The Maryland Virtual High School

MVHS of Science and Mathematics

CoreModels

Pan Water Cycle

A Core Learning Goals Activity for Science and Mathematics

Summary: Students will use a STELLA model to understand conservation of mass in a closed cyclic system.

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Pan Water Cycle
Teacher Guide

Purpose:

The purpose of this activity is to introduce students to the concepts of equilibrium and conservation of mass through a model of the global water cycle. After investigating open and closed systems using pan water models, the students continue their work with a STELLA model which allows them to further explore a closed cyclic system.

Teacher Notes

Demonstrations:

Before this lesson can be done, two demonstrations need to be set up in the classroom.

Materials:

Two hot plates
Two "salad bar" containers, one with at lid. The round aluminum pans with the transparent plastic lids work best because the aluminum bottom can be tightly sealed over the edge of the lid.
200 ml of water

Open Pan Water Cycle:

Place 100 ml of water in the first container.
Place the container on the first hot plate.
Heat the water until boiling.
Have students observe what is happening to the system.

Closed Pan Water Cycle:

Place 100 ml of water in the second container.
Place the lid on the container.
Place the container on the second hot plate.
Heat the water until boiling.
Have students observe what is happening to the system.

Other Materials Needed:

Students will need a copy of "Generic Graph Questions" and "CoreModels Graph Interpretation Guidelines" which can be found in your graph packet.

Pan Water Cycle
Teacher Guide – Answer Key
Section I

Q1. Which components of the pan water cycle would be represented by stocks?
Water in the pan and water in the air would be represented by stocks.

Q2. Which processes of the pan water cycle would be represented by a flow?
Evaporation would be represented by a flow.

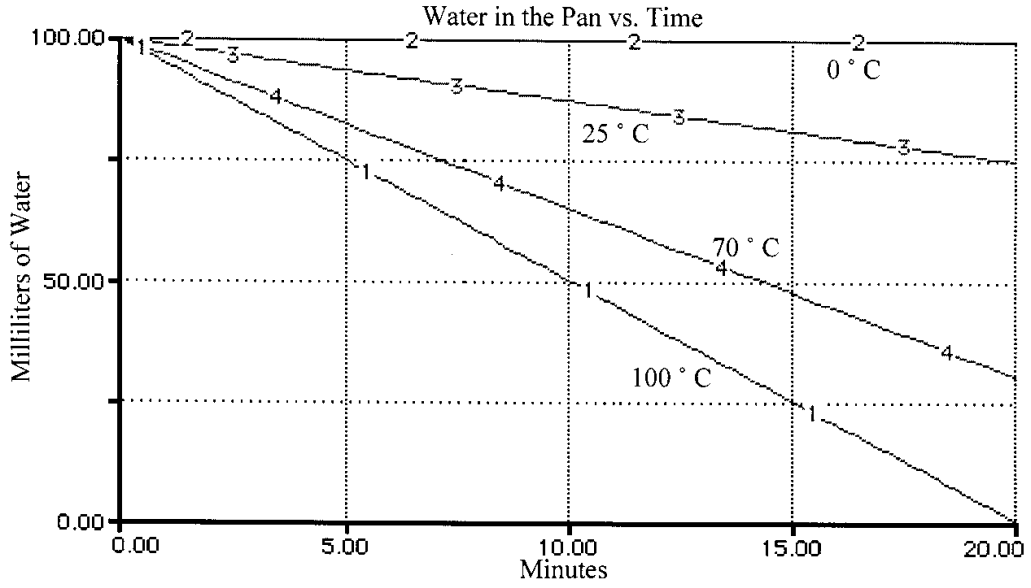
Q3. What effect did turning up the temperature of the hot plate have on how much evaporation occurred in our pan model? How does this relate to the real ocean-atmosphere system?
Turning up the temperature of the hot plate sped up the evaporation process. This relates to the real ocean-atmosphere system by representing the fact that when the oceans are warmer, water evaporates more quickly.

Q4. What effect would moving the earth closer to the sun have on the real ocean-atmosphere system?
If the earth were moved closer to the sun, then sun would heat up the oceans and water would evaporate more quickly.

Q5. The model represents a situation in which 100 ml of water would evaporate into the air at the rate of 100 {degrees Celsius} *1/20 {ml/min/degree Celsius}. How many minutes should it take for the water in the pan to completely evaporate?
*100° C *1/20 ml/min/° C = 5 ml/min. If 5 ml of water are evaporating every minute, it would take 20 minutes for the entire 100 ml of water to evaporate. (5*20 = 100)*

Q6. On the axes provided, sketch a graph that represents the number of ml of water in the pan during 20 minutes of evaporation. Label your graph according to the Level I Generic Graph Questions.
The line drawn may vary; however, it should start at the upper left corner of the graph and end at the lower right corner of the graph.

Q7. **Referring to the Level I Generic Graph Questions, sketch the Water in Pan graph on the axes provided.**
At this point, the only line on the graph will be the 100° C line.

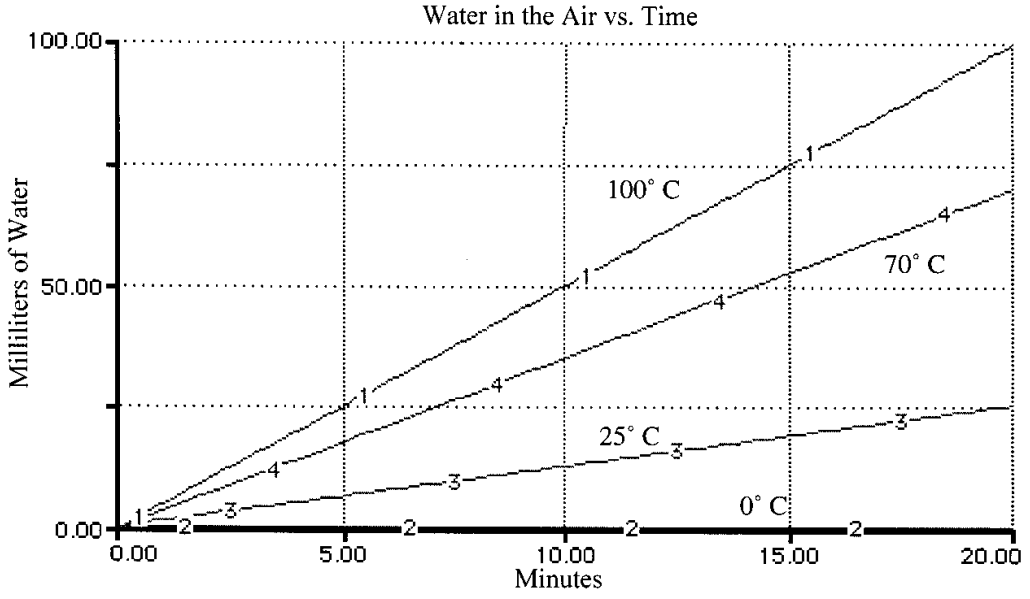


Q8. **Referring back to your copy of the Graph Interpretation Guidelines, describe the graph in the context of the situation being modeled.**
The amount of water in the pan starts at 100 ml and decreases at a constant rate of 5 ml/min for 20 minutes. The slope of the line represents the rate of evaporation per minute. At 20 minutes, the amount of water in the pan is 0 ml.

Q9. **If the water in the pan is decreasing from 100 ml to 0 ml over a 20 minute time period of evaporation at 100 degrees Celsius, describe what should be happening to the water in the air during the same time period.**
The water in the air should be increasing over the 20 minute time period.

Q10. Referring to the Level I Generic Graph Questions, sketch the Water in Air graph on the axes provided.

At this point, the only line on the graph will be the 100° C line.



Q11. Referring back to your copy of the Graph Interpretation Guidelines, describe the graph in the context of the situation being modeled.

The amount of water in the air starts at 0 ml and increases at a constant rate of 5 ml/min for 20 minutes. The slope of the line represents the rate of evaporation per minute. At 20 minutes, the amount of water in the air is 100 ml.

Q12. If the water temperature were lowered to 0 degrees Celsius, how would the evaporation change?

*If the water temperature were lowered to 0 degrees Celsius, the water would be at freezing temperature and there would be extremely little evaporation. If the water were frozen, there be no evaporation. Mathematically, evaporation would take place at a rate of 0*1/20 = 0 ml/min.*

Q13. If the water temperature were lowered to 0 degrees Celsius, how would the lines for the Water in Pan and Water in Air graphs be different from the lines drawn for a water temperature of 100 degrees C?

Both of the lines would be horizontal (slope = 0) instead of either increasing or decreasing. The line for the Water in Pan would be horizontal at 100 ml. The line for Water in Air would be horizontal at 0 ml.

Q14. Sketch the new lines on the axes already used in Q7 and Q10. Label each line with the water temperature setting used when the line was drawn.
See graphs from Q7 and Q10. The lines labeled 0° C are the ones drawn for this question.

Q15. Pick two temperatures between 0 degrees Celsius and 100 degrees Celsius. Write a description of where the lines for Water in Pan and Water in Air should be for those temperatures in relation to the two existing lines on each of those graphs.
On each of the graphs, the two new lines should fall between the lines created with temperatures 0 and 100 degrees Celsius. The line created by the higher temperature picked should be closer to the 100 degrees Celsius line and the line created by the lower temperature picked should be closer to the 0 degrees Celsius line. The slope for the 100 degree Celsius line would be the steepest. The one created at the next highest temperature would be the next steepest, and the one with the lower temperature would be the least steep but greater than zero.

Q16. Sketch the new lines of the axes already use in Q7 and Q10. Label each line with the water temperature setting used when the line was drawn.
Answers will vary depending on the temperatures chosen by the students. See graphs from Q7 and Q10 for an example. The lines should be labeled with the temperature settings that were used when the line was drawn.

Q17. On the Water in Air graph, what does the slope of each line tell you about evaporation?
On the Water in Air graph, the slope of each line is the rate of evaporation in ml per min. The steeper the slope, the greater the evaporation rate. Since the lines with steeper slopes correspond to the higher temperatures, we see that higher temperatures result in faster rates of evaporation.

Pan Water Cycle
Teacher Guide – Answer Key
Section II

Q1: How should the model be changed to represent a closed container system?
A new stock called Water on Cover needs to be added. It needs to have a flow coming from Water in Air and another flow going to Water in Pan.

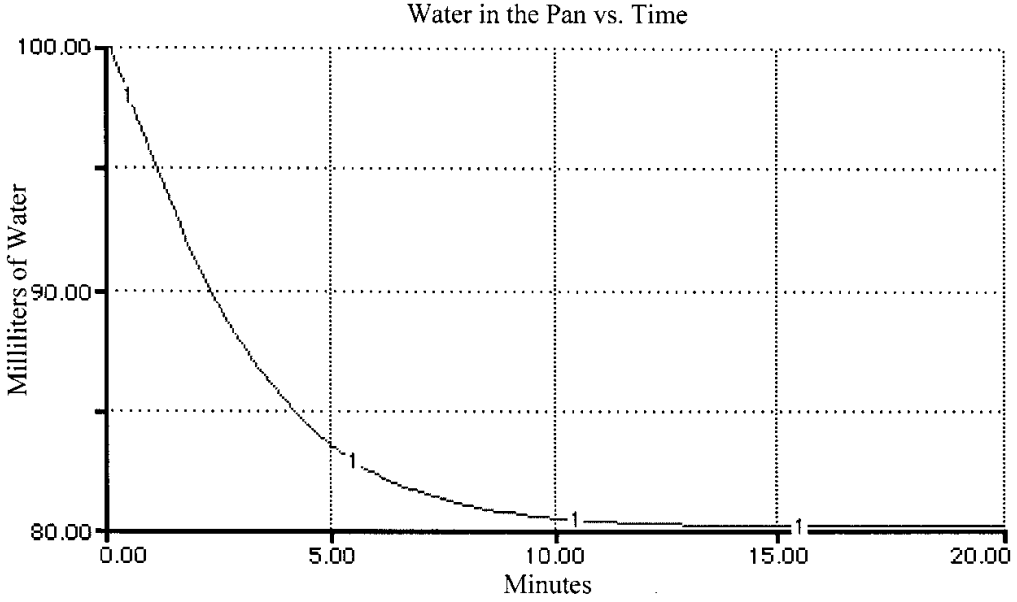
Q2: What should you name the flow that transforms evaporated water in the air to liquid water on the cover?
The flow should be named Condensation.

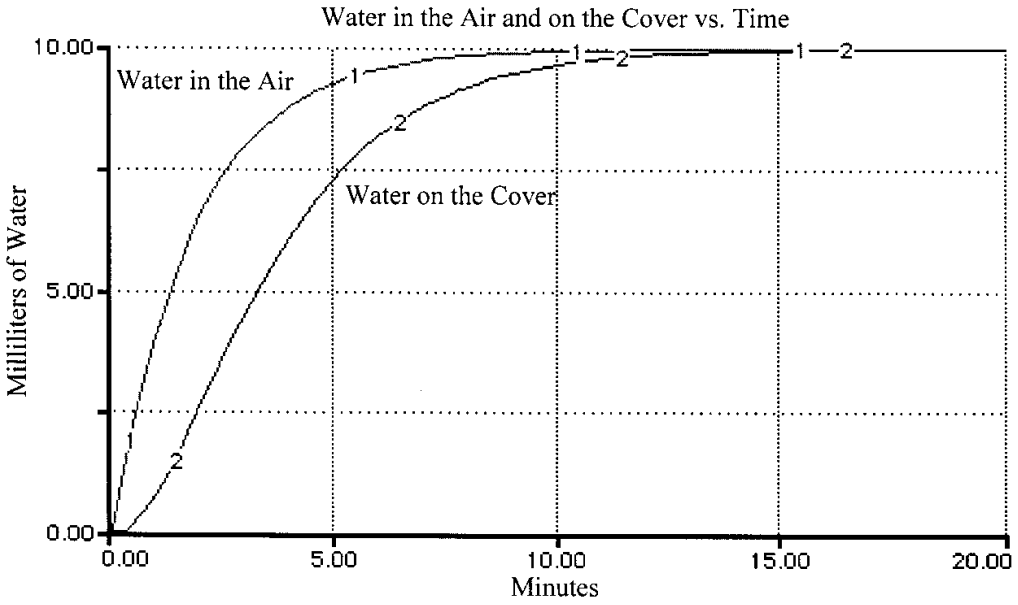
Q3: What should you name the flow that moves liquid water on the cover to water in the pan?
The flow should be named Precipitation.

Q4: From the graphs, estimate the value of each stock after 20 minutes.
a) **Water in Pan** *80 ml*
b) **Water in Air** *10 ml*
c) **Water on Cover** *10 ml*

Q5: What is your prediction for the value of each stock after 20 more minutes?
a) **Water in Pan** *80 ml**
b) **Water in Air** *10 ml**
c) **Water on Cover** *10 ml**
**If the student has given the same answers for Q5 as they did for Q4, they should receive credit because they have showed the understanding of reaching equilibrium.*

Q6: Referring to the Level I Generic Graph Questions, sketch each curve on the axes provided.





Q7: Referring back to your copy of the Graph Interpretation Guidelines, describe the curves in the context of the situation being modeled.

The amount of water in the pan starts at 100 ml and decreases to 80 ml, where it stays constant. The amount of water in the air and on the cover both start at 0 ml and increase to 10 ml, where they stay constant. The water in the air, however, rises more rapidly than the water on the cover. The slopes for all of these curves represent the rate of change in water for each stock.

Q8: What does it mean to say that our model of the closed pan water cycle is in equilibrium?

It means that the amounts of water in each stock will remain constant no matter how long the model is run for.

Q9: How is our computer model of the pan water cycle unlike the actual covered pan system?

The actual covered pan system has water on the sides that drip down into the pan.

Q10: How is the pan water cycle like the water cycle in the real world?

It is a small scale model of the actual water cycle, with the water in the pan representing the water on Earth, the water in the air representing the water in the atmosphere, and the water on the cover representing the water that is in clouds.

Q11: How is the pan water cycle different from the water cycle in the real world?
There is no land or runoff in the pan water cycle.