6. Heat Transfer in Fluids

Mixing Temperatures

Driving Question

What is the resulting temperature when you mix equal parts hot and cold water?

Materials and Equipment

For each student or group:

- ☐ Data collection system
- ☐ Temperature sensor, fast response
- ☐ Graduated cylinder, 250-mL
- ☐ Beakers or cups (2), 150-mL
- ☐ Insulated container
- ☐ Hot water, 125 mL
- ☐ Cold water, 125 mL
- ☐ Red and blue food dyes (optional)
- ☐ Stirring rod

Safety

Add these important safety precautions to your normal laboratory procedures:

- Wear safety goggles for the duration of this activity.
- Do not use water above 40 °C. Painful burns may result.

Thinking about the Question

Have you ever heated a drink only to discover that it became too hot to drink? You could let the drink sit for a time until it cooled enough to drink, or you could add a cooler substance to the cup to cool it faster.

If you've ever taken a bath, you're probably familiar with bath-water that's too hot to get into comfortably, or water that's not warm enough for your preference. Either way, you know that you can change the temperature of the bath-water by adding more water of the temperature you want. You simply add more cold water to your bath if it's too hot, or you add more hot water if it's not warm enough.

When two liquids of different temperatures are mixed together, the warmer one loses heat energy and the cooler one gains heat energy. The final temperature of the mixture is always somewhere between the two starting temperatures. Discuss with your lab group how the amount of the cooler substance added determines the final temperature.

_____

_____

Sequencing Challenge

☐ **The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.**

○	○	○	○	○
Make certain that each member of your lab group is aware of the safety rules and procedures for this activity.	In an insulated container, carefully combine equal volumes of hot and cold water samples of known temperatures.	Obtain equal volumes of hot and cold water.	Determine the final temperature of the mixture of the hot and cold water samples.	Measure the temperature of the hot and the cold water samples.

Investigating the Question

☐ **Note:** When you see the symbol "**[?]**" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Making predictions

1. ☐ What will happen when equal amounts of hot and cold water are mixed.

_____

_____

_____

2. ☐ In the space below, sketch a temperature versus time graph that reflects your prediction.

Part 2 – Measuring temperatures of solutions

3. ☐ Start a new experiment on the data collection system. (1.2)

4. ☐ Connect a temperature sensor to the data collection system. (2.1)

5. ☐ Display Temperature in a graph display. (7.1.1)

6. ☐ If you are using food dye, color the hot water red and the cold water blue.

7. ☐ Measure 125 mL of hot water into a 150-mL beaker.

8. ☐ Insert the temperature sensor into the beaker and begin data recording. (6.2)

9. ☐ When the temperature stabilizes, record it in Table 1. You may need to adjust the scale of the graph to see all of your data. (7.1.2)

10. ☐ Stop data recording. (6.2)

11. ☐ Measure 125 mL of cold water into a 150-mL beaker

12. ☐ Insert the temperature sensor into the beaker and begin data recording. (6.2)

13. ☐ When the temperature stabilizes, record it in Table 1. You may need to adjust the scale of the graph to see all of your data. (7.1.2)

14. ☐ Stop data recording. (6.2)

Table 1: Water sample volumes and temperatures

Volume of Water Samples	
Temperature of Hot Water	
Temperature of Cold Water	

Part 3 – Observing the temperature changes of the water mixture

15. ☐ Mix the equal amounts of hot and cold water in the insulated container.

16. ☐ Place the temperature sensor into the mixture in the insulated container and close the lid as much as possible.

17. ☐ Begin data recording. (6.2) After the temperature of the mixture stabilizes, record the temperature.

Temperature of mixture: _____ °C

18. ☐

a. Why is it important to use the same volume of water for each sample in this part of the activity?

_____

_____

_____

b. If you pour equal volumes of hot and cold water together into one container, what fraction of the mixture is represented by the hot water? Once you have tested your prediction for equal volumes of hot and cold water, what other fractional amounts could you measure and test?

_____

_____

_____

19. ☐ Use the equation your class came up with to calculate the final temperature. Is this what your lab group predicted or expected? In the space below, record your calculations and your results.

_____

_____

_____

Answering the Question

Analysis

1. After reviewing your data, describe the relationship that you see from the beginning and final temperatures of your water mixture.

_____

_____

2. How did your predictions from Part 1 compare to the results from Part 3? How closely does your predicted graph match what you actually recorded? How can you explain any difference you saw between the prediction you made and the experimental results?

_____

_____

_____

3. Where does the heat energy go when two liquids of different temperatures are mixed together?

_____

_____

_____

Key Term Challenge

☐ **Fill in the blanks from the randomly ordered words below. Note that words may be used more than once:**

heat	warm	degrees Celsius	temperature
average	flow	cold	energy

1. By measuring the _____ of a substance you can get an idea of how much thermal energy its particles contain.

2. _____ is a form of _____ that is associated with the motion of the molecules of that substance.

3. Thermal or heat _____ tends to _____ from _____ objects or substances to _____ objects or substances.

4. In the SI system _____ is the unit of measure for _____.

5. When equal amounts of a _____ and a _____ substance are mixed, the resulting _____ is the _____ of the two initial temperatures.

6. When _____things and _____things come into contact with each other eventually both reach the same_____, or in other words both have the same amount of _____ _____.