

5. (20 points) Answer each of the questions below with the appropriate letter on your answer sheet.

5.1 Three objects are kept outside for a long time on a cold day: a piece of cotton, a piece of wood

and a piece of metal. Which object would feel the coldest when you touched it?

A) The cotton **B)** The wood **C)** The metal **D)** They would all feel the same

5.2. Which of the objects in 5.1 would have the lowest temperature?

A) The cotton **B)** The wood **C)** The metal **D)** They would all have the same temperature

5.3. The objects in questions 5.1 and 5.2 are placed in an oven heated to 90°C and left for a long time.

Which object will feel warmest when you touch it?

A) The cotton **B)** The wood **C)** The metal **D)** They would all feel the same

5.4. Which of the objects in the situation described in 5.3 would have the highest temperature?

A) The cotton **B)** The wood **C)** The metal **D)** They would all have the same temperature

II. (15 points) In class, we discussed a number of concepts relating to the sense of hot and cold: temperature, thermal energy, and heat flow among them. We made an attempt to both connect to our personal experience of heat and cold and to reconcile our senses with a consistent scientific picture. Discuss one apparent sensory conflict and how it can be resolved with a consistent scientific picture. If you did not have a conflict yourself, discuss one expressed by someone in class or a plausible one that your roommate might have.

A 500 g piece of copper is accidentally dropped into liquid nitrogen ($T = -180\text{ }^\circ\text{C}$). In order to warm up the copper, a student removes it from the nitrogen and immediately places it in a Styrofoam cup containing 400 g of water. The water is at a temperature of 15 °C. Predict the final equilibrium state that is attained within the Styrofoam cup. Explain your reasoning and interpret, in words, the physical meaning of each separate term that is present in any equation you use.

Some of the following constants may be of use:

$$c_{\text{water}} = 1.0 \text{ cal/g } ^\circ\text{C};$$

$$c_{\text{ice}} = 0.49 \text{ cal/g } ^\circ\text{C};$$

$$c_{\text{copper}} = 0.092 \text{ cal/g } ^\circ\text{C};$$

$$L_{f,\text{water}} = 80 \text{ cal/g};$$

$$L_{f,\text{copper}} = 49 \text{ cal/g};$$

$$k = 1.38 \times 10^{-23} \text{ J/}^\circ\text{C}$$

$$1 \text{ cal} = 4.186 \text{ J}$$

Questions 1 through 4 refer to two cups, A and B, which contain different amounts of water. The water in each cup is heated as described. In questions 1 through 3 the cups are in a room where the temperature is 25 °C. In question 4 the cups are in different environments. For each question choose one of the four answers **A** through **D**.

- A) Cup A had more heat energy transferred
- B) Cup B had more heat energy transferred
- C) Both cups had the same amount of heat energy transferred
- D) not enough information is given to determine the answer

___1. Cup A contains 100 grams of water and cup B contains twice as much water. The water in both cups was initially at room temperature. Cup A was heated to 75°C and cup B was heated to 50°C. Which cup had more heat energy transferred to it?



___2. Cup A contains 100 grams of water and cup B contains 50 grams of water. The water in both cups was initially at room temperature. Cup A was then heated to 45°C and cup B was heated to 90°C. Which cup had more heat energy transferred to it?



___3. Cup A contains 100 grams of water and cup B contains 80 grams of water. The water in both cups was initially at room temperature. Cup A was then heated to 45°C and cup B was heated to 50°C. Which cup had more heat energy transferred to it?



___4. Cup A contains 100 grams of water and is initially at 10°C in a refrigerator. Cup A is heated until its temperature is 20°C. Cup B contains 50 grams of water initially at 70°C in an oven. Cup B is heated until its temperature is 90°C. Which cup had more heat energy transferred to it?

