Heat by Design

Choose materials by comparing specific heat

PS.1.c "Construct explanations to justify the selection of materials for specific applications based on the materials' specific heat values."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the two sentences that explain how specific heat affects temperature change and energy release. Circle each material and its value in the list in paragraph 2, then number the three possible jobs named at the end.

Choosing Materials for a Greenhouse

1. At a school greenhouse, the design team wants materials that control temperature, not just materials that feel warm to the touch. Specific heat tells how much energy it takes to change the temperature of one kilogram of a substance by one degree Celsius. If two equal masses gain the same amount of energy, the material with the higher specific heat warms less. If those masses start at the same temperature and cool by the same number of degrees, the higher-specific-heat material releases more energy. These comparisons assume the masses and other conditions really are the same.

2. Here are values the team can use, measured in joules per kilogram per degree Celsius. Water has a specific heat of about 4,180, while vegetable oil is about 2,000. Aluminum is about 900, dry sand about 830, steel about 490, and copper about 385. Each value describes how much energy one kilogram needs for a one-degree rise. For instance, raising one kilogram of copper by one degree takes about 385 joules; raising the same mass of water by one degree takes about 4,180 joules. These are approximate values, since material mixtures and conditions can vary.

3. Imagine a copper canister beside an equal mass of water in the greenhouse. After each absorbs 4,180 joules, the water warms about one degree, but the copper warms much more. That example concerns temperature change, not how quickly heat travels through a wall. Specific heat alone cannot tell whether a material is a good insulator or whether it will leak, rust, or cost too much. For a fair choice, first name the job: should the material change temperature quickly, absorb energy with little warming, or release stored energy while cooling? Then compare specific heats under equal-mass conditions.

2 ANSWER WITH EVIDENCE

Use the passage

1. The greenhouse needs a heat reservoir for nighttime. Equal masses of water and dry sand start at the same temperature and cool by 5°C. Which would release more energy? Justify your choice with specific heat values.

2. A small test piece must warm quickly when it receives energy. If equal masses of steel and aluminum absorb the same amount of energy, which should the team choose? Explain.

3. A cooling system must absorb energy without getting much warmer. Based only on specific heat, should it use an equal mass of water or vegetable oil? Explain.

4. Equal masses of dry sand and steel are heated to the same temperature, then allowed to cool by the same number of degrees. Which would release more energy? Explain.

3 YOUR TURN

Your own words

Design a warming pouch using either 0.5 kilogram of vegetable oil in a sealed pouch or a 0.5-kilogram aluminum block. Both begin at the same temperature and cool by 10°C. Choose the material that releases more energy, calculate how much each would release, and explain your choice.

Heat by Design

PART 1 · READ AND MARK

Underline the two sentences that explain how specific heat affects temperature change and energy release. Circle each material and its value in the list in paragraph 2, then number the three possible jobs named at the end. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	The greenhouse needs a heat reservoir for nighttime. Equal masses of water and dry sand start at the same temperature and cool by 5°C. Which would release more energy? Justify your choice with specific heat values.	**Water would release more energy. Its specific heat is about 4,180 J per kilogram per degree Celsius, compared with about 830 for dry sand, so equal masses cooling by 5°C release different amounts of energy.**
2	A small test piece must warm quickly when it receives energy. If equal masses of steel and aluminum absorb the same amount of energy, which should the team choose? Explain.	**Choose steel. Its lower specific heat, about 490 compared with aluminum's 900, means its temperature rises more for the same energy input.**
3	A cooling system must absorb energy without getting much warmer. Based only on specific heat, should it use an equal mass of water or vegetable oil? Explain.	**Choose water. Its higher specific heat, about 4,180 compared with vegetable oil's 2,000, means it warms less while absorbing the same energy.**
4	Equal masses of dry sand and steel are heated to the same temperature, then allowed to cool by the same number of degrees. Which would release more energy? Explain.	**Dry sand would release more energy because its specific heat, about 830, is higher than steel's 490.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would choose the sealed pouch of vegetable oil because it releases more energy as it cools. The oil releases 0.5 × 2,000 × 10 = 10,000 joules, while the aluminum releases 0.5 × 900 × 10 = 4,500 joules. With equal masses and equal temperature drops, the material with the higher specific heat releases more energy.

Accept explanations that correctly connect higher specific heat to a smaller temperature rise for equal energy input or greater energy release for an equal temperature drop. The choices are based on specific heat alone, not on insulation or other practical properties.