

Crystal Systems

Introduction

Each of the more than 3800 minerals found on Earth has a distinct **crystal form** that is the result of the mineral's internal arrangement of atoms. These unique forms allow every mineral to be classified into one of six crystal systems, which are shown in the Data Table. Crystals in each system have a specific number of imaginary axes, which are indicated by the letters *a*, *b*, and *c*. These axes can vary in length and intersect at specific angles, designated by the Greek letters α , β , and γ . The angles between adjacent faces of a crystal can be measured with a simple instrument called a **contact goniometer**.

In this investigation, you will make a contact goniometer and use it to measure angles between adjacent faces of model crystals. You will then use your measurements to identify the system to which each model belongs.

Problem

How do crystal forms vary among the six different crystal systems?

Pre-Lab Discussion

Read the entire investigation. Then work with a partner to answer the following questions.

- 1. Interpreting Diagrams** Look at Figure 1. In your own words, describe how you will use the goniometer to measure the angles between adjacent crystal faces.

- 2. Comparing and Contrasting** Look at the Data Table. How are minerals in the orthorhombic and monoclinic systems the same? How do they differ?

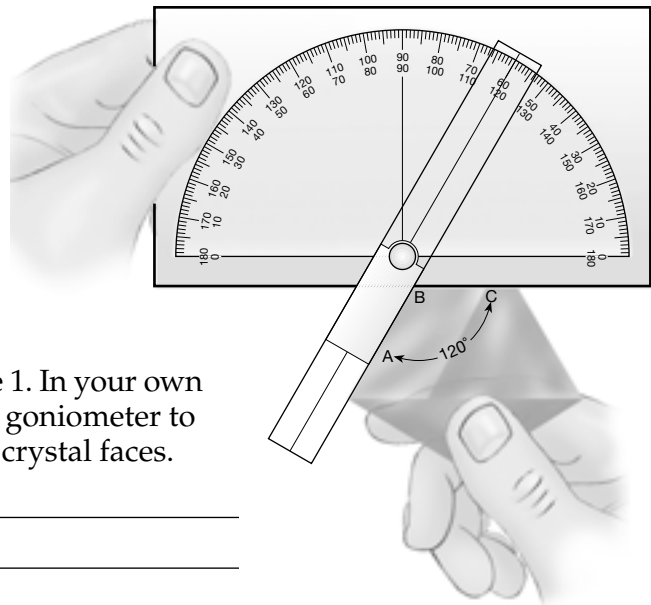


Figure 1

- 3. Comparing and Contrasting** Look at the Data Table. Compare and contrast characteristics of minerals in the cubic and triclinic systems.

- 4. Interpreting Diagrams** Study the diagrams in the Data Table. Which system of crystals has three identical planes of symmetry? Explain your choice.

Materials *(per group)*

small, thin protractor (like the one shown in Figure 1)

stiff, white cardboard (~ 20 cm × 10 cm)

clear, quick-drying glue

metric ruler

thin, clear, rigid plastic strip (~ 15 cm × 2 cm)

hole punch

2 gummed reinforcements

metal brad

copies of the model crystals on pages 26–28

scissors

cellophane tape

Safety

Always use care when using scissors. Note the sharp object safety alert symbol next to Step 5 in the Procedure.

Procedure

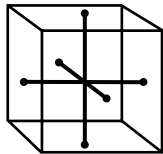
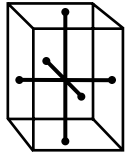
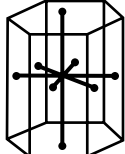
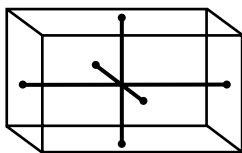
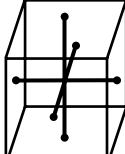
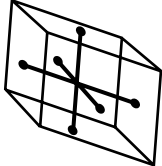
Part A: Constructing the Contact Goniometer

1. Use a thin layer of glue to bind the protractor to the cardboard. Make sure the base of the protractor is about 1 cm from and parallel to the bottom edge of the cardboard, as shown in Figure 1. Wait for the glue to dry completely before trying to use the instrument.
2. Use the hole punch to make a hole in the center of the plastic strip, as shown in Figure 1.
3. Use the hole punch to make a hole in the cardboard along the bottom edge, as shown in Figure 1. Moisten and place the gummed reinforcements over the hole on either side of the cardboard.
4. Use the metal brad to attach the plastic strip to the cardboard. Adjust the brad so that the plastic strip moves freely.

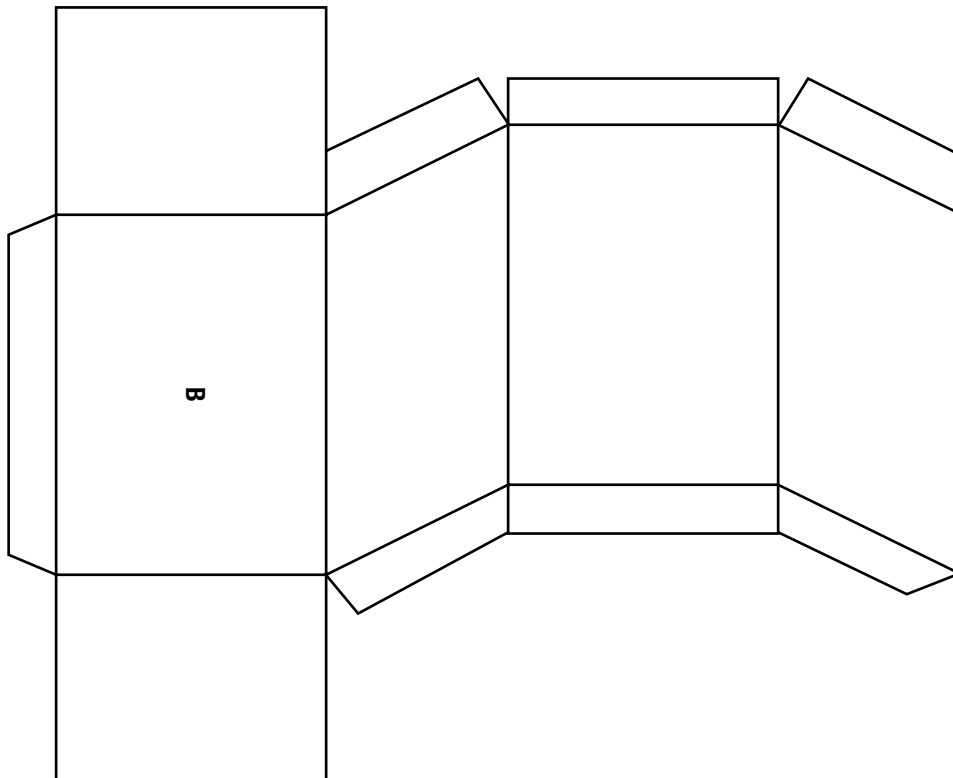
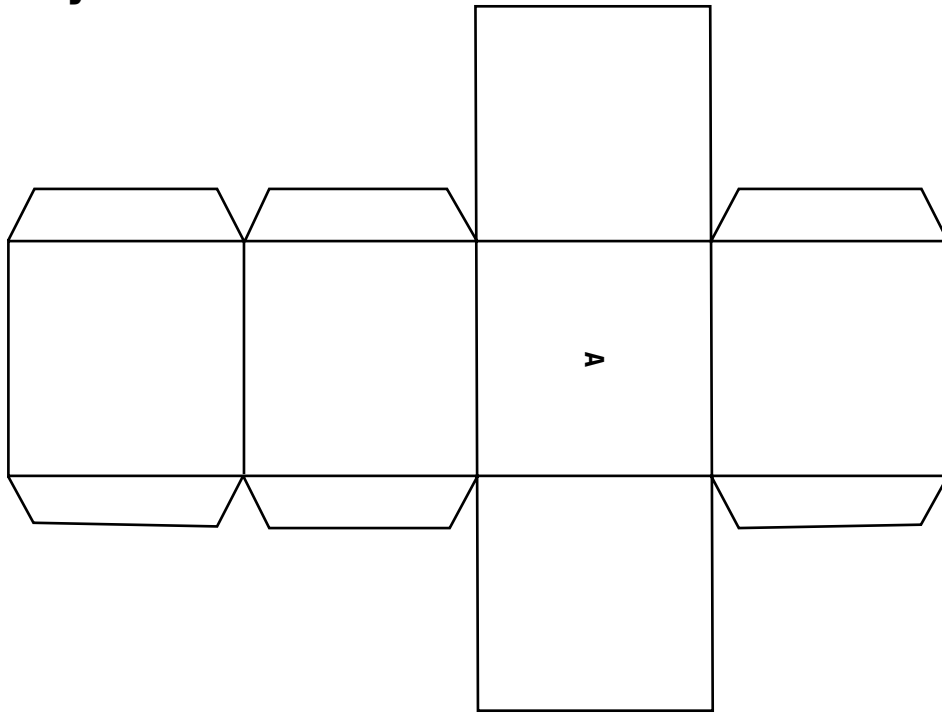
Part B: Making and Measuring the Model Crystals

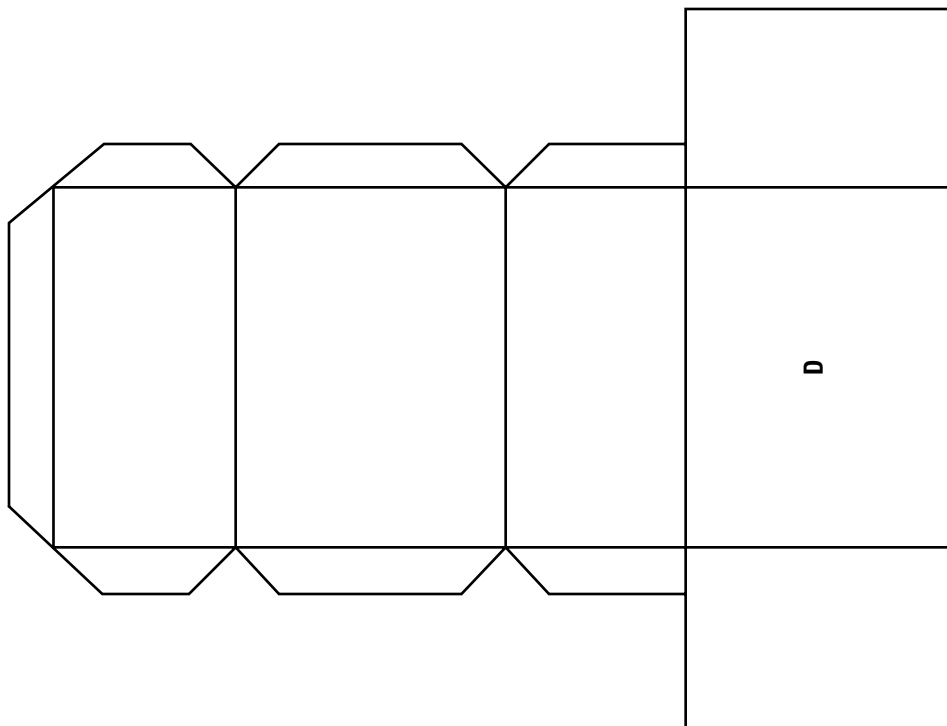
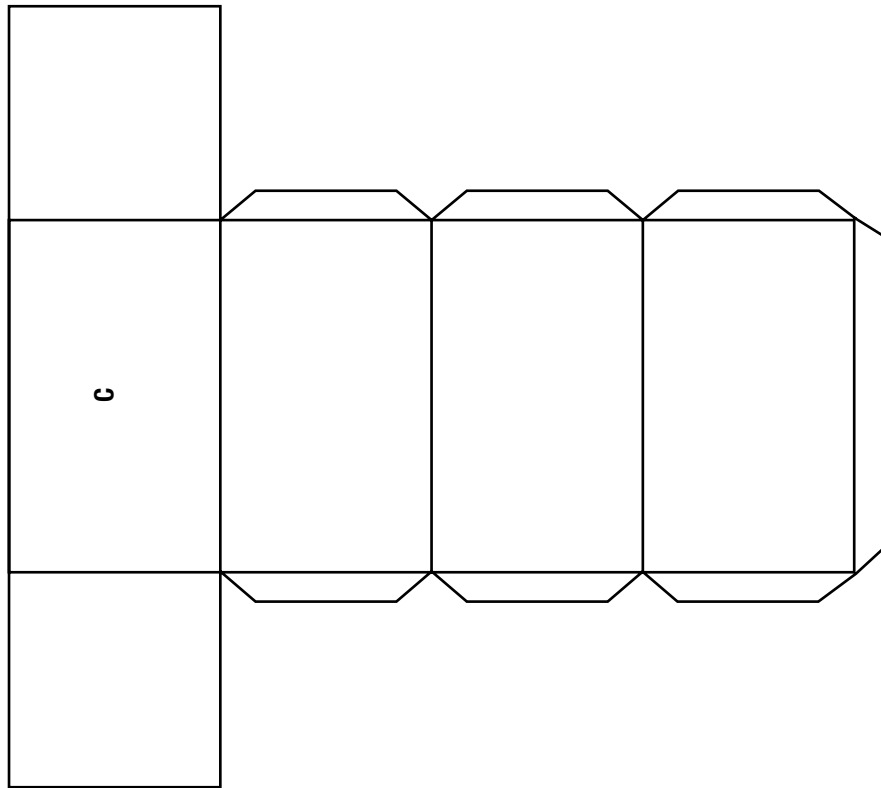
-  5. Carefully cut out each of the photocopied models provided by your teacher. Cut only along the outermost lines of each figure.
6. Using the Data Table as a guide, fold and tape the models to form six, three-dimensional crystals. After you make each fold, gently run your fingernail along the fold so that the angles between the faces in the model crystals will be more exact.
7. Use Figure 1 as a guide to measure the angles between adjacent faces in crystal A. Use your measurements to identify to which of the systems crystal A belongs. Record your choice on the appropriate line in the Data Table.
8. Repeat Step 7 for the other five model crystals.

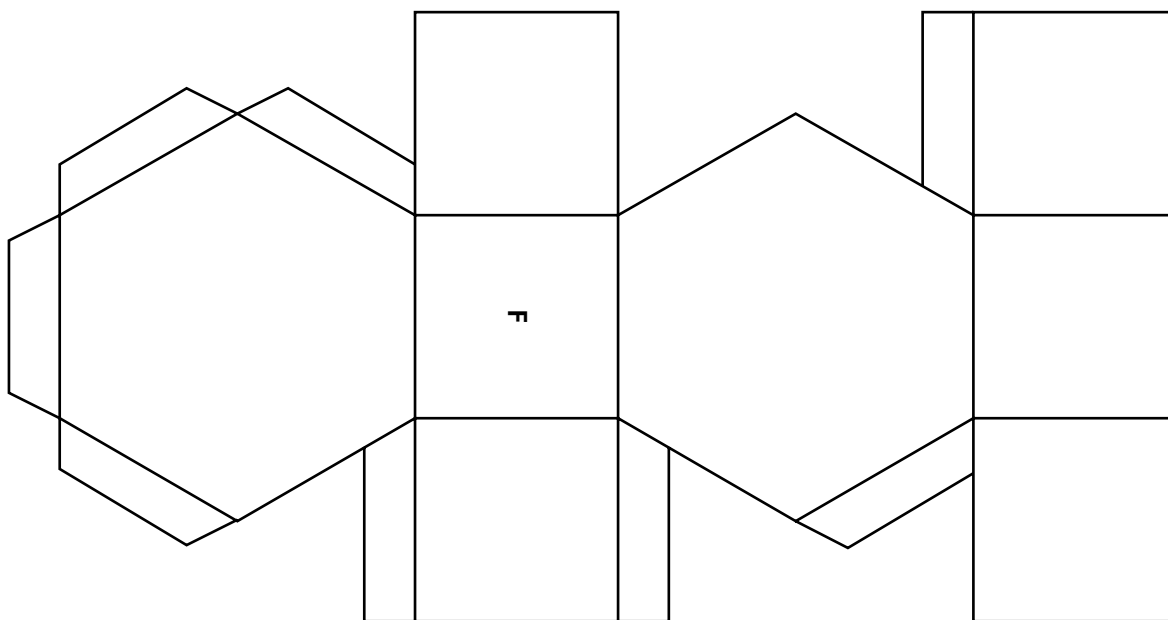
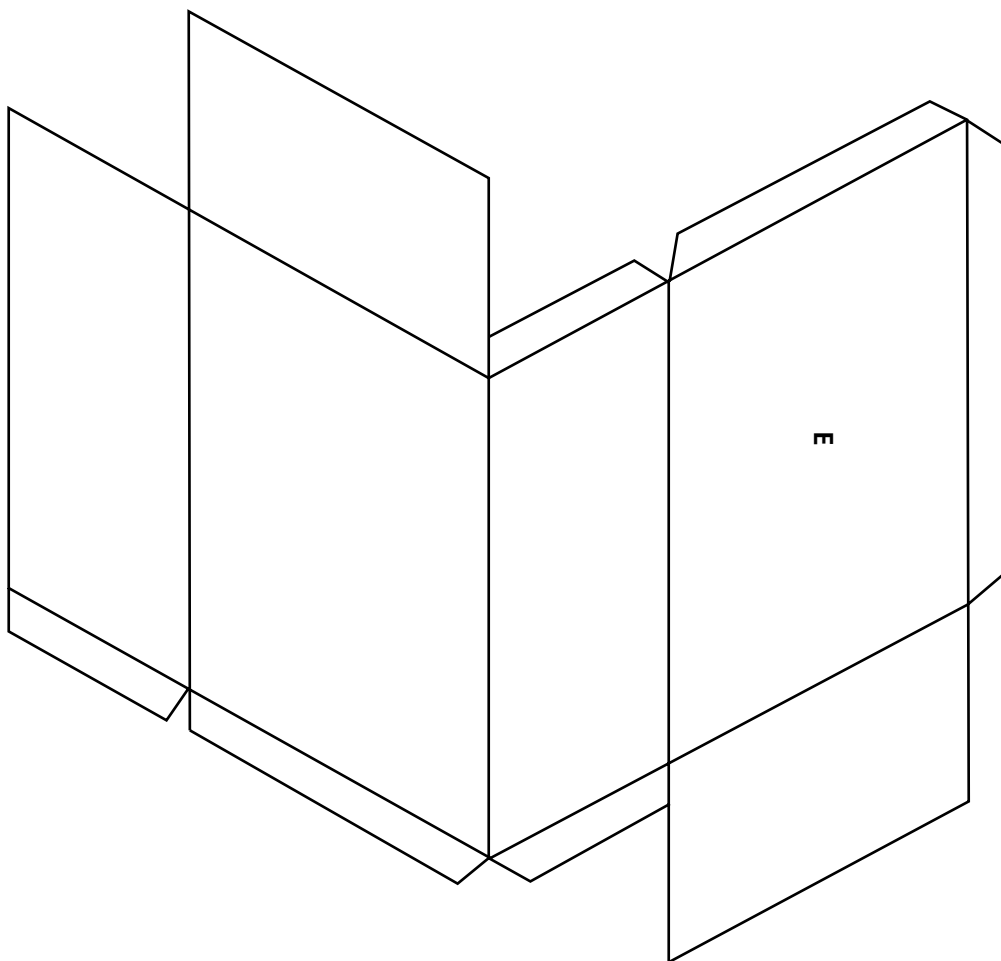
Observations**DATA TABLE The Six Crystal Systems**

System Name	Description	Typical Forms
Cubic Model ____	All crystals in the cubic system have three axes that are all the same length. The axes intersect at 90° angles.	$a = b = c$; $\alpha = \beta = \gamma = 90^\circ$ 
Tetragonal Model ____	All crystals in the tetragonal system have three axes that intersect at 90° angles. Two of the axes are the same length.	$a = b \neq c$; $\alpha = \beta = \gamma = 90^\circ$ 
Hexagonal Model ____	All crystals in the hexagonal system have four axes. Three of the axes are the same length and intersect at 60° angles. The fourth axis is longer or shorter than the other three.	$a = b \neq c$; $\alpha = \beta = 90^\circ$; $\gamma = 120^\circ$ 
Orthorhombic Model ____	All crystals in the orthorhombic system have three axes. Each axis is a different length. The axes intersect each other at 90° angles.	$a \neq b \neq c$; $\alpha = \beta = \gamma = 90^\circ$ 
Monoclinic Model ____	All crystals in the monoclinic system have three axes each of which is a different length. Two of the axes in these crystals intersect at a 90° angle. The third axis intersects the other two at an angle greater than 90° .	$a \neq b \neq c$; $\alpha = \beta = 90^\circ \neq \gamma$ 
Triclinic Model ____	All crystals in the triclinic system have three unequal axes that make oblique angles with each other.	$a \neq b \neq c$; $\alpha \neq \beta \neq \gamma \neq 90^\circ$ 

Model Crystals







Analysis and Conclusions

1. **Classifying** To which crystal system does each of the models belong?

2. **Comparing and Contrasting** How do the angles between major crystal faces differ among the various systems?

3. **Drawing Conclusions** Why is crystal form probably the most useful property to use when identifying unknown minerals?

Go Further

Study the crystals shown in the photographs on Resource 2 in the DataBank. Use what you've learned in this investigation to identify the crystal system to which each mineral belongs.