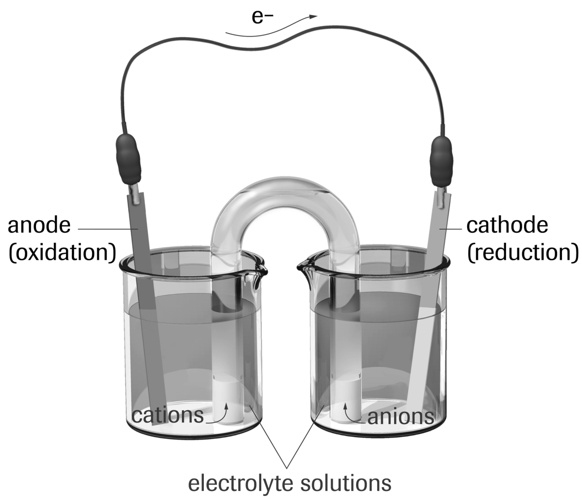
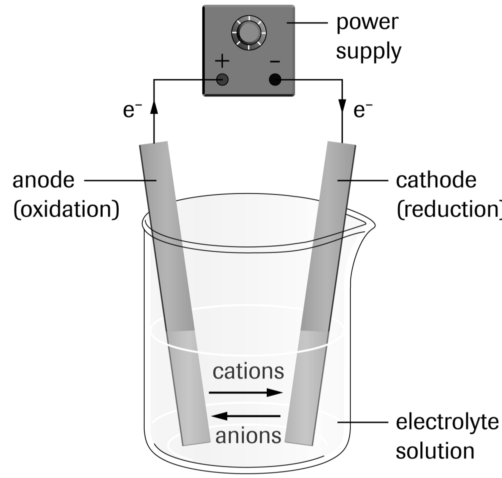
2. (a)





(b) Applications of galvanic cells:
batteries
fuel cells
corrosion

(c) Applications of electrolytic cells:

Application	Anode	Cathode	Electrolyte
electrorefining	impure copper	pure copper	a soluble copper compound such as copper(II) sulfate
production of aluminum	graphite	graphite	cryolite
gold plating	gold	object to be plated	a soluble gold compound such as gold(III) chloride

UNIT 5 PERFORMANCE TASK: BUILDING AN ELECTRICAL INVENTION

(Pages 442–443)

The following is a sample Performance Task report.

INVENTION: FRUIT CELLS

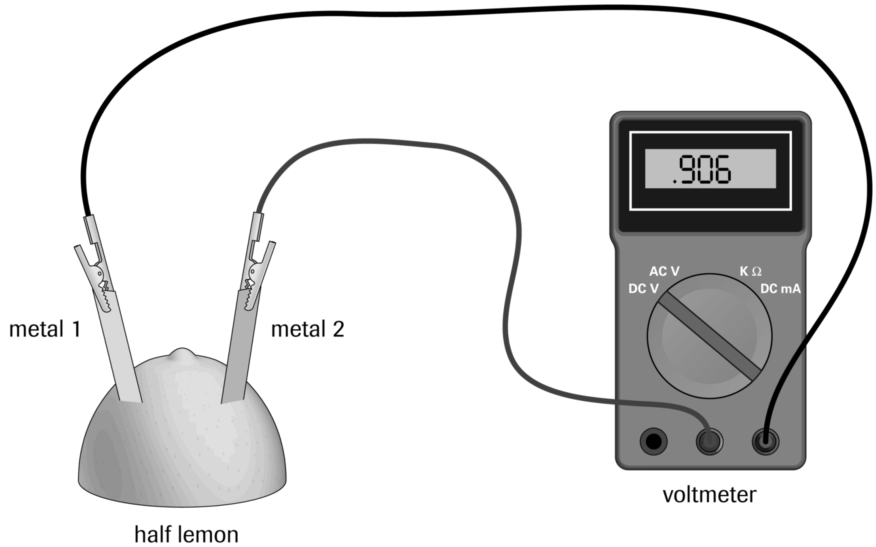
Planning and Proposal

(a) **Preparation**
In this performance task, I will construct galvanic cells using different metals and fruit to see how many fruit cells it takes to light an LED. Research indicates that citrus fruits are usually a good choice, and that several pieces of fruit will be needed, connected in series.

(b) **Proposal**

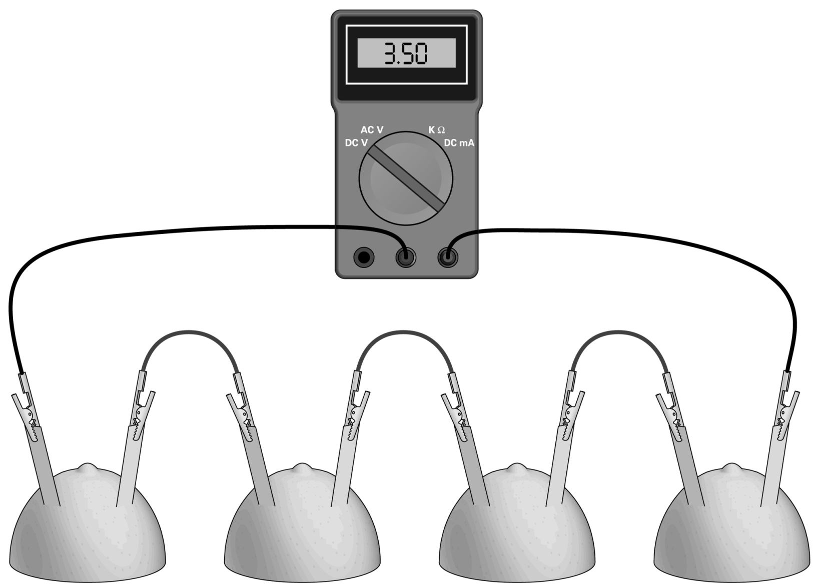
Experimental Design

I will first experiment to see which type of fruit gives the largest cell potential.



I will then use the "best" fruit to test pairs of metals to see which ones give the largest cell potential. The metal pair and fruit with the largest cell potential will then be used to light an LED. I will use as many fruit cells as necessary, in series, to light an LED.

There are no particular safety concerns associated with this experimental design.



Materials

lemon
orange
banana
apple
lime
grapefruit
three 8-cm strips of magnesium
3 galvanized nails (to be used as zinc electrodes)
3 pennies (to be used as copper electrodes)

steel wool or sandpaper
LED
connecting wires
digital multimeter and connecting wires

Principles of Operation

The fruit cell is an example of a galvanic cell. The oxidation of one electrode releases electrons. These electrons flow through an electrical load, such as a light or buzzer, to the cathode where they participate in a reduction reaction. Since each fruit sample is a complex mixture of chemicals, it will be difficult to make accurate predications about the reduction reactions occurring in them. The fluid in the fruit is an electrolyte solution, which completes the internal circuit of the cell. Positive ions (cations) in the fruit flow toward the cathode while negatively charged ions (anions) flow toward the anode. Ions in the fruit are essential for the fruit cell to operate. As we learned in Section 5.9, connecting cells in series results in a cell whose potential is the sum of the cell potentials of the individual cells.

Development

(c) **Procedure**

Part 1: Which Fruit Gives the Largest Cell Potential?

1. Clean the metals with sandpaper to remove any oxide coating.
2. Insert a galvanized nail and a penny, about 5 cm apart, into a lemon. Be sure that the metals do not touch inside the fruit.
3. Connect the electrodes to a voltmeter and measure the cell potential.
4. Repeat steps 1 and 2 for each of the other fruit samples. Clean the metals before inserting them into the next fruit sample.
5. When the fruits are no longer required for the investigation, they can be composted. The metals can be rinsed and reused.

Part 2: Which Metal Combinations Give the Largest Cell Potential?

1. Insert the galvanized nail and penny 5 cm apart into the fruit that had the largest cell potential in Part 1.
2. Connect the electrodes to a voltmeter and measure the cell potential.
3. Repeat steps 6 and 7 for all the other metal combinations.
4. When the fruits are no longer required for the investigation, they can be composted. The metals can be rinsed and reused.

Part 3: How many cells will it take to light the LED?

1. Make two fruit cells, using the fruit and pair of metals that gave the largest cell potential.
2. Connect the cells in series, then connect them to the LED. Connect a voltmeter in parallel with the cells.
3. If the LED does not light, connect another cell, in series, to the first two. Continue adding cells until the LED lights.
4. When the fruits are no longer required for the investigation, they can be composted. The metals can be rinsed and reused.

(d) **Building and Testing**

Observations

Part 1 Cell Potentials of Various Fruit Tested with Zn and Cu Electrodes

Type of Fruit	Cell potential (V) of Zn/Cu cell
lemon	0.82
apple	0.80
orange	0.83
banana	0.80
strawberry	0.79
lime	0.87
grapefruit	0.80

Part 2 Cell Potentials of Various Metal Combinations in a Lime

Metal combinations	Cell potential (V)
Mg/Cu	1.87
Zn/Cu	0.87
Mg/Zn	0.35

Part 3 Total Potentials of Mg/Cu–Lime Cells in Series

Number of cells	LED brightness	Cell potential (V)
1	not lit	1.87
2	lit	3.60
3	lit slightly brighter	5.21

Marketing

(e) Students should devise a variety of creative formats to market their inventions: poster, magazine advertisement, radio commercial, TV infomercial, sports team sponsorship, etc.

UNIT 5 REVIEW

(Pages 444–447)

Understanding Concepts

1. (a) The gain of electrons is called *reduction*.
   (b) The loss of electrons is called *oxidation*.
   (c) An element's oxidation number *increases* when the element is oxidized.
   (d) An element's oxidation number *decreases* when the element is reduced.
2. Reactant oxidized — Reactant reduced
   (a) $Zn_{(s)}$ — $Cl_{2(g)}$
   (b) $Ca_{(s)}$ — $O_{2(g)}$
   (c) $Zn_{(s)}$ — $Cu^{2+}_{(aq)}$
   (d) $Zn_{(s)}$ — $Ag^{+}_{(aq)}$ (in $AgNO_{3(aq)}$)
   (e) $Al_{(s)}$ — $Fe^{3+}_{(s)}$ (in $Fe_2O_{3\,(s)}$)
   (f) $H_{2(g)}$ — $O_{2(g)}$
   (g) $Mg_{(s)}$ — $CO_{2(g)}$
   (h) $I^{-}_{(aq)}$ (in $KI_{(aq)}$) — $Cl_{2(g)}$