

Problem Set #6  
CHEM101A: General College Chemistry

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September 26, 2025

## 1 Topic D Problem 1

What is the sign of  $q$  for each of the following processes, assuming that the water is the system? You do not need to calculate the numerical values of  $q$ .

- a) 50 g of ice melts
- b) 50 L of steam condenses
- c) 50 mL of water cools down from  $20^{\circ}\text{C}$  to  $10^{\circ}\text{C}$

### 1.1 Solution

- a) Positive.
- b) Negative.
- c) Negative.

## 2 Topic D Problem 2

A student puts a hot rock into some cold water and waits until the temperature of the rock and the water are no longer changing.

- a) The student writes the following equation:  $\text{final } T_{\text{rock}} = \text{final } T_{\text{water}}$ . Is this a true statement? If not, how should it be modified to make it true?
- b) The student then writes the following equation:  $q_{\text{rock}} = q_{\text{water}}$ . Is this a true statement? If not, how should it be modified to make it true? *(Assume that the rock and water are in an insulated container, so no energy can enter or leave.)*

### 2.1 Solution (a)

The statement is true. A temperature difference would require subsequent heat exchange to reach thermal equilibrium.

### 2.2 Solution (b)

The statement is false. A correct statement would have either value but not both as negative.

$$0 = \Delta E = q_{\text{rock}} + q_{\text{water}} \rightarrow \boxed{q_{\text{rock}} = -q_{\text{water}}} \quad (1)$$

### 3 Topic D Problem 3

Use the following properties of bromine ( $\text{Br}_2$ ) to answer parts a through g below.

Specific heat capacity of  $\text{Br}_2(\text{l}) = 0.473 \text{ J/g} \cdot ^\circ\text{C}$

Heat of fusion of  $\text{Br}_2 = 33.1 \text{ J/g}$

Heat of vaporization of  $\text{Br}_2 = 96.6 \text{ J/g}$

Melting point of  $\text{Br}_2 = -7.2^\circ\text{C}$

Boiling point of  $\text{Br}_2 = 58.9^\circ\text{C}$

- a) How much heat is needed to raise the temperature of 40.0 g of liquid bromine from  $-5.8^\circ\text{C}$  to  $11.9^\circ\text{C}$ ?
- b) How much heat is needed to boil 40.0 g of liquid bromine?
- c) How much heat is needed to melt 40.0 g of solid bromine?
- d) A 25.0 g sample of liquid bromine is at  $10.0^\circ\text{C}$ . If you add 125 J of heat to the bromine, what will its final temperature be?
- e) A 25.0 g sample of liquid bromine is at its boiling point. If you add 1.500 kJ of heat to the bromine, how much of it will boil?
- f) How much heat is needed to convert 10.0 g of solid bromine at  $-7.2^\circ\text{C}$  into gaseous bromine at  $58.9^\circ\text{C}$ ?

#### 3.1 Solution (a)

## 4 Topic D Problem 4

A 34.82 g piece of beryllium at  $61.9^{\circ}\text{C}$  is placed into 41.33 g of water at  $16.1^{\circ}\text{C}$ . What will the temperature be after the water and the beryllium have reached thermal equilibrium, assuming that no heat is lost to the surroundings? The specific heat capacity of beryllium is  $1.82 \text{ J/g} \cdot ^{\circ}\text{C}$ , and that of water is  $4.18 \text{ J/g} \cdot ^{\circ}\text{C}$ .

### 4.1 Solution

## 5 Topic D Problem 5

A chemist puts an unknown mass of aluminum at  $68.0^{\circ}\text{C}$  and  $67.3\text{ g}$  of chromium at  $75.0^{\circ}\text{C}$  into  $125.0\text{ g}$  of water at  $8.2^{\circ}\text{C}$ . When the mixture reaches thermal equilibrium, the temperature is  $16.4^{\circ}\text{C}$ . Using this information, and assuming that no heat is lost to the surroundings, calculate the mass of the piece of aluminum. The relevant specific heat capacities are: aluminum =  $0.902\text{ J/g} \cdot ^{\circ}\text{C}$ , chromium =  $0.448\text{ J/g} \cdot ^{\circ}\text{C}$ , water =  $4.18\text{ J/g} \cdot ^{\circ}\text{C}$ .

### 5.1 Solution

## 6 Topic D Problem 6

A 46.51 g piece of copper at  $71.2^{\circ}\text{C}$  is put into 51.32 g of liquid ethanol ( $\text{C}_2\text{H}_5\text{OH}$ ) at  $4.9^{\circ}\text{C}$ . When the mixture reaches thermal equilibrium, the temperature is  $13.2^{\circ}\text{C}$ . The specific heat capacity of copper is  $0.385 \text{ J/g} \cdot ^{\circ}\text{C}$ . Calculate the specific heat capacity of liquid ethanol.

### 6.1 Solution

## 7 Topic D Problem 7

The melting point of gallium (Ga) is  $29.8^{\circ}\text{C}$ ; this is also the temperature at which liquid gallium freezes. A chemist pours 54.72 g of liquid gallium at  $29.8^{\circ}\text{C}$  into 67.09 g of water at  $5.2^{\circ}\text{C}$ . When the mixture reaches thermal equilibrium, the gallium has solidified and the temperature is  $21.4^{\circ}\text{C}$ . The specific heat of gallium is  $0.371\text{ J/g} \cdot ^{\circ}\text{C}$  and the specific heat of water is  $4.18\text{ J/g} \cdot ^{\circ}\text{C}$ . Use this information to calculate the heat of fusion of gallium. Give your answer in J/g and in kJ/mol.

### 7.1 Solution



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