Proposed introduction or description—take this as a suggestion:

This article describes an engaging, thought-provoking capstone activity for the Redox/Electrochemistry unit in AP Chemistry[1]. It may be used as a homework assignment, a collaborative in-class assignment, or as a challenging test or exam question.[2] It can also be used as a hands-on and MINDS-ON laboratory activity or teacher demonstration. (See footnote 4)

Students will need access to a fulsome table of Standard Reduction Potentials.[3]

Answers to the questions, and the student-ready assignment may be found in the supplementary materials.

A Knowledge of Electrolysis Thwarts a Scam

A salesman knocks at your door selling home water distillers.

Figure 1. The electrolysis apparatus used by the door-to-door salesman. Note that it can simultaneously electrolyze two solutions.[4]

He claims that your municipal tap water contains dissolved heavy metal ions, which can be removed when you use his fancy-schmancy distiller. When you question the salesman, he produces an electric-powered gizmo, pictured above, that supposedly precipitates heavy metal cations in your tap water. He does a side-by-side test (see the two drinking glasses above) using your municipal tap water and distilled water produced by the home distiller. After a short while, you notice a brown precipitate, whose amount increases with time, forming in the tap water. The distilled water (from his high-priced distiller), of course, does

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[1] Also suitable for IB-HL and College-level General Chemistry

[2] I heard this at a talk delivered by Dr Joe Schwartz of McGill University many years ago. I was unable find the reference on-line.

[3] For example, see D Ebbing and S Gammon, General Chemistry, 10th edition, Brooks/Cole, Cengage Learning, Belmont California, pp A-16.

[4] Water Electrolyzer Quick Water Quality Tester Canada | Ubuy

not react and remains precipitate-free. He then puts the arm on you to buy his expensive home distiller, so that "you, too, can enjoy *pure* water".

You smell a rat.

Instead of buying the home distiller, you manage to purchase the gizmo (Figure 1), which you believe the salesman used to create some kind of electrolytic cell.

You bring the electrolysis apparatus to the Chemistry lab and conduct some experiments.

Here are your findings:

- The electrolysis apparatus (Figure 1) converts AC to DC
- Of each pair of electrodes, one is iron, the other is aluminium
- The brown precipitate produced in the tap water is determined to be $Fe(OH)_3$[5]
- The quantity of $Fe(OH)_3$ increases in direct proportion to how long a current is passed through the tap water
- In the tap water, bubbles are produced at the Al electrode
- There is no visible reaction in the distilled water sample

Questions

1. a) Why was a reaction observed in the tap water sample and NOT with the distilled water? {2}

2. a) Sketch a fully labelled diagram of the electrolytic cell occurring in the tap water. Include the relevant half equation for each electrode. Label each electrode as either Fe or Al; indicate which is the anode and cathode; label their respective polarities. Show the direction of electron and ion movement. {6}

   b) Provide the balanced chemical equation for the overall reaction; calculate ϵ^{o}_{cell}. {2}

—fin—

[5] Iron(III) oxide-hydroxide - Wikipedia