Sample Problems

1. Heat flows from the system (wax) to the surroundings (air). The process is exothermic.

2. Since the beaker becomes cold, heat is absorbed by the system (chemicals within the beaker) from the surroundings (beaker and surrounding air). The process is endothermic.

3. $q = mc\Delta T$ solve for $c = q / m\Delta T$
$c = 435$ j / 3.4 g x (85 C – 21 C)
$c = 2.0$ j/g·C $\Delta T = T_f - T_i$

4. $q = mc\Delta T$ *c_{Hg} = 0.14 j/g·C from table 17.1*
q = (250.0 g) x 0.14 j/g·C x (52 C)
q = 1800 j = 1.8 kj

Lesson Check Answers

5. Energy changes occur as either heat transfer or work, or a combination of both.

6. The energy of the universe remains unchanged.

7. mass and chemical composition

8. Heat flows from the blanket to your body. If you body is the system, the process is endothermic.

9. 2.36×10^{-1} J/(g · °C)

10. 1.76×10^3 cal (1.76 kcal);
7.36×10^3 J (7.36 kJ)

11. Chemical energy in the gasoline is transformed into energy to move the car. None of the energy is lost in the process.

9. $q = mc\Delta T$ solve for $c = q / m\Delta T$
The heat capacity combines the heat (q) with temperature (ΔT)
c = 42.9 j/C / 181 g = 0.236 j/g·C

10. $q = mc\Delta T$ *c_{H_2O} = 1 cal/g·C = 4.18 j/g·C*
q = (32.0 g) x 1 cal/g·C x (80.0 C – 25.0 C) = 1760 cal
q = 1760 cal x 4.18 j/cal = 7360 j = 7.36 kj

Sample Problems

12. *Water's density is 1 g/ml so 50.0 mL = 50.0 g*
    The total mass of water is 100.0 g; Molarity is not an issue here.
    q = mcΔT $\Delta T = T_f - T_i$
    c = 4.18 j/g·C
    q = 100.0 g x 4.18 j/g·C x (26.0 C – 22.5 C) = 1460 j = 1.4 kj
    The chemical reaction releases the heat into the water, making it an exothermic reaction (-1.4 kj). According to the law of conservation of energy (heat), the amount of heat gained by the water was lost by the reaction.

13. *Water's density is 1 g/ml so 25.0 mL = 25.0 g*
    q = mcΔT $\Delta \mathrm{T} = \mathrm{T_f} - \mathrm{T_i}$
    c = 4.18 j/g·C
    q = 25.0 g x 4.18 j/g·C x (26.4 C – 25.0 C) = 146 j
    According to the law of conservation of energy (heat), the amount of heat gained by the water was lost by the pebble. The pebble gave off heat (exothermic; -146 j) while the water gained the heat (endothermic; +146 j).

14. *According to chemical equation (reaction), 26.3 kj of heat are released (exothermic) for each mole of Fe_2O_3 that reacts (coefficient of "1").*
    3.40 mol/1 mol Fe_2O_3 = X/26.3 kj
    X = 89.4 kj

15. *According to chemical equation (reaction), 89.3 kj of heat are absorbed (endothermic) for each mole of CS_2 that reacts (coefficient of "1").*
    5.66 g x 1 mol/76.0 g/mol CS_2 = 0.0745 mol CS_2
    0.0745 mol/1 mol CS_2 = X/89.3 kj
    X = 6.65 kj

Lesson Check Answers

16. The value of ΔH of a reaction can be determined by measuring the heat flow of the reaction at constant pressure.

17. The enthalpy change in a chemical reaction can be written as either a reactant or a product.

18. 520 J

19. Heat of combustion is the heat of reaction for the complete burning of one mole of a substance.

20. $2Mg(s) + O_2(g) \rightarrow 2MgO(s) + 1204$ kJ, or $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ $\Delta H = -1204$ kJ

21. 3.72×10^2 kJ

18. *Water's density is 1 g/ml so 40.0 mL = 40.0 g*
q = mcΔT $\Delta T = T_f - T_i$
c = 4.18 j/g·C
q = 40.0 g x 4.18 j/g·C x (20.0 C – 17.0 C) = 501.6 j = 502 j j
According to the law of conservation of energy (heat), the amount of heat gained by the water was lost by the lead. The lead gave off heat (exothermic; -502 j) while the water gained the heat (endothermic; +502 j).

21. *According to chemical equation (reaction), 1368 kj of heat are released (exothermic) for each mole of ethanol that reacts (coefficient of "1").*
12.5 g x 1 mol/46.0 g/mol C_2H_6O = 0.272 mol C_2H_6O
0.272 mol/1 mol C_2H_6O = X/1368 kj
X = 371.7 kj = 372 kj

Sample Problems

22. *This involves the heat of fusion of water since it is ice at 0 C.*
q = mΔH_f ΔH_f = *6.01 kj/mol*
solve for m = q/ΔH_f
m = 0.400 kj/6.01 kj/mol
Find grams of water → *0.0666 mol x 18.0 g/mol = 1.20 g*

23. *This involves the heat of fusion of water since it is ice at 0 C.*
Normally, q = mΔH_f . *However, since heat of fusion is per mol,* find mol of water → 50.0 g water x 1 mol/18.0 g = 2.78 mol
ΔH_f = *6.01 kj/mol*
q = 6.01 kj/mol x 2.78 mol = 16.7 kj

24. *This involves the heat of vaporization of water since it is gas at 100 C.*
Normally, $q = m\Delta H_f$. *However, since heat of fusion is per mol*, find mol of water → 63.7 g water x 1 mol/18.0 g = 3.54 mol ΔH_v = *40.7 kj/mol*
q = 40.7 kj/mol x 3.54 mol = 144 kj

25. *This involves the heat of vaporization of chloroethane gas at 12.3 C.*
Normally, $q = m\Delta H_f$. *However, since heat of fusion is per mol*, find mol of C_2H_3Cl → 0.46 g C_2H_3Cl x 1 mol/62.5 g = 0.00736 mol; ΔH_v = *24.7 kj/mol*
q = 24.7 kj/mol x 0.00736 mol = 0.18 kj
Incorporate the mass into the mol of chloroethane.

26. *This involves the heat of solution of NaOH(s).*
ΔH_{soln} = *-44.5 kj/mol*
Use mol of NaOH → 0.677 mol
q = -44.5 kj/mol x 0.677 mol = -30.1 kj
The heat of solution was per mol.

27. *This involves the heat of solution of $NH_4NO_3(s)$.*
ΔH_{soln} = *88.0 kj/mol*
88.0 kj/mol / 25.7 kj = 3.42 mol
The heat of solution was per mol.

Lesson Check Answers

28. Molar heat of fusion and molar heat of solidification have an identical numerical value but are of opposite sign.

29. Molar heat of vaporization and molar heat of condensation have an identical numerical value but are of opposite sign.

30. Heat is either released or absorbed in the formation of a solution.

31. 75.1 KJ

32. 42.0 KJ

33. –27.9 KJ

34. Water molecules are very polar, and many hydrogen bonds form among the molecules. It takes a great deal of energy to break the hydrogen bonds and pull the water molecules apart.

31. *This involves the heat of fusion of water since it is ice at 0 C.*
Normally, $q = m\Delta H_f$. *However, since heat of fusion is per mol*, find mol of water → 225 g water x 1 mol/18 g = 12.5 mol ΔH_f = *6.01 kj/mol*
q = 6.01 kj/mol x 12.5 mol = 75.1 kj

32. *This involves the heat of vaporization of ethanol since gas at 78.3 C.*
Normally, $q = m\Delta H_f$. *However, since heat of fusion is per mol*, find mol of
C_2H_6O → 50.0 g C_2H_6O x 1 mol/46.0 g = 1.09 mol ΔH_v = *38.6 kj/mol*
q = 38.6 kj/mol x 1.09 mol = 41.9 kj

33. *This involves the heat of solution of NaOH(s).*
ΔH_{soln} = *-44.5 kj/mol*
Find mol of NaOH → 25.0 g x 1 mol/40.0 g = 0.625 mol
q = -44.5 kj/mol x 0.625 mol = -27.8 kj
The heat of solution was per mol.

Sample Problems

35. $\Delta H^0 = \Delta H_f^0$ *(products) -* ΔH_f^0 *(reactants)*
Br_2 *(l) is a free elements and therefore,* $\Delta H_f^0 = 0$
Use Table 17.4 to find ΔH_f^0 Br_2 *(g) = 30.91 kj/mol*
ΔH^0 = 0 – 30.91 kj/mol = -30.91 kj

36. *You need a balanced chemical equation:* $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$
$\Delta H^0 = \Delta H_f^0$ *(products) -* ΔH_f^0 *(reactants)*
O_2 *(g) is a free elements and therefore,* $\Delta H_f^0 = 0$
Use Table 17.4 to find ΔH_f^0
Incorporate mol of each substance (use coefficients):
ΔH^0 = (2 mol x 33.85 kj/mol) – (2 mol x 90.37 kj/mol + 0) = -113 kj

Lesson Check Answers

37. Use Hess's law of heat summation or use standard heats of formation.

38. –8.539 x 10^2 kJ

39. $\Delta H^0 = \Delta H_f^0$(products) – ΔH_f^0(reactants)

40. -1.960×10^2 kJ

41. 165 KJ

38. $\Delta H^0 = \Delta H_f^0$ *(products) -* ΔH_f^0 *(reactants)*
Al(s) and Fe(s) are free elements and therefore, $\Delta H_f^0 = 0$
Incorporate mol of each substance (use coefficients):
ΔH^0 = (1 mol x -1676.0 kj/mol) – (1 mol x -822.1 kj/mol + 0) = -853.9 kj

40. $\Delta H^0 = \Delta H_f^0$ *(products) -* ΔH_f^0 *(reactants)*
O_2 (g) is a free elements and therefore, $\Delta H_f^0 = 0$
Use Table 17.4 to find ΔH_f^0
Incorporate mol of each substance (use coefficients):
ΔH^0 = (2 mol x -285.8 kj/mol + 0) – (2 mol x -187.8 kj/mol) = -196 kj

41. *Hess' Law allows you to determine the heat of reaction indirectly by using the known heats of reaction of two or more thermochemical reactions.*
$2H_2O(l) \rightarrow 2\ H_2(g) + O_2(g)$ $\Delta H_f^0 = +572$ kj ... *too expensive*

$H_2O(g) + CH_4(g) \rightarrow CO(g) + 3H_2(g)$ $\Delta H_f^0 = +206$ kj
$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$ $\Delta H_f^0 = -41$ kj

Combine the reactions (add them together:
$2H_2O(g) + CH_4(g) \rightarrow CO_2(g) + 4H_2(g)$
ΔH_f^0 *+206 kj + (-41 kj) = -165 kj*