

## UNIT 3 SELF-QUIZ

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1. False: A physical change usually involves a *larger* enthalpy change than does a chemical change.
2. True
3. False: The potential energy of the products is *smaller* than the potential energy of the reactants in an exothermic change.
4. True
5. False: An *endothermic* reaction absorbs heat from the surroundings.
6. True
7. True
8. False: *Three-quarters* of a radioisotope will have changed after two half-lives.
9. False: In an endothermic reaction, *only* the potential energy of the chemical system increases.
10. True
11. (b)
12. (c)
13. (e)
14. (a)
15. (e)
16. (c)
17. (b)
18. (d)
19. (b)
20. (e)
21. (b)
22. (a)
23. (c)
24. (c)
25. (e)
26. (c)
27. (b)
28. (d)
29. (c)
30. (d)

## UNIT 3 REVIEW

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### Understanding Concepts

1.  $q_{\text{water}} = mc\Delta T$   
 $= 1500 \text{ g} \times 4.18 \text{ J}/(\text{g}\cdot^{\circ}\text{C}) \times (75 - 20)^{\circ}\text{C}$   
 $q_{\text{water}} = 340 \text{ kJ}$
2.  $M_{\text{Cl}_2} = 70.9 \text{ g/mol}$   
 $n_{\text{Cl}_2} = 2250 \text{ g} \times \frac{1 \text{ mol}}{70.9 \text{ g}}$   
 $n_{\text{Cl}_2} = 31.7 \text{ mol}$   
 $\Delta H = n_{\text{Cl}_2} \Delta H_{\text{vap}}$   
 $= 31.7 \text{ mol} \times 20.7 \text{ kJ/mol}$   
 $\Delta H = 657 \text{ kJ}$

### Analysis

(g) The  $\Delta H_r$  was about the same for all three acids. For example, for the hydrochloric acid,

$$q = mc\Delta T$$

$$= 50 \text{ g} \times (31.0 - 24.2)^\circ\text{C} \times 4.18 \text{ J/g}\cdot^\circ\text{C}$$

$$q = 1.4 \text{ kJ}$$

omit.

The amount of Mg (in moles) was

$$n = m/M$$

$$= \frac{0.075 \text{ g}}{(24.3 \text{ g/mol})}$$

$$n = 3.1 \times 10^{-3} \text{ mol}$$

$$\text{Thus, } H_{\text{hydrochloric acid}} = \frac{q}{n}$$

$$= \frac{1.4 \text{ kJ}}{3.1 \times 10^{-3} \text{ mol}}$$

$$\Delta H_{\text{hydrochloric acid}} = -4.6 \times 10^2 \text{ kJ/mol (negative sign for exothermic reaction)}$$

Similarly, for sulfuric acid,

$$\Delta H_{\text{sulfuric acid}} = -4.2 \times 10^2 \text{ kJ/mol}$$

and for acetic acid,

$$\Delta H_{\text{acetic acid}} = -4.5 \times 10^2 \text{ kJ/mol}$$

The rates of production of hydrogen gas, expressed as mL  $\text{H}_2$  produced per s, varied considerably for the acids.

The rate for hydrochloric acid:

$$r_{\text{hydrochloric acid}} = 20 \text{ mL}/31 \text{ s}$$

$$r_{\text{hydrochloric acid}} = 0.65 \text{ mL/s}$$

The rate for sulfuric acid:

$$r_{\text{sulfuric acid}} = 20 \text{ mL}/15 \text{ s}$$

$$r_{\text{sulfuric acid}} = 1.3 \text{ mL/s}$$

The rate for acetic acid:

$$r_{\text{acetic acid}} = 20 \text{ mL}/60 \text{ s}$$

$$r_{\text{acetic acid}} = 0.33 \text{ mL/s}$$

### Evaluation

(h) The molar enthalpies of reaction are about the same for all three acids. The rate of reaction for sulfuric acid is about double the rate for hydrochloric acid and more than ten times the rate for acetic acid. (The student predictions will vary, but generally, students tend to expect the heat of reaction to be different for the acids.)

### Synthesis

- The energy produced by the reaction is a function of the time taken for the roughly fixed mass of magnesium to be consumed. The dibasic sulfuric acid has twice the amount of  $\text{H}^+$  as hydrochloric acid, and reacts roughly twice as fast. The weak organic acetic acid has a much smaller concentration of  $\text{H}^+$  in solution, and reacts much more slowly.
- Possibilities could include solution conductivity, or volume or pressure of gas produced.
- As time passes, the rate increases because solution temperature increases but decreases as reactant concentration decreases.
- (Answers will vary.) The materials used are somewhat toxic for consumer products and the reaction occurs very quickly. Most consumer handwarmers use a slower reaction like the oxidation of iron filings.

$$3. (a) \quad q_{\text{water}} = mc\Delta T$$

$$= 100.0 \text{ g} \times 4.18 \text{ J/(g}\cdot\text{°C)} \times 5.6\text{°C}$$

$$q_{\text{water}} = 2341 \text{ J}$$

$$n_{\text{NaOH}} = MV$$

$$= 0.700 \text{ mol/L} \times 0.600 \text{ L}$$

$$n_{\text{NaOH}} = 0.420 \text{ mol}$$

$$n\Delta H_{\text{neut}} = q_{\text{water}}$$

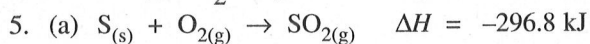
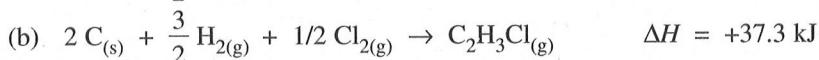
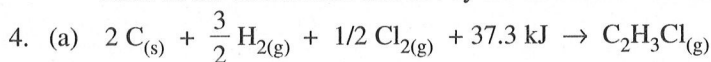
$$\Delta H_{\text{neut}} = \frac{q_{\text{water}}}{n}$$

$$= \frac{2341 \text{ J}}{0.420 \text{ mol}}$$

$$\Delta H_{\text{neut}} = 5573 \text{ J/mol, or } 5.57 \text{ kJ/mol}$$

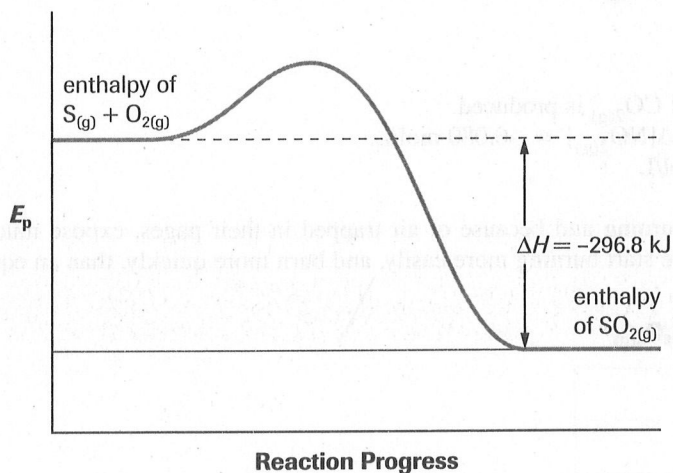
Because the reaction is exothermic,  $\Delta H_{\text{neut}} = -5.57 \text{ kJ/mol}$ .

(b) The assumption is that the reaction went to completion and that all heat from the reaction was absorbed by the water in the calorimeter and not by the calorimeter or surroundings.



(b)

**Potential Energy Diagram of the  
Formation of Sulfur Dioxide**



$$(c) \quad M_{\text{SO}_2} = 64.07 \text{ g/mol}$$

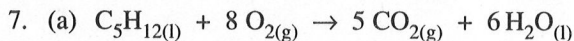
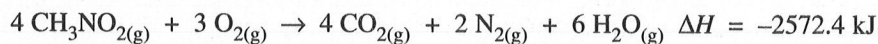
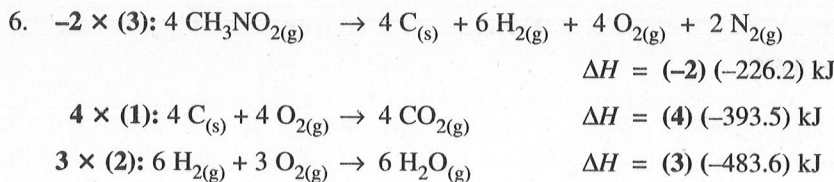
$$n_{\text{SO}_2} = 9.63 \text{ g} \times 1 \text{ mol}/64.07 \text{ g}$$

$$n_{\text{SO}_2} = 0.150 \text{ mol}$$

$$q = n_{\text{SO}_2} \Delta H_f$$

$$= 0.150 \text{ mol} \times 296.8 \text{ kJ}$$

$$q = 44.6 \text{ kJ}$$



(b)  $\Delta H = 5 \Delta H_{f(\text{CO}_{2(g)})}^\circ + 6 \Delta H_{f(\text{H}_2\text{O}_{(l)})}^\circ - 1 \Delta H_{f(\text{C}_5\text{H}_{12(l)})}^\circ - 8 \Delta H_{f(\text{O}_{2(g)})}^\circ$   
 $= 5(-393.5) + 6(-285.8) - 1(-146) - 8(0)$

$\Delta H = -3536.3 \text{ kJ}$

(c)  $M_{\text{pentane}} = 72.0 \text{ g/mol}$

$n_{\text{pentane}} = 20 \text{ g} \times 1 \text{ mol} / 72.0 \text{ g}$

$n_{\text{pentane}} = 0.278 \text{ mol}$

$q = n \Delta H_{\text{comb}}$

$= 0.278 \text{ mol} \times 3536.3 \text{ kJ/mol}$

$q = 982 \text{ kJ}$

982 kJ would be released, when 20 g of pentane is burned.

8. Properties include colour, volume or pressure, and conductivity.

9. (a) As 1 mol of  $\text{CO}_{(g)}$  is consumed, 1 mol of  $\text{CO}_{2(g)}$  is produced.

At time 0,  $[\text{CO}_{2(g)}] = 0 \text{ mol/L}$

At time 40,  $[\text{CO}_{2(g)}] = 0.067 \text{ mol/L}$

At time 100,  $[\text{CO}_{(g)}] = 0.017 \text{ mol/L}$

(b) As 1 mol of  $\text{NO}_{2(g)}$  is consumed, 1 mol of  $\text{CO}_{2(g)}$  is produced.

In 80 s,  $\Delta[\text{CO}_{2(g)}] = 0.080 \text{ mol/L}$ . Thus,  $\Delta[\text{NO}_{2(g)}] = -0.080 \text{ mol/L}$ .

$[\text{NO}_{2(g)}]_{100 \text{ s}} = 0.250 \text{ mol/L} - 0.080 \text{ mol/L}$

$[\text{NO}_{2(g)}]_{100 \text{ s}} = 0.170 \text{ mol/L}$

10. Newspapers, particularly as they curl while burning and because of air trapped in their pages, expose much more surface area to reaction with air. They therefore start burning more easily, and burn more quickly, than an equivalent quantity of wood.

11. (a)

Graph of Decomposition of  $\text{X}_2\text{O}_{5(g)}$

