Where Do Our Used Batteries Go?

Older models of batteries are designed to use series of galvanic cells to convert chemical energy into electrical energy. Traditional examples include the lead acid battery in gasoline/diesel fueled cars and other small appliances. These batteries are often useful but are single-use only. As a result of being single-use, these batteries will ultimately end up in municipal waste facilities. The metals which are used in traditional batteries are a cause for concern for environmentalists as some of these materials can contaminate water supplies or otherwise be harmful to the environment if mishandled. With newer lithium-ion and other rechargeable batteries, fewer cells end up in waste facilities per year as these batteries typically have lifespans of 3-5 years. However, there are scenarios in which large amounts of lithium-ion battery cells also end up in waste facilities. Imperfections in the battery cells can lead to structural compromise and ultimately cell damage. This occurred in 2016 when Samsung released a new phone that had faulty batteries which were found to combust under certain circumstances, releasing large amounts of CO_2 and CO. Samsung has since paid $5.8 billion CAD over damages and recall costs and has since scrapped all pre-existing battery cells for recycling purposes.

Figure 1(https://www.mirror.co.uk/tech/samsung-take-note-new-lithium-13116610)

Recycling Process

The recycling process is similar for all battery types. Batteries are crushed in large batches so that the plastics can be separated from the inner components. The electrolytes are neutralized, and the metal components are separated using specific techniques for each respective metal. For lithium ion batteries, the metals are smelted and extracted. Through this process metals such as iron, nickel, manganese, and cobalt can be recovered and ultimately reused for other purposes.

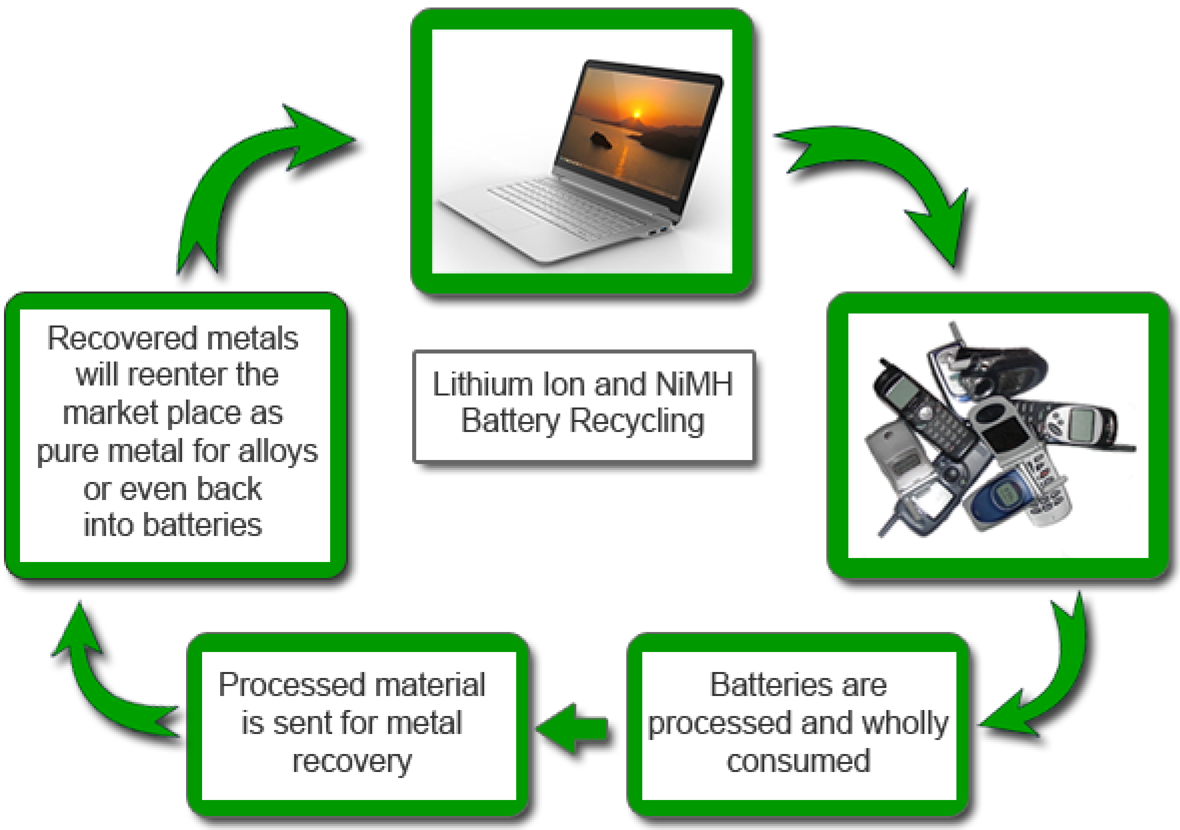

Figure 2http://www.recyclingcoordinators.com/batteries.html

Dangers of Recycling

Currently there is little being done to educate people about how to recycle their used batteries. It costs too much to separate batteries from everyday waste, yet many types of batteries contain toxic materials such as cobalt and mercury which are pollutants if not disposed of properly. Even if batteries are brought to proper recycling facilities they are often without labels regarding the contents and specific metals inside them. This can lead to dangerous situations involving lithium ion batteries, which contain highly flammable materials. Typically, these unlabelled batteries may require other preliminary tests to determine what metals and materials are inside so that the appropriate measures can be taken during the recycling process.

Student Instructions

You are an electrochemist working in an analytical lab that recycles old batteries. Your routine job is to analyze samples of metals to identify and properly store each metal to be recycled for other purposes. You are given four unknown metal samples and have been asked to identify them. Your task today is to construct a galvanic cell using the provided materials and identify your sample of four metals using your electrochemistry background.

Consider possible methods that a recycling facility could use in order to deal with mislabelled batteries. Think of possible ways that you could use to construct a simple, low-cost setup to qualitatively identify metals. You may want to consider how to incorporate table 1 into your methodology.

Table 1: Provided Reactions and Standard Reduction Potentials

Reactions	Standard Reduction Potentials E°(V)
$Fe^{+2} + 2e^{-} \rightarrow Fe$	-0.41
$Cu^{+2} + 2e^{-} \rightarrow Cu$	0.34
$Mg^{+2} + 2e^{-} \rightarrow Mg$	-2.38
$Zn^{+2} + 2e^{-} \rightarrow Zn$	-0.76

Student Questions

1) Once you have identified each of the unknown metal samples: A, B, C, and D, provide the shorthand notation of the following chemical cells.

A + B|

C+D|

2) Label each metal in question (**1**) as either the anode or cathode and briefly explain your reasoning.

3) Using the half-reactions in (**1**), write the equations for the complete redox reactions and calculate the cell potentials using Table 1.

4) How do your calculated potentials compare to your measured potentials? If they are different, provide a reason for this.

5) Which metal has the greatest potential to be oxidized?

6) What makes these chemical cells non-reversible? Give one example of any battery that is rechargeable and briefly explain some of the features that make it rechargeable.

7) Given the background information on battery recycling and your test results of determining the identity of each metal. Would this method be a suitable way to identify the metals inside an unlabelled battery in the real world? What might be some risks associated with this method?