# Year 12 Science: The chemistry behind the lithium-ion battery

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

## Practice

1. Write the oxidation half equation at the graphite electrode during discharge.

2. Give the oxidation number of cobalt in $CoO_2$ and in $LiCoO_2$, and say whether cobalt is oxidised or reduced on discharge.

3. Explain why water cannot be used as the solvent in the electrolyte.

4. Explain why Yoshino's carbon electrode made the battery safer than Whittingham's.

5. A laptop battery is labelled 11.1 V and 4.0 Ah. How many 3.7 V cells are in series, and how much energy does it store in Wh?

## Fix the mistake

6. Correct this statement: "Electrons travel through the electrolyte from one electrode to the other."

7. Correct this statement: "The lithium-ion battery runs out because the lithium gets used up."

8. Correct this statement: "My report lists the history and the equations in separate sections."

9. Correct this statement: "$CoO_2 + e^- \rightarrow LiCoO_2$ is the reduction half equation."

## Answer key (for parents and tutors)

1. Write the oxidation half equation at the graphite electrode during discharge.
   **$LiC_6 \rightarrow C_6 + Li^+ + e^-$.**
2. Give the oxidation number of cobalt in $CoO_2$ and in $LiCoO_2$, and say whether cobalt is oxidised or reduced on discharge.
   **+4 in $CoO_2$ and +3 in $LiCoO_2$; cobalt gains an electron, so it is reduced.**
3. Explain why water cannot be used as the solvent in the electrolyte.
   **The cell runs at about 4 V, far above the 1.23 V that splits water, and lithium reacts with water to make hydrogen: $2Li + 2H_2O \rightarrow 2LiOH + H_2$.**
4. Explain why Yoshino's carbon electrode made the battery safer than Whittingham's.
   **Carbon holds lithium as ions between its layers, so no lithium metal is deposited on charging and no dendrites grow to short-circuit the cell.**
5. A laptop battery is labelled 11.1 V and 4.0 Ah. How many 3.7 V cells are in series, and how much energy does it store in Wh?
   **11.1 ÷ 3.7 = 3 cells; energy = 11.1 V × 4.0 Ah = 44.4 Wh.**
6. Correct this statement: "Electrons travel through the electrolyte from one electrode to the other."
   **Electrons go through the external circuit; only ions, $Li^+$, move through the electrolyte and separator.**
7. Correct this statement: "The lithium-ion battery runs out because the lithium gets used up."
   **The lithium ions just move to the other electrode; recharging moves them back. Cells wear out slowly through side reactions.**
8. Correct this statement: "My report lists the history and the equations in separate sections."
   **Merit and Excellence need links: say which chemical property caused each design change, and evaluate the trade-off.**
9. Correct this statement: "$CoO_2 + e^- \rightarrow LiCoO_2$ is the reduction half equation."
   **The lithium has to appear on both sides: $CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$, balanced for atoms and charge.**