Inv.1.4.1 Properties of Alcohols (Nelson p.63) **Name:**

1. Draw the structures of ethanol, propan-1-ol, and butan-1-ol. Rank them from least polar to most polar.

ethanol	propan-1-ol	butan-1-ol

2. How are the structures of these three alcohols similar? How are they different?

3. Draw the structures of water and of cyclohexane. Analyze the polarity of these solvents. What types of compounds are able to dissolve in each?
    - The Mobile Hyperchem iPad app may be useful.

	Water	Cyclohexane
Structure and polarity		
Effective solvent for _____ compounds		

4. Take a picture of the hazardous material WHMIS label on the container of one of the compounds we're using in the lab today. You may find it useful when designing a WHMIS label for your application task in this course.
    a. What information goes onto the label?

    b. How is this material hazardous?

    c. Take a look at the part of the label that shows what protective equipment should be used when handling this compound. How should you prepare to handle this compound?

5. Describe the interactions between molecules that makes polar compounds more soluble in water and nonpolar compounds more soluble in cyclohexane.

6. Based on your and on your neighbour's prior learning, use ideas related to intermolecular forces of attraction to rank the three alcohols above in terms of boiling point, melting point, and solubility in water from lowest (3) to highest (1). Explain your thinking.

Compound	Boiling point	Melting point	Solubility in water
Ethanol			
Propan-1-ol			
Butan-1-ol			

7. State the idea you used to rank the alcohols. How did you make your decision?

Investigation 1.5.1 OBSERVATIONAL STUDY

SKILLS MENU

- Questioning
- Researching
- Hypothesizing
- Predicting
- Planning
- Controlling Variables
- Performing
- Observing
- Analyzing
- Evaluating
- Communicating

Reactions of Three Isomers of Butanol

Alcohols that have different structures form different products. The location of the hydroxyl bond is particularly important. In this investigation, isomers of butanol are used as examples of primary (1°), secondary (2°), and tertiary (3°) alcohols. You will examine the relationship between structure and product formed.

First, you will mix each of the three isomers of butanol with concentrated hydrochloric acid. The presence of an alkyl halide will be indicated by the cloudiness of the mixture because alkyl halides are only slightly soluble in water.

Next, you will mix each alcohol with dilute potassium permanganate solution. This provides the conditions for controlled oxidation. Any colour change of the potassium permanganate solution is an indication that an oxidation reaction has taken place.

Purpose

To test the reactions of primary, secondary, and tertiary alcohols with acid and with an oxidizing agent

Equipment and Materials

- chemical safety goggles
- lab apron
- protective gloves
- 3 test tubes
- test-tube rack
- eyedropper
- dropper bottles containing
  - butan-1-ol
  - butan-2-ol
  - 2-methylpropan-2-ol
  - potassium permanganate solution, $KMnO_4(aq)$ (0.01 mol/L)
  - concentrated hydrochloric acid, HCl(aq) (12 mol/L) (for teacher use only)

Alcohols are flammable. They should be used only in a well-ventilated area. There should be no open flames or other sources of ignition in the laboratory.

Concentrated hydrochloric acid is very corrosive. It should only be handled by the teacher in a fume hood or fume cupboard.

Potassium permanganate solution is corrosive and may stain the skin. If you spill potassium permanganate on your skin, wash the affected area with lots of cool water and inform your teacher.

Procedure

SKILLS HANDBOOK A1, A2.3, A5.1

1. Put on your safety goggles, apron, and protective gloves.
2. Put 3 test tubes in a test-tube rack. From the dropper bottles, place 2 drops of butan-1-ol in the first test tube, 2 drops of butan-2-ol in the second test tube, and 2 drops of 2-methylpropan-2-ol in the third test tube.
3. Under the fume hood, your teacher will add 10 drops of concentrated hydrochloric acid to each of your 3 test tubes. Gently shake the mixtures very carefully. Return to your lab bench with the test-tube rack and test tubes. Allow the tubes to stand for 1 min and observe for evidence of cloudiness. Record your observations.
4. Follow your teacher's instructions for the disposal of the contents of the test tubes and for cleaning the test tubes.
5. Set up the 3 test tubes again, as described in the setup part of Step 2. This time, use 4 drops of each alcohol.
6. To each test tube, carefully add about 20 drops of potassium permanganate solution. Shake the mixture carefully.
7. Allow the tubes to stand for 5 min with occasional gentle shaking. Observe and record the colour of the solution in each tube.

Analyze and Evaluate

(a) What evidence of reactions did you observe?

(b) Write structural formula equations to represent each of the reactions that occurred. If there was no reaction, write NR.

(c) Does the evidence collected allow you to achieve the Purpose? Explain.

(d) Summarize in a few sentences the halogenation and controlled oxidation reactions of primary, secondary, and tertiary alcohols.

Apply and Extend

(e) Research to find an application for at least two of the reactions that you observed. How does this reaction benefit society? Does it have any drawbacks? Combine your findings with those of four or five classmates and create a graphic organizer summarizing your findings.

WEB LINK

Investigation 1.4.1 CONTROLLED EXPERIMENT

SKILLS MENU

- Questioning
- Researching
- Hypothesizing
- Predicting
- Planning
- Controlling Variables
- Performing
- Observing
- Analyzing
- Evaluating
- Communicating

Properties of Alcohols

Chemical properties within a group of alcohols may follow a trend. In this investigation, you will use your knowledge of intermolecular forces and the structure of alcohol molecules to predict trends in the properties of alcohols. You will test one of your predictions experimentally.

Testable Question

What is the trend in melting points, boiling points, and solubility of the primary alcohols butan-1-ol, propan-1-ol, and ethanol?

Hypothesis

Use your understanding of the structures of alcohols to predict the trend of the melting points, boiling points, and solubility of primary alcohols. Give reasons for your predictions.

Variables

Identify all the major variables that will be measured and/or controlled in this experiment. Also identify the independent variable and the dependent variable.

Experimental Design

Use reference sources to determine the melting points and boiling points of three alcohols. The solubility of each alcohol is determined by mixing the alcohol with a non-polar solvent, cyclohexane, and with a polar solvent, water.

Equipment and Materials

- chemical safety goggles
- lab apron
- MSDS for each chemical used
- 3 test tubes
- test-tube rack
- wax pencil
- 3 mL calibrated disposable pipette (or similar pipetting device)
- small stoppered bottles containing
  - butan-1-ol
  - ethanol
  - propan-1-ol
  - cyclohexane
- wash bottle containing distilled water

Alcohols and cyclohexane are flammable. They should be used only in a well-ventilated area. There should be no open flames or other sources of ignition in the laboratory.

Procedure

SKILLS HANDBOOK A1, A2.2, A3.3

1. Read through the MSDS and list the hazards of the chemicals you will be using. Include this information, and how to minimize the hazards, in your report.
2. Put on your safety goggles and apron.
3. Use the wax pencil to label the 3 test tubes. Using the pipette, place about 1 mL of ethanol in one test tube, 1 mL of propan-1-ol in the second test tube, and 1 mL of butan-1-ol in the third test tube.
4. To each test tube, add 1 mL of cyclohexane. Record your observations.
5. Follow your teacher's instructions for the disposal of the liquids and for cleaning the test tubes.
6. Set up the test tubes as described in Step 3. Follow Step 4 but use distilled water in place of cyclohexane.

Observations

Prepare a table in which to record your observations. In addition, record the melting point and boiling point data.

Analyze and Evaluate

(a) What variables were measured/recorded and/or manipulated in this investigation? What type of relationship was being tested?

(b) Did the evidence that you collected allow you to answer the testable question? If so, answer the question. If not, explain why not.

(c) Compare your answer in (b) to your hypothesis. Did the evidence support your hypothesis? Explain.

(d) Evaluate your hypothesis.

Apply and Extend

(e) Predict, in a qualitative way, the melting points, boiling points, and solubilities of larger primary alcohols. Include an explanation for your prediction, referring to the forces of attraction between molecules.