CHE 1302

Basic Principles of Modern Chemistry II

Week 15

Hello and welcome to the weekly resources for Chemistry 1302! This resource covers topics typically taught by professors during the 15th week of classes.

On our website, https://baylor.edu/tutoring, you'll find the following links:

"Online Study Guide Resources" – If you don't see the topics you're learning right now, click here to find the weekly resources for the rest of the semester!

"How to Participate in Group Tutoring" - See if there is a Chemistry 1302 group tutoring session being hosted this semester – these are weekly question/answer sessions taught by our master tutors!

You can also view tutoring times for your course or schedule a private 30-minute appointment! Check out the website to learn more. You can also give us a call at (254)710-4135, or drop in. Our hours are Monday-Thursday 9 am – 8 pm on class days.

KEY WORDS: Balancing Redox Reactions, Nonstandard Cells, Standard Reduction Potentials

TOPIC OF THE WEEK: Worked Example: Balancing Redox Reactions

Balance the following oxidation-reduction reaction that will occur in an acidic solution:

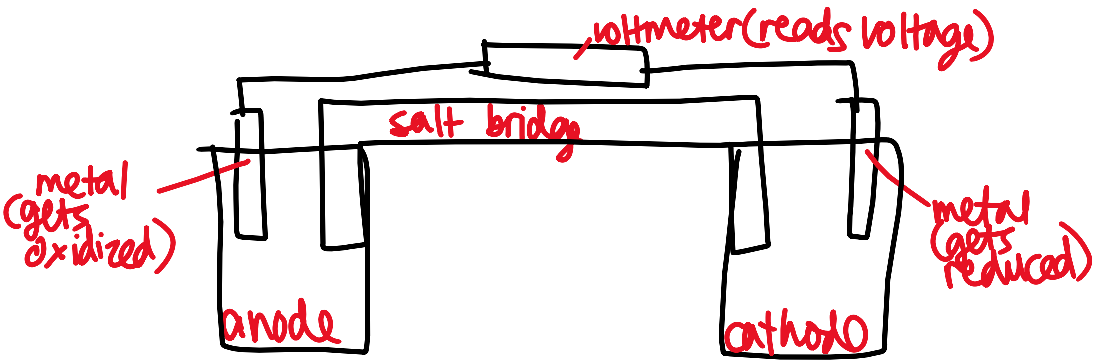
$$Br^{-}_{(aq)} + MnO_4^{-}{}_{(aq)} \rightarrow MnCl^{2}_{(aq)} + Br_{2\,(l)} + Mn^{2+}_{(aq)}$$

HOW TO SOLVE:

1. Calculate oxidation numbers. Which species is being oxidized, and which reduced? (Br- and MnO4 here) Write them out as half reactions ($Br^{-}_{(aq)} \rightleftharpoons Br_{2\,(l)}$ & $MnO_4^{-} \rightarrow Mn^{2+}$…notice that **spectator ions have been left out**)
2. Balance the half reactions. Balance the half-reactions. Keep in mind: **can change the coefficients but not the subscripts**!
    a. H_2O to balance oxygen, then H^+ for hydrogen.
    b. Balance the charge by ensuring the total charge on the right-hand side is equal to that on the left-hand side for each half-reaction.
    c. Your balanced half-reactions should be as follows: $2Br^{-}_{(aq)} \rightleftharpoons Br_{2\,(l)} + 2e^{-}$ (Oxidation half-reaction) $MnO_4^{-} + 8H^{+} + 5e^{-} \rightarrow Mn^{2+} + 4H_2O$ (Reduction half-reaction)

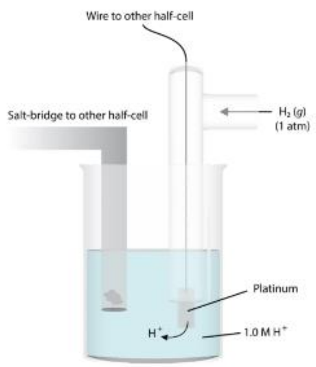
3. In order to combine the half reactions to give the overall redox reaction, make the number of electrons equal in both cases by multiplying the oxidation half-reaction by 5 and the reduction half-reaction by 2.
4. Cancel out similar species on both left- and right-hand side of the equation (none in this situation) to get the overall redox reaction. $2MnO_4^- + 10Br^- + 16H^+ \rightarrow 5Br^{2+} + 2Mn^{2+} + 8H_2O$

Highlight 1: Reduction Potential



Reduction potential measures how likely reduction is to occur at an electrode, **relative to the Standard Hydrogen Electrode (SHE)**. In other words, it measures how likely reduction is to occur for some half reaction, if the other half reaction is the hydrogen cell shown below. The SHE is used as a reference—a half cell can't be set up by itself—and assigned a value of 0 V.

The SHE, from https://byjus.com/chemistry/standard-hydrogen-electrode/:



Negative reduction potential: wants to **oxidize** (harder to reduce than hydrogen)

Positive reduction potential: wants to **reduce** (easier to reduce than hydrogen)

Each electrode has a reduction potential; the potential of the cell can be calculated by adding two quantities:

$E^o_{cathode}$ (how likely the **cathode** is to **reduce**)

$-E^o_{anode}$ (how likely the **anode** is to **reduce**. If the anode **"wants" to oxidize**, as is favorable for the cell, this will be a **negative** value. Multiply this by negative 1, to get a positive value: The more negative the anode's reduction potential, the better it is at its oxidizing job.)

The total: $\boldsymbol{E^o_{cell} = E^o_{cathode} - E^o_{anode}}$

If this total is positive (if the cathode "wants" to reduce, and the anode "wants" to oxidize), the process is spontaneous.

*Note: When balancing equations, do not change E^o. If you have to change the stoichiometric coefficients, E^o will still stay the same.

An electrochemical cell can be abbreviated using a line notation that shows the **anode on the left** and the **cathode on the right**.

> For example, $Cu_{(s)}|Cu^{2+}_{(aq)}||Ag^{+}_{(aq)}|Ag_{(s)}$ is the line notation for the galvanic cell shown in the figure above. "|" stands for phase boundary and "||" represents salt bridge or porous barrier separating two half-cells.

Highlight 2: Nonstandard Cells

This equation is the Nernst equation:

$$E_{cell} = E^o_{cell} - \left(\frac{RT}{nF}\right) lnQ = E^o_{cell} - \left(\frac{0.0592}{n}\right) lnQ$$

Where F=96485 C/mol, and R=8.3145 J/mol*K

Scroll down a little on this page and you'll find its derivation: https://chemistrytalk.org/nernst-equation/#:~:text=The%20Nernst%20equation%20is%20derived%20from%20the%20Gibbs,the%20Nernst%20equation%20as%20it%20is%20commonly%20written.

The tabulated standard values (E^o) apply to cells at standard temperature and pressure, and it assumes that the reaction has reached equilibrium. If any of these are not the case, the Nernst equation can be used to adjust the standard potentials.

Highlight 3: Study Tips

Start studying for the final early – this will allow you to practice spaced and interleaved studying, which are proven effective techniques!

Spaced studying: Many short study periods is better than fewer longer study periods. The more times you practice recalling something, the better – recall is what you'll have to do on the exam, and each time you make your brain trace the path to find that information, the faster and easier it will become. If you allow time between study periods to begin forgetting the material, and then you relearn it, your ultimate ability to recall the information will last longer.

Interleaved studying: Interleaved studying is a special kind of spaced studying for which you alternate between subjects. Study some chemistry, then study Spanish, then bio, then come back to chemistry… this way, you can give certain parts of your brain a break while staying productive. For me, this helps with focus – it's harder to get off track if the time periods are smaller (try 30 minutes per subject). Also, you start to forget what you learned from subject while you study the other…which is good! It increases ultimate retention time, just like other types of spaced studying.

Last study tip for now: Get excited! Even if you don't want to study chemistry in the future, it'll be easier to remember if you focus on the interesting aspects. It's hard to feel invested in material when there's a lot going on – don't forget to do things that you know will help with stress. Studying is great, but if you overdo it, it won't be as effective!

Check Your Understanding

1. Balance the following oxidation-reduction reaction that will occur in a basic solution: Al(s) + MnO4 - (aq) → MnCl2(aq) + MnO2(s)(l) + Al(OH)4 - (aq)
2. A galvanic cell is based on the following half-reactions at 25oC. $Ag^+ + e^- \rightarrow Ag$ and $H_2O_2 + 2H^+ + 2e^- \rightarrow$2H2O Predict whether E_{cell} is larger or smaller than E^o_{cell} for the following cases:
   a. [Ag+] = 1.0 M, [H2O2] = 2.0 M, [H+] = 2.0 M
   b. [Ag+]=2.0M,[H2O2]=1.0M,[H+]=1.0x10-7 M

Things You May Struggle With

1. Practice identifying the species being reduced and oxidized in each redox reaction equation. Contrast with reducing agent/oxidizing agent.
2. Make sure you subtract anode from cathode when calculating cell potential!
3. Remember the proper equations for finding parameters in electrochemistry.
4. Don't forget to balance the redox equation before getting the value of n (number of moles of electrons) needed to substitute into the Nernst equation.

That's all this week! Please reach out if you have any questions and don't forget to visit the Tutoring Center website for further information at www.baylor.edu/tutoring. Answers to the Check Your Learning section are below.

1. Al(s) + MnO4 - + 2H2O(l) → MnO2(s) + Al(OH)4-(aq)
2. Use Nernst equation. You'll need the standard reduction potential – make two half cell equations and balance them, then find the potential for each. Use this to find the balanced equation for the cell: $2Ag^+(aq) + H_2O_2\ (aq) + 2H^+(aq)\ 2Ag(s) + 2H_2O(l)\ E^o = 0.98$. Now, plug in the concentrations to find Q.
   a. lnQ is negative, so E_{cell} is larger
   b. lnQ is positive, so E_{cell} is smaller