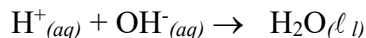


Problem

10. 2002 D



A student is asked to determine the molar enthalpy of neutralization, ΔH_{neut} , for the reaction represented above. The student combines equal volumes of 1.0 M HCl and 1.0 M NaOH in an open polystyrene cup calorimeter. The heat released by the reaction is determined by using the equation $q = mc\Delta T$.

Assume the following.

- Both solutions are at the same temperature before they are combined.
- The densities of all the solutions are the same as that of water.
- Any heat lost to the calorimeter or to the air is negligible.
- The specific heat capacity of the combined solutions is the same as that of water.

(a) Give appropriate units for each of the terms in the equation $q = mc\Delta T$. (2 pts)

(b) List the measurements that must be made in order to obtain the value of q . (2 pts)

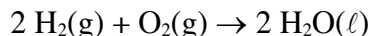
(c) Explain how to calculate each of the following.

(i) The number of moles of water formed during the experiment (1 pt)

(ii) The value of the molar enthalpy of neutralization, ΔH_{neut} , for the reaction between $\text{HCl}_{(aq)}$ and $\text{NaOH}_{(aq)}$ (2 pts)

- (d) The student repeats the experiment with the same equal volumes as before, but this time uses 2.0 M HCl and 2.0 M NaOH.
- Indicate whether the value of q increases, decreases, or stays the same when compared to the first experiment. Justify your prediction. (1 pt)
 - Indicate whether the value of the molar enthalpy of neutralization, ΔH_{neut} , increases, decreases, or stays the same when compared to the first experiment. Justify your prediction. (1 pt)
- (e) Suppose that a significant amount of heat were lost to the air during the experiment. What effect would this have on the calculated value of the molar enthalpy of neutralization, ΔH_{neut} ? Justify your answer. (1 pt)

11. Hydrogen gas burns in air according to the equation below. (2011A, 4 points total)

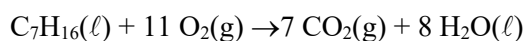


- Calculate the standard enthalpy change, ΔH_{rxn}° , for the reaction represented by the equation above. (The molar enthalpy of formation, ΔH_f° , for $\text{H}_2\text{O}(\ell)$ is -285.8 kJ/mol at 298 K.)
- Calculate the amount of heat, in kJ, that is released when 10.0 g of $\text{H}_2(\text{g})$ is burned in air.

c). Given that the molar enthalpy of vaporization, ΔH_{vap}° , for $\text{H}_2\text{O}(\ell)$ is 44.0 kJ/mol at 298 K, what is the standard enthalpy change, ΔH_{rxn}° , for the reaction $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2 \text{H}_2\text{O}(\text{g})$?

12. 2003 B

In another experiment, liquid heptane, $\text{C}_7\text{H}_{16}(\ell)$, is completely combusted to produce $\text{CO}_2(\text{g})$ and $\text{H}_2\text{O}(\ell)$, as represented by the following equation.



The heat of combustion, ΔH_{comb}° , for one mole of $\text{C}_7\text{H}_{16}(\ell)$ is -4.85×10^3 kJ.

a) Using the information in the table below, calculate the value of ΔH_f° for $\text{C}_7\text{H}_{16}(\ell)$ in kJ mol^{-1} . (2 pts)

Compound	ΔH_f° (kJ mol^{-1})
$\text{CO}_2(\text{g})$	-393.5
$\text{H}_2\text{O}(\ell)$	-285.8

b) A 0.0108 mol sample of $\text{C}_7\text{H}_{16}(\ell)$ is combusted in a bomb calorimeter.

- Calculate the amount of heat released to the calorimeter. (1 pt)
- Given that the total heat capacity of the calorimeter is $9.273 \text{ kJ } ^{\circ}\text{C}^{-1}$, calculate the temperature change of the calorimeter. (1 pt)

13. 1995 B

Propane, C_3H_8 , is a hydrocarbon that is commonly used as fuel for cooking.

(a) Write a balanced equation for the complete combustion of propane gas, which yields $CO_2(g)$ and $H_2O(l)$.

(b) The heat of combustion of propane is $-2,220.1$ kJ/mol. Calculate the enthalpy of formation, ΔH_f° , of propane given that ΔH_f° of $H_2O(l) = -285.3$ kJ/mol and ΔH_f° of $CO_2(g) = -393.5$ kJ/mol.

(c) Assuming that all of the heat evolved in burning 30.0 grams of propane is transferred to 8.00 kilograms of water (specific heat = 4.18 J/g·K), calculate the increase in temperature of water.

Chapter 5 Practice Problems

Answer Section

MULTIPLE CHOICE

- | | | |
|-----------|--------|---|
| 1. ANS: E | PTS: 1 | |
| 2. ANS: D | PTS: 1 | OBJ: 6.7 Hess's Law |
| 3. ANS: A | PTS: 1 | |
| 4. ANS: C | PTS: 1 | |
| 5. ANS: B | PTS: 1 | OBJ: 6.8 Standard Enthalpies of Formation |
| 6. ANS: C | PTS: 1 | OBJ: 6.2 Specific Heat Capacity and Heat Transfer |
| 7. ANS: A | PTS: 1 | OBJ: 6.5 Enthalpy Changes for Chemical Reactions |
| 8. ANS: B | PTS: 1 | OBJ: 6.8 Standard Enthalpies of Formation |
| 9. ANS: D | PTS: 1 | OBJ: 6.3 Energy and Changes of State |

PROBLEM

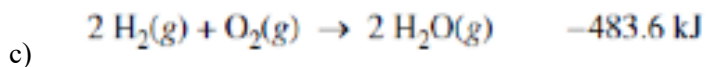
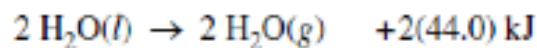
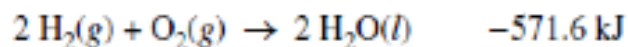
10. ANS:
 q in J, m in grams, C in J/g°C, T in °C
(b) mass or volume of each solution
starting temperature of each reagent
ending temperature of mixture
(c) (i) both are 1 M acid and base and react on a 1:1 basis
volume \times \times = mol of H⁺
H⁺ + OH⁻ → H₂O
(ii)
(d) (i) increases. Twice as much water is produced so it is twice the energy released in the same volume of solution
(ii) same. = same result
(e) smaller. heat lost to the air gives a smaller amount of temperature change in the solution, which leads to a smaller measured heat release

PTS: 1

11. ANS:

a)
$$\Delta H_{298}^{\circ} = [2(-285.8)] - [2(0) + 1(0)] = -571.6 \text{ kJ mol}^{-1}$$
 (1 pt)

b)
$$q = 10 \text{ g H}_2 \times \frac{1 \text{ mol H}_2}{2.016 \text{ g H}_2} \times \frac{285.8 \text{ kJ}}{1 \text{ mol H}_2} = 1.42 \times 10^3 \text{ kJ}$$
 (1 pt for setup, 1 pt for answer)



1 pt for answer

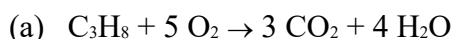
PTS: 1

12. ANS:

- a) -191 kJ/mol
- b) 52.4 kJ released
- c) +5.65 °C

PTS: 1

13. ANS:



(b) $10.0 \text{ g C}_3\text{H}_8 \times 1 \text{ mol C}_3\text{H}_8 / 44.0 \text{ g} \times 5 \text{ mol O}_2 / 1 \text{ mol C}_3\text{H}_8 = 1.14 \text{ mol O}_2$

$$V_{\text{O}_2} = \frac{nRT}{P} = \frac{(1.14 \text{ mol})(0.0821 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(303 \text{ K})}{1.00 \text{ atm}}$$

$$= 28.3 \text{ L O}_2 ; f(28.3 \text{ L}, 21.0\%) = 135 \text{ L of air}$$

(c) $\Delta H_{\text{comb}}^\circ = [\Delta H_f^\circ(\text{CO}_2) + \Delta H_f^\circ(\text{H}_2\text{O})]$

$$- [\Delta H_f^\circ(\text{C}_3\text{H}_8) + \Delta H_f^\circ(\text{O}_2)]$$

$$-2220.1 = [3(-393.5) + 4(-285.3)] - [X + 0]$$

$$X = \Delta H_{\text{comb}}^\circ = -101.6 \text{ kJ/mol}$$

(d) $q = 30.0 \text{ g C}_3\text{H}_8 \times 1 \text{ mol} / 44.0 \text{ g} \times 2220.1 \text{ kJ} / 1 \text{ mol} = 1514 \text{ kJ}$

$$q = (m)(C_p)(\Delta T)$$

$$1514 \text{ kJ} = (8.00 \text{ kg})(4.184 \text{ J/g}\cdot\text{K})(\Delta T)$$

$$\Delta T = 45.2^\circ$$

PTS: 1