CHAPTER 6 Thermochemistry

1. A gas absorbs 0.0 J of heat and then performs 15.2 J of work. The change in internal energy of the gas is

   a) –24.8 J
   b) 14.8 J
   c) 55.2 J
   d) –15.2 J
   e) none of these

   ANS: d) –15.2 J **PAGE:** 6.1

2. Calculate the work for the expansion of CO_2 from 1.0 to 2.5 liters against a pressure of 1.0 atm at constant temperature.

   a) 1.5 liter · atm
   b) 2.5 liter · atm
   c) 0
   d) –1.5 liter · atm
   e) –2.5 liter · atm

   ANS: d) –1.5 liter · atm **PAGE:** 6.1

3. Of energy, work, enthalpy, and heat, how many are state functions?

   a) 0
   b) 1
   c) 2
   d) 3
   e) 4

   ANS: c) 2 **PAGE:** 6.1, 6.2

4. Which of the following statements correctly describes the signs of q and w for the following exothermic process at P = 1 atm and T = 370 K?

   $$H_2O(g) \rightarrow H_2O(l)$$

   a) q and w are negative.
   b) q is positive, w is negative.
   c) q is negative, w is positive.
   d) q and w are both positive.
   e) q and w are both zero.

   ANS: c) q is negative, w is positive. **PAGE:** 6.1

5. One mole of an ideal gas is expanded from a volume of 1.00 liter to a volume of 10.00 liters against a constant external pressure of 1.00 atm. How much work (in joules) is performed on the surroundings? (T = 300 K; 1 L atm = 101.3 J)

   a) 456 J
   b) 912 J
   c) 2740 J
   d) 2870 J
   e) none of these

   ANS: b) 912 J **PAGE:** 6.1

6. For a particular process q = 20 kJ and w = 15 kJ. Which of the following statements is true?

   a) Heat flows from the system to the surroundings.
   b) The system does work on the surroundings.
   c) ΔE = 35 kJ.
   d) All of these are true.
   e) None of these are true.

   ANS: c) ΔE = 35 kJ. **PAGE:** 6.1

7. Which statement is *true* of a process in which one mole of a gas is expanded from state A to state B?

   a) When the gas expands from state A to state B, the surroundings are doing work on the system.
   b) The amount of work done in the process must be the same, regardless of the path.
   c) It is not possible to have more than one path for a change of state.
   d) The final volume of the gas will depend on the path taken.
   e) The amount of heat released in the process will depend on the path taken.

   ANS: e) The amount of heat released in the process will depend on the path taken. **PAGE:** 6.1

8. Which of the following statements is correct?

   a) The internal energy of a system increases when more work is done by the system than heat was flowing into the system.
   b) The internal energy of a system decreases when work is done on the system and heat is flowing into the system.
   c) The system does work on the surroundings when an ideal gas expands against a constant external pressure.
   d) All statements are true.
   e) All statements are false.

   ANS: c) The system does work on the surroundings when an ideal gas expands against a constant external pressure. **PAGE:** 6.1

9. Which one of the following statements is *false*?
   a) The change in internal energy, ΔE, for a process is equal to the amount of heat absorbed at constant volume, q_v.
   b) The change in enthalpy, ΔH, for a process is equal to the amount of heat absorbed at constant pressure, q_p.
   c) A bomb calorimeter measures ΔH directly.
   d) If q_p for a process is negative, the process is exothermic.
   e) The freezing of water is an example of an exothermic reaction.

   ANS: c) A bomb calorimeter measures ΔH directly. **PAGE:** 6.1,2

10-13. Consider a gas in a 1.0 L bulb at STP that is connected via a valve to another bulb that is initially evacuated. Answer the following concerning what occurs when the valve between the two bulbs is opened.

10. What is true about the value of q?
   a) It is greater than zero.
   b) It is equal to zero.
   c) It is less than zero.
   d) More information is needed.
   e) none of these

   ANS: b) It is equal to zero. **PAGE:** 6.1

11. What is true about the value of ΔH?
   a) It is greater than zero.
   b) It is equal to zero.
   c) It is less than zero.
   d) More information is needed.
   e) none of these

   ANS: b) It is equal to zero. **PAGE:** 6.2

12. What is true about the value of w?
   a) It is greater than zero.
   b) It is equal to zero.
   c) It is less than zero.
   d) More information is needed.
   e) none of these

   ANS: b) It is equal to zero. **PAGE:** 6.1

13. What is true about the value of ΔE?
   a) It is greater than zero.
   b) It is equal to zero.
   c) It is less than zero.
   d) More information is needed.

e) none of these

ANS: b) It is equal to zero. **PAGE:** 6.1

14. Two metals of equal mass with different heat capacities are subjected to the same amount of heat. Which undergoes the smallest change in temperature?

    a) The metal with the higher heat capacity.
    b) The metal with the lower heat capacity.
    c) Both undergo the same change in temperature.
    d) You need to know the initial temperatures of the metals.
    e) You need to know which metals you have.

    ANS: a) The metal with the higher heat capacity. **PAGE:** 6.2

15. A 25.0 g piece of aluminum (which has a molar heat capacity of 24.03J/°Cmol) is heated to 82.4°C and dropped into a calorimeter containing water (specific heat capacity of water is 4.18J/g°C) initially at 22.3°C. The final temperature of the water is 24.9°C. Calculate the mass of water in the calorimeter.

    a) 118 g
    b) 6.57 g
    c) 3180 g
    d) 2120 g
    e) none of these

    ANS: a) 118 g **PAGE:** 6.2

16. A 40.2 g sample of a metal is heated to 99.3°C and then placed in a calorimeter containing 120.0 g of water (c = 4.18J/g°C) at 21.8°C. The final temperature of the water is 24.5°C. Which metal was used?

    a) Aluminum (c = 0.89J/g°C)
    b) Iron (c = 0.45J/g°C)
    c) Copper (c = 0.20J/g°C)
    d) Lead (c = 0.14J/g°C)
    e) none of these

    ANS: b) Iron **PAGE:** 6.2

17. You take 200. g of a solid at 30.0°C and let it melt in 400. g of water. The water temperature decreases from 85.1°C to 30.0°C. Calculate the heat of fusion of this solid.

    a) 125 J/g
    b) 285 J/g
    c) 461 J/g
    d) 518 J/g
    e) cannot without the heat capacity of the solid

    ANS: c) 461 J/g **PAGE:** 6.2

18. Consider a rigid insulated box containing 20.0 g of He(g) at 25.0°C and 1.00 atm in one compartment and 20.0 g of N_2(g) at 115.0°C and 2.00 atm in the other compartment. These compartments are connected by a partition which transmits heat. What will be the final temperature in the box at thermal equilibrium? (C_v(He) = 12.5 J/K mol, C_v(N_2) = 20.7 J/K mol)

a) 42.2°C
b) 58.9°C
c) 70.0°C
d) 81.0°C
e) none of these

ANS: a) 42.2°C **PAGE:** 6.2

19. Which of the following properties is (are) intensive properties?

I. mass
II. temperature
III. volume
IV. concentration
V. energy

a) I, III, and V
b) II only
c) II and IV
d) III and IV
e) I and V

ANS: c) II and IV **PAGE:** 6.1,2

20. The enthalpy of fusion of ice is 6.020 kJ/mol. The heat capacity of liquid water is 75.4 J/mol°C. What is the smallest number of ice cubes at 0°C, each containing one mole of water, necessary to cool 500. g of liquid water initially at 20°C to 0°C?

a) 1
b) 7
c) 14
d) 15
e) 126

ANS: b) 7 **PAGE:** 6.2

21. 30.0 mL of pure water at 280. K is mixed with 50.0 mL of pure water at 330. K. What is the final temperature of the mixture?

    a) 290. K
    b) 311 K
    c) 320. K
    d) 326 K
    e) 405 K

    ANS: b) 311 K **PAGE:** 6.2

22. For a particular process q = –17 kJ and w = 21 kJ. Which of the following statements is *false*?

    a) Heat flows from the system to the surroundings.
    b) The system does work on the surroundings.
    c) E = +4 kJ
    d) The process is exothermic.
    e) None of these is false.

    ANS: c) E = +4 kJ **PAGE:** 6.1

23. Calculate the work associated with the expansion of a gas from 152 L to 189 L at a constant pressure of 14 atm.

    a) 520 L · atm
    b) –520 L · atm
    c) –260 L · atm
    d) 175 L · atm
    e) 260 L · atm

    ANS: b) –520 L · atm **PAGE:** 6.1

24. Calculate the work associated with the compression of a gas from 121 L to 80. L at a constant pressure of 11 atm.

    a) –450 L · atm
    b) 450 L · atm
    c) 3.7 L · atm
    d) –3.7 L · atm
    e) 120 L · atm

    ANS: b) 450 L · atm **PAGE:** 6.1

25. Consider the reaction

$$H_2(g) + (1/2)O_2(g) \rightarrow H_2O(l) \quad \Delta H° = -286 \text{ kJ}$$

Which of the following is true?

a) The reaction is exothermic.
b) The reaction is endothermic.
c) The enthalpy of the products is less than that of the reactants.
d) Heat is absorbed by the system.
e) Both a and c are true.

ANS: e) Both a and c are true. **PAGE:** 6.2

26. In the lab, you mix two solutions (each originally at the same temperature) and the temperature of the resulting solution decreases. Which of the following is true?

a) The chemical reaction is releasing energy.
b) The energy released is equal to $s \times m \times T$.
c) The chemical reaction is absorbing energy.
d) The chemical reaction is exothermic.
e) More than one of these.

ANS: c) The chemical reaction is absorbing energy. **PAGE:** 6.2

27. What is the heat capacity of mercury if it requires 167 J to change the temperature of 15.0 g mercury from 25.0°C to 33.0°C?

a) 6.92×10^{-3} J/g°C
b) 1.12×10^{-2} J/g°C
c) 0.445 J/g°C
d) 1.39 J/g°C
e) 313 J/g°C

ANS: d) 1.39 J/g°C **PAGE:** 6.2

28. A 140.0-g sample of water at 25.0°C is mixed with 100.0 g of a certain metal at 100.0°C. After thermal equilibrium is established, the (final) temperature of the mixture is 29.6°C. What is the heat capacity of the metal, assuming it is constant over the temperature range concerned?

a) 0.38 J/g°C
b) 0.76 J/g°C
c) 0.96 J/g°C
d) 0.031 J/g°C
e) none of these

ANS: a) 0.38 J/g°C **PAGE:** 6.2

29. For the reaction $H_2O(l) \rightarrow H_2O(g)$ at 298 K, 1.0 atm, ΔH is more positive than ΔE by 2.5 kJ/mol. This quantity of energy can be considered to be

a) the heat flow required to maintain a constant temperature.
b) the work done in pushing back the atmosphere.
c) the difference in the H—O bond energy in $H_2O(l)$ compared to $H_2O(g)$.
d) the value of ΔH itself.
e) none of these

ANS: b) the work done in pushing back the atmosphere. **PAGE:** 6.2

30. Consider the reaction

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l),\ \Delta H = -1.37 \times 10^3 \text{ kJ}$$

When a 15.1-g sample of ethyl alcohol (molar mass = 46.1 g/mol) is burned, how much energy is released as heat?

a) 0.449 kJ
b) 2.25×10^3 kJ
c) 4.49×10^2 kJ
d) 1.02×10^3 kJ
e) 196 kJ

ANS: c) 4.49×10^2 kJ **PAGE:** 6.2

31. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l),\ \Delta H = -1.37 \times 10^3$ kJ

For the combustion of ethyl alcohol as described in the above equation, which of the following is true?

I. The reaction is exothermic.
II. The enthalpy change would be different if gaseous water were produced.
III. The reaction is not an oxidation–reduction one.
IV. The products of the reaction occupy a larger volume than the reactants.

a) I, II
b) I, II, III
c) I, III, IV
d) III, IV
e) Only I

ANS: a) I, II **PAGE:** 6.2,4

32. The ΔH value for the reaction $(1/2)O_2(g) + Hg(l) \rightarrow HgO(s)$ is –90.8 kJ. How much heat is released when 32.5 g Hg is reacted with oxygen?

a) 9.32 kJ
b) 90.8 kJ
c) 14.7 kJ
d) 40.0 kJ
e) none of these

ANS: c) 14.7 kJ **PAGE:** 6.2

33. If 5.0 kJ of energy is added to a 15.5-g sample of water at 10.°C, the water is

a) boiling.
b) completely vaporized.
c) frozen solid.
d) decomposed.
e) still a liquid.

ANS: e) still a liquid. **PAGE:** 6.2

34. Exactly 313.5 J will raise the temperature of 10.0 g of a metal from 25.0°C to 60.0°C. What is the specific heat capacity of the metal?

a) 3.74 J/g°C
b) 0.896 J/g°C
c) 9.70 J/g°C
d) 1.73 J/g°C
e) none of these

ANS: b) 0.896 J/g°C **PAGE:** 6.2

35. The total volume of hydrogen gas needed to fill the Hindenburg was 2.00×10^8 L at 1.00 atm and 25.0°C. How much energy was evolved when it burned?

$$H_2(g) + (1/2)O_2(g) \rightarrow H_2O(l),\ \Delta H = -286 \text{ kJ}$$

a) 3.5×10^{11} kJ
b) 8.18×10^6 kJ
c) 2.86×10^4 kJ
d) 2.34×10^9 kJ
e) 5.72×10^{10} kJ

ANS: d) 2.34×10^9 kJ **PAGE:** 6.2

36. $CH_4 + 4Cl_2(g) \rightarrow CCl_4(g) + 4HCl(g)$, $\Delta H = -434$ kJ

Based on the above reaction, what energy change occurs when 1.2 moles of methane reacts?

a) 5.2×10^5 J are released.
b) 5.2×10^5 J are absorbed.
c) 3.6×10^5 J are released.
d) 3.6×10^5 J are absorbed.
e) 4.4×10^5 J are released.

ANS: a) 5.2×10^5 J are released. **PAGE:** 6.2

37. Given the equation $S(s) + O_2(g) \rightarrow SO_2(g)$, $\Delta H = -296$ kJ, which of the following statement(s) is (are) true?

I. The reaction is exothermic.
II. When 0.500 mole sulfur is reacted, 148 kJ of energy is released.
III. When 32.0 g of sulfur are burned, 2.96×10^5 J of energy is released.

a) All are true.
b) None is true.
c) I and II are true.
d) I and III are true.
e) Only II is true.

ANS: a) All are true. **PAGE:** 6.2

38. Consider the reaction:

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l); \Delta H = -1.37 \times 10^3 \text{ kJ}$$

Consider the following propositions:

I. The reaction is endothermic
II. The reaction is exothermic.
III. The enthalpy term would be different if the water formed was gaseous.

Which of these propositions is (are) true?

a) I
b) II
c) III
d) I, II
e) II, III

ANS: e) II, III **PAGE:** 6.2,4

39. What is the specific heat capacity of gold if it requires 48.8 J to raise the temperature of 15 grams of gold 25°C?

a) 29 J/g°C
b) 0.13 J/g°C
c) 79 J/g°C
d) 0.011 J/g°C
e) none of these

ANS: b) 0.13 J/g°C **PAGE:** 6.2

40. The heat of formation of $Fe_2O_3(s)$ is –826 kJ/mol. Calculate the heat of the reaction $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$ when a 55.8-g sample of iron is reacted.

a) –206 kJ
b) –413 kJ
c) –826 kJ
d) –1650 kJ
e) -3.30×10^3 kJ

ANS: b) –413 kJ **PAGE:** 6.2,4

41. When 0.157 mol NH_3 is reacted with excess HCl, 6.91 kJ of energy is released as heat. What is ΔH for this reaction per mole of NH_3 consumed?

a) –22.7 J
b) –1.08 kJ
c) –44.0 kJ
d) +22.7 J
e) +44.0 kJ

ANS: c) –44.0 kJ **PAGE:** 6.2

42. A 4.0-g sample of Colorado oil shale is burned in a bomb calorimeter, which causes the temperature of the calorimeter to increase by 5.0°C. The calorimeter contains 1.00 kg of water (CH_2O = 4.184 J/g°C) and the heat capacity of the empty calorimeter is 0.10 kJ/°C. How much heat is released per gram of oil shale when it is burned?

a) 21 kJ/g
b) 42 kJ/g
c) 0 kJ/g
d) 5.4 kJ/g
e) 5.2 kJ/g

ANS: d) 5.4 kJ/g **PAGE:** 6.2

43. If a student performs an endothermic reaction in a calorimeter, how does the calculated value of ΔH differ from the actual value if the heat exchanged with the calorimeter is not taken into account?

    a) ΔH_{calc} would be more negative because the calorimeter always absorbs heat from the reaction.
    b) ΔH_{calc} would be less negative because the calorimeter would absorb heat from the reaction.
    c) ΔH_{calc} would be more positive because the reaction absorbs heat from the calorimeter.
    d) ΔH_{calc} would be less positive because the reaction absorbs heat from the calorimeter.
    e) ΔH_{calc} would equal the actual value because the calorimeter does not absorb heat.

    ANS: d) ΔH_{calc} would be less positive because the reaction absorbs heat from the calorimeter. **PAGE:** 6.2

44. A bomb calorimeter has a heat capacity of 2.47 kJ/K. When a 0.105-g sample of ethylene (C_2H_4) was burned in this calorimeter, the temperature increased by 2.14 K. Calculate the energy of combustion for one mole of ethylene.

    a) –5.29 kJ
    b) –50.3 kJ
    c) –572 kJ
    d) –661 kJ
    e) -1.41×10^3 kJ

    ANS: e) -1.41×10^3 kJ **PAGE:** 6.2

45. How much heat is required to raise the temperature of a 6.21-g sample of iron (specific heat = 0.450 J/(g°C) from 25.0°C to 79.8°C?

    a) 70.0 J
    b) 101 J
    c) 386 J
    d) 756 J
    e) 153 J

    ANS: e) 153 J **PAGE:** 6.2

46. Consider the following processes:

$2A \rightarrow 1/2B + C$	$\Delta H_1 = 5$ kJ/mol
$(3/2)B + 4C \rightarrow 2A + C + 3D$	$\Delta H_2 = -15$ kJ/mol
$E + 4A \rightarrow C$	$\Delta H_3 = 10$ kJ/mol

Calculate ΔH for: $C \rightarrow E + 3D$

a) 0 kJ/mol
b) 10 kJ/mol
c) –10 kJ/mol
d) –20 kJ/mol
e) 20 kJ/mol

ANS: c) –10 kJ/mol **PAGE:** 6.3

47. Consider the following processes:

	ΔH (kJ/mol)
$(1/2)A \rightarrow B$	150.
$3B \rightarrow 2C + D$	–125
$E + A \rightarrow D$	350.

Calculate ΔH for: $B + D \rightarrow E + 2C$

a) 325 kJ/mol
b) 525 kJ/mol
c) –175 kJ/mol
d) –325 kJ/mol
e) none of these

ANS: c) –175 kJ/mol **PAGE:** 6.3

48. Which of the following does *not* have a standard enthalpy of formation equal to zero at 25°C and 1.0 atm?

a) $F_2(g)$
b) Al(s)
c) $H_2O(l)$
d) $H_2(g)$
e) They all have a standard enthalpy equal to zero.

ANS: c) $H_2O_{(1)}$ **PAGE:** 6.4

49. Consider the following numbered processes:

I. $A \rightarrow 2B$
II. $B \rightarrow C + D$
III. $E \rightarrow 2D$

ΔH for the process $A \rightarrow 2C + E$ is

a) $\Delta H_1 + \Delta H_2 + \Delta H_3$
b) $\Delta H_1 + \Delta H_2$
c) $\Delta H_1 + \Delta H_2 - \Delta H_3$
d) $\Delta H_1 + 2\Delta H_2 - \Delta H_3$
e) $\Delta H_1 + 2\Delta H_2 + \Delta H_3$

ANS: d) $\Delta H_1 + 2\Delta H_2 - \Delta H_3$ **PAGE:** 6.3

50. At 25°C, the following heats of reaction are known:

	ΔH (kJ/mol)
$2ClF + O_2 \rightarrow Cl_2O + F_2O$	167.4
$2ClF_3 + 2O_2 \rightarrow Cl_2O + 3F_2O$	341.4
$2F_2 + O_2 \rightarrow 2F_2O$	–43.4

At the same temperature, calculate ΔH for the reaction:

$ClF + F_2 \rightarrow ClF_3$

a) –217.5 kJ/mol
b) –130.2 kJ/mol
c) +217.5 kJ/mol
d) –108.7 kJ/mol
e) none of these

ANS: d) –108.7 kJ/mol **PAGE:** 6.3

51. Calculate $\Delta H°$ for the reaction $C_4H_4(g) + 2H_2(g) \rightarrow C_4H_8(g)$, using the following data:

$\Delta H°_{combustion}$ for $C_4H_4(g) = -2341$ kJ/mol
$\Delta H°_{combustion}$ for $H_2(g) = -286$ kJ/mol
$\Delta H°_{combustion}$ for $C_4H_8(g) = -2755$ kJ/mol

a) –128 kJ
b) –158 kJ
c) 128 kJ
d) 158 kJ
e) none of these

ANS: b) –158 kJ **PAGE:** 6.3

52. Given the following two reactions at 298 K and 1 atm, which of the statements is true?

1. $N_2(g) + O_2(g) \rightarrow 2NO(g)$ ΔH_1
2. $NO(g) + (1/2)O_2(g) \rightarrow NO_2(g)$ ΔH_2

a) ΔH_f° for $NO_2(g) = \Delta H_2$
b) ΔH_f° for $NO(g) = \Delta H_1$
c) $\Delta H_f^\circ = \Delta H_2$
d) ΔH_f° for $NO_2(g) = \Delta H_2 + (1/2)\Delta H_1$
e) none of these

ANS: d) ΔH_f° for $NO_2(g) = \Delta H_2 + (1/2)\Delta H_1$ **PAGE:** 6.3,4

53. Given the heats of the following reactions:

		$\Delta H°$ (kJ)
I.	$P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(g)$	–1225.6
II.	$P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$	–2967.3
III.	$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$	–84.2
IV.	$PCl_3(g) + (1/2)O_2(g) \rightarrow Cl_3PO(g)$	–285.7

Calculate the value of $\Delta H°$ for the reaction below:

$$P_4O_{10}(s) + 6PCl_5(g) \rightarrow 10Cl_3PO(g)$$

a) –110.5 kJ
b) –610.1 kJ
c) –2682.2 kJ
d) –7555.0 kJ
e) None of these is within 5% of the correct answer.

ANS: b) –610.1 kJ **PAGE:** 6.3

54. Given: $Cu_2O(s) + (1/2)O_2(g) \rightarrow 2CuO(s)$ $\Delta H° = -144$ kJ
$Cu_2O(s) \rightarrow Cu(s) + CuO(s)$ $\Delta H° = +11$ kJ

Calculate the standard enthalpy of formation of CuO(s).

a) –166 kJ
b) –299 kJ
c) +299 kJ
d) +155 kJ
e) –155 kJ

ANS: e) –155 kJ/mol **PAGE:** 6.3,4

55. The heat combustion of acetylene, $C_2H_2(g)$, at 25°C, is –1299 kJ/mol. At this temperature, ΔH_f° values for $CO_2(g)$ and $H_2O(l)$ are –393 and –286 kJ/mol, respectively. Calculate ΔH_f° for acetylene.

a) 2376 kJ/mol
b) 625 kJ/mol
c) 227 kJ/mol
d) –625 kJ/mol
e) none of these

ANS: c) 227 kJ/mol **PAGE:** 6.4

56. Choose the correct equation for the standard enthalpy of formation of CO(g), where ΔH_f° for CO = –110.5 kJ/mol (gr indicates graphite).

a) $2C(gr) + O_2(g) \rightarrow 2CO(g)$, $\Delta H° = -110.5$ kJ
b) $C(gr) + O(g) \rightarrow CO(g)$, $\Delta H° = -110.5$ kJ
c) $C(gr) + (1/2)O2(g) \rightarrow CO(g)$, $\Delta H° = -110.5$ kJ
d) $C(gr) + CO_2(g) \rightarrow 2CO(g)$, $\Delta H° = -110.5$ kJ
e) $CO(g) \rightarrow C(gr) + O(g)$, $\Delta H° = -110.5$ kJ

ANS: c) $C(gr) + (1/2)O_2(g) \rightarrow CO(g)$, $\Delta H° = -110.5$ kJ **PAGE:** 6.4

57. For the reaction

$AgI(s) + (1/2)Br_2(g) \rightarrow AgBr(s) + (1/2)I_2(s)$, $\Delta H_{298}^\circ = -54.0$ kJ

ΔH_f° for AgBr(s) = –100.4 kJ/mol

ΔH_f° for $Br_2(g)$ = +30.9 kJ/mol

The value of ΔH_f° (298) for AgI(s) is:

a) –123.5 kJ/mol
b) +77.3 kJ/mol
c) +61.8 kJ/mol
d) –77.3 kJ/mol
e) –61.8 kJ/mol

ANS: e) –61.8 kJ/mol **PAGE:** 6.4

58. Using the following data, calculate the standard heat of formation of the compound ICl in kJ/mol:

	$\Delta H°$ (kJ/mol)
$Cl_2(g) \rightarrow 2Cl(g)$	242.3
$I_2(g) \rightarrow 2I(g)$	151.0
$ICl(g) \rightarrow I(g) + Cl(g)$	211.3
$I_2(s) \rightarrow I_2(g)$	62.8

a) –211 kJ/mol
b) –14.6 kJ/mol
c) 16.8 kJ/mol
d) 245 kJ/mol
e) 439 kJ/mol

ANS: c) 16.8 kJ/mol **PAGE:** 6.3,4

59. Using the information below, calculate ΔH_f° for PbO(s)

$PbO(s) + CO(g) \rightarrow Pb(s) + CO_2(g)$ ΔH = –131.4 kJ

ΔH_f° for $CO_2(g)$ = –393.5 kJ/mol

ΔH_f° for CO(g) = –110.5 kJ/mol

a) –151.6 kJ/mol
b) –283.0 kJ/mol
c) +283.0 kJ/mol
d) –372.6 kJ/mol
e) +252.1 kJ/mol

ANS: a) –151.6 kJ/mol **PAGE:** 6.4

60. For which of the following reaction(s) is the enthalpy change for the reaction *not* equal to ΔH_f° of the product?

I. $2H(g) \rightarrow H_2(g)$
II. $H_2(g) + O_2(g) \rightarrow H_2O_2(l)$
III. $H_2O(l) + O(g) \rightarrow H_2O_2(l)$

a) I
b) II
c) III
d) I and III
e) II and III

ANS: d) I and III **PAGE:** 6.4

61. Consider the following reaction:

$$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s); \quad \Delta H = -1390.81 \text{ kJ}$$

a) Is the reaction exothermic or endothermic?
b) Calculate the heat produced when 10.0 g $AlCl_3$ forms.
c) How many grams of Al are required to produce 1.00 kJ of energy?

ANS: a) exothermic; b) 52.2 kJ; c) 0.0388 g Al **PAGE:** 6.2

62, 63. To carry out the reaction $N_2 + 2O_2 \rightarrow 2NO_2$ requires 67.7 kJ.

To carry out the reaction $N_2 + 2O_2 \rightarrow N_2O_4$ requires 9.7 kJ.
Consider the reaction $2NO_2 \rightarrow N_2O_4$.

62. How much energy (absolute value) is involved in the reaction $2NO_2 \rightarrow N_2O_4$?

ANS: 58.0 kJ **PAGE:** 6.3

63. Is the reaction endothermic or exothermic?

ANS: exothermic **PAGE:** 6.3

64. Consider the following data:

	ΔH (kJ)
$Ca(s) + 2C(\text{graphite}) \rightarrow CaC_2(s)$	–62.8
$Ca(s) + 1/2O_2(g) \rightarrow CaO(s)$	–635.5
$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$	–653.1
$C_2H_2(g) + (5/2)O_2(g) \rightarrow 2CO_2 + H_2O(l)$	–1300
$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g)$	–393.51

Use Hess's law to find the change in enthalpy at 25°C for the following equation:

$$CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + C_2H_2(g)$$

ANS: –713 kJ **PAGE:** 6.3

65. Consider the following standard heats of formation:

$P_4O_{10}(s) = -3110$ kJ/mol

$H_2O(l) = -286$ kJ/mol

$H_3PO_4(s) = -1279$ kJ/mol

Calculate the change in enthalpy for the following process:

$$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(s)$$

ANS: –290 kJ **PAGE:** 6.4

66. The following statements concerning petroleum are all true *except*:

a) It is a thick, dark liquid composed mostly of hydrocarbons.
b) It must be separated into fractions (by boiling) in order to be used efficiently.
c) Some of the commercial uses of petroleum fractions include gasoline and kerosene.
d) It was probably formed from the remains of ancient marine organisms.
e) All of its hydrocarbon chains contain the same number of carbon atoms.

ANS: e) All of its hydrocarbon chains contain the same number of carbon atoms. **PAGE:** 6.5

67. This fossil fuel was formed from the remains of plants that were buried and exposed to high pressure and heat over time. It is

a) coal.
b) natural gas.
c) diesel fuel.
d) propane.
e) gasoline.

ANS: a) coal. **PAGE:** 6.5

68. The coal with the highest energy available per unit burned is

a) lignite.
b) subbituminous.
c) bituminous.
d) anthracite.
e) They are equal in energy value.

ANS: d) anthracite. **PAGE:** 6.5

69. All of the following statements about the greenhouse effect are true *except*:

a) It occurs only on earth.
b) The molecules H_2O and CO_2 play an important role in retaining the atmosphere's heat.
c) Low humidity allows efficient radiation of heat back into space.
d) The carbon dioxide content of the atmosphere is quite stable.
e) a and d

ANS: e) a and d **PAGE:** 6.5

70. One of the main advantages of hydrogen as a fuel is that

a) the only product of hydrogen combustion is water.
b) it exists as a free gas.
c) it can be economically supplied by the world's oceans.
d) plants can economically produce the hydrogen needed.
e) it contains a large amount of energy per unit volume of hydrogen gas.

ANS: a) the only product of hydrogen combustion is water. **PAGE:** 6.6

71. Which of the following is *not* being considered as an energy source for the future?

a) ethanol
b) methanol
c) seed oil
d) shale oil
e) carbon dioxide

ANS: e) carbon dioxide **PAGE:** 6.6

72. Acetylene (C_2H_2) and butane (C_4H_{10}) are gaseous fuels. Determine the ratio of energy available from the combustion of a given volume of acetylene to butane at the same temperature and pressure using the following data:

The change in enthalpy of combustion for

$C_2H_2(g) = -49.9$ kJ/g.

The change in enthalpy of combustion for

$C_4H_{10} = -49.5$ kJ/g.

ANS: About 2.21 times the volume of acetylene is needed to furnish the same energy as a given volume of butane. **PAGE:** 6.6

73. A property that is independent of the pathway is called an intensive property.

ANS: False **PAGE:** 6.1

74. In exothermic reaction, potential energy stored in chemical bonds is being converted to thermal energy via heat.

ANS: True **PAGE:** 6.1

75. A state function does not depend on the system's past or future.

ANS: True **PAGE:** 6.1

76. When a system performs work on the surroundings, the work is reported with a negative sign.

ANS: True **PAGE:** 6.1

77. The change in enthalpy can always be thought of as equal to energy flow as heat.

ANS: False **PAGE:** 6.2

78. The specific heat capacities of metals are relatively low.

ANS: True **PAGE:** 6.2

79. The _____ of a system is the sum of the kinetic and potential energies of all the particles in the system.

ANS: internal energy **PAGE:** 6.1

80. _____ involves the transfer of energy between two objects due to a temperature difference.

ANS: Heat **PAGE:** 6.1