Background

What kinds of substances are present in a glass of water? We know that there are molecules of water (H_2O) present, but are there other substances as well? People often say that water from a different area has a different taste. Could there be small amounts of substances dissolved in a water sample from one area that gives it a different composition from another sample of water?

In fact, drinking water does contain many different substances. Some are added deliberately during the process of water purification. But many substances in water occur naturally. As rainwater passes through the ground, minerals dissolve into the water. These minerals are ionic compounds that may contain ions such as calcium (Ca^{2+}), magnesium (Mg^{2+}), iron (Fe^{3+}), chloride (Cl^-), nitrate (NO^{3-}), or sulfate (SO_4^{2-}).

One method of detecting these ions is to use chemical tests. Such tests can also be used to identify unknown ions. A **positive test** for a substance is one that clearly indicates the substance is present. A positive test for a dissolved ion may produce an insoluble precipitate or it may produce a coloured product. The amount of precipitate or the intensity of the coloured product could also be used to determine how much ion was present in the solution as well. In this investigation, you will use chemical tests to investigate the ions that are dissolved in water.

Question

How can samples of water be tested for the presence of chloride ions (Cl^-), sulfate ions (SO_4^{2-}), and iron ions (Fe^{3+})?

Design

In this investigation you will test solutions containing three known ions with various testing solutions. You will then test some unknown solutions with the same testing solutions and compare your observations to determine which ions are present in the unknown solutions. Design an observation table similar to the one below.

		TESTING SOLUTIONS		
		silver nitrate	barium chloride	potassium thiocyanate
SOLUTIONS	potassium chloride			
	sodium sulfate			
	iron (III) nitrate			
	Unknown #1			
	Unknown #2			
	Unknown #3			

Materials

- apron
- safety goggles
- labelled dropper bottles
- microtrays
- unknown solutions
- testing solutions:
  - silver nitrate
  - barium chloride
  - potassium thiocyanate
- sample solutions:
  - potassium chloride
  - sodium sulfate
  - iron (III) nitrate

NOTE: Silver nitrate is toxic and can stain skin and clothing. Barium chloride and potassium thiocyanate are toxic. Iron (III) nitrate is an irritant. Any spills on the skin, in the eyes, or on clothing should be washed immediately with cold water.

Method

Part 1: Testing Known Solutions

1. Put on your apron and safety goggles.
2. Obtain a dropper bottle containing potassium chloride solution (source of chloride ion) and a second dropper bottle containing silver nitrate solution.
3. Add one or two drops of the first solution to one of the wells on the microtray. Add one or two drops of the second solution to the same well. Record your observation, particularly noting the appearance and colour of both starting materials and any product.
4. Obtain a dropper bottle containing sodium sulfate solution (source of sulfate ion) and a dropper bottle containing barium chloride solution. Repeat step 3 in another well on the microtray. Record your observations.
5. Obtain a dropper bottle containing iron (III) nitrate solution (a source of iron (III) ions) and a dropper bottle containing potassium thiocyanate solution. Repeat step 3 in another well on the microtray. Record your observations.

NOTE: Avoid cross-contamination of dropper bottles and solutions; let the solutions "free-fall" into the microtray wells rather than touching the dropper bottle to the microtray.

Part 2: Testing Unknown Solutions

6. Obtain a dropper bottle containing one of the unknown solutions provided by your teacher. Use the testing solutions in separate microtray cells to determine whether chloride, sulfate, or iron (III) ions are present in the solution. Record your observations.
7. Repeat step 6 for other unknown solutions.
8. Dispose of the mixtures and put away your materials as directed by the teacher. Clean up your work station. Wash your hands.

Conclusion

9. Answer the initial question by completing the following:
   (a) Make a table to summarize the observations that indicate a positive test for chloride ions (Cl^-), sulfate ions (SO_4^{2-}), and iron (III) ions (Fe^{3+}). Possible headings could be: Type of Ion, Reagent solution added, and Observation for positive test.
   (b) Make a table to summarize your analyses of the unknown solutions.

Analysis (Be sure to use full sentences, particularly when it asks you to explain, discuss, describe, ...)

1. (a) What is meant by a positive test for an ion.
   (b) Describe two types of changes that demonstrate a positive test.
2. Write the chemical formulas for the substances listed below. (Hint: look at the dropper bottles.)
   (a) silver nitrate
   (b) barium chloride
   (c) sodium sulfate
   (d) iron (III) nitrate
3. (a) What is the difference between quantitative and qualitative analyses?
   (b) With reference to (a) what type of analysis was used in this investigation?
4. Suppose that you were asked to determine whether an ion was present in a solution and how much ion was present.
   (a) Compare the amounts of precipitate that you would expect if you added barium chloride to two solutions that contained different amounts of sulfate ion.
   (b) Compare the colour intensity that you would expect if you added potassium thiocyanate to two solutions that contained different amounts of iron (III) ion.

MARKING SCHEME	
• Title	/1
• Question	/1
• Materials	/1
• Method	/1
• Observations	/6
• Conclusion	/7
• Analysis	
• Q1	/3
• Q2	/2
• Q3	/3
• Q4	/4
• Spelling/Grammar	/3
• Form	/3
TOTAL	/35