

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
- 24.8 J
 - 14.8 J
 - 55.2 J
 - 15.2 J
 - none of these

ANS: d) -15.2 J

PAGE: 6.1

2. Calculate the work for the expansion of CO₂ from 1.0 to 2.5 liters against a pressure of 1.0 atm at constant temperature.
- 1.5 liter · atm
 - 2.5 liter · atm
 - 0
 - 1.5 liter · atm
 - 2.5 liter · atm

ANS: d) -1.5 liter · atm

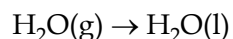
PAGE: 6.1

3. Of energy, work, enthalpy, and heat, how many are state functions?
- 0
 - 1
 - 2
 - 3
 - 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?



- q and w are negative.
- q is positive, w is negative.
- q is negative, w is positive.
- q and w are both positive.
- q and w are both zero.

ANS: c) q is negative, w is positive.

PAGE: 6.1

CHAPTER 6 Thermochemistry

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? ($T = 300\text{ K}$; $1\text{ L atm} = 101.3\text{ J}$)
- 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 $q = 20\text{ kJ}$ and $w = 15\text{ kJ}$. 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) $\Delta E = 35\text{ kJ}$.
 - d) All of these are true.
 - e) None of these are true.

ANS: c) $\Delta E = 35\text{ kJ}$.

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

CHAPTER 6 Thermochemistry

9. Which one of the following statements is *false*?
- The change in internal energy, ΔE , for a process is equal to the amount of heat absorbed at constant volume, q_v .
 - The change in enthalpy, ΔH , for a process is equal to the amount of heat absorbed at constant pressure, q_p .
 - A bomb calorimeter measures ΔH directly.
 - If q_p for a process is negative, the process is exothermic.
 - 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 ?
- It is greater than zero.
 - It is equal to zero.
 - It is less than zero.
 - More information is needed.
 - none of these

ANS: b) It is equal to zero.

PAGE: 6.1

11. What is true about the value of ΔH ?
- It is greater than zero.
 - It is equal to zero.
 - It is less than zero.
 - More information is needed.
 - none of these

ANS: b) It is equal to zero.

PAGE: 6.2

12. What is true about the value of w ?
- It is greater than zero.
 - It is equal to zero.
 - It is less than zero.
 - More information is needed.
 - none of these

ANS: b) It is equal to zero.

PAGE: 6.1

13. What is true about the value of ΔE ?
- It is greater than zero.
 - It is equal to zero.
 - It is less than zero.
 - More information is needed.

CHAPTER 6 Thermochemistry

e) none of these

ANS: b) It is equal to zero.

PAGE: 6.1

CHAPTER 6 Thermochemistry

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?
- The metal with the higher heat capacity.
 - The metal with the lower heat capacity.
 - Both undergo the same change in temperature.
 - You need to know the initial temperatures of the metals.
 - 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 $24.03\text{J}/^\circ\text{Cmol}$) is heated to 82.4°C and dropped into a calorimeter containing water (specific heat capacity of water is $4.18\text{J}/\text{g}^\circ\text{C}$) initially at 22.3°C . The final temperature of the water is 24.9°C . Calculate the mass of water in the calorimeter.
- 118 g
 - 6.57 g
 - 3180 g
 - 2120 g
 - 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 ($c = 4.18\text{J}/\text{g}^\circ\text{C}$) at 21.8°C . The final temperature of the water is 24.5°C . Which metal was used?
- Aluminum ($c = 0.89\text{J}/\text{g}^\circ\text{C}$)
 - Iron ($c = 0.45\text{J}/\text{g}^\circ\text{C}$)
 - Copper ($c = 0.20\text{J}/\text{g}^\circ\text{C}$)
 - Lead ($c = 0.14\text{J}/\text{g}^\circ\text{C}$)
 - 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.
- 125 J/g
 - 285 J/g
 - 461 J/g
 - 518 J/g
 - cannot without the heat capacity of the solid

ANS: c) 461 J/g

PAGE: 6.2

CHAPTER 6 Thermochemistry

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 N₂(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? ($C_v(\text{He}) = 12.5 \text{ J/K mol}$, $C_v(\text{N}_2) = 20.7 \text{ J/K mol}$)
- 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

CHAPTER 6 Thermochemistry

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

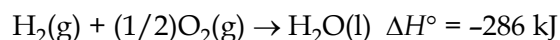
24. Calculate the work associated with the compression of a gas from 121 L to 80. L at a constant pressure of 11 atm.
- a) -450 L · atm
 - b) 450 L · atm
 - c) 3.7 L · atm
 - d) -3.7 L · atm
 - e) 120 L · atm

ANS: b) 450 L · atm

PAGE: 6.1

CHAPTER 6 Thermochemistry

25. Consider the reaction



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) $6.92 \times 10^{-3} \text{ J/g}^\circ\text{C}$
- b) $1.12 \times 10^{-2} \text{ J/g}^\circ\text{C}$
- c) $0.445 \text{ J/g}^\circ\text{C}$
- d) $1.39 \text{ J/g}^\circ\text{C}$
- e) $313 \text{ J/g}^\circ\text{C}$

ANS: d) $1.39 \text{ J/g}^\circ\text{C}$

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) $0.38 \text{ J/g}^\circ\text{C}$
- b) $0.76 \text{ J/g}^\circ\text{C}$
- c) $0.96 \text{ J/g}^\circ\text{C}$
- d) $0.031 \text{ J/g}^\circ\text{C}$
- e) none of these

ANS: a) $0.38 \text{ J/g}^\circ\text{C}$

PAGE: 6.2

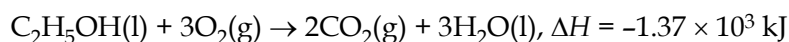
CHAPTER 6 Thermochemistry

29. For the reaction $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$ 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
- the heat flow required to maintain a constant temperature.
 - the work done in pushing back the atmosphere.
 - the difference in the H–O bond energy in $\text{H}_2\text{O}(\text{l})$ compared to $\text{H}_2\text{O}(\text{g})$.
 - the value of ΔH itself.
 - none of these

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

PAGE: 6.2

30. Consider the reaction



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

- 0.449 kJ
- 2.25×10^3 kJ
- 4.49×10^2 kJ
- 1.02×10^3 kJ
- 196 kJ

ANS: c) 4.49×10^2 kJ

PAGE: 6.2

31. $\text{C}_2\text{H}_5\text{OH}(\text{l}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l}), \Delta H = -1.37 \times 10^3 \text{ kJ}$

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

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

ANS: a) I, II

PAGE: 6.2,4

CHAPTER 6 Thermochemistry

32. The ΔH value for the reaction $(1/2)\text{O}_2(\text{g}) + \text{Hg}(\text{l}) \rightarrow \text{HgO}(\text{s})$ 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 $10.^\circ\text{C}$, the water is
- a) boiling.
 - b) completely vaporized.
 - c) frozen solid.
 - d) decomposed.
 - e) still a liquid.

ANS: e) still a liquid.

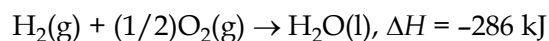
PAGE: 6.2

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 $^\circ\text{C}$
 - b) 0.896 J/g $^\circ\text{C}$
 - c) 9.70 J/g $^\circ\text{C}$
 - d) 1.73 J/g $^\circ\text{C}$
 - e) none of these

ANS: b) 0.896 J/g $^\circ\text{C}$

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?

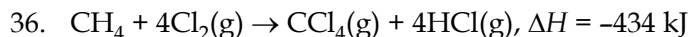


- a) 3.5×10^{11} kJ
- b) 8.18×10^6 kJ
- c) 2.86×10^4 kJ
- d) 2.34×10^9 kJ
- e) 5.72×10^{10} kJ

ANS: d) 2.34×10^9 kJ

PAGE: 6.2

CHAPTER 6 Thermochemistry

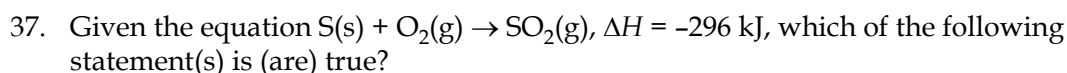


Based on the above reaction, what energy change occurs when 1.2 moles of methane reacts?

- a) $5.2 \times 10^5 \text{ J}$ are released.
- b) $5.2 \times 10^5 \text{ J}$ are absorbed.
- c) $3.6 \times 10^5 \text{ J}$ are released.
- d) $3.6 \times 10^5 \text{ J}$ are absorbed.
- e) $4.4 \times 10^5 \text{ J}$ are released.

ANS: a) $5.2 \times 10^5 \text{ J}$ are released.

PAGE: 6.2

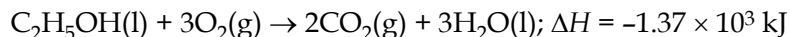


- I. The reaction is exothermic.
 - II. When 0.500 mole sulfur is reacted, 148 kJ of energy is released.
 - III. When 32.0 g of sulfur are burned, $2.96 \times 10^5 \text{ J}$ of energy is released.
- a) All are true.
 - b) None is true.
 - c) I and II are true.
 - d) I and III are true.
 - e) Only II is true.

ANS: a) All are true.

PAGE: 6.2

38. Consider the reaction:



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

CHAPTER 6 Thermochemistry

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 $\text{Fe}_2\text{O}_3(\text{s})$ is -826 kJ/mol . Calculate the heat of the reaction $4\text{Fe}(\text{s}) + 3\text{O}_2(\text{g}) \rightarrow 2\text{Fe}_2\text{O}_3(\text{s})$ when a 55.8-g sample of iron is reacted.
- a) -206 kJ
 - b) -413 kJ
 - c) -826 kJ
 - d) -1650 kJ
 - e) $-3.30 \times 10^3 \text{ kJ}$

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) $+22.7 \text{ J}$
 - e) $+44.0 \text{ kJ}$

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 ($C_{\text{H}_2\text{O}} = 4.184 \text{ J/g}^\circ\text{C}$) 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

CHAPTER 6 Thermochemistry

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

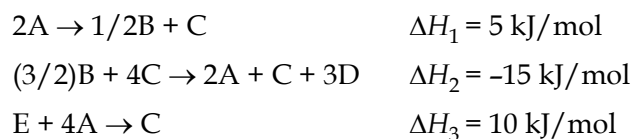
45. How much heat is required to raise the temperature of a 6.21-g sample of iron (specific heat = 0.450 J/(g°C) from 25.0°C to 79.8°C?
- a) 70.0 J
 - b) 101 J
 - c) 386 J
 - d) 756 J
 - e) 153 J

ANS: e) 153 J

PAGE: 6.2

CHAPTER 6 Thermochemistry

46. Consider the following processes:



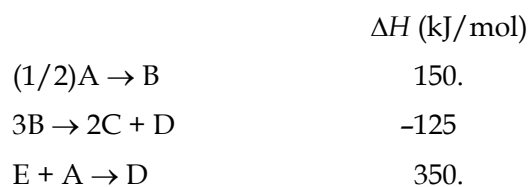
Calculate ΔH for: $C \rightarrow E + 3D$

- 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:



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) $H_2O(l)$

PAGE: 6.4

CHAPTER 6 Thermochemistry

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) $\Delta H_1 + 2\Delta H_2 + \Delta H_3$

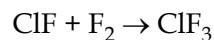
ANS: d) $\Delta H_1 + 2\Delta H_2 - \Delta H_3$

PAGE: 6.3

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

	ΔH (kJ/mol)
$2\text{ClF} + \text{O}_2 \rightarrow \text{Cl}_2\text{O} + \text{F}_2\text{O}$	167.4
$2\text{ClF}_3 + 2\text{O}_2 \rightarrow \text{Cl}_2\text{O} + 3\text{F}_2\text{O}$	341.4
$2\text{F}_2 + \text{O}_2 \rightarrow 2\text{F}_2\text{O}$	-43.4

At the same temperature, calculate ΔH for the reaction:



- 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 ΔH° for the reaction $\text{C}_4\text{H}_4(\text{g}) + 2\text{H}_2(\text{g}) \rightarrow \text{C}_4\text{H}_8(\text{g})$, using the following data:

$$\Delta H^\circ_{\text{combustion}} \text{ for } \text{C}_4\text{H}_4(\text{g}) = -2341 \text{ kJ/mol}$$

$$\Delta H^\circ_{\text{combustion}} \text{ for } \text{H}_2(\text{g}) = -286 \text{ kJ/mol}$$

$$\Delta H^\circ_{\text{combustion}} \text{ for } \text{C}_4\text{H}_8(\text{g}) = -2755 \text{ kJ/mol}$$

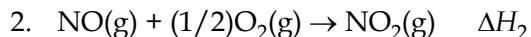
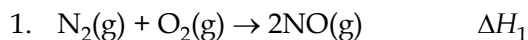
- a) -128 kJ
- b) -158 kJ
- c) 128 kJ
- d) 158 kJ
- e) none of these

ANS: b) -158 kJ

PAGE: 6.3

CHAPTER 6 Thermochemistry

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



- a) ΔH_f° for $\text{NO}_2(\text{g}) = \Delta H_2$
- b) ΔH_f° for $\text{NO}(\text{g}) = \Delta H_1$
- c) $\Delta H_f^\circ = \Delta H_2$
- d) ΔH_f° for $\text{NO}_2(\text{g}) = \Delta H_2 + (1/2)\Delta H_1$
- e) none of these

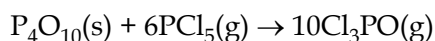
ANS: d) ΔH_f° for $\text{NO}_2(\text{g}) = \Delta H_2 + (1/2)\Delta H_1$

PAGE: 6.3,4

53. Given the heats of the following reactions:

	ΔH° (kJ)
I. $\text{P}_4(\text{s}) + 6\text{Cl}_2(\text{g}) \rightarrow 4\text{PCl}_3(\text{g})$	-1225.6
II. $\text{P}_4(\text{s}) + 5\text{O}_2(\text{g}) \rightarrow \text{P}_4\text{O}_{10}(\text{s})$	-2967.3
III. $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{PCl}_5(\text{g})$	-84.2
IV. $\text{PCl}_3(\text{g}) + (1/2)\text{O}_2(\text{g}) \rightarrow \text{Cl}_3\text{PO}(\text{g})$	-285.7

Calculate the value of ΔH° for the reaction below:

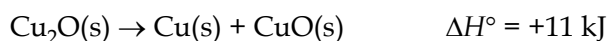


- a) -110.5 kJ
- b) -610.1 kJ
- c) -2682.2 kJ
- d) -7555.0 kJ
- e) None of these is within 5% of the correct answer.

ANS: b) -610.1 kJ

PAGE: 6.3

54. Given: $\text{Cu}_2\text{O}(\text{s}) + (1/2)\text{O}_2(\text{g}) \rightarrow 2\text{CuO}(\text{s}) \quad \Delta H^\circ = -144 \text{ kJ}$



Calculate the standard enthalpy of formation of $\text{CuO}(\text{s})$.

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

ANS: e) -155 kJ/mol

PAGE: 6.3,4

CHAPTER 6 Thermochemistry

55. The heat combustion of acetylene, $C_2H_2(g)$, at $25^\circ C$, 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.
- 2376 kJ/mol
 - 625 kJ/mol
 - 227 kJ/mol
 - -625 kJ/mol
 - none of these

ANS: c) 227 kJ/mol

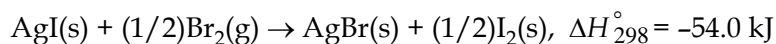
PAGE: 6.4

56. Choose the correct equation for the standard enthalpy of formation of $CO(g)$, where ΔH_f° for $CO = -110.5 \text{ kJ/mol}$ (gr indicates graphite).
- $2C(gr) + O_2(g) \rightarrow 2CO(g), \quad \Delta H^\circ = -110.5 \text{ kJ}$
 - $C(gr) + O(g) \rightarrow CO(g), \quad \Delta H^\circ = -110.5 \text{ kJ}$
 - $C(gr) + (1/2)O_2(g) \rightarrow CO(g), \quad \Delta H^\circ = -110.5 \text{ kJ}$
 - $C(gr) + CO_2(g) \rightarrow 2CO(g), \quad \Delta H^\circ = -110.5 \text{ kJ}$
 - $CO(g) \rightarrow C(gr) + O(g), \quad \Delta H^\circ = -110.5 \text{ kJ}$

ANS: c) $C(gr) + (1/2)O_2(g) \rightarrow CO(g), \quad \Delta H^\circ = -110.5 \text{ kJ}$

PAGE: 6.4

57. For the reaction



$$\Delta H_f^\circ \text{ for } AgBr(s) = -100.4 \text{ kJ/mol}$$

$$\Delta H_f^\circ \text{ for } Br_2(g) = +30.9 \text{ kJ/mol}$$

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

- -123.5 kJ/mol
- $+77.3 \text{ kJ/mol}$
- $+61.8 \text{ kJ/mol}$
- -77.3 kJ/mol
- -61.8 kJ/mol

ANS: e) -61.8 kJ/mol

PAGE: 6.4

CHAPTER 6 Thermochemistry

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

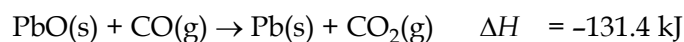
	ΔH° (kJ/mol)
$\text{Cl}_2(\text{g}) \rightarrow 2\text{Cl}(\text{g})$	242.3
$\text{I}_2(\text{g}) \rightarrow 2\text{I}(\text{g})$	151.0
$\text{ICl}(\text{g}) \rightarrow \text{I}(\text{g}) + \text{Cl}(\text{g})$	211.3
$\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{g})$	62.8

- 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)



$$\Delta H_f^\circ \text{ for } \text{CO}_2(\text{g}) = -393.5 \text{ kJ/mol}$$

$$\Delta H_f^\circ \text{ for } \text{CO}(\text{g}) = -110.5 \text{ kJ/mol}$$

- 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. $2\text{H}(\text{g}) \rightarrow \text{H}_2(\text{g})$
 II. $\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}_2(\text{l})$
 III. $\text{H}_2\text{O}(\text{l}) + \text{O}(\text{g}) \rightarrow \text{H}_2\text{O}_2(\text{l})$
 a) I
 b) II
 c) III
 d) I and III
 e) II and III

ANS: d) I and III

PAGE: 6.4

CHAPTER 6 Thermochemistry

61. Consider the following reaction:



- Is the reaction exothermic or endothermic?
- Calculate the heat produced when 10.0 g AlCl_3 forms.
- 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 $\text{N}_2 + 2\text{O}_2 \rightarrow 2\text{NO}_2$ requires 67.7 kJ.

To carry out the reaction $\text{N}_2 + 2\text{O}_2 \rightarrow \text{N}_2\text{O}_4$ requires 9.7 kJ.

Consider the reaction $2\text{NO}_2 \rightarrow \text{N}_2\text{O}_4$.

62. How much energy (absolute value) is involved in the reaction $2\text{NO}_2 \rightarrow \text{N}_2\text{O}_4$?

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)
$\text{Ca}(s) + 2\text{C}(\text{graphite}) \rightarrow \text{CaC}_2(s)$	-62.8
$\text{Ca}(s) + 1/2\text{O}_2(g) \rightarrow \text{CaO}(s)$	-635.5
$\text{CaO}(s) + \text{H}_2\text{O}(l) \rightarrow \text{Ca}(\text{OH})_2(\text{aq})$	-653.1
$\text{C}_2\text{H}_2(g) + (5/2)\text{O}_2(g) \rightarrow 2\text{CO}_2 + \text{H}_2\text{O}(l)$	-1300
$\text{C}(\text{graphite}) + \text{O}_2(g) \rightarrow \text{CO}_2(g)$	-393.51

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



ANS: -713 kJ

PAGE: 6.3

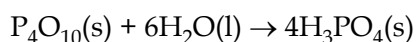
65. Consider the following standard heats of formation:

$$\text{P}_4\text{O}_{10}(s) = -3110 \text{ kJ/mol}$$

$$\text{H}_2\text{O}(l) = -286 \text{ kJ/mol}$$

$$\text{H}_3\text{PO}_4(s) = -1279 \text{ kJ/mol}$$

Calculate the change in enthalpy for the following process:



ANS: -290 kJ

PAGE: 6.4

CHAPTER 6 Thermochemistry

66. The following statements concerning petroleum are all true *except*:
- It is a thick, dark liquid composed mostly of hydrocarbons.
 - It must be separated into fractions (by boiling) in order to be used efficiently.
 - Some of the commercial uses of petroleum fractions include gasoline and kerosene.
 - It was probably formed from the remains of ancient marine organisms.
 - 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
- coal.
 - natural gas.
 - diesel fuel.
 - propane.
 - gasoline.

ANS: a) coal.

PAGE: 6.5

68. The coal with the highest energy available per unit burned is
- lignite.
 - subbituminous.
 - bituminous.
 - anthracite.
 - 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*:
- It occurs only on earth.
 - The molecules H_2O and CO_2 play an important role in retaining the atmosphere's heat.
 - Low humidity allows efficient radiation of heat back into space.
 - The carbon dioxide content of the atmosphere is quite stable.
 - a and d

ANS: e) a and d

PAGE: 6.5

CHAPTER 6 Thermochemistry

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?

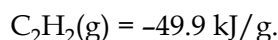
- a) ethanol
- b) methanol
- c) seed oil
- d) shale oil
- e) carbon dioxide

ANS: e) carbon dioxide

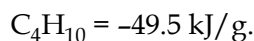
PAGE: 6.6

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



The change in enthalpy of combustion for



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

CHAPTER 6 Thermochemistry

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