

CHAPTER 2

Problem 2.1

What is the SI unit for energy?

- (a). Newton
- * (b). Joule
- (c). Pascal
- (d). calorie
- (e). 1000 calorie (1 Dietary calorie)

Solution

The SI unit for energy is Joule (J), also referred to as $N.m$.

Problem 2.2

Which of the following is correct?

- *(a). The sign of heat (q) is positive when heat is absorbed by a system
- (b). The sign of heat (q) is negative when heat is absorbed by a system
- (c). The sign of heat (q) is positive when heat is released by a system

Solution

According to the sign convention that we have adopted, the sign of heat (q) is positive when heat is absorbed by a system.

Problem 2.3

From the following, select the process (or reaction) that is ENDOTHERMIC.

- (a). $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
- (b). $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$
- (c). $H_2O(g) \rightarrow H_2O(l)$
- *(d). $H_2O(s) \rightarrow H_2O(l)$
- (e). $H_2O(l) \rightarrow H_2O(s)$

Solution

The first two are combustion reactions, in which heat is released, and are thus EXOTHERMIC. The processes in (c) and (e) are also exothermic.

Problem 2.4

From the following, select the process that is EXOTHERMIC.

- (a). $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{l})$
- (b). $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$
- *(c). $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$
- (d). $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{g})$

Solution

In an exothermic process, heat is released. Processes (a), (b) and (d) all entail absorption of heat.

Problem 2.5

Consider pieces of different metals, each with the mass of 100.0 g and each with a temperature of 100°C. Which will cause the greatest change in temperature for a beaker containing 100.0 g of water, initially at 25.0°C?

- *(a). Aluminum, specific heat 0.90 J/(g.°C)
- (b). Zinc, specific heat 0.39 J/(g.°C)
- (c). Silver, specific heat 0.23 J/(g.°C)
- (d). Gold, specific heat 0.13 J/(g.°C)

Solution

$$q_{\text{metal}} = -q_{\text{water}}$$

$$m_{\text{metal}} C_{\text{metal}} \Delta T_{\text{metal}} = -m_{\text{water}} C_{\text{water}} \Delta T_{\text{water}}$$

We NEED NOT plug in actual numbers; The higher the value of the specific heat of the metal, the greater the change in the temperature of the water, other factors being equal.

Problem 2.6

A student heated a 25.0 g piece of a metal to a temperature of 100.0°C, and placed it in 100.0 g of water, initially at a temperature of 10.0°C. The final temperature of the system (metal and water) is 12.0°C. What is the specific heat of the metal? The specific heat of water is 4.18 J/(g.°C).

- (a) -0.38 J/(g.°C)
- * (b) 0.38 J/(g.°C)
- (c) -2.63 J/(g.°C)
- (d) 2.63 J/(g.°C)

Solution

$$q_{\text{metal}} = -q_{\text{water}}$$

$$m_{\text{metal}} C_{\text{metal}} \Delta T_{\text{metal}} = -m_{\text{water}} C_{\text{water}} \Delta T_{\text{water}}$$

$$C_{\text{metal}} = -\frac{m_{\text{water}} C_{\text{water}} \Delta T_{\text{water}}}{m_{\text{metal}} \Delta T_{\text{metal}}} = -\frac{100.0 \text{ g} \times 4.18 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}} \times (12.0 - 10.0) ^\circ\text{C}}{25.0 \text{ g} \times (100.0 - 12.0) ^\circ\text{C}} = 0.38 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}}$$

Problem 2.7

A heater provides 1.00 kJ of heat to a 100.0 g sample of water initially at 20.0°C. Assuming no heat losses, what is the final temperature of water?

Useful data:

The specific heat of water is 4.18 J/(g.°C)

- (a). 0.0024C
- (b). 2.4°C
- (c) 20.0°C
- * (d). 22.4°C
- (e). 55.0°C

Solution

$$q = m_{\text{water}} C_{\text{water}} \Delta T_{\text{water}}$$

$$\Delta T_{\text{water}} = \frac{q_{\text{water}}}{m_{\text{water}} C_{\text{water}}} = \frac{1000 \text{ J}}{100.0 \text{ g} \times 4.18 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}}} = 2.40 ^\circ\text{C}$$

$$\Delta T_{\text{water}} = T_{\text{final}} - T_{\text{initial}}$$

$$\text{Thus } T_{\text{final}} = 20.0^{\circ}\text{C} + 2.40^{\circ}\text{C} = 22.4^{\circ}\text{C}.$$

Problem 2.8

When a six pack of Coca Cola, initially at room temperature (25°C) is placed in a bucket of ice (at 0°C), the process that occurs is that _____.

- *(a). Some of the ice melts
- (b). Some of the Coca Cola freezes

Solution

As the Coca Cola cools down, it releases heat which melts some of the ice.

Problem 2.9

Dietary calories obtained from foods are: 9 per gram of fat and 4 each from proteins and carbohydrates. Which of the following provides the most calories?

- *(a) 25.0 g fat
- (b) 25.0 g proteins
- (c) 25 g carbohydrates

Solution

Masses being equal, fats provided the highest calories.

Problem 2.10

Dietary Calories obtained from foods are: 9 per *g* of fat and 4 each from proteins and carbohydrates. A bag of potato chip contains 19 *g* fat, 25 *g* carbohydrate and 3 *g* of protein provides _____ Calories. (Round to the nearest Calorie)

Solution

$$\begin{aligned} \text{Total Calories} &= \\ (19 \text{ g fat} \times 9 \text{ Calories/g}) &+ (25 \text{ g carb} \times 4 \text{ Calories/g}) + (3 \text{ g protein} \times 4 \text{ Calories/g}) \\ &= 283 \text{ Calories} \end{aligned}$$

Problem 2.11

Water is stored in clay pots. Over time, some of the water in the pots evaporates. Which of the following is true?

- (a). There is no change in the temperature of the water remaining in the pot.
- (b). The water remaining in the pot warms up.
- *(c). The water remaining in the pot cools down.

Solution

This is a technique followed since ancient times, and even today, in places where refrigeration is prohibitively expensive. As some of the water evaporates through the pores in clay, it takes away some of the thermal energy (heat) from the remaining water which cools down!

Problem 2.12

The initial temperature of the water in a clay pot is 25.0°C. What is the final temperature, assuming that 1.00% of the water evaporates. The enthalpy of vaporization of water is 40.7 kJ/mol, and the heat capacity of water is 4.18 J/g°C.

Solution

$$q_{\text{evap}} = -q_{\text{water}}$$

$$q_{\text{evap}} = -mC(T_{\text{final}} - T_{\text{initial}})$$

$$1.00g \frac{40.7 \times 10^3 \frac{J}{mol}}{18.016 \frac{g}{mol}} = -99.0g \left(\frac{4.18 J}{g \cdot ^\circ C} \right) (T_{\text{final}} - 25.0^\circ)$$

This gives $T_{\text{final}} = 19.5^\circ\text{C}$; thus cooling takes place!