

ANSWERS

red solution (any time you add something in equilibrium it never gets completely consumed)



Why did the addition of solid KSCN create a darker color than adding aqueous iron ion if both push the equilibrium to the right?

The KSCN will create a higher concentration of $\text{SCN}^{-}_{(aq)}$ leading to a higher production of $\text{Fe}(\text{SCN})^{2+}_{(aq)}$

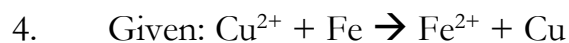
3. In the oxidation of the iron nail-lab with copper solution by consulting the table of reduction potentials, can you think of a replacement for Cu^{2+} and a replacement for iron that would lead to a very similar lab?

Make sure that the oxidizing agent (like Cu^{2+}) has a higher reduction potential than the ion that becomes the metal who will replace iron.

So you could choose Ag^{+} instead of Cu^{2+} and Sn or Zn instead of iron.

Standard Reduction Potentials at 25°C (298 K) for Many Common Half-Reactions

Half-Reaction	E° (V)	Half-Reaction	E° (V)
$\text{F}_2 + 2\text{e}^{-} \rightarrow 2\text{F}^{-}$	2.87	$\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^{-} \rightarrow 4\text{OH}^{-}$	0.40
$\text{Ag}^{2+} + \text{e}^{-} \rightarrow \text{Ag}^{+}$	1.99	$\text{Cu}^{2+} + 2\text{e}^{-} \rightarrow \text{Cu}$	0.34
$\text{Co}^{3+} + \text{e}^{-} \rightarrow \text{Co}^{2+}$	1.82	$\text{Hg}_2\text{Cl}_2 + 2\text{e}^{-} \rightarrow 2\text{Hg} + 2\text{Cl}^{-}$	0.27
$\text{H}_2\text{O}_2 + 2\text{H}^{+} + 2\text{e}^{-} \rightarrow 2\text{H}_2\text{O}$	1.78	$\text{AgCl} + \text{e}^{-} \rightarrow \text{Ag} + \text{Cl}^{-}$	0.22
$\text{Ce}^{4+} + \text{e}^{-} \rightarrow \text{Ce}^{3+}$	1.70	$\text{SO}_4^{2-} + 4\text{H}^{+} + 2\text{e}^{-} \rightarrow \text{H}_2\text{SO}_3 + \text{H}_2\text{O}$	0.20
$\text{PbO}_2 + 4\text{H}^{+} + \text{SO}_4^{2-} + 2\text{e}^{-} \rightarrow \text{PbSO}_4 + 2\text{H}_2\text{O}$	1.69	$\text{Cu}^{2+} + \text{e}^{-} \rightarrow \text{Cu}^{+}$	0.16
$\text{MnO}_4^{-} + 4\text{H}^{+} + 3\text{e}^{-} \rightarrow \text{MnO}_2 + 2\text{H}_2\text{O}$	1.68	$2\text{H}^{+} + 2\text{e}^{-} \rightarrow \text{H}_2$	0.00
$2\text{e}^{-} + 2\text{H}^{+} + \text{IO}_4^{-} \rightarrow \text{IO}_3^{-} + \text{H}_2\text{O}$	1.60	$\text{Fe}^{3+} + 3\text{e}^{-} \rightarrow \text{Fe}$	-0.036
$\text{MnO}_4^{-} + 8\text{H}^{+} + 5\text{e}^{-} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$	1.51	$\text{Pb}^{2+} + 2\text{e}^{-} \rightarrow \text{Pb}$	-0.13
$\text{Au}^{3+} + 3\text{e}^{-} \rightarrow \text{Au}$	1.50	$\text{Sn}^{2+} + 2\text{e}^{-} \rightarrow \text{Sn}$	-0.14
$\text{PbO}_2 + 4\text{H}^{+} + 2\text{e}^{-} \rightarrow \text{Pb}^{2+} + 2\text{H}_2\text{O}$	1.46	$\text{Ni}^{2+} + 2\text{e}^{-} \rightarrow \text{Ni}$	-0.23
$\text{Cl}_2 + 2\text{e}^{-} \rightarrow 2\text{Cl}^{-}$	1.36	$\text{PbSO}_4 + 2\text{e}^{-} \rightarrow \text{Pb} + \text{SO}_4^{2-}$	-0.35
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^{+} + 6\text{e}^{-} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	1.33	$\text{Cd}^{2+} + 2\text{e}^{-} \rightarrow \text{Cd}$	-0.40
$\text{O}_2 + 4\text{H}^{+} + 4\text{e}^{-} \rightarrow 2\text{H}_2\text{O}$	1.23	$\text{Fe}^{2+} + 2\text{e}^{-} \rightarrow \text{Fe}$	-0.44
$\text{MnO}_2 + 4\text{H}^{+} + 2\text{e}^{-} \rightarrow \text{Mn}^{2+} + 2\text{H}_2\text{O}$	1.21	$\text{Cr}^{3+} + \text{e}^{-} \rightarrow \text{Cr}^{2+}$	-0.50
$\text{IO}_3^{-} + 6\text{H}^{+} + 5\text{e}^{-} \rightarrow \frac{1}{2}\text{I}_2 + 3\text{H}_2\text{O}$	1.20	$\text{Cr}^{3+} + 3\text{e}^{-} \rightarrow \text{Cr}$	-0.73
$\text{Br}_2 + 2\text{e}^{-} \rightarrow 2\text{Br}^{-}$	1.09	$\text{Zn}^{2+} + 2\text{e}^{-} \rightarrow \text{Zn}$	-0.76
$\text{VO}_2^{+} + 2\text{H}^{+} + \text{e}^{-} \rightarrow \text{VO}^{2+} + \text{H}_2\text{O}$	1.00	$2\text{H}_2\text{O} + 2\text{e}^{-} \rightarrow \text{H}_2 + 2\text{OH}^{-}$	-0.83
$\text{AuCl}_4^{-} + 3\text{e}^{-} \rightarrow \text{Au} + 4\text{Cl}^{-}$	0.99	$\text{Mn}^{2+} + 2\text{e}^{-} \rightarrow \text{Mn}$	-1.18
$\text{NO}_3^{-} + 4\text{H}^{+} + 3\text{e}^{-} \rightarrow \text{NO} + 2\text{H}_2\text{O}$	0.96	$\text{Al}^{3+} + 3\text{e}^{-} \rightarrow \text{Al}$	-1.66
$\text{ClO}_2 + \text{e}^{-} \rightarrow \text{ClO}_2^{-}$	0.954	$\text{H}_2 + 2\text{e}^{-} \rightarrow 2\text{H}^{-}$	-2.23
$2\text{Hg}^{2+} + 2\text{e}^{-} \rightarrow \text{Hg}_2^{2+}$	0.91	$\text{Mg}^{2+} + 2\text{e}^{-} \rightarrow \text{Mg}$	-2.37
$\text{Ag}^{+} + \text{e}^{-} \rightarrow \text{Ag}$	0.80	$\text{La}^{3+} + 3\text{e}^{-} \rightarrow \text{La}$	-2.37
$\text{Hg}_2^{2+} + 2\text{e}^{-} \rightarrow 2\text{Hg}$	0.80	$\text{Na}^{+} + \text{e}^{-} \rightarrow \text{Na}$	-2.71
$\text{Fe}^{3+} + \text{e}^{-} \rightarrow \text{Fe}^{2+}$	0.77	$\text{Ca}^{2+} + 2\text{e}^{-} \rightarrow \text{Ca}$	-2.76
$\text{O}_2 + 2\text{H}^{+} + 2\text{e}^{-} \rightarrow \text{H}_2\text{O}_2$	0.68	$\text{Ba}^{2+} + 2\text{e}^{-} \rightarrow \text{Ba}$	-2.90
$\text{MnO}_4^{-} + \text{e}^{-} \rightarrow \text{MnO}_4^{2-}$	0.56	$\text{K}^{+} + \text{e}^{-} \rightarrow \text{K}$	-2.92
$\text{I}_2 + 2\text{e}^{-} \rightarrow 2\text{I}^{-}$	0.54	$\text{Li}^{+} + \text{e}^{-} \rightarrow \text{Li}$	-3.05
$\text{Cu}^{+} + \text{e}^{-} \rightarrow \text{Cu}$	0.52		



This reaction with the nail in direct contact was fast --- you even saw the blue color of Cu^{2+} fade. And yet the same concentration of Cu^{2+} in the battery lab created a very slow reaction? How come?

Since the Cu^{2+} is in direct contact with the nail it's much easier for electrons to transfer from the nail to the ion. In the electrochemical setup, far fewer electrons travel through a wire while ions from the bridge have to constantly maintain the ion gradient to maintain adequate voltage.

5. How many measurements do you need in the lab to get a weak acid's K_A ? What equipment is needed for each measurement?

You need a pH which ideally should be measured with a meter, but given that we spent the money on a barely-used telescope (and the bouncy things for grade 7s too), we had to use pH paper.

The equilibrium concentration of the weak acid can be figured out from its volume and from measuring

the base's volume during a neutralization. To apply $n = CV$ to the base we also needed to know its concentration.

6. Are any sig fig errors being made at any stage in solving this problem? Why or why not?

Problem: Calculate the quantity of electricity (Coulombs) necessary to deposit 100.00 g of copper from a CuSO_4 solution. Analyze all three steps.

Solution:

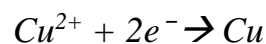
1) Determine moles of copper plated out:

$$100.00 \text{ g divided by } 63.546 \text{ g/mole} = 1.573663 \text{ mol}$$

No mistakes. These guys are good.

They used at least 5 SF in the molar mass to match the 5Sf of 100.00 g, and they are not rounding off prematurely.

2) Determine moles of electrons required:



therefore, every mole of Cu plated out requires two moles of electrons.

$$1.573663 \text{ mol} \times 2 = 3.147326 \text{ mol } e^- \text{ required}$$

No mistakes. These guys are still good.

They carried on the full no-rounded answer from the previous step and 2 is an exact number so it will not affect anything later on.

3) Convert moles of electrons to Coulombs of charge:

$$3.147326 \text{ mol } e^{-} * 96,485.309 \text{ C/mol} = 3.0367 \times 10^5 \text{ C}$$

No mistakes. These guys are still good.

The final answer has 5 SF, even though the C/mol had 8Sf. We have to go with the measurement used in the calculation that has the least SF, which would be the emolar mass and mass, both with 5SF