Cycling water and heat in the lab – and the globe
Demonstrating the water cycle, latent heat and global energy transfer

This lab demonstration of the water cycle can be approached in a number of ways, depending upon the age and ability of the pupils and the purposes of the lesson.

A. Water cycle demonstration

Set up the apparatus as shown in the diagram below.

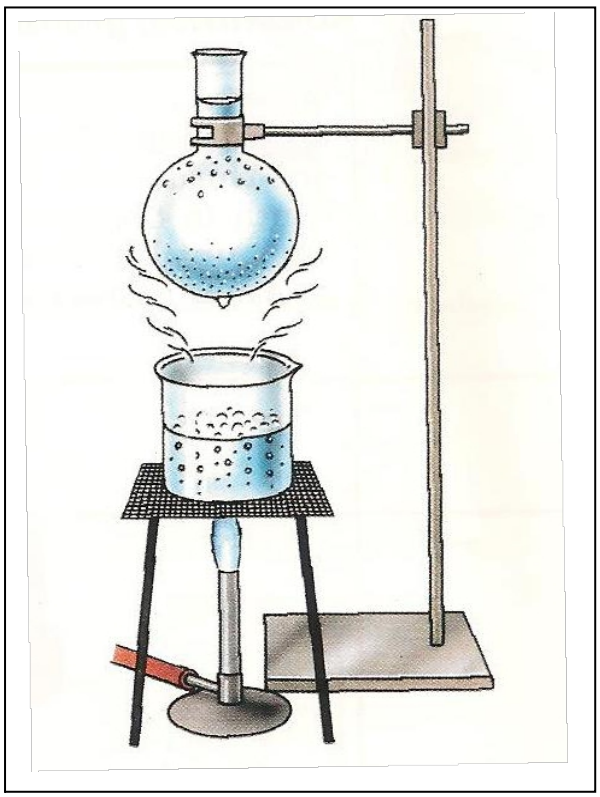
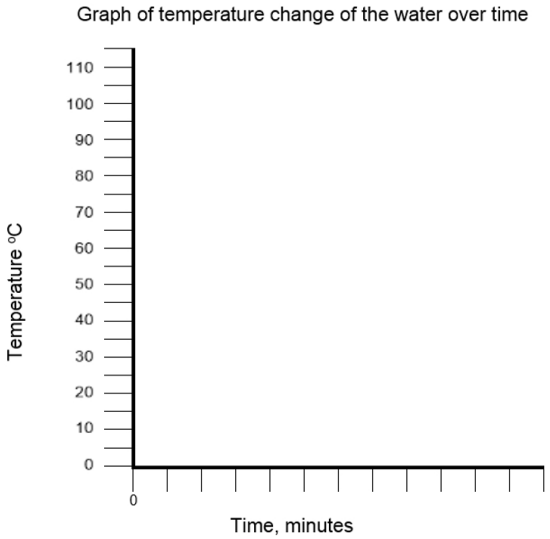


Diagram source – see below

Fill the round-bottomed flask with cold water and light the burner. Soon the water evaporating from the beaker starts condensing on the cold round-bottomed flask and eventually drips back into the beaker. This illustrates the evaporation and condensation parts of the water cycle – with evaporation from warm surfaces, condensation on cold surfaces and the droplets of condensed water growing until they fall – like rain.

B. Predicting temperature changes

Extend the demonstration into a prediction activity which helps pupils to deepen their understanding of the processes involved. Add thermometers or temperature probes to both the beaker and the round-bottomed flask. Ask them to draw a blank graph like the one opposite (or give them a prepared version). Measure the starting temperatures and ask them to plot these on the graph. Then ask them to sketch a line on the graph to show what will happen to the temperature of the water in the beaker as the water heats up, boils and continues to boil. Finally ask them to draw a second line predicting the changes in the temperature of the water in the round-bottomed flask over time.



Then light the burner to show them what happens as the water boils and heat is transferred over time. The temperature in the beaker will rise steadily towards 100°C and then flatten out. Pupils may ask what is happening to the heat energy as the burner continues to heat the beaker, but the temperature doesn't rise above 100°C. The answer is given below. After a time, the temperature of the water in the round-bottomed flask also begins rising, for the reasons also given below.

C. Discussing heat transfer

Ask the pupils to recall the different ways in which heat can be transferred. They normally recount:

- by conduction
- by convection
- by radiation

They may be able to add:

- by conduction through solids
- by convection of fluids (liquids and gases)
- by radiation (without any medium)

Then ask how, if the water in the round-bottomed flask becomes warmer, the heat is being transferred.

The answer is that none of the above is significant here. Most of the heat is transferred from the hot water into each molecule of water vapour as it evaporates – as latent heat. The heat energy is required to break the molecular bonds, so releasing individual molecules. The opposite occurs as each molecule condenses on the surface of the round-bottomed flask, releasing the latent heat and warming the flask and the water it contains

The total amount of energy (flux) transferred through the oceans and atmosphere by latent heat transfer through the water cycle processes of evaporation and condensation is enormous – and forms a key part of the Earth's heat balance.

The back up

Title: Cycling water and heat in the lab – and the globe

Subtitle: Demonstrating the water cycle, latent heat and global energy transfer

Topic: A lab demonstration of the water cycle that can be used to develop thinking skills and to understand latent heat transfer and its global effects.

Age range of pupils: 11 – 19 years

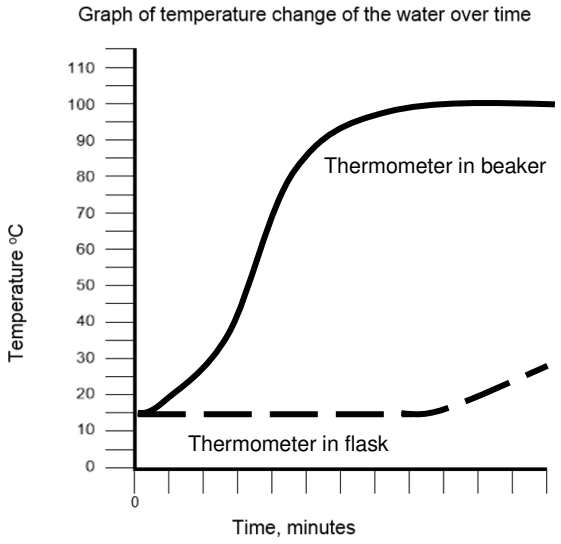
Time needed to complete activity: 20 – 30 mins

Pupil learning outcomes: Pupils can:

- A. use a diagram of the apparatus to show evaporation and condensation;
- A. explain how the apparatus demonstrates key water cycle processes;
- B. sketch a graph to show temperature change in the apparatus over time;
- B. explain the different elements of the graph;
- C. explain how latent heat is transferred by the apparatus;
- C. explain why latent heat transfer is an important part of the global heat flux.

Context:
The apparatus can be used at different levels to develop understanding of water cycle processes.

The graph in Part B looks like this:



Following up the activity:
Pupils can explore the part that latent heat transfer plays in the 'Earth's energy budget' by typing this phrase into a search engine like Google™ and following the leads.

Underlying principles:

- As the temperature of water increases, so does surface evaporation.
- Evaporation continues during boiling.
- Air containing abundant water vapour molecules has high humidity.
- When humid air is cooled, such as by contact with cool surfaces, the air becomes super-saturated with water vapour, and droplets of liquid water condense.
- As condensation continues, the droplets grow and eventually fall.
- As water is heated, the heat energy is absorbed as its temperature rises.
- When it reaches boiling point (100°C at standard atmospheric pressure), the temperature no longer increases, instead all the energy is absorbed as latent heat in the evaporation of molecules from liquid to vapour.
- When the water condenses, latent heat is released, warming the surrounding area.
- Global latent heat transfer (flux) through this mechanism is enormous and plays a major part in the global energy budget.
- Conduction is transfer between adjacent molecules by vibration/collision – requiring close-packed molecules i.e. solids.
- Convection is transfer by assemblies of molecules which are free to move in fluids.
- Radiation can be conceptualised as a stream of photons.

Thinking skill development:
In part B pupils have to visualise what will happen to the temperature of the water (construction) and use the pattern they have identified to sketch a predictive graph. Differences in graphs between pupils will cause cognitive conflict, which can be enhanced through metacognition, by asking pupils to explain their graphs to one another or to the teacher. Transferring the learning from this activity to understanding part of the global water cycle and global heat budget is a bridging activity.

Resource list:

- Bunsen burner
- tripod, gauze, heat-proof mat
- 500 ml glass beaker
- round-bottomed flask
- clamp, stand and boss
- water supply
- for B. 2 x thermometers (100°C) or temperature probes and monitors

Useful links:
See the other Earthlearningidea 'watery' activities at:
http://www.earthlearningidea.com/home/Teaching_strategies.html

Source: The drawing of the apparatus came from *Earth science for secondary teachers – an INSET handbook*, published by the National Curriculum Council, York in 1993. This was based on an activity described in *Coordinated Science: Earth Science* by P. Whitehead, Oxford University Press, 1993. Parts B. and C. were devised by Chris King of the Earthlearningidea Team.

The progression of thinking skills shown by the Earthlearningidea Water Cycle exercises

Earthlearningidea	Strategies and skills developed
Changing state – transforming water: practical activities to change the state of water; solid, liquid, gas	Demonstrations of the change of state of water in a tactile way, enabling language skill development
Mini-world water cycle: a water cycle demonstration model in a box	Demonstration of key water cycle processes in a simple model, allowing bridging to the more abstract water cycle and the development of higher level thinking skills through discussion
Water cycle world: a discussion activity on the natural water transformations on Earth	Extended discussion about the different elements of the water cycle and the many different products of the cycle
Cycling water and heat in the lab – and the globe: demonstrating the water cycle, latent heat and global energy transfer	A lab demonstration of the water cycle, extended to promote higher level thinking skills and an understanding of the abstract process of latent heat transfer