Name:_____Class:_____ Date:_____

Heat

Problem C

CALORIMETRY

PROBLEM

In 1906, a 636.73-g diamond was found at the Premier Mine in South Africa—making it the world's largest uncut diamond. After being cut, the diamond pieces were dropped into an insulated water bath containing 1.00 kg of water. The water temperature increased by 1.30°C, and the diamond's temperature decreased by 15.54°C. What is the specific heat capacity of diamond? The specific heat capacity of water is 4186 J/kg• °C.

SOLUTION

1. **DEFINE**

Given: $m_d = 636.73\ \text{g}$ $m_w = 1.00\ \text{kg}$ $\Delta T_d = -15.54°\text{C}$

$\Delta T_w = 1.30°\text{C}$ $c_{p,w} = 4186\ \text{J/kg} \bullet °\text{C}$

Unknown: $c_{p,d} = ?$

2. **PLAN** **Choose the equation(s) or situation:** Use the equation for specific heat capacity to equate the energy removed from the diamond to the energy absorbed by the water. Energy absorbed by water = Energy removed from diamond

$$c_{p,w} m_w \Delta T_w = -c_{p,d} m_d \Delta T_d$$

Rearrange the equation(s) to isolate the unknown(s):

$$c_{p,d} = \frac{c_{p,w} m_w \Delta T_w}{-m_d \Delta T_d}$$

3. **CALCULATE** **Substitute the values into the equation(s) and solve:**

$$c_{p,d} = \frac{(4186\ \text{J/kg}\bullet°\text{C})(1.00\ \text{kg})(1.30°\text{C})}{-(0.63673\ \text{kg})(-15.54°\text{C})} = \boxed{5.50 \times 10^2\ \text{J/kg}\bullet°\text{C}}$$

4. **EVALUATE** The answer can be estimated using rounded values for $c_{p,w}$ (4200 J/kg•°C), $md\left(\frac{2}{3}\ \text{kg}\right)$, and the ratio of ΔT_w to $\Delta T_d\left(\frac{1}{12}\right)$.The resulting value for $c_{p,d}$ is then 530 J/kg•°C, which is close to the calculated value.

ADDITIONAL PRACTICE

1. Mixing equal parts of hydrogen peroxide and water to use as a mouthwash disinfects the mouth and whitens teeth. Suppose you mix 15 g of each into a plastic foam cup. The water's temperature increases 1.0°C and the hydrogen peroxide decreases 1.6°C. Disregarding energy transfer as heat to the solution's surroundings, what is the specific heat capacity of hydrogen peroxide?

2. Vinegar, which contains acetic acid, can be used as an effective and environmentally-friendly household cleanser. Suppose you mix 0.340 kg of vinegar at 21.0°C with 1.00 kg hot water at 90.0°C in a plastic bucket. The solution of vinegar and water reaches a final equilibrium temperature of 73.7°C. Disregarding energy transfer as heat to the surrounding air and bucket, what is the specific heat capacity of vinegar?
3. After eating a hearty stew you cooked over a campfire with your 0.250-kg aluminum-alloy pot, you place the pot in a plastic bucket containing 1.00 kg of water. The water's temperature increases 1.00°C and the temperature of the pot decreases 17.5°C. Disregarding energy transfer as heat to the surrounding air and bucket, what is the specific heat capacity of the pot?
4. Suppose you bake cornbread in a 3.0-kg cast iron skillet. After removing the cornbread from the oven, you place the hot skillet in a sink filled with 5.0 kg of dishwater. The water's temperature increases 2.25°C, and the temperature of the skillet decreases 29.6°C. Disregarding energy transfer as heat to the surrounding air and sink, what is the specific heat capacity of the skillet?
5. The water in a swimming pool transfers 1.09×10^{10} J of energy as heat to the cool night air. If the temperature of the water, which has a specific heat of 4186 J/kg• °C, decreases by 5.0°C, what is the mass of the water in the pool?
6. Bismuth's specific heat is 121 J/kg• °C, the lowest of any non-radioactive metal. What is the mass of a bismuth sample if 25 J raises its temperature 5.0°C?
7. The temperature of air in a foundry increases when molten metals cool and solidify. Suppose 4.5×10^{7} J of energy is added to the surrounding air by the solidifying metal. The air's temperature increases by 55°C, and the air has a specific heat capacity of 1.0×10^{3} J/kg• °C. What is the mass of the heated air?
8. A 0.190 kg piece of copper is heated and fashioned into a bracelet. The amount of energy transferred as heat to the copper is 6.62×10^{4} J. If the specific heat of copper is 387 J/kg• °C, what is the change in the temperature of the copper?
9. A 0.225 kg sample of tin, which has a specific heat of 2.2×10^{3} J/kg• °C, is cooled in water. The amount of energy transferred to the water is 3.9×10^{4} J. What is the change in the tin's temperature?
10. Tantalum is an element used, among other things, in making aircraft parts. Suppose the properties of a tantalum part are being tested at high temperatures. Tantalum has a specific heat of about 140 J/kg• °C. The part, which has a mass of 0.23 kg, is cooled by being placed in water. If 3.0×10^{4} J of energy is transferred to the water, what is the change in the part's temperature?