UNIT 1 PERFORMANCE TASK: IDENTIFYING THE IONS IN A MYSTERY SOLUTION

(Pages 68–70)

Prediction

(a) If the mystery solution contains ions, it will conduct electricity. When electrodes attached to the positive and negative terminals of a battery are placed in the solution, the positively charged electrode attracts the negatively charged ions, and the negatively charged electrode attracts the positively charged ions. The movement of ions causes current to flow through the solution.

(b) If all three of the ions are present, the silver ions will precipitate as silver acetate, $AgC_2H_3O_{2(s)}$, the copper(I) ions will precipitate as copper(I) chloride, $CuCl_{(s)}$, and the barium ions will precipitate as barium sulfate, $BaSO_{4(s)}$, according to the following net ionic equations:

$$Ag^+_{(aq)} + C_2H_3O_2{}^-_{(aq)} \rightarrow AgC_2H_3O_{2(s)}$$

$$Cu^+_{(aq)} + Cl^-_{(aq)} \rightarrow CuCl_{(s)}$$

$$Ba^{2+}_{(aq)} + SO^{2-}_{4(aq)} \rightarrow BaSO_{4(s)}$$

(c) If silver acetate is subjected to a flame test, the flame colour will not be affected. If copper(I) chloride is subjected to a flame test, the colour of the flame will be light blue-grey. If barium sulfate is subjected to a flame test, the colour of the flame will be yellow-green.

Experimental Design

(d) **Part A:** Determine whether the solution contains ions by using conductivity apparatus and equipment to test if the solution conducts electricity. **Part B:** Determine which ions (copper(I), silver, and/or barium) are present in the solution using precipitation reactions. **Part C:** Confirm the identity of the ions present in solution by subjecting their precipitates to flame tests, observing the characteristic colours of the flame, and comparing these colours to those in a flame test identification key.

Materials

(e) Student answers will vary. Some key equipment and materials include:

mystery solution
sodium acetate solution, $NaC_2H_3O_{2(aq)}$
sodium chloride solution, $NaCl_{(aq)}$
sodium sulfate solution, $Na_2SO_{4(aq)}$
eye protection
lab apron
nichrome test wire
test-tube rack
Bunsen burner
5 mL dilute hydrochloric acid, $HCl_{(aq)}$
low-voltage conductivity apparatus
small beaker
centrifuge tubes
centrifuge
3 eyedroppers

Procedure

(f) Student answers will vary. A sample procedure is provided.

Part A: Testing for the Presence of Ions

1. Pour the mystery solution into a small beaker.
2. Using the low-voltage conductivity apparatus, test for conductivity as demonstrated by your teacher. Record your observations.

Part B: Testing for Specific Ions Using Precipitation Reactions

3. Carefully pour the mystery solution from the small beaker in Part A into a centrifuge tube so that the centrifuge tube is $\frac{1}{3}$ full.

4. Using an eyedropper, add a few drops of sodium acetate solution to the mystery solution. Record your observations. If a precipitate forms, continue adding sodium acetate solution until no more precipitate forms.
5. If no precipitate forms, go to step 8.
6. Place the centrifuge tube containing the precipitate into the centrifuge. Spin for approximately 1 min.
7. Remove the centrifuge tube and slowly decant the supernate into a clean centrifuge tube. Place the centrifuge tube containing the precipitate into the test-tube rack.
8. Using a clean eyedropper, add a few drops of sodium chloride solution to the supernate. Record your observations. If a precipitate forms, continue adding sodium chloride solution until no more precipitate forms.
9. If no precipitate forms, go to step 12.
10. Place the centrifuge tube containing the precipitate into the centrifuge. Spin for approximately 1 min.
11. Remove the centrifuge tube and slowly decant the supernate into a clean centrifuge tube. Place the centrifuge tube containing the precipitate into the test-tube rack.
12. Using a clean eyedropper, add a few drops of sodium sulfate solution to the supernate. Record your observations.

Part C: Using Flame Tests to Confirm the Presence of Copper(I), Silver, and/or Barium Ions

13. Arrange any precipitates formed in Part B in the test-tube rack.
14. Light the Bunsen burner and adjust it until it is burning with a blue flame.
15. To clean the nichrome test wire, dip it in the hydrochloric acid, then hold the wire in the flame of the Bunsen burner. Repeat this step until the wire adds no colour to the flame.
16. Pick up a small amount of the first precipitate using the nichrome test wire. Hold the end of the wire in the flame. Record your observations.
17. Clean the wire as described in step 15.
18. Repeat step 16 with the remaining precipitate(s). Remember to clean the nichrome test wire between tests. Record your observations.

Observations

(g) Student answers will vary. Sample observations are provided assuming that all three ions are present in the mystery solution.

Table 1 Observations and Inferences

Part A: Conductivity Test		
Substance tested	**Conducts/Does not conduct electricity**	**Inference**
Mystery solution	conducts	solution must contain ions
Part B: Precipitation Reaction		
Ion possibly present	**Ion added**	**Observation and inference**
$Ag^+_{(aq)}$	$C_2H_3O^-_{2(aq)}$	precipitate formed ($AgC_2H_3O_{2(s)}$), therefore $Ag^+_{(aq)}$ present
$Cu^+_{(aq)}$	$Cl^-_{(aq)}$	precipitate formed ($CuCl_{(s)}$), therefore $Cu^+_{(aq)}$ present
$Ba^{2+}_{(aq)}$	$SO^{2-}_{4(aq)}$	precipitate formed ($BaSO_{4(s)}$), therefore $Ba^{2+}_{(aq)}$ present
Part C: Flame Tests		
Precipitate	**Colour of flame**	**Inference**
$AgC_2H_3O_{2(s)}$	no colour	$Ag^+_{(aq)}$ present
$CuCl_{(s)}$	light blue-grey	$Cu^+_{(aq)}$ present
$BaSO_{4(s)}$	yellow-green	$Ba^{2+}_{(aq)}$ present

Analysis

(h) All three ions, barium, silver, and copper(I), are present in the mystery solution.

Evaluation

(i) Student answers will vary depending on their experimental design. Confidence levels will vary depending on how well the experimental design was carried out.

Synthesis

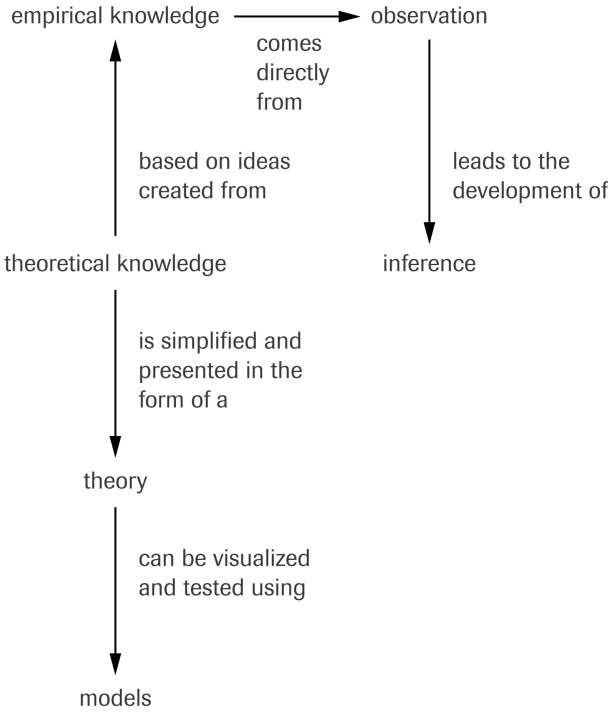
(j) Other tests that could be performed to increase confidence in results include flame emission spectroscopy and thermal emission spectroscopy.

UNIT 1 REVIEW

(Pages 71–73)

Understanding Concepts

1. (a) An observation is a statement based on what you see, hear, taste, touch, and smell. An inference is a judgment or opinion based on observations and conclusions from testing. An example of an observation is "The water is boiling." An example of an inference is "Since the water is boiling, it must be hot."
   (b) Empirical knowledge comes directly from observations. Theoretical knowledge is based on ideas created to explain observations. An example of empirical knowledge is "Water boils at 100°C." Theoretical knowledge that explains this observation is "When water boils, water molecules have gained enough kinetic energy to escape the liquid state and enter the gaseous state."
   (c) A theory is an explanation of a large number of related observations. A model is a representation of a theory that helps scientists visualize a theory as well as test it. An example of a theory is the kinetic molecular theory. An example of a model is Bohr's model of the atom.

2. 

3. **Table 1** History of Atomic Theory

Scientist	Contribution to atomic theory
John Dalton	Matter consists of particles called atoms that are unique to each element.
J.J. Thomson	The atom is like a raisin bun, with negatively charged electrons scattered within a positively charged sphere.
Ernest Rutherford	The atom contains a dense positive core (the nucleus) that consists of positively charged subatomic particles known as protons. Negatively charged electrons orbit the nucleus like planets around the Sun.