

# Our Chemical World

## ACTIVITY SHEET I : ACID-ETCHING

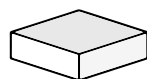
### Aim:

To explore if:

- 1) Drawings can be etched on a marble slab or shell surface using chemicals.
- 2) This activity can be used to understand various introductory topics in chemistry.

### What you need:

Surface to etch on (1 per group of students)



or



or



Marble slab of any shape with at least one plane surface to paint on

Sea-shell of any dark shade (medium size so that you can hold it and paint on it)

Any "fizzy rock" (a rock that is reactive to acid, like limestone, chalk stone) that is easily available locally with at least one plane surface to paint on



10% to 20% by volume of aqueous hydrochloric acid solution (add acid to water rather than water to acid)



Any quick-drying water-resistant acrylic liquid paint (like nail polish) of any colour (1 bottle per group of students)



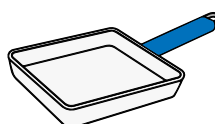
Acetone or nail polish remover (about 50 ml) to clean any left-over paint or drawing mistakes on the surface



Some cotton or a piece of cloth to rub acetone against the surface if needed



Some tap water to wash the stones or shells after acid etching



A shallow transparent plastic pan



A variety of watercolours and crayons to repaint/ decorate the surface after etching is over

### What to do:

#### (a) Painting

- Discuss within your group and agree on what you would like to draw on the base surfaces (marble slab or shell) provided. Start by drawing the selected design on paper before you paint it on the base surface.
- Identify two people from your group to do the drawing. Use coloured nail polish to slowly and carefully paint the agreed-upon shape on the base surfaces. You can use nail polish brushes or painting brushes for this purpose.

- Clean the base surface with acetone if you would like to re-draw or modify the shape. This can be done multiple times to ensure that everyone in the group is satisfied with the final artwork. (Hint: starting with a paper-pencil drawing can help minimize the number of such iterations).

(b) Acid etching

- Give your group's painted sample to your teacher, who will carry out the acid etching step, one sample at a time.
- Observe the acid etching demonstration carefully. Record any observations, questions and ideas that your group comes up with. Particularly look for signs to suggest the starting and ending of any change in your sample.

(c) Cleaning

- Observe how your sample is cleaned to remove any acid residue before it is handed back to you.
- See, touch, and feel the texture of the etched surfaces. Compare the etching with your original drawing. Record your observations. Also, make note of any differences you notice between the kind of finish you expected and the actual surface finish.

(d) Finishing (Optional)

- Wipe off the nail polish colours by rubbing it with cotton or a piece of cloth dipped in acetone.
- Use watercolours or crayons to give finishing touches to your drawings.

**Think about:**

- Why is nail polish used to draw shapes for etching?
- Why is acetone used to wipe away the nail polish?
- What changes do you observe when the base surface is: (a) placed in the tray? (b) left in the acid solution? (c) removed from the tray? (d) washed with water? (e) cleaned with acetone to remove the nail polish? How would you explain these changes?
- What changes do you observe in the colour, texture, and appearance of: (a) the 'drawn' and 'not drawn' surfaces of the base material, and (b) the hydrochloric acid solution in the tray? How would you explain these changes?
- Why do you think bubbles were formed when the base surface was placed in the acid solution? Why do the bubbles come up to the surface of the solution? Have you seen something similar elsewhere?

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### ACTIVITY SHEET I: ACID-ETCHING

1. Two consecutive classes can be used on different days. In the first class, students can understand the process and finish the artwork. The second class can be used for the teacher-led demonstration of acid etching.
2. This is designed as a group activity. Break the class into groups of 2-4 students each to ensure maximum participation by all the students.
3. Explain the activity step-by-step, the time required, and the precautions to be taken in each step.
4. Introduce the students to the materials they will be using as the base for their etching. Give each group one piece of marble slab or shell and tell them that they are going to paint on the surface which will be etched eventually.
5. Use the blackboard to explain hydrophobic and hydrophilic properties. Explain clearly which areas of the surface will get etched by acid due to the acid-base reaction.
6. Clearly explain which tasks will be performed by the student groups and which ones will be demonstrated by the teacher. Also, instruct the students to observe and take notes during the demonstration.
7. Some groups might need help deciding what to draw on their base surface. Also, the students who are chosen to paint images on the base material may require support and guidance to do this with care. Nail polish brushes are not as firm as a paintbrush, and using these may require dexterity and careful manipulation.
8. Make students aware of specific precautions that must be taken in handling acetone and acids in general:
  - Acetone is volatile and flammable and can irritate the skin, nose, and eyes. Ensure that the activity is done in a well-ventilated area. Students should avoid contact with acetone. In the event of contact, ensure that they wash the contact area thoroughly.
  - Use acid-alkali gloves when handling hydrochloric acid, and explain to students the importance of using protective gear when handling corrosive acids, solvents, and alkalis.
  - Explain the safety aspects of mixing acid and water to students. Specify why it is safer to add acid to water rather than the other way around.
9. For the demonstration of the etching step:
  - Prepare etchant (diluted acid solution) by adding concentrated hydrochloric acid (37% standard solution) to distilled water in the shallow pan. Ensure that you slowly add the concentrated acid to the water in the ratio of 10% to 20% by volume. If the acid is too dilute, the reaction may take longer. Decide the final volume of the solution depending on the size of the base materials.
  - Using acid-alkali gloves, immerse each sample carefully in the etchant for about 10-15 minutes. Make sure that the surfaces which need to be etched are facing upwards.

- Draw your students' attention to the appearance of bubbles as it signals the start of the reaction. Ask students to note when the reaction slows down (typically after 10 to 20 minutes of immersing the samples depending on the initial strength of the acid solution) and stops.
  - Remove the pieces 5 minutes or so after the bubbles have disappeared. You may continue with the next fresh piece with the same solution. If the reaction does not happen or the solution has become cloudy, prepare a new solution for each new set of etchings.
  - One or more samples can be etched together depending on the volume of etchant. However, the etching tends to get shallower as the number of samples increases. One can try this out with 1 or 2 samples at first and then decide. This can be a point of observation and discussion.
  - Wash the etched samples with tap water to remove any residual acid.
10. Encourage the students to make their observations and record them as a group. Clarify that this activity is an invitation to think and discuss as a group.

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## TEACHER DEMO : IS ACID ETCHING SELF-LIMITING?

### Aim:

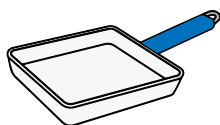
To explore if:

- 1) The reaction between the marble and the dilute acid solution stops by itself.
- 2) The concentration of the acid affects the reaction time.

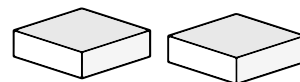
### What you need:



100 mL each of 10% by volume of aqueous hydrochloric acid solution.



A shallow transparent plastic or glass container to hold the acid solution.



Two small pieces of marble that are as close as possible to each other in shape, size, and weight; and can be easily placed in the plastic tray. The weight of each piece should be between 20–30 g.

### What to do:

1. Clean both marble pieces with tap water. Ask the students to weigh the two pieces of marble and make note of their weights. Use this step to confirm that the two pieces have identical weights.
2. Gently place the first piece of marble in the 10% acid solution. Ask students to record the time when bubbles start appearing (indicating the start of the reaction). Also, ask the students to record the time when the bubbles stop appearing (end of the reaction).
3. Use a pair of tongs to pull the marble piece out of the acid solution and wash with tap water. Ask the students to weigh the washed marble piece and make note of the weight.
4. Put the marble piece back in the same batch of 10% acid solution. Leave it for 10–15 minutes. Take it out again, wash it, and ask students to weigh the piece again.
5. Repeat steps 2–3 of the experiment with the second piece of marble.
6. Put the second marble piece in a fresh batch of 10% acid solution. Leave it for 10–15 minutes. Take it out again, wash it, and ask students to weigh the piece again.

### Ask students to record:

|  | Piece 1: | Piece 2: |
|--|----------|----------|
| Initial weight (grams)   |          |          |
| Weight after the 1st round of etching (grams)                            |          |          |
| Weight after the 2nd round of etching (grams)                            |          |          |
| % weight change  |          |          |
| Duration of appearance of bubbles in 1st round of acid etching (minutes) |          |          |
| Duration of appearance of bubbles in 2nd round of acid etching (minutes) |          |          |

### Ask students to think about:

- With each marble piece, was there any difference in the duration of appearance of bubbles between the first and second rounds of etching?
- What was the % weight change in each of the two marble pieces after the first and second rounds of etching?

### Invite students to discuss:

- Why do bubbles form during acid etching? Can you think of any reasons for this observation?
- Compare the % of weight change in each of the two marble pieces after the first round of etching. Was there a difference? Can you think of any reasons for this difference?
- Compare the % of weight change in each of the two marble pieces after the second round of etching. Was there a difference? Can you think of any reasons for this difference?
- Compare the duration for which bubbles appeared in the first round of etching. Was this different for the two marble pieces? Can you think of any reasons for this difference?
- Compare the duration for which bubbles appeared in the second round of etching. Was this different for the two marble pieces? Can you think of any reasons for this difference?
- Do you think that acid etching is self-limiting or ends by itself? What factors help end this reaction?

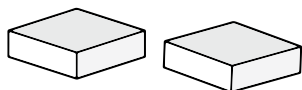
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## ACTIVITY SHEET II : LESS ACID FOR ETCHING

### Aim:

To explore if etching an upside-down (inverted) marble surface will involve less HCl solution.

### What you need:



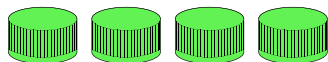
Two marble slabs that are identical in size, shape, and weight; and have at least one plane surface (preferably with an area of 2-3 square inches) of identical dimensions on each



20% by volume of aqueous hydrochloric acid solution



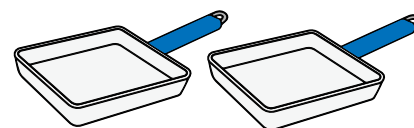
One bottle of nail polish of any colour



Four identical plastic bottle caps to support one of the slabs



Tap water to wash the slab after acid etching



Two shallow transparent plastic pans

### What to do:

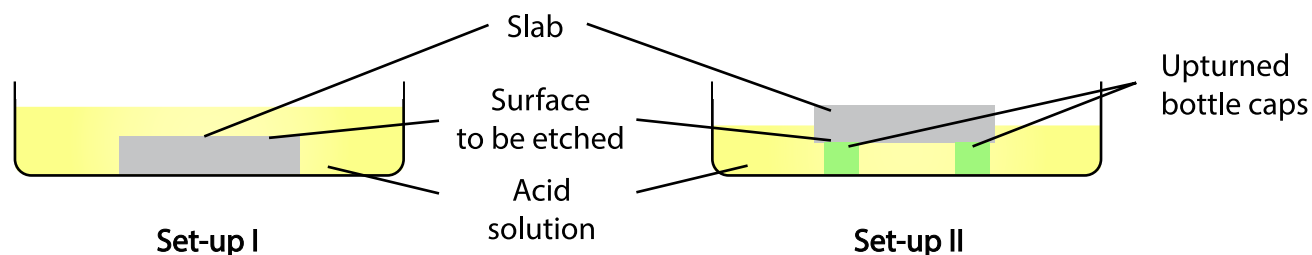
#### (a) Painting on the marble slabs

- Paint all the surfaces of both the slabs with nail polish except the flat surfaces where etching is supposed to happen.
- Leave aside for 5-10 minutes to let the paint dry.

#### (b) Setting up acid etching:

Assemble the following acid etching set-ups (see Figures A and B).

- Set-up 1 (see Figure A): Take one of the plastic pans and place the 1st slab inside it with its flat surface facing upwards.
- Set-up 2 (see Figure B): In the second plastic pan, place the 2nd slab with its flat surface facing downwards and supported by the four bottle caps.



(c) Acid etching (this step is a teacher demonstration)

- Observe how your teacher slowly pours acid solution into both the set-ups. This volume must be enough to cover the upward-facing surface (which is to be etched) of the slab in Set-up I, and the lower-facing surface of the slab in Set-up II. The volume of acid needed in Set-up II will be much less than that needed in Set-up I.
- After bubbles stop appearing, observe how your teacher uses a pair of tongs to pull out each of the slabs and then washes it under tap water to remove any residue of the acid.
- Observe the extent and quality of etching on both slabs.

#### Observe and think about:

- How long does it take for bubbles to appear in Set-up I? Where do they appear? How long does it take for the bubbles to stop appearing?
- How long does it take for bubbles to appear in Set-up II? Where do they appear? How long does it take for the bubbles to stop appearing?

#### Discuss:

- Compare the two set-ups for the number of bubbles and the rate at which they appear. Do you see any differences? If yes, can you suggest any reasons for the difference?
- Compare the extent and quality of etching on both slabs. Do you see any differences? If yes, can you suggest any reasons for the difference?

