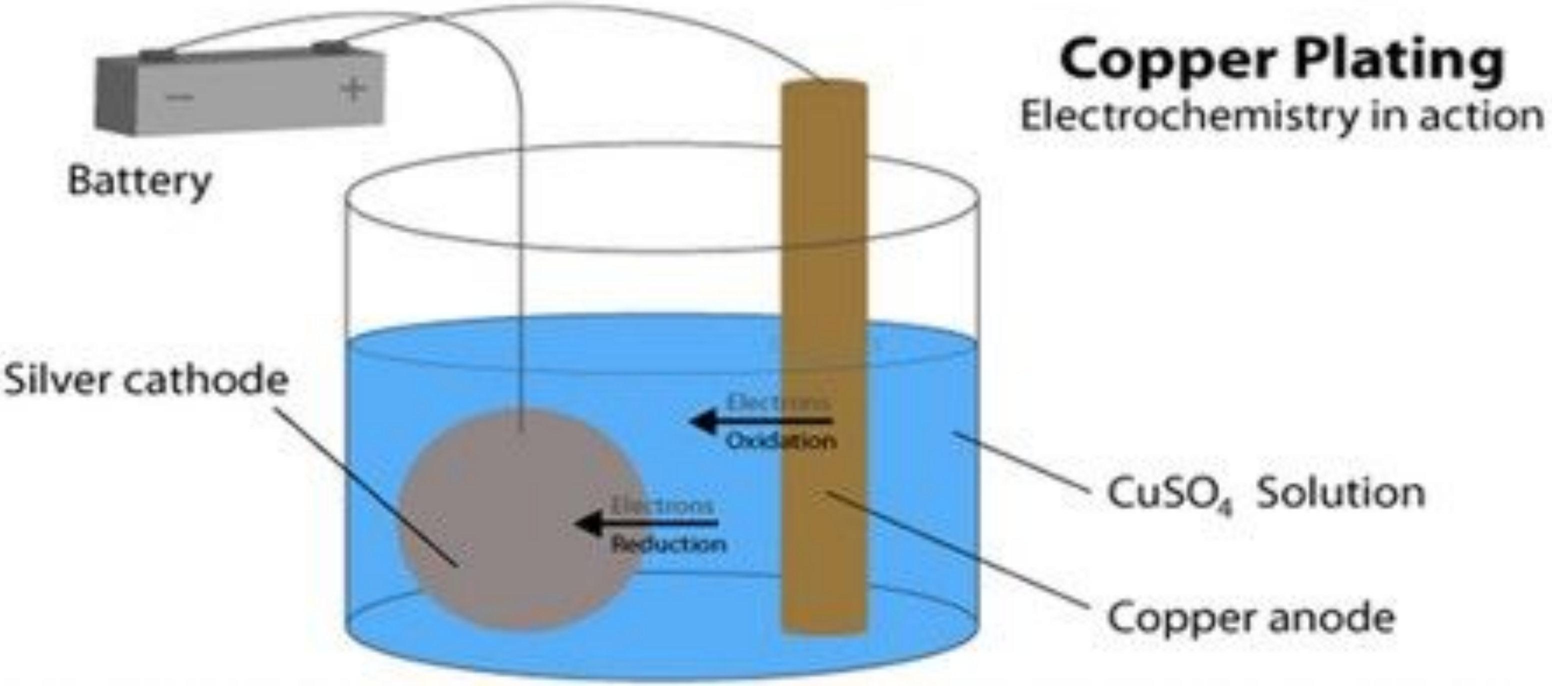
U.S. Circulating Coins Composition History

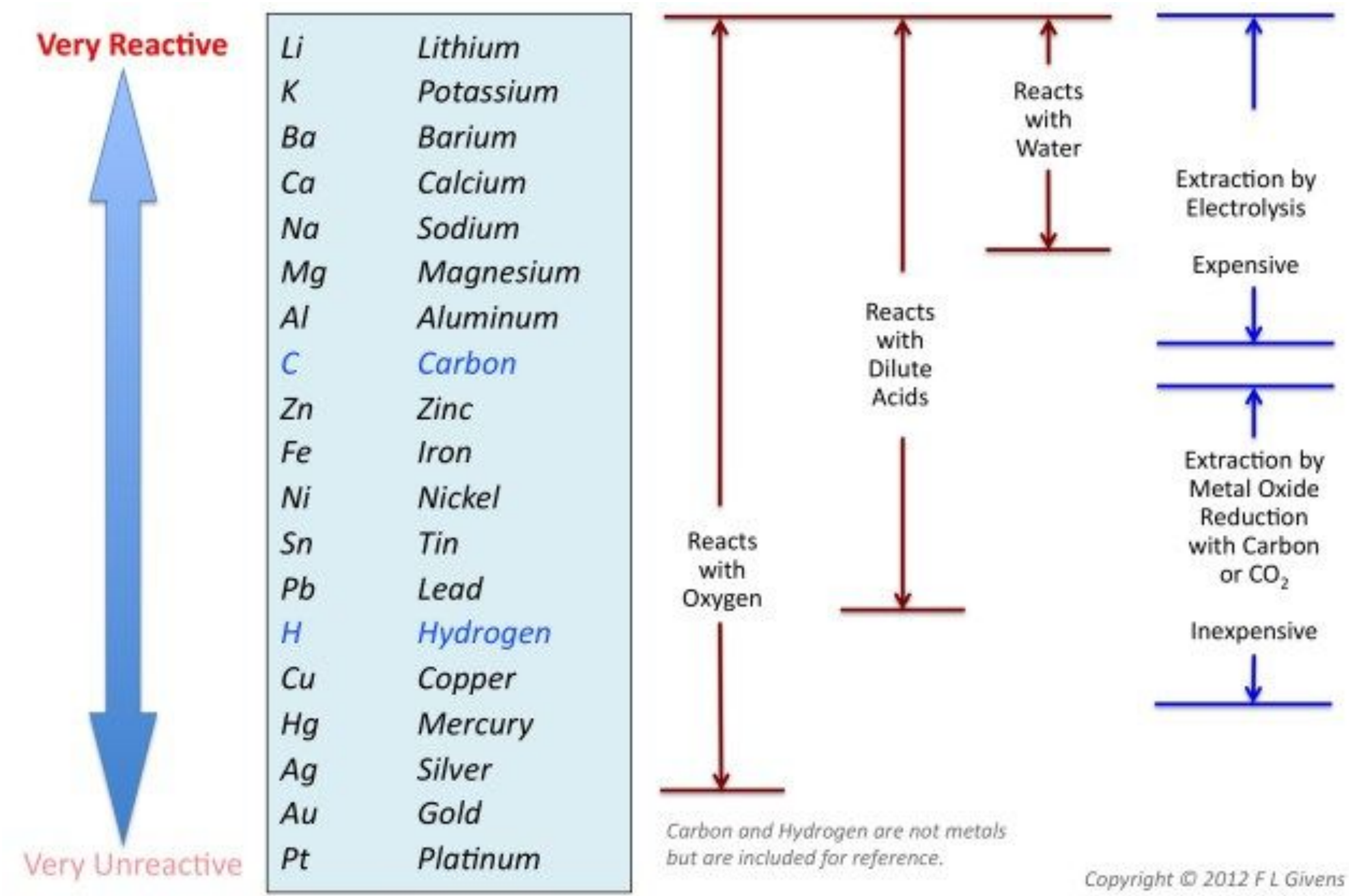



Metals
Nonmetals
Metalloids
Unknown
Increasing reactivity


Electroplating
Switch
e⁻
Cathode
e⁻
Battery
Anode
Zinc
Copper
Cu^{2+}
SO_4^{2-}
$CuSO_4 \rightarrow Cu^{2+} + SO_4^{2-}$
ChemistryLearner.com

Electroplating




Very Reactive
Very Unreactive
Li Lithium
K Potassium
Ba Barium
Ca Calcium
Na Sodium
Mg Magnesium
Al Aluminum
C Carbon
Zn Zinc
Fe Iron
Ni Nickel
Sn Tin
Pb Lead
H Hydrogen
Cu Copper
Hg Mercury
Ag Silver
Au Gold
Pt Platinum
Reacts with Oxygen
Reacts with Dilute Acids
Reacts with Water
Extraction by Electrolysis
Expensive
Extraction by Metal Oxide Reduction with Carbon or CO_2
Inexpensive
Carbon and Hydrogen are not metals but are included for reference.
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