# Mineral testing and identification

## Aim

To carry out standard tests for mineral identification and use these tests to identify unknown minerals.

Time required for activity: 1 hour

## Introduction

In this practical activity you will be investigating diagnostic properties of a mineral samples and applying your results to identify the samples using reference materials. There are hundreds of naturally occurring minerals. By applying the skills developed in this practical you will be able use a standard identification key to identify most of them.

The key diagnostic tests you are required to carry out are:

* **Colour**: Used to identify minerals, but some minerals can be more than one colour, and there are multiple minerals which are the same colour.
* **Lustre**: Used to describe the surface appearance and its ability to reflect light. Uses descriptive terms such as metallic, pearly, earthy.
* **Shape**: The shape or habit of some minerals is distinctive. Typical shapes are cubic (like halite or fluorite), rhombic (like calcite) or hexagonal (like quartz).
* **Hardness**: Using the Mohs scale with either a set of the ten reference minerals on the Mohs scale, or reference materials to compare the hardness of different unknown minerals. Harder minerals scratch softer ones, softer minerals write on harder ones. The scale is a non-linear scale.
* **Streak**: This is the colour of the powder left when the mineral is scraped across an unglazed porcelain tile or plate (a streak plate).
* **Cleavage** and fracture: Cleavage planes are planes of weakness caused by the arrangement of the atomic structure. For example, minerals with one perfect plane of cleavage produce thin sheets. There may be more than one plane of cleavage and the angle between cleavage planes can help identify the mineral. Minerals with no cleavage may show a conchoidal fracture.
* **Reaction with acid:** Carbonate rocks react with acid, fizz and produce carbon dioxide gas.

The skills covered will be revisited later in the course in applied and fieldwork contexts. You are expected to have a basic understanding of rock forming minerals in order to understand these concepts.

## Specification content links

2.1.1 (c)(i); 2.1.1 (c)(ii); 2.1.1 (c)(iii); 2.2.1 (c)(iv).

Mathematical skills must be applied in the recording of the data and calculations, and in analysing the data. These steps require the appropriate application of the following mathematical skills:

* M1.1 Recognise and make use of appropriate units in calculations.
* M1.3 Use an appropriate number of significant figures.

## Health and Safety

* Use together with Hazcard 47a for Hydrochloric acid. HC*l* is an acid (anything between 0.5M and 2M will be suitable) and may cause skin burns and eye damage, safety glasses/goggles must be worn and wash hands after use.
* Handle any glassware with care.
* Be aware of any water spillages and risk of slips or falls.

## Equipment

* hand lens, ×10 magnification;
* Mohs hardness testing kit, hardness pencils or Mohs mineral set or simple substitutes such as finger nail, 2mm copper wire, glass and steel nail
* streak plate, or unglazed porcelain tile such as bathroom tiles
* dropper bottle with HCl (<2 moldm–3);
* displacement can and 25, 50 or 100ml measuring cylinder, dependent on sample size
* balance reading to at least two decimal places
* splash-resistant goggles
* a minimum of five rock forming minerals with at least one carbonate mineral
* mineral testing resource sheets (attached)

| Procedure | Understanding |
| --- | --- |
| 1. Decide how you will organise your practical work and organise your minerals and tests before you start your investigation, as well as how you will record observations and measurements. It is not essential that you carry out the tasks in the order given.
 | Which tests will be easiest to carry out quickly? Which of the tests will be most useful at first? |
| 1. Record the overall colour of each mineral. Be as accurate as possible, for example “dark bluey grey” rather than just “grey”.
 |  |
| 1. Make sure you have a fresh, unweathered surface of the mineral. Record the lustre of each mineral. Hold it in direct light and decide which adjective best describes the appearance of the mineral: metallic, adamantine (diamond), vitreous (glassy), earthy (dull), pearly, or waxy (resinous).
 | Can you identify any minerals from these characteristics alone? |
| 1. Record the crystal shape and any planes of cleavage or fracture?
 | How do you know whether it is cleavage or fracture? How many planes of cleavage are there and what are the angles between them? Can you describe the crystal shape?Which of the minerals you have tested and identified are sheets, chains or frameworks?Which properties of the minerals you have observed help you determine this? |
| 1. Record the relative hardness of minerals using the Mohs scale of hardness:

Select an unscratched surface to test and hold the sample firmly against the bench. Starting with the softest reference material (fingernail, copper coin, steel nail) or reference minerals, drag it firmly across the mineral face.Use the hand lens to check whether there is a line left by the test material or a scratch on the mineral being tested.Complete the test with other reference minerals or materials. | Can you tell the hardness of a mineral from just one test or comparison? How can you determine the actual hardness?The Mohs scale goes up in ½ units so you can interpret between minerals or reference materials. |
| 1. Record the streak colour of each mineral.

Select a clean, unweathered point on the specimen; Put the streak plate flat on the desk or bench; Hold the plate firmly and pull the point of the specimen across the streak plate; Examine the streak. Make sure that a powder has been produced. If it is a white streak you may need to use your finger to pick up a small quantity and confirm as it is difficult to see against the streak plate. | Is the streak the same colour as the minerals’ overall appearance? Why might a streak not be produced? |
| 1. Record how vigorously the mineral reacts with a few drops of dilute HC*l*.
 | Use correct terminology to describe your observations. What is being produced? What is the chemical reaction occurring? |
| 1. Calculate the density of the mineral sample.

Measure the mass of the sample to a resolution of 0.01g; Lower the sample by the thread into the displacement jar and measure the volume of the water displaced to determine the volume of the sample.Divide mass by volume to calculate the density of the sample in gcm–3. Record all your measurements in an appropriate results table. | What other methods could you use to determine the volume of a hand specimen?Why should you record all your measurements and not just your calculated values in your results table?How should you lay out your table properly? |
| 1. Compare the values in your results table with the reference table and identify each mineral.
 | Have you got one final answer or could the mineral be more than one based on your results?How could you carry out further testing to confirm which mineral it is? |

| Practical skills, apparatus and techniques assessed |
| --- |
| a | Reference | Description of skill/technique |
|  | 1.2.1 (a) | apply investigative approachesJustify reasons for the choice or order of tests. |
|  | 1.2.1 (b) | safely and correctly use Hydrochloric acid and other mineral testing techniques |
|  | 1.2.1 (c)  | follow written instructions without guidance |
|  | 1.2.1 (d)  | make and record observations using correct terminology and measurements made accurately using the measuring cylinders and mass balances |
|  | 1.2.1 (e)  | keep appropriate records of experimental activities Recorded all measurements and observations in an appropriate table. |
|  | 1.2.1 (f) | Produced an appropriate table to record data collected.Used correct heading and units |
|  | 1.2.1 (j) | Demonstrated competency using the Eureka cans, measuring cylinders and mass balances.Demonstrated competency at carrying out mineral identification techniques.  |
|  | 1.2.2 (f) | Correctly used classification systems using distinguishing characteristics to identify unknown minerals |
|  | 1.2.2 (j) | Demonstrated competency using the measuring cylinders and mass balances. |
|  | 1.2.2 (k) | Demonstrated correct use of physical and chemical testing to identify minerals  |

## Further investigations and extension questions

1. Can you describe clearly how to identify the difference between quartz and calcite in the field?
2. Can you describe how to identify the difference between pyroxene and hornblende (amphibole)?
3. Compare the two methods used for measuring density (the Eureka can and the water displacement mass measurement). Which do you think is most accurate and why?
4. The following tasks will develop your mathematical skills. M2.4: identify uncertainties in measurements and use simple techniques.
	1. Evaluate the sources of error in the density test. These will include instrument errors (balance and measuring cylinders) and may also include errors caused by the method used.
	2. Which of these are random errors and which are systematic?
	3. Calculate the percentage error in the measurements made and the density values calculated.

## Scientific and Practical Understanding

Geologists should be able to describe how to use mineral identification tests both in the field and in the lab, for example determining the difference between quartz and calcite.

* It is not possible to determine the difference by colour, as they both appear clear to white in the field.
* A streak test is not an option as the mineral will often be embedded within the rock.

The obvious answer is to state to use hydrochloric acid, but it is also necessary to describe what observations will be seen and how it confirms that the mineral is a carbonate with carbon dioxide gas given off.

Another test that could be described are the difference between cleavage and fracture, with calcite breaking along the three cleavage planes, and quartz producing a conchoidal fracture.

A final test that could be described is the hardness test, stating that quartz will not be scratched by a steel nail meaning its hardness is >6, but calcite can be scratched by a copper coin meaning its hardness is <3.

It is not possible to give an exact hardness value using these tests, just a greater than or less than value.

Hornblende (amphibole group) and pyroxene are both dark green to black, hardness around 6, and both have two planes of cleavage, but the angles between them are different (hornblende at 60, pyroxene at 90) due to hornblende being a double chain silicate and pyroxene being a single chain silicate.

Micas display one perfect plane of cleavage and produce thin sheets. The distinction between biotite and muscovite is then determined by the colour of the mineral.

The displacement activity can be carried out using three different methods, either by measuring the volume of water displaced, measuring the mass of water displaced, or by measuring the increase in mass of a beaker of water when the sample is suspended into the water ((H2O displaced by the sample creates a buoyancy force). Remember to convert the change in weight into a volume (1 g = 1 cm3)).

The water displacement can also be carried out by suspending the sample in the Eureka can with a thread, or by lowering the sample into the water carefully. Both of these methods should be considered in terms of potential for errors and accuracy.

If the volume of the sample is determined by applying Archimedes’ principle: an object fully or partially immersed in a fluid is buoyed up by a force equal to the weight of the fluid that the object displaces. This method is significantly more accurate and precise than measuring overflow from a Eureka can or changing level in a graduated measuring cylinder.



thread

Tension force (thread) =

weight of mineral sample

Volume displaced water

= volume of sample

Buoyancy force =

weight of displaced water

Mineral

sample

Gravitational force =

buoyancy + tension force

Electronic

balance

sample

Because the weight of the mineral sample is balanced out by the tension in the thread tied to the sample, the change in weight displayed on the balance is equal to the buoyancy force and hence the weight/volume of the displaced water. Note that weight = mass × *g* (9.81ms–2)

### Worked example of percentage error

Using a Eureka can (displacement jar) has lots of potential sources of error, and the accuracy of results will depend on students identifying sources of error and modifying their technique. Even when used very carefully results are not precise (poor reproducibility). Systematic errors in the measuring cylinder and balance which could be identified by a calibration (for example weigh 10 × £1 coins = 87.50g). Measuring cylinder is an analogue instrument with an instrument error of ±½ of one scale division = ±0.5cm3 (= ±1.0cm3 if using the differencing method). The balance is a digital instrument and the instrument error will be quoted in the instruction booklet (e.g. ±0.01g). Random errors may be caused by the student, others will be environmental (e.g. precise point over flow starts and stops).

|  |  |
| --- | --- |
| systematic error  | mass of 10 × £1 coins = 87.72g zero error = 87.50 – 87.72 = –0.22g  |
| volume of quartz sample  | 4.5 ± 0.5cm3  |
| mass of quartz sample  | 11.00 – 0.22 = 10.78 ± 0.01g  |
| maximum density  | 10.79 ÷ 4.0 = 2.7gcm–3 |
| minimum density  | 10.77 ÷ 5.0 = 2.2gcm–3 |

## Notes and References

This activity may be used in both Year 1 in conjunction with Module 2, or in Year 2 in conjunction with Module 5.

The displacement activity can be carried out using three different methods, either by measuring the volume of water displaced, measuring the mass of water displaced, or by measuring the increase in mass of a beaker of water when the sample is suspended into the water ((H2O displaced by the sample creates a buoyancy force). Convert the change in weight into a volume (1 g = 1 cm3))

The water displacement can be carried out by suspending the sample in the Eureka can with a thread, or by lowering the sample into the water carefully. Both methods give good discussion points for accuracy and errors.

There is a range of mineral identification sheets available and you can determine which you prefer to use but it is preferable to not stray too far from the minerals given in the specification or listed in the OCR endorsed text book.

Resource sheet 3 **Abbreviated Minsocam Mineral Identification Key** is available on Teach Cambridge.

[Resource Sheet 3 - Mineral Testing](https://teachcambridge.org/item/2fd0b9d1-03d3-4e3c-9c7a-1e4d61e0e62b)

This activity has been adapted from a *SchoolRocks!* activity which accompanies their school loan boxes. Schools can request a Rock Box containing a selection of fossils, minerals and rock that support the relevant primary or secondary curriculum from *SchoolRocks!* Contact *SchoolRocks!* by email at [schoolrocks@geologistsassociation.org.uk](file://filestorage/OCR/PD/ProdSup/ProjMan/Projects/GCE/Geol/FT17/Studio/PAG/1_2/schoolrocks%40geologistsassociation.org.uk).

Minerals should be clean and unweathered; they do not need to be museum grade. There is not a requirement to have a teaching set containing every major rock forming mineral. The availability and cost of mineral samples varies all the time and a teaching set can be supplemented with field samples and incidental acquisition. Suppliers such as Geo Supplies Ltd and UKGE Ltd will offer advice and can create sets of loose samples. Having a few more spectacular minerals or examples that will key out can be a useful learning tool. Be aware that the more luridly coloured mineral samples found in crystal shops may be dyed.

## RESOURCE SHEET 1

### Geology PAG 1.1 Mineral testing

Mohs hardness scale

|  Mohs Scale Hardness  | Test Mineral  | Substitutes/reference materials  |
| --- | --- | --- |
| 1  | Talc  |  |
| 2  | Gypsum  | 2½ fingernail  |
| 3  | Calcite  | 3½ copper coin |
| 4  | Fluorite  |  |
| 5  | Apatite  | 5½ glass  |
| 6  | Feldspar  | 6½ steel nail/streak plate  |
| 7  | Quartz  |  |
| 8  | Topaz  |  |
| 9  | Corundum  |  |
| 10  | Diamond  |  |

Some minerals may be harder in one direction and softer in another. For example, mica is twice as hard across the thin edges of the crystals compared to the wider flat faces of the crystal.

Note that the practical geology skill you are developing is being able to use reference material and identification keys – you are not expected to memorise this reference material.

## RESOURCE SHEET 2

### Geology PAG 1.1 Mineral testing

Rock forming minerals – examples of common minerals

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Hardness Mohs scale  | Colour  | Streak  | Lustre  | Acid Test  | Density gcm–3  | Mineral  |
| 2  | colourless, white or grey  | white  | vitreous, pearly or earthy  | no reaction  | 2.3  | gypsum  |
| 2–2½  | white to pale green/yellow  | white  | vitreous  | no reaction  | 2.8–2.9  | muscovite  |
| 2½  | grey-black to black  | bluish-black to grey  | metallic  | no reaction  | 7.6  | galena  |
| 3  | colourless, tan, white, or grey  | white  | vitreous, pearly or waxy  | reacts vigorously  | 2.7  | calcite  |
| 3½–4  | white to tan or pinky grey  | white  | vitreous or pearly  | reacts slowly  | 2.85  | dolomite  |
| 3½–4  | colourless, white, or grey  | white  | vitreous to waxy  | reacts vigorously  | 2.95  | aragonite  |
| 4  | colourless, green, purple, blue, yellow, pink  | white  | vitreous  | no reaction  | 3.2  | fluorite  |
| 5–6  | greenish-black or dark green  | white  | vitreous  | no reaction  | 3.0–3.5  | amphibole  |
| 5–6  | medium-green, light-yellow to pale-bronze  | white  | vitreous or earthy  | no reaction  | 3.2–3.6  | pyroxene  |
| 6–6½  | white to salmon pink  | white  | vitreous  | no reaction  | 2.5–2.6  | orthoclase  |
| 6–6½  | white to dark grey  | white  | vitreous  | no reaction  | 2.6–2.8  | plagioclase  |
| 6½–7  | pale-yellow to olive-green to dark brown  | white  | vitreous to sub-metallic  | no reaction  | 3.3–4.4  | olivine  |
| 6–6½  | brass-yellow  | black  | metallic  | no reaction  | 5.0  | pyrite  |
| 7  | colourless, rose to purple, smoky-grey to brown-yellow  | – | vitreous  | no reaction  | 2.65  | quartz (crystal)  |
| 7  | milky, grey to Black, red, to brown-yellow, green, blue,  | – | vitreous to waxy to earthy  | no reaction  | 2.65  | quartz (massive)  |

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