PROBLEM \PageIndex{1}

A 500-mL bottle of water at room temperature and a 2-L bottle of water at the same temperature were placed in a refrigerator. After 30 minutes, the 500-mL bottle of water had cooled to the temperature of the refrigerator. An hour later, the 2-L of water had cooled to the same temperature. When asked which sample of water lost the most heat, Student A replied that both bottles lost the same amount of heat because they started at the same temperature and finished at the same temperature. Student B thought that the 2-L bottle of water lost more heat because there was more water. A third student believed that the 500-mL bottle of water lost more heat because it cooled more quickly. A fourth student thought that it was not possible to tell because we do not know the initial temperature and the final temperature of the water.

Indicate which of these answers is correct and describe the error in each of the other answers.

Answer

Student A is incorrect because the mass of water in both containers is not the same.

Student C is incorrect because the bottle cooled quicker due to less mass of water.

Student D is incorrect because it doesn’t matter what the change in temperature is as long as it is the same for both bottles.

Student B is correct: if the change in temperature is the same, the one with the more mass (the 2L bottle) had more heat loss. We could prove this using \(q=c\times m\times \Delta T=c\times m\times (T_{\text{final}}-T_{\text{initial}})\) from Section 8.1.

PROBLEM \PageIndex{2}

How many milliliters of water at 23 °C with a density of 1.00 g/mL must be mixed with 180 mL (about 6 oz) of coffee at 95 °C so that the resulting combination will have a temperature of 60 °C? Assume that coffee and water have the same density and the same specific heat (4.184 J/g °C).

Answer

170 mL
PROBLEM \(\PageIndex{3}\)

How much will the temperature of a cup (180 g) of coffee at 95 °C be reduced when a 45 g silver spoon (specific heat 0.24 J/g °C) at 25 °C is placed in the coffee and the two are allowed to reach the same temperature? Assume that the coffee has the same density and specific heat as water.

Answer

The temperature of the coffee will drop 1 degree.

PROBLEM \(\PageIndex{4}\)

A 45-g aluminum spoon (specific heat 0.88 J/g °C) at 24 °C is placed in 180 mL (180 g) of coffee at 85 °C and the temperature of the two become equal.

a. What is the final temperature when the two become equal? Assume that coffee has the same specific heat as water.
b. The first time a student solved this problem she got an answer of 88 °C. Explain why this is clearly an incorrect answer.

Answer a

81.95 °C
Answer b

This temperature is higher than the starting temperature of the coffee, which is impossible.

Click here to see a video of the solution

*The section number changed after this video was made*

PROBLEM \(\PageIndex{5}\)

The temperature of the cooling water as it leaves the hot engine of an automobile is 240 \(^\circ\)F. After it passes through the radiator it has a temperature of 175 \(^\circ\)F. Calculate the amount of heat transferred from the engine to the surroundings by one gallon of water with a specific heat of 4.184 J/g \(^\circ\)C.

Answer

\((5.7 \times 10^2\) kJ\)

PROBLEM \(\PageIndex{6}\)

When 50.0 g of 0.200 M NaCl(aq) at 24.1 \(^\circ\)C is added to 100.0 g of 0.100 M AgNO\(_3\)(aq) at 24.1 \(^\circ\)C in a calorimeter, the temperature increases to 25.2 \(^\circ\)C as AgCl(s) forms. Assuming the specific heat of the solution and products is 4.20 J/g \(^\circ\)C, calculate the approximate amount of heat in joules produced.

Answer

693 J
PROBLEM \(\PageIndex{7}\)

The addition of 3.15 g of Ba(OH)\(_2\)•8H\(_2\)O to a solution of 1.52 g of NH\(_4\)SCN in 100 g of water in a calorimeter caused the temperature to fall by 3.1 °C. Assuming the specific heat of the solution and products is 4.20 J/g °C, calculate the approximate amount of heat absorbed by the reaction, which can be represented by the following equation:

\[
\text{Ba(OH)}_2 \cdot 8\text{H}_2\text{O}_{(s)} + 2\text{NH}_4\text{SCN}_{(aq)} \rightarrow \text{Ba(SCN)}_2(aq) + 2\text{NH}_3(aq) + 10\text{H}_2\text{O}_{(l)}
\]

Answer

1.4 kJ

PROBLEM \(\PageIndex{8}\)

When 1.0 g of fructose, C\(_6\)H\(_{12}\)O\(_6\)(s), a sugar commonly found in fruits, is burned in oxygen in a bomb calorimeter, the temperature of the calorimeter increases by 1.58 °C. If the heat capacity of the calorimeter and its contents is 9.90 kJ/°C, what is \(q\) for this combustion?

Answer

15.64 kJ
PROBLEM \( \PageIndex{9} \)

One method of generating electricity is by burning coal to heat water, which produces steam that drives an electric generator. To determine the rate at which coal is to be fed into the burner in this type of plant, the heat of combustion per ton of coal must be determined using a bomb calorimeter. When 1.00 g of coal is burned in a bomb calorimeter, the temperature increases by 1.48 °C. If the heat capacity of the calorimeter is 21.6 kJ/°C, determine the heat produced by combustion of a ton of coal (2000 pounds). Remember 1 kg = 2.2 pounds

Answer

\[
2.91 \times 10^7 \text{ kJ}
\]

PROBLEM \( \PageIndex{10} \)

A teaspoon of the carbohydrate sucrose (common sugar) contains 16 Calories (16 kcal). What is the mass of one teaspoon of sucrose if the average number of Calories for carbohydrates is 4.1 Calories/g?

Answer

\[
3.9 \text{ g}
\]
*This problem was renumbered after the video was made*

**PROBLEM \(\PageIndex{11}\)**

What is the maximum mass of carbohydrate in a 6-oz serving of diet soda that contains less than 1 Calorie per can if the average number of Calories for carbohydrates is 4.1 Calories/g?

**Answer**

0.24 g

**PROBLEM \(\PageIndex{12}\)**

A pint of premium ice cream can contain 1100 Calories. What mass of fat, in grams and pounds, must be produced in the body to store an extra \(1.1 \times 10^3\) Calories if the average number of Calories for fat is 9.1 Calories/g? Remember 1 kg = 2.2 pounds
A serving of a breakfast cereal contains 3 g of protein, 18 g of carbohydrates, and 6 g of fat. What is the Calorie content of a serving of this cereal if the average number of Calories for fat is 9.1 Calories/g, for carbohydrates is 4.1 Calories/g, and for protein is 4.1 Calories/g?

**Answer**

1.4 × 10² Calories
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