Teacher's Guide

Water

Part 1

Based on the curriculum for Kerala State Board
Standard VIII

JANAAGRAHA CENTRE FOR CITIZENSHIP & DEMOCRACY

Janaagraha's initiative to improve citizen engagement in India's democracy through their civic learning program

Developed in collaboration with Young Leaders for Active Citizenship (YLAC)

Water| Teacher's Guide (1/3)
Part 1

Class VIII
Board – Kerala State Board
Subject – Science
Textbook – Basic Science Part 2
Chapter 16 – Water
Number of parts – 03
Length – 75-85 minutes (estimated, for a class of 40-45 students)
Note: Teachers may divide the lesson plan into as many periods as they see fit

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Section I – What are we going to learn and why is it important?

Learning objectives

Students will:

- Understand the physical properties of water and its effects on everyday life.

Learning outcomes

Students will be able to:

- explain boiling point of water and the effect of pressure on the boiling point of water.
- explain the anomalous expansion of water and its significance in everyday life.
- identify and explain the surface tension of water and its practical applications.
- write experiments in the standard format.

Key Terms

Boiling Point	Specific heat/Heat Capacity	Surface Tension	Cohesion	Anomalous Expansion

Materials needed

- Images to be shown/drawn.
- Materials for the experiments.

Section II – How are we going to learn?

1. Introduction to water

Time: 5 minutes

Facilitation notes:

- Draw a large circle on the board and tell students that this is planet Earth
- How much of earth's surface is covered with water? (Take a few responses)
- It is 71%, which means that only about 29% is covered with land. (Shade 70% of the drawn circle)
- Where are the different places that we find water on the surface of earth? (Take a few responses)
- Oceans, seas, rivers, lakes, ice caps, glaciers
- With water available in so many different places, and in such vast amounts, what percentage of water do you think can be used for drinking by humans and animals? (Take a few responses)
- Only 3% of all the water available on land is not saline (salty) and can be consumed. (Shade a small portion as 3%)
- But out of that, 2.5% of it is available as ice caps and glaciers (solid form) so we cannot access it. Less than 0.5% of water is actually available as fresh water (rivers and lakes) on the surface of earth that can be consumed by humans and animals. (Now a small circle or dot, to show 0.5% of the full circle)
- Even though we see water everywhere, it is a very limited resource and that is why it becomes that much more important for us to learn about its properties, so that we can apply that knowledge and look at ways to conserve it.

For this lesson, make this table in your notebook (draw the below table on the board)

Note to the facilitator:
The below table helps in summarizing a lesson and helps students organise their learnings from every chapter. It is not an assessment, but a list of key terms learnt in each chapter. The first 2 columns help them in becoming more aware about their knowledge. This table is only meant for the students and need not be checked by anyone.

Terms that I know and am sure about	Terms that I do not know about	Terms that I learnt in today's class

Classify the following terms as whether you already know about it or whether you do not know about it at all. You do not have to define these terms. Do not write anything in the third column. At the end of the class you will be writing down the terms you learnt in today's class in the last column.

1. Boiling
2. Boiling point
3. Freezing
4. Anomalous expansion
5. Specific heat
6. Surface tension
7. Cohesion

Take 30 seconds to classify these terms in the first 2 columns.

1. Experiment on Boiling point of water

Time: 10 minutes

Facilitation notes:

- Has anyone boiled water at home? Can you explain what it is? (take a few answers)
- What happens when you boil water? (take a few answers)
- Boiling is the process of heating a liquid till it changes into gaseous state.
- Can anyone guess what does the boiling point of water mean?
- Boiling point of water is the temperature at which water starts to change to water vapour.
- We are going to do an experiment to determine the boiling point of water.

The standard format of documenting an experiment is – Objective, Materials Required, Steps, Observation and Conclusion. Write these headings on the board, so that the students can refer to it for the rest of the lesson. For the first experiment, guide them in a step-by-step manner with writing under these headings, so that they would be able to fill the following ones by themselves.

Objective: To determine the boiling point of water.

Materials Required:

1. Bunsen Burner
2. Tripod stand
3. Beaker
4. Distilled water
5. Thermometer
6. Tap water

Steps:

1. Take about 75 ml of distilled water in a beaker and heat it with a Bunsen burner.
2. When the water starts boiling put the thermometer in the water and check the measurement.
3. Make a note of the change in temperature every 30 seconds for 4 mins.
4. Repeat the same experiment with tap water and check the measurement.

Observations

The measurement would likely be 100 degrees (+/- 2) for distilled water. It will be higher for tap water.

Conclusion

Distilled water (pure water) has a boiling point of 100 and tap water (impure water) has a higher boiling point.

- Once water started boiling why did the temperature of the water not change too much? (Think-pair-share – Ask them to discuss with their partners and share a few responses with the class)
- This is because once the boiling point is reached, all the heat is used to convert from liquid to gaseous form (steam), which means that steam has more energy stored than boiling water. This makes steam more dangerous than boiling water. For example, the steam coming out of a pressure cooker can cause severe burns in comparison to the boiling water inside the cooker.

- How many of you have observed rice being cooked in pressure cookers and without pressure cookers? Which takes more time? Why? (Take a few responses)
- Since the pressure cooker is completely covered, when heat is provided to it, high pressure is created. At high pressure, water converts to water vapour at a higher temperature – about 120 degrees; i.e. the boiling point of water increases to about 120 degrees. The temperature of water vapour is maintained at 120 degrees inside the pressure cooker until all the water converts to water vapour. Since the temperature is higher inside the cooker, the rice cooks faster. In case of an open vessel, the pressure is not high and the boiling point of water is around 100 degrees. Since the temperature remains at 100 degrees until all the water gets converted to steam, it takes longer to cook the rice as compared to the pressure cooker.
- We also know that in higher altitudes the atmospheric pressure is lower, so do you think it would be easier or more difficult to cook food on top of a mountain? (Take a few responses) Answer – It takes longer to cook food in higher altitudes as the boiling point of water is lower than 100 degrees. Since the temperature is lower, the food takes longer to cook.
- *Before moving on to the next topic, ask students if there is any way that water can turn to water vapour without giving it external heat such as a live flame. To check, if that is possible, pour a little amount of water in the corner of the classroom and ask the students to observe what happens to that water throughout the day/next day morning. Ensure that that spot is undisturbed.*

2. Experiment on specific heat of water

Time: 10 minutes

Facilitation notes:

- Has anyone heated oil at home, or seen oil being heated? Does it take a lot of time to heat oil? (Take a few responses)
- Between water and oil, if the same quantity is taken, which do you think will heat faster? (Take a few responses)
- The energy required to change the temperature of 1 gm of a substance by 1°C is known as the specific heat or heat capacity of the substance.
- Our next experiment is to compare the specific heat of water and oil and to see which is greater.

(Ask the students to fill the headings in their notebooks by themselves in a similar format once the experiment is conducted)

Objective: To determine if the specific heat of water is greater than the specific heat of oil.

Materials required

1. Bunsen Burner

2. Tripod stand
3. Beakers
4. Distilled water
5. Thermometer
6. Oil

Steps:

1. Measure 50 ml of water in a beaker and heat it for 4 mins.
2. Measure the temperature every 30 seconds.
3. Repeat the same for 50 ml of oil in a different beaker for the same period of time and measure the temperature every 30 seconds.

Observations

In the given time the increase in temperature of oil is greater than the increase in temperature of water.

Conclusion

We can conclude that more heat energy is required to change the temperature of water than oil. The specific heat of water is higher than that of oil.

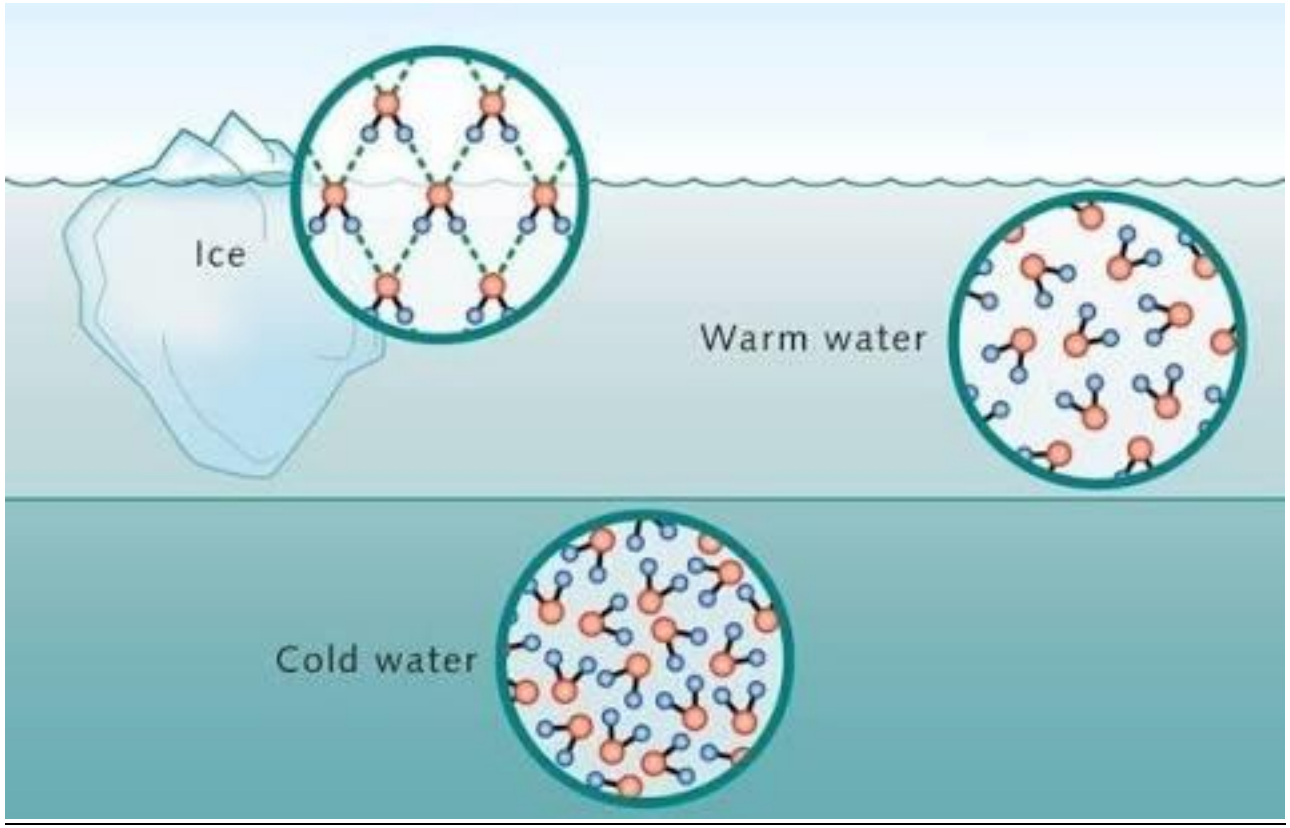
- We know that water has a higher heat capacity/specific heat, but how is this useful? If water takes more heat to increase its temperature, where can it be used or where is it already being used? (take a few responses, probe them to think of objects that get really hot like cars and vehicles)
- What does it do in such cases? It helps the object or machine cool down by absorbing the extra heat – it helps prevent overheating.
- If 65% of the bodies of humans and other animals are made of water, how can it help?
- Water plays a crucial role in maintaining body temperature.

3. Freezing and the anomalous expansion of water

Time: 10 minutes

Facilitation Notes:

- How many of you know what freezing is? (Take a few responses)
- It is the process of converting water from liquid state to solid state by reducing the temperature. The freezing point is the temperature at which it converts to ice which is at 0 degree Celsius.
- I want to tell you all a story. When I was young, during hot summers we would put a bottle of juice in the freezer to turn it into ice so that we could have it really cold. Rasna orange used to be a favourite, so I made 1 litre and filled it up to the top in a glass bottle and put it in the freezer. After a few hours when I opened the freezer I saw that the bottle had shattered and there was ice rasna everywhere and pieces of glass all over the freezer. What do you think went wrong? (Think-pair-share with your partner)
- The answer is that I should not have filled it to the top as the volume of ice is greater than that of water.
- If you remember studying solids, liquids and gases, we studied that the molecules are closest to each other in solids, a little further apart in liquids and the furthest apart in gases. If that is true then ice should be more compact than water, why is it bigger?
- This property is known as the anomalous expansion of water. The word anomalous means unusual or abnormal. This is because water has the unusual property of expanding when it turns to solid ice.
- How many of you have seen ice in a glass of water? Where does the ice stay – at the top of the glass or bottom? What do you think this means? (Take a few responses)
- Like every other liquid, when water starts cooling down from normal temperature, the space between the molecules start decreasing and it takes lesser space until it reaches 4 degrees C. So, it is at its least volume at 4 degree Celsius. This means that the molecules are closest to each other at 4 degree Celsius; i.e. water achieves highest density at 4 degree Celsius. Until degree Celsius, water molecules show normal behaviour of contraction. It starts exhibiting abnormal/unusual expansion when the temperature starts getting lesser than degree Celsius. The water molecules start forming a crystalline structure through the bonds created by the hydrogen atoms. This happens by the molecules moving away from each other. At 0 degree Celsius (freezing point of water) water starts converting to ice and the crystalline structure is fully formed, thus taking up more space than water at room temperature. Thus, the molecules in ice are further apart from each other than the molecules in water; i.e. the density of molecules in ice is lower than the density of molecules in water. Thus, ice floats on top of water. (Show image below)



4. Surface tension of water

Time: 15 minutes

Facilitation Notes:

- Show the above image and ask the students if they have seen these insects that walk on water? (Take a few responses)
- They are called water striders. Stride means to walk and since they can be seen walking on water, they are known as water striders.
- Notice how there are 'dents' in the surface of water where their limbs are touching the water surface. Their legs are not inside the water, they don't seem to be floating the way ice floats in water, but they look like they are sitting on water. How is this possible? Can we recreate something like this in class?

Experiment 3:
Objective: To demonstrate the property of surface tension of water
Materials required:

1. A wide-mouthed bowl
2. A steel paper pin
3. Water
4. A ping-pong ball or any other light object that floats in water.

Steps:

1. Fill the wide mouthed bowl with water.
2. Place the pin gently on the surface of water such that it sits on the surface of water.
3. Put some pressure on the pin such that it sinks to the bottom
4. Place a ping pong ball or any other substance that naturally floats in water
5. Press it down and observe it bouncing back and float on water

Observation

1. The pin does not naturally float in water, but it sits on the surface of water when placed lightly.
2. The ping pong ball naturally floats in water and does not place itself on the surface of water.

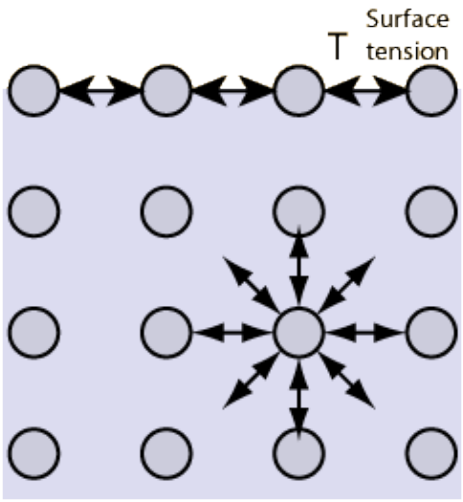
Conclusion

The pin does not float in water. The Surface tension of water allows it to be placed on the surface of the water without letting it sink.

After doing step one and two, ask the students as to what is happening and why the pin is not sinking. Take a few responses and then demonstrate step 3. After step 4 and 5 ask the students what the difference in observation is made between the 2 objects. Now ask if the insect shown in the image is doing what the pin did or what the ping-pong ball did. Let the students know that the insect has tiny but dense cover of hair on its legs that helps the insect to not sink.

Surface tension of water is high, which means that the surface of water is strong, because the attraction of the water molecules on the surface. Water molecules exhibit a property where they show high attraction towards each other which is called cohesion. As seen in the image below, the molecules below the surface, gets equally attracted to all the molecules around it and they get pulled in all directions with equal force. Since the molecules on the surface of the water do not get pulled in the upward direction, they form a stronger attraction to the molecules next to each other. The molecules in the topmost layer come closer together, due to the higher force of attraction, thus making the surface layer stronger. Thus, the surface of water is strong enough to hold more denser objects like an insect, metal pin etc. on top.

This high attraction (cohesion) among water molecules, make them stay as close to each other. This can be seen in nature, when dew drops are formed on any surface like a leaf. The molecules stay close to each other, getting attracted to molecules in an inward direction, thus assuming the smallest volume possible – in the shape of a sphere. Observe water droplets on bottles and their ability to stay close to each other.



Section III –Assessment

Time: 10 minutes

Materials needed: Blackboard and chalk

Facilitation notes:

1. A definite quantity of water and coconut oil are heated for the same period of time.
    a. Water's temperature rises more quickly than oil. True/False?
    b. What property of water is associated with this occurrence?
    c. Where can water be used because of this property?
2. Water should be filled to the brim in a bottle before freezing in a refrigerator. True/false?
    a. What property of water is the above associated with?
3. Food cooks faster in a pressure cooker than when it is cooked on an open pan. True/False? Give reasons
4. After trekking to the top of Anamudi mountain, Sarah decides to cook something for herself. It takes her lesser time to cook the same quantity of food, while on top of the mountain, than it would when she is back home near the beach. True/false? Give reasons.

5. The boiling point of water is _____ degree C and the freezing point of water is _____degree C at sea level. (mention the atmospheric pressure criteria, these temperatures vary according to the atmospheric pressure).
6. Just as ice floats in water because it has lesser density than water, metals can float in water because it is lesser dense than water. True/False.
    a. Which property of water is responsible for this?

Answer Key

1.
a. False. The temperature of oil increases faster than water.
b. Heat capacity/Specific heat of water
c. Vehicles, Heavy machinery where temperatures rise.

2. False.
a. Anomalous expansion of water.

3. True. As higher pressure increases the boiling point of water, food in the pressure cooker cooks at a higher temperature than food in an open pan.

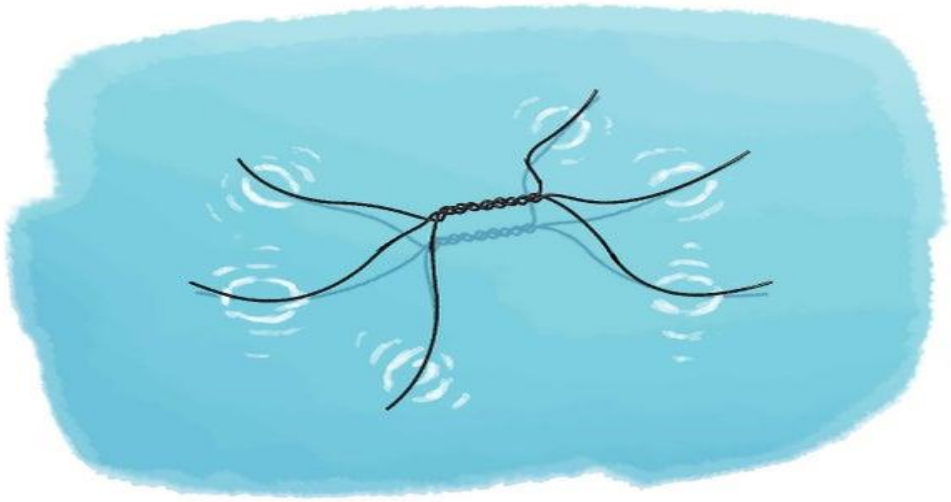
4. False. The atmospheric pressure on top of the mountain is lower than the atmospheric pressure at sea level. When pressure is lower, the boiling point of water reduces and since the food cooks at a lower temperature, it takes longer for Sarah to cook on top of the mountain than near the beach.

5. 100 and 0.

6. False. Metals cannot float on water as it is denser than water. The pin we saw could be placed on the surface of water due to the high surface tension of water and the lesser pressure exerted by the pin on the surface of the water.
a. The property of water which is responsible for this is cohesion (attraction) between water molecules, which increases the surface tension of water.

Section IV – Homework

1. Take a bottle, fill it with water till 1 inch below the top. Mark the level of water. Keep the bottle in the freezer till it completely turns to ice. Take out the bottle and mark the level of the ice. Write this as an experiment in the same format as discussed in class in your notebook.
2. Make your own water strider at home. Take very thin copper wires (even old phone charger wires can be used. Make sure to remove both the layers of insulation. Take the help of an adult to cut the insulation with a knife or scissors.) Take 3 wires of 3-4 inch each and twist them together right in the middle such that they are twisted in the middle together. Bend the ends of the wires slightly upwards. (Refer the below image to explain to students)



Section IV – Closure

Time: 5 minutes

Summary by students

Get a student to summarise the physical characteristics of water that were discussed in class by writing their learning in the 3rd column of the table drawn on page 1. Ask different students to share the points one by one with the whole class.

Recap by a student

Time: 2 minutes

Recap by the teacher

Time: 3 minutes

Please ensure that all the following points are covered in the recap by the teacher and student.

- Boiling is the process of heating a liquid till it changes to gaseous state.
- Boiling point of water is the temperature at which water starts to change to water vapour.
- Once the boiling point is reached, all the heat is used to convert from liquid to gaseous form (steam), which means that steam has more energy stored than boiling water.
- The energy required to change the temperature of 1gm of a substance by 1°C is known as the specific heat or heat capacity of the substance.
- The specific heat of water is higher than that of oil.
- Anomalous expansion of water – Water becomes denser and occupies least volume at 4 deg C, below which water starts to expand because of its crystalline structure.
- Cohesion is the attraction of water molecules towards each other. The molecules on the surface of water show high cohesion towards each other leading to high surface tension, allowing us to place objects that do not float in water without sinking.

Section V – Additional Resources

Resources for teachers

1. Video: Khan Academy video on Surface tension
   This video explains cohesion, surface tension and adhesion.
   Link: Video

2. Video: Khan Academy video on Anomalous expansion of water
   This video explains the anomalous expansion of water
   Link: Video

Resources for students

1. Video: Making a water strider
   This video shows how a water strider can be made at home
   Link: YouTube

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