Name ______________________________ Class__________________Date_________________

Skills Worksheet

Math Skills

Specific Heat

After you study each sample problem and solution, work out the practice problems on a separate sheet of paper. Write your answers in the space provided.

PROBLEM

Lithium has the highest specific heat of any pure metal. The temperature of a 25.00 g sample of lithium will increase by 7.69 K when 684.4 J of energy is added to it. What is lithium's specific heat?

SOLUTION

Step 1: List the given and unknown values.

Given: $\Delta t = 7.69$ K

$m = 25.00 \text{ g} = 25.00 \times 10^{-3}$ kg

energy = 684.4 J

Unknown: c = ? J/kg • K

Step 2: Write down the specific heat equation, and rearrange it to solve for specific heat.

$$energy = cm\Delta t$$

$$\frac{energy}{m\Delta t} = \frac{cm\Delta t}{m\Delta t}$$

$$c = \frac{energy}{m\Delta t}$$

Step 3: Substitute the energy, mass, and temperature change values, and solve.

$$c = \left(\frac{684.4 \text{ J}}{(25.00 \times 10^{-3} \text{ kg}) \times 7.69 \text{ K}}\right)$$

c = 3,560 J/kg • K

PRACTICE

1. Brass is an alloy made from copper and zinc. A 0.59 kg brass candlestick has an initial temperature of 98.0°C. If 2.11×10^4 J of energy is removed from the candlestick to lower its temperature to 6.8°C, what is the specific heat of brass?

____

2. Mercury has one of the lowest specific heats. This fact added to its liquid state at most atmospheric temperatures makes it effective for use in thermometers. If 257 J of energy are added to 0.450 kg of mercury, the mercury's temperature will increase by 4.09 K. What is the specific heat of mercury?

____

3. A 0.38 kg drinking glass is filled with a hot liquid. The liquid transfers 7,032 J of energy to the glass. If the temperature of the glass increases by 22 K, what is the specific heat of the glass?

____

PROBLEM

The water in a swimming pool gives up 1.09×10^{10} J of energy to the cool night air. If the temperature of the water, which has a specific heat of 4,186 J/kg • K, decreases by 5.0 K, what is the mass of the water in the pool?

SOLUTION

Step 1: List the given and unknown values.

Given: *energy* $= 1.09 \times 10^{10}$ J

$c = 4{,}186$ J/kg • K

$\Delta t = 5.0$ K

Unknown: $m = ?$ kg

Step 2: Write down the specific heat equation, and rearrange it to solve for mass.

$$energy = cm\Delta t$$

$$\frac{energy}{c\Delta t} = \frac{cm\Delta t}{c\Delta t}$$

$$m = \frac{energy}{c\Delta t}$$

Step 3: Substitute the energy, specific heat, and temperature change values, and solve.

$$m = \left(\frac{1.09 \times 10^{10}\ \text{J}}{(4{,}186\ \text{J/kg} \bullet \text{K}) \times 5.0\ \text{K}} \right)$$

$$m = 5.2 \times 10^{5}\ \text{kg}$$

PRACTICE

4. Bismuth's specific heat is 121 J/kg • K, the lowest of any non-radioactive metal. What is the mass of a bismuth sample if 25 J raises its temperature 5.0 K?

____

5. The temperature of air in a foundry increases when molten metals cool and solidify. Suppose 9.9×10^6 J of energy is added to the surrounding air by the solidifying metal. The air's temperature increases by 55 K, and the air has a specific heat capacity of 1.0×10^3 J/kg • K.

   a. What is the mass of the heated air?

   ____

   b. Assuming a density of 1.29 kg/m^3, what is the heated air's volume?

   ____

6. The temperature of air above coastal areas is greatly influenced by the large specific heat of water. The specific heat of air between temperatures of 40°F and 90°F is about 1,000.0 J/kg • K. Consider the situation where 4,186 J of energy is given up by 1.0 kg of water, causing its temperature to drop by 1.0 K.

   a. If the air over the water increases temperature by 5.5 K, what is its mass?

   ____

   b. What is the volume of the air over the water, assuming that the air's density is 1.29 kg/m^3?

   ____

PROBLEM

A 0.150 kg iron bolt is heated by 1.245×10^4 J of energy. If the bolt, which has a specific heat of 448 J/kg • K, reaches a temperature of 455 K after heating, what was its initial temperature?

SOLUTION

Step 1: List the given and unknown values.

Given: $m = 0.150$ kg

$energy = 1.245 \times 10^4$ J

$c = 448$ J/kg • K

$final\ T = 455$ K

Unknown: $initial\ T = ?$ K

Step 2: Rearrange the specific heat equation to solve for initial temperature.

$$energy = cm\Delta t$$

$$\frac{energy}{cm} = \frac{cm\Delta t}{cm}$$

$$\Delta t = final\ T - initial\ T = \frac{energy}{cm}$$

$$initial\ T = final\ T - \frac{energy}{cm}$$

Step 3: Substitute the specific heat, mass, and energy values, and solve.

$$initial\ T = 455\ \text{K} - \left(\frac{1.245 \times 10^4\ \text{J}}{(448\ \text{J/kg} \cdot \text{K}) \times 0.150\ \text{kg}}\right) = 455\ \text{K} - 185\ \text{K}$$

$$initial\ T = 2.7 \times 10^2\ \text{K}$$

PRACTICE

7. A 0.190 kg piece of copper is heated and fashioned into a bracelet. The amount of energy transferred by heat to the copper is 6.62×10^4 J. If the specific heat of copper is 385 J/kg • K what is the change in the temperature of the copper?

____

8. A 0.225 kg sample of tin, which has a specific heat of 2.3×10^2 J/kg • K, is cooled in water. The amount of energy transferred to the water is 3.9×10^3 J. If the final temperature of the tin is 18°C, what was its initial temperature?

____

9. Tantalum is an element that is 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 • K. The aircraft part has a mass of 0.23 kg and is cooled from a temperature of 1,200 K by being placed in water. If 3.0×10^4 J of energy is transferred to the water, what is the final temperature of the part?

____

PROBLEM

A cup is made of an experimental material that can hold hot liquids without significantly increasing its own temperature. The cup's mass is 0.75 kg, and its specific heat is 1,860 J/kg • K. If the temperature of the cup increases from 20.0°C to 36.5°C, what is the amount of energy that has been transferred by heat into the cup?

SOLUTION

Step 1: List the given and unknown values.

Given: Δt = 36.5ºC – 20.0º C = 16.5º C = 16.5 K

m = 0.75 kg

c = 1,860 J/kg • K

Unknown: *energy* = ?

Step 2: Write out the equation for specific heat.

$$energy = cm\Delta t$$

Step 3: Substitute the specific heat, mass, and temperature change values, and solve.

$$energy = \left(\frac{1{,}860\ \text{J}}{\text{kg}\bullet\text{K}}\right) \times (0.75\ \text{kg}) \times (16.5\ \text{K})$$

$$energy = 2.3 \times 10^4\ \text{J} = 23\ \text{kJ}$$

PRACTICE

10. The element hydrogen has the highest specific heat of all elements. At a temperature of 25°C, hydrogen's specific heat is 1.43×10^4 J/kg • K. If the temperature of a 0.34 kg sample of hydrogen is to be raised by 25 K, how much energy will have to be added to the hydrogen?

____

11. The element radon is at the opposite end of the range with the lowest specific heat of all naturally occurring elements. At 25°C, radon's specific heat is 94 J/kg • K. If the temperature of a 0.34 kg sample of radon is to be raised by 25 K, how much energy will have to be added to the radon?

____

12. The soup in a bowl is too hot to eat, so you need to find some way to cool it quickly. Although there are no ice cubes in the freezer, there are several stainless steel spoons that have been stored in the freezer for several hours. By placing the cold spoons in the bowl of hot soup, the soup's temperature is lowered from a temperature of 82°C to 48°C. The mass of the soup is 0.10 kg, while the mass of each spoon is 0.04 kg.

    a. Assuming the soup has the same specific heat as water (4,186 J/kg • K), how much energy is removed from the soup?

    ____

    b. If the initial temperature of the spoons is –15°C and their specific heat is the same as iron, how many spoons are needed to cool the soup?

    ____

MIXED PRACTICE

13. The technique known as *calorimetry* allows you to measure how much energy is added to or removed from a substance by heat. By placing the substance in a known quantity of water, which has a specific heat of 4,186 J/kg • K, and measuring the change in the water's temperature, the amount of energy added to or removed from the water can be determined. If the initial temperature and mass of the substance are also known, the substance's specific heat can also be determined. Suppose calorimetry is used to measure the energy given up by a hot piece of metal that is submerged in 1.5 kg of water. If the energy added to the water equals 3.14×10^4 J, how much does the water's temperature increase?

____

14. A ring with a mass of 25.5 g appears to be pure silver. Rather than test for density, you can confirm the ring's composition by determining its specific heat. Suppose the ring is heated to a temperature of 84.0°C and then immersed in a container of water until the ring's temperature is 25.0°C. If the ring gives up 667.5 J of energy to the water, what is its specific heat? Is the ring made of silver (c = 234 J/kg • K), nickel (c = 444 J/kg • K), or palladium (c = 244 J/kg • K)?

____

15. Beryllium is used for making rocket parts because of its light weight and sturdiness. It also has a high specific heat that is second among pure metals only to lithium. This specific heat, which is 1,825 J/kg • K, gives beryllium a high resistance to temperature change. Suppose a beryllium rocket component with a mass of 1.4 kg is tested at a high temperature and then cooled to 300.0 K. If the energy given up by the component is 2.555×10^6 J, what was its initial temperature?

____

16. Of the four bodies of water on Earth that are called oceans, the smallest by far is the Arctic Ocean, which surrounds the North Pole. The Arctic Ocean is also the only large body of water in the world with a surface that is frozen throughout the year. The liquid water that lies beneath the layer of ice has a mass of about 1.33×10^{19} kg and a temperature of 4.00°C. Suppose 4.20×10^{17} J, which is the energy produced in one year by one of the world's largest power plants, is added to the Arctic Ocean. Assuming that the ocean's water has a heat capacity of 4,186 J/kg • K, what will the water's final temperature be?

____

17. The planet Jupiter consists mostly of gases. Even the surface that appears as dark bands in photographs is a dense gas of mostly hydrogen and helium. The lighter bands of frozen ammonia (NH_3) lie 50 km above the dense surface gases. Although these clouds are only about 5 km thick and appear to cover about half of the planet's surface area, they have a volume of about 1.6×10^{11} km^3. Assume that the density of these clouds is 0.77 kg/m^3 and that the specific heat of ammonia ice is the same as ammonia gas (2.1×10^3 J/kg • K). If the temperature of these clouds increases by 1.0 K, how much energy will they have absorbed?

____

18. When a driver brakes an automobile, friction between the brake disks and the brake pads converts part of the car's kinetic energy to energy that is transferred to the pads and disks by heat. During braking, 1.92×10^5 J of energy is added to each wheel's disk and brake pads, increasing temperature by 122 K. If the combined mass of each brake and its pads is 3.5 kg, what is their specific heat?

____