

To our teachers:

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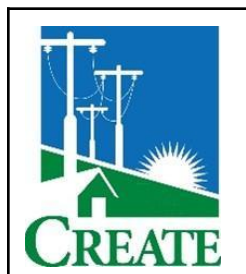
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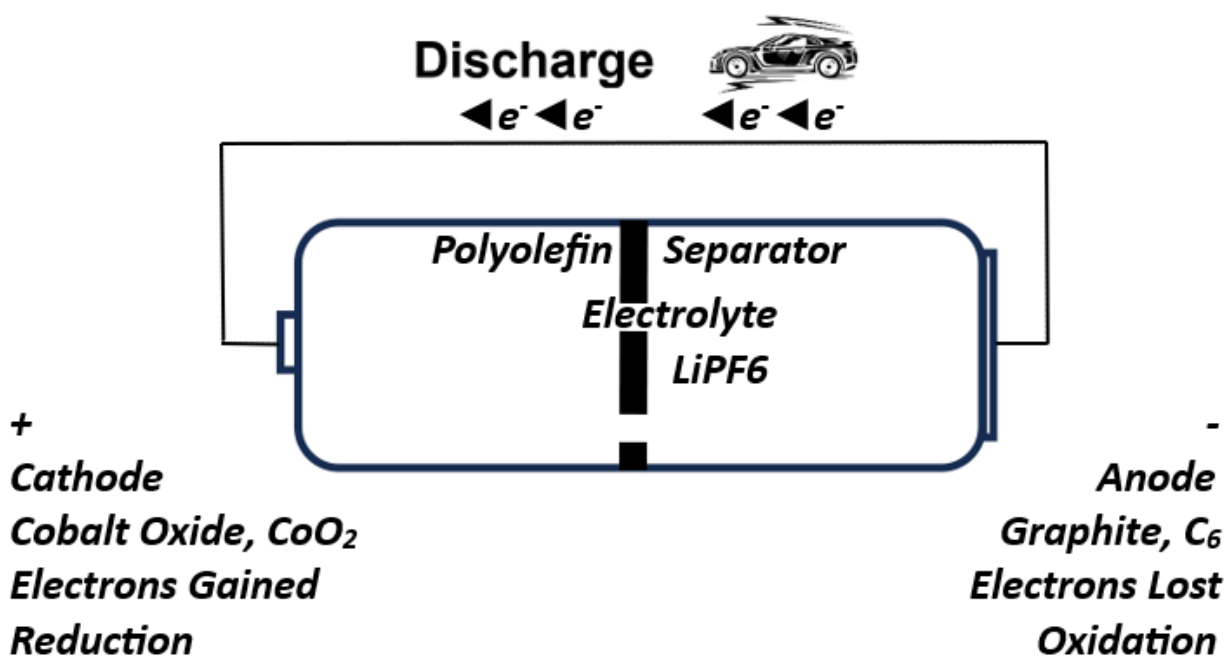


Wisconsin Public Service
SolarWise for Schools
and the
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BATTERY BASICS:

CHAPTER THREE – THE SECONDARY BATTERY

INSTRUCTOR ANSWER KEY



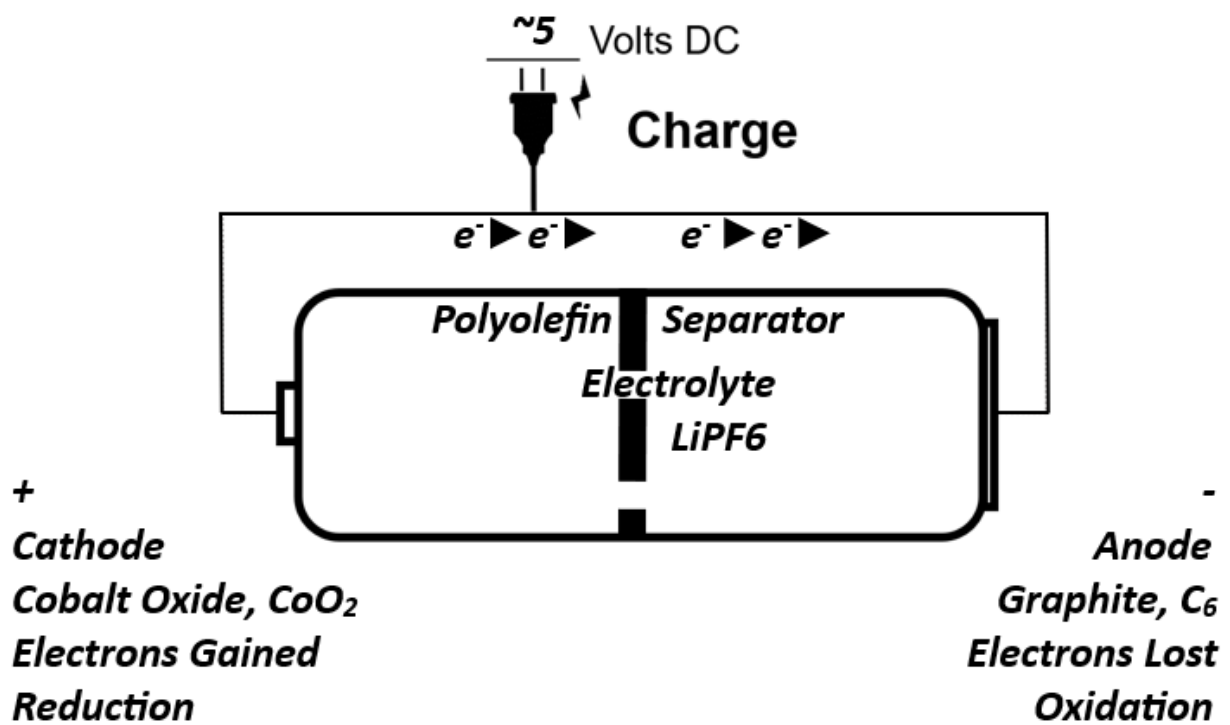
Battery Discharging

Write and draw on the picture from the preceding page according to the directions that follow. For digital submission, take a cell photo of your completed picture, delete our picture, and paste your photo in its place.

1. Write **+** (a positive sign) at the terminal, or electrode, that is positive.
2. Write **Cathode** at the electrode that is called the cathode.
3. Write **—** (a negative sign) at the electrode that is negative.
4. Write **Anode** at the electrode that is called the anode.
5. Draw a **wired electrical circuit** connecting anode to cathode. The load for this battery, and several thousand more just like it, is the EV already drawn.
6. Draw several **e⁻** (electrons) flowing through your electrical circuit. Indicate the direction of their flow with **→** (an arrow).
7. Write **Graphite, C₆** at the electrode where it is found.
8. Write **Electrons Lost** at the electrode where electrons are lost.
9. Write **Oxidation** at the electrode where oxidation takes place.
10. Write **Cobalt Oxide, CoO₂** at the electrode where it is found.
11. Write **Electrons Gained** at the electrode where electrons are gained.
12. Write **Reduction** at the electrode where reduction takes place.
13. Write **Electrolyte, LiPF₆** where it is likely to be found.
14. Draw a *separator* where it is likely to be found. Label it **Polyolefin Separator**.
15. In your own words, explain the function of the electrolyte.

“As you’ve been taught, every battery must have a well-chosen electrolyte. The electrolyte provides two important functions. One, it allows for the movement of ions through the electrolyte. Two, it prevents the transfer of electrons through it.

To move from the anode to cathode—or back during recharging—electrons must use a wired electrical circuit for their path.”



Battery Charging

Stop the video! before watching how the battery charging process works (about 6:00). Complete drawing and labeling steps 1-14 before viewing the rest of the video. All of the steps are the same *except for number 6*. Then restart the video and finish your drawing and labeling beginning with step 15. For digital submission, take a cell photo of your completed picture, delete our picture, and paste your photo in its place.

1. Write **+** (a positive sign) at the terminal, or electrode, that is positive.
 2. Write **Cathode** at the electrode that is called the cathode.
 3. Write **—** (a negative sign) at the electrode that is negative.
 4. Write **Anode** at the electrode that is called the anode.
 5. Draw a **wired electrical circuit** connecting anode to cathode.
 6. **Do not draw several e^- (electrons) flowing through your electrical circuit yet!**
 7. Write **Graphite, C_6** at the electrode where it is found.
 8. Write **Electrons Lost** at the electrode where electrons are lost.
 9. Write **Oxidation** at the electrode where oxidation takes place.
 10. Write **Cobalt Oxide, CoO_2** at the electrode where it is found.
 11. Write **Electrons Gained** at the electrode where electrons are gained.
 12. Write **Reduction** at the electrode where reduction takes place.
 13. Write **Electrolyte, $LiPF_6$** where it is likely to be found.
 14. Draw a *separator* where it is likely to be found. Label it **Polyolefin Separator**.
-
15. A cord with a plug on the end of your **wired electrical circuit** symbolizes that this battery and several thousand more just like it, are being charged in the EV. On the blank just above the plug, indicate approximately how many Volts of Direct Current are used to charge the Battery.
 16. Draw several e^- (electrons) flowing through your electrical circuit during the *charging process*. Indicate the direction of their flow with $\rightarrow$ (an arrow).
-

17. In your own words, explain the function of a Battery Management System (BMS).

“Overcharging can cause physical damage and harmful side reactions to occur at the graphite anode. And over *dis*charging can cause physical damage and harmful side reactions to occur at the cobalt oxide cathode. For these reasons almost every kind of lithium-ion rechargeable battery includes some type of battery management system to limit both charging and discharging to within a safe range. This protects the health of the battery materials and promotes longer battery life.”

18. In your own words, explain the function of a Thermal Management System (TMS).

“Surely you’ve noticed that your cell phone gets warm when it’s charging. In larger batteries the amount of heat released can be quite large. That’s why many larger lithium-ion battery applications also employ a thermal management system, to measure and maintain a stable battery operating temperature.”

19. You learned at the conclusion of the video that there are several kinds of lithium-ion renewable battery chemistries and battery types. Each has its own advantages, disadvantages, and applications. This means those who make products powered by rechargeables have different choices available from which to make their “preferred” or “best” battery choice for use in their products.

Do a little research on your own. Describe a current focus of research to improve rechargeable lithium-ion battery technologies or their uses.

Write at least one good paragraph in your description. Your writing must:

- Explain why this interesting to you
- Have an introductory sentence (or two)
- End with a concluding sentence (or two)
- Give details in the middle providing a clear understanding of the research and its purpose
- Be complete, but brief
- Be clear
- ...and most importantly, be written in your own words.

Begin writing here: ***

Of course, many different student answers are possible here. Consider modifying the writing prompts above (decreasing or increasing some of them) to match what you want to accomplish with your students.

