

5.1 Multiple-Choice and Bimodal Questions

1) Calculate the kinetic energy in J of an electron moving at 6.00×10^6 m/s. The mass of an electron is 9.11×10^{-28} g.

- A) 4.98×10^{-48}
- B) 3.28×10^{-14}
- C) 1.64×10^{-17}
- D) 2.49×10^{-48}
- E) 6.56×10^{-14}

2) Calculate the kinetic energy in joules of an automobile weighing 2135 lb and traveling at 55 mph. (1 mile = 1.6093 km, 1lb = 453.59 g).

- A) 1.2×10^4
- B) 2.9×10^5
- C) 5.9×10^5
- D) 3.2×10^6
- E) 3.2×10^{-6}

3) The kinetic energy of a 7.3 kg steel ball traveling at 18.0 m/s is _____ J.

- A) 1.2×10^3
- B) 66
- C) 2.4×10^3
- D) 1.3×10^2
- E) 7.3

4) Calculate the kinetic energy in joules of a 150 lb jogger (68.1 kg) traveling at 12.0 mile/hr (5.36 m/s).

- A) 1.96×10^3
- B) 365
- C) 978
- D) 183
- E) 68.1

5) Calculate the kinetic energy in joules of an 80.0 g bullet traveling at 300.0 m/s.

- A) 3.60×10^6
- B) 1.20×10^4
- C) 3.60×10^3
- D) 12.0
- E) 80.0

6) The kinetic energy of a 23.2-g object moving at a speed of 81.9 m/s is _____ J.

- A) 145
- B) 0.95
- C) 77.8
- D) 77,800
- E) 1900

7) The kinetic energy of a 23.2-g object moving at a speed of 81.9 km/hr is _____ J.

- A) 1900
- B) 77.8
- C) 145
- D) 1.43×10^{-3}
- E) 6.00

8) The kinetic energy of a 23.2-g object moving at a speed of 81.9 km/hr is _____ kcal.

- A) 1.43×10^{-3}
- B) 6.00
- C) 1900
- D) 454
- E) 0.0251

9) A 100-watt electric incandescent light bulb consumes _____ J of energy in 24 hours. [1 Watt (W) = 1 J/sec]

- A) 2.40×10^3
- B) 8.64×10^3
- C) 4.17
- D) 2.10×10^3
- E) 8.64×10^6

10) The ΔE of a system that releases 12.4 J of heat and does 4.2 J of work on the surroundings is

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

_____ J.

- A) 16.6
- B) 12.4
- C) 4.2
- D) -16.6
- E) -8.2

11) The value of ΔE for a system that performs 213 kJ of work on its surroundings and loses 79 kJ of heat is _____ kJ.

- A) +292
- B) -292
- C) +134
- D) -134
- E) -213

12) Calculate the value of ΔE in joules for a system that loses 50 J of heat and has 150 J of work performed on it by the surroundings.

- A) 50
- B) 100
- C) -100
- D) -200
- E) +200

13) The change in the internal energy of a system that absorbs 2,500 J of heat and that does 7,655 J of work on the surroundings is _____ J.

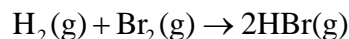
- A) 10,155
- B) 5,155
- C) -5,155
- D) -10,155
- E) 1.91×10^7

14) The change in the internal energy of a system that releases 2,500 J of heat and that does 7,655 J of work on the surroundings is _____ J.

- A) -10,155
- B) -5,155
- C) -1.91×10^7

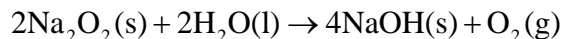
- D) 10,155
- E) 5,155

15) The value of ΔH° for the reaction below is -72 kJ. _____ kJ of heat are released when 1.0 mol of HBr is formed in this reaction.



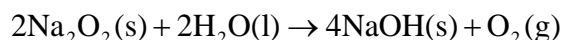
- A) 144
- B) 72
- C) 0.44
- D) 36
- E) -72

16) The value of ΔH° for the reaction below is -126 kJ. _____ kJ are released when 2.00 mol of NaOH is formed in the reaction?



- A) 252
- B) 63
- C) 3.9
- D) 7.8
- E) -126

17) The value of ΔH° for the reaction below is -126 kJ. The amount of heat that is released by the reaction of 25.0 g of Na_2O_2 with water is _____ kJ.



- A) 20.2
- B) 40.4
- C) 67.5
- D) 80.8
- E) -126

18) The value of ΔH° for the reaction below is -790 kJ. The enthalpy change accompanying the reaction of 0.95 g of S is _____ kJ.

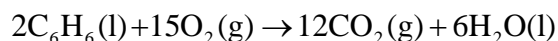


- A) 23
- B) -23

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

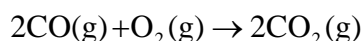
- C) -12
D) 12
E) -790

19) The value of ΔH° for the reaction below is -6535 kJ. _____ kJ of heat are released in the combustion of 16.0 g of $C_6H_6(l)$?



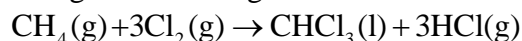
- A) 1.34×10^3
B) 5.23×10^4
C) 669
D) 2.68×10^3
E) -6535

20) The value of ΔH° for the reaction below is -482 kJ. Calculate the heat (kJ) released to the surroundings when 12.0 g of CO (g) reacts completely.



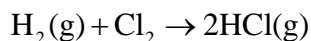
- A) 2.89×10^3
B) 207
C) 103
D) 65.7
E) -482

21) The value of ΔH° for the reaction below is -336 kJ. Calculate the heat (kJ) released to the surroundings when 23.0 g of HCl is formed.



- A) 177
B) 2.57×10^3
C) 70.7
D) 211
E) -336

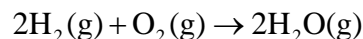
22) The value of ΔH° for the reaction below is -186 kJ. Calculate the heat (kJ) released from the reaction of 25 g of Cl_2 .



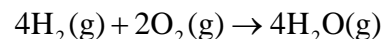
- A) 66
B) 5.3×10^2

- C) 33
D) 47
E) -186

23) The enthalpy change for the following reaction is -483.6 kJ:



Therefore, the enthalpy change for the following reaction is _____ kJ:



- A) -483.6
B) -967.2
C) 2.34×10^5
D) 483.6
E) 967.2

24) The value of ΔH° for the reaction below is +128.1 kJ:



How many kJ of heat are consumed when 15.5 g of $CH_3OH(l)$ decomposes as shown in the equation?

- A) 0.48
B) 62.0
C) 1.3×10^2
D) 32
E) 8.3

25) The value of ΔH° for the reaction below is +128.1 kJ:



How many kJ of heat are consumed when 5.10 g of $H_2(g)$ is formed as shown in the equation?

- A) 162
B) 62.0
C) 128
D) 653
E) 326

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

26) The value of ΔH° for the reaction below is +128.1 kJ:



How many kJ of heat are consumed when 5.10 g of CO(g) is formed as shown in the equation?

- A) 0.182
- B) 162
- C) 8.31
- D) 23.3
- E) 62.0

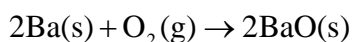
27) The value of ΔH° for the reaction below is +128.1 kJ:



How many kJ of heat are consumed when 5.75 g of CO(g) is formed as shown in the equation?

- A) 23.3
- B) 62.0
- C) 26.3
- D) 162
- E) 8.3

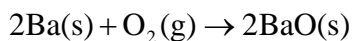
28) The value of ΔH° for the reaction below is -1107 kJ:



How many kJ of heat are released when 5.75 g of Ba(s) reacts completely with oxygen to form BaO(s)?

- A) 96.3
- B) 26.3
- C) 46.4
- D) 23.2
- E) 193

29) The value of ΔH° for the reaction below is -1107 kJ:

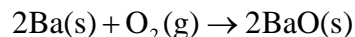


How many kJ of heat are released when 5.75 g of

BaO(s) is produced?

- A) 56.9
- B) 23.2
- C) 20.8
- D) 193
- E) 96.3

30) The value of ΔH° for the reaction below is -1107 kJ:



How many kJ of heat are released when 15.75 g of Ba(s) reacts completely with oxygen to form BaO(s)?

- A) 20.8
- B) 63.5
- C) 114
- D) 70.3
- E) 35.1

31) The molar heat capacity of a compound with the formula $\text{C}_2\text{H}_6\text{SO}$ is 88.0 J/mol-K. The specific heat of this substance is _____ J/g-K.

- A) 88.0
- B) 1.13
- C) 4.89
- D) 6.88×10^3
- E) -88.0

32) A sample of aluminum metal absorbs 9.86 J of heat, upon which the temperature of the sample increases from 23.2 °C to 30.5 °C. Since the specific heat capacity of aluminum is 0.90 J/g-K, the mass of the sample is _____ g.

- A) 72
- B) 1.5
- C) 65
- D) 8.1
- E) 6.6

33) The specific heat capacity of lead is 0.13 J/g-K. How much heat (in J) is required to raise the temperature of 15g of lead from 22 °C to 37 °C?

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

- A) 2.0
- B) -0.13
- C) 5.8×10^{-4}
- D) 29
- E) 0.13

34) The temperature of a 15-g sample of lead metal increases from 22 °C to 37 °C upon the addition of 29.0 J of heat. The specific heat capacity of the lead is _____ J/g-K.

- A) 7.8
- B) 1.9
- C) 29
- D) 0.13
- E) -29

35) The specific heat of bromine liquid is 0.226 J/g · K. The molar heat capacity (in J/mol-K) of bromine liquid is _____.

- A) 707
- B) 36.1
- C) 18.1
- D) 9.05
- E) 0.226

36) The specific heat of liquid bromine is 0.226 J/g-K. How much heat (J) is required to raise the temperature of 10.0 mL of bromine from 25.00 °C to 27.30 °C? The density of liquid bromine: 3.12 g/mL.

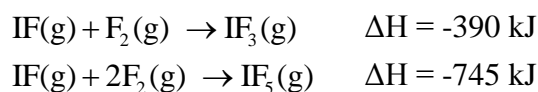
- A) 5.20
- B) 16.2
- C) 300
- D) 32.4
- E) 10.4

37) The ΔH for the solution process when solid sodium hydroxide dissolves in water is 44.4 kJ/mol. When a 13.9-g sample of NaOH dissolves in 250.0 g of water in a coffee-cup calorimeter, the temperature increases from 23.0 °C to _____ °C. Assume that the solution has the same specific heat as liquid water, i.e., 4.18 J/g-K.

- A) 35.2 °C
- B) 24.0 °C
- C) 37.8 °C
- D) 37.0 °C
- E) 40.2 °C

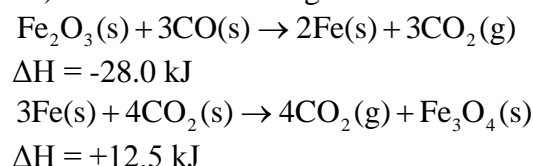
38) ΔH for the reaction

$\text{IF}_5(\text{g}) \rightarrow \text{IF}_3(\text{g}) + \text{F}_2(\text{g})$
is _____ kJ, give the data below.



- A) +355
- B) -1135
- C) +1135
- D) +35
- E) -35

39) Given the following reactions

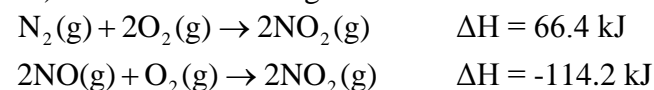


the enthalpy of the reaction of Fe_2O_3 with CO

$3\text{Fe}_2\text{O}_3(\text{s}) + \text{CO}(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{Fe}_3\text{O}_4(\text{s})$
is _____ kJ.

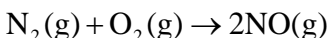
- A) -59.0
- B) 40.5
- C) -15.5
- D) -109
- E) +109

40) Given the following reactions



the enthalpy of the reaction of the nitrogen to produce nitric oxide

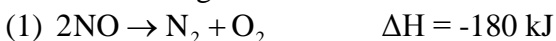
Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry



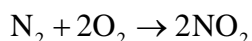
is _____ kJ.

- A) 180.6
- B) -47.8
- C) 47.8
- D) 90.3
- E) -180.6

41) Given the following reactions



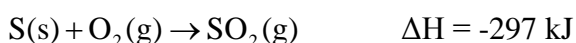
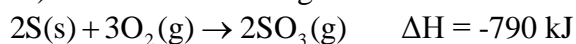
the enthalpy of the reaction of nitrogen with oxygen to produce nitrogen dioxide



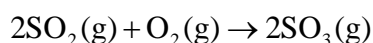
is _____ kJ.

- A) 68
- B) -68
- C) -292
- D) 292
- E) -146

42) Given the following reactions:



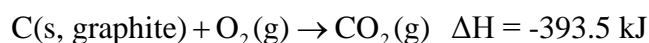
the enthalpy of the reaction in which sulfur dioxide is oxidized to sulfur trioxide



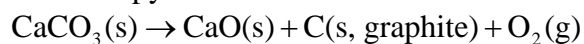
is _____ kJ.

- A) 196
- B) -196
- C) 1087
- D) -1384
- E) -543

43) Given the following reactions



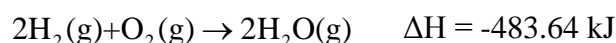
the enthalpy of the reaction



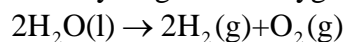
is _____ kJ.

- A) 215.4
- B) 571.6
- C) -215.4
- D) -571.6
- E) 7.01×10^4

44) Given the following reactions



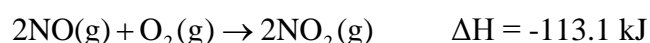
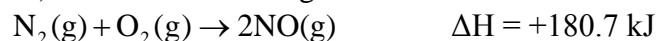
the enthalpy for the decomposition of liquid water into gaseous hydrogen and oxygen



is _____ kJ.

- A) -395.62
- B) -527.65
- C) 439.63
- D) 571.66
- E) 527.65

45) Given the following reactions



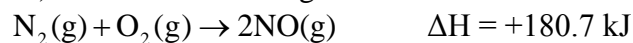
the enthalpy for the decomposition of nitrogen dioxide into molecular nitrogen and oxygen



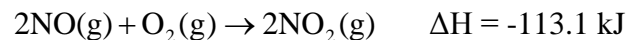
is _____ kJ.

- A) 67.6
- B) -67.6
- C) 293.8
- D) -293.8
- E) 45.5

46) Given the following reactions



Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry



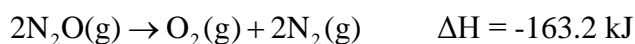
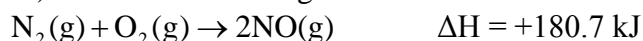
the enthalpy of reaction for



is _____ kJ.

- A) 67.6
- B) 45.5
- C) -293.8
- D) -45.5
- E) 293.8

47) Given the following reactions



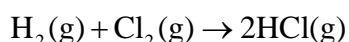
the enthalpy of reaction for



is _____ kJ.

- A) 145.7
- B) 343.9
- C) -343.9
- D) 17.5
- E) -145.7

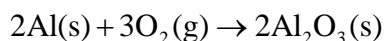
48) The value of ΔH° for the reaction below is -186 kJ.



The value of ΔH_f° for HCl (g) is _____ kJ/mol.

- A) -3.72×10^2
- B) -1.27×10^2
- C) -93.0
- D) -186
- E) +186

49) The value of ΔH° for the following reaction is -3351 kJ:

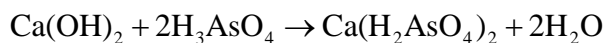


The value of ΔH_f° for $\text{Al}_2\text{O}_3\text{(s)}$ is _____ kJ.

- A) -3351
- B) -1676

- C) -32.86
- D) -16.43
- E) +3351

50) Given the data in the table below, $\Delta H^\circ_{\text{rxn}}$ for the reaction

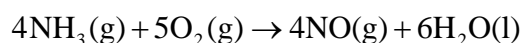


is _____ kJ.

Substance	ΔH_f° (kJ/mol)
Ca(OH)_2	-986.6
H_3AsO_4	-900.4
$\text{Ca(H}_2\text{AsO}_4)_2$	-2346.0
H_2O	-285.9

- A) -744.9
- B) -4519
- C) -4219
- D) -130.4
- E) -76.4

51) Given the data in the table below, $\Delta H^\circ_{\text{rxn}}$ for the reaction



is _____ kJ.

Substance	ΔH_f° (kJ/mol)
$\text{H}_2\text{O (l)}$	-286
NO (g)	90
$\text{NO}_2\text{(g)}$	34
$\text{HNO}_3\text{(aq)}$	-207
$\text{NH}_3\text{(g)}$	-46

- A) -1172
- B) -150
- C) -1540
- D) -1892
- E) The ΔH_f° of $\text{O}_2\text{(g)}$ is needed for the calculation.

52) Given the data in the table below, $\Delta H^\circ_{\text{rxn}}$ for the reaction

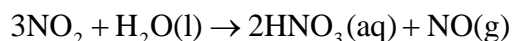
Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

$\text{C}_2\text{H}_5\text{OH}(\text{l}) + \text{O}_2(\text{g}) \rightarrow \text{CH}_3\text{CO}_2\text{H}(\text{l}) + \text{H}_2\text{O}(\text{l})$
is _____ kJ.

Substance	ΔH_f° (kJ/mol)
$\text{C}_2\text{H}_4(\text{g})$	52.3
$\text{C}_2\text{H}_5\text{OH}(\text{l})$	-277.7
$\text{CH}_3\text{CO}_2\text{H}(\text{l})$	-484.5
$\text{H}_2\text{O}(\text{l})$	-285.8

- A) -79.0
B) -1048.0
C) -476.4
D) -492.6
E) The value of ΔH_f° of $\text{O}_2(\text{g})$ is required for the calculation.

53) Given the data in the table below, $\Delta H^\circ_{\text{rxn}}$ for the reaction

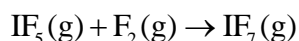


is _____ kJ.

Substance	ΔH_f° (kJ/mol)
$\text{H}_2\text{O}(\text{l})$	-286
$\text{NO}(\text{g})$	90
$\text{NO}_2(\text{g})$	34
$\text{HNO}_3(\text{aq})$	-207
$\text{NH}_3(\text{g})$	-46

- A) 64
B) 140
C) -140
D) -508
E) -64

54) Given the data in the table below, $\Delta H^\circ_{\text{rxn}}$ for the reaction

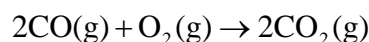


is _____ kJ.

Substance	ΔH_f° (kJ/mol)
$\text{IF}(\text{g})$	-95
$\text{IF}_5(\text{g})$	-840
$\text{IF}_7(\text{g})$	-941

- A) 1801
B) -1801
C) 121
D) -121
E) -101

55) Given the data in the table below, ΔH° for the reaction



is _____ kJ.

Substance	ΔH_f° (kJ/mol)
$\text{CO}(\text{g})$	-110.5
$\text{CO}_2(\text{g})$	-393.7
$\text{CaCO}_3(\text{s})$	-1207.0

- A) -566.4
B) -283.2
C) 283.2
D) -677.0
E) The ΔH_f° of $\text{O}_2(\text{g})$ is needed for the calculation.

56) The value of ΔH° for the following reaction is 177.8 kJ. The value of ΔH_f° for $\text{CaO}(\text{s})$ is _____ kJ/mol.

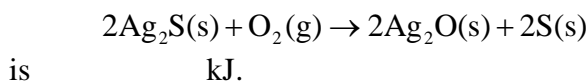


Substance	ΔH_f° (kJ/mol)
$\text{CO}(\text{g})$	-110.5
$\text{CO}_2(\text{g})$	-393.7
$\text{CaCO}_3(\text{s})$	-1207.0

- A) -1600
B) -813.4
C) -635.5
D) 813.4
E) 177.8

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

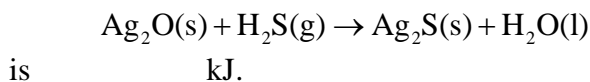
57) Given the data in the table below, $\Delta H^\circ_{\text{rxn}}$ for the reaction



Substance	ΔH_f° (kJ/mol)
$\text{Ag}_2\text{O (s)}$	-31.0
$\text{Ag}_2\text{S (s)}$	-32.6
$\text{H}_2\text{S (g)}$	-20.6
$\text{H}_2\text{O (l)}$	-286

- A) -1.6
B) +1.6
C) -3.2
D) +3.2
E) The ΔH_f° of S(s) and of $\text{O}_2\text{(g)}$ are needed for the calculation.

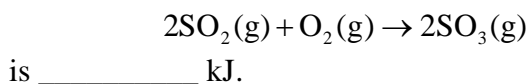
58) Given the data in the table below, $\Delta H^\circ_{\text{rxn}}$ for the reaction



Substance	ΔH_f° (kJ/mol)
$\text{Ag}_2\text{O (s)}$	-31.0
$\text{Ag}_2\text{S (s)}$	-32.6
$\text{H}_2\text{S (g)}$	-20.6
$\text{H}_2\text{O (l)}$	-286

- A) -267
B) -370
C) -202
D) -308
E) More data are needed to complete the calculation.

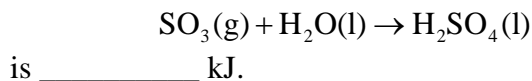
59) Given the data in the table below $\Delta H^\circ_{\text{rxn}}$ for the reaction



Substance	ΔH_f° (kJ/mol)
$\text{SO}_2\text{ (g)}$	-297
$\text{SO}_3\text{ (g)}$	-396
$\text{SO}_2\text{Cl}_2\text{ (g)}$	-364
$\text{H}_2\text{SO}_4\text{ (l)}$	-814
$\text{H}_2\text{O (l)}$	-286

- A) -99
B) 99
C) -198
D) 198
E) The ΔH_f° of $\text{O}_2\text{(g)}$ is needed for the calculation.

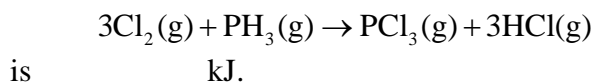
60) Given the data in the table below $\Delta H^\circ_{\text{rxn}}$ for the reaction



Substance	ΔH_f° (kJ/mol)
$\text{SO}_2\text{ (g)}$	-297
$\text{SO}_3\text{ (g)}$	-396
$\text{SO}_2\text{Cl}_2\text{ (g)}$	-364
$\text{H}_2\text{SO}_4\text{ (l)}$	-814
$\text{H}_2\text{O (l)}$	-286

- A) -132
B) 1496
C) 704
D) -704
E) -2.16×10^3

61) Given the data in the table below, $\Delta H^\circ_{\text{rxn}}$ for the reaction



Compound	ΔH_f° (kJ/mol)
$\text{PCl}_3\text{ (g)}$	-288.07
HCl (g)	-92.30
$\text{PH}_3\text{ (g)}$	5.40

- A) -385.77
B) -570.37

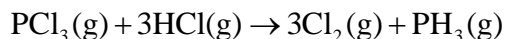
Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

C) 570.37

D) 385.77

E) The ΔH_f° of $\text{Cl}_2(\text{g})$ is needed for the calculation.

62) Given the data in the table below, $\Delta H_{\text{rxn}}^\circ$ for the reaction



is _____ kJ.

Compound	ΔH_f° (kJ/mol)
$\text{PCl}_3(\text{g})$	-288.07
$\text{HCl}(\text{g})$	-92.30
$\text{PH}_3(\text{g})$	5.40

A) -570.37

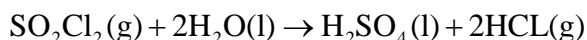
B) -385.77

C) 570.37

D) 385.77

E) The ΔH_f° of $\text{Cl}_2(\text{g})$ is needed for the calculation.

63) Given the data in the table below and $\Delta H_{\text{rxn}}^\circ$ for the reaction



$$\Delta H^\circ = -62 \text{ kJ}$$

ΔH_f° of $\text{HCl}(\text{g})$ is _____ kJ/mol.

Substance	ΔH_f° (kJ/mol)
$\text{SO}_2(\text{g})$	-297
$\text{SO}_3(\text{g})$	-396
$\text{SO}_2\text{Cl}_2(\text{g})$	-364
$\text{H}_2\text{SO}_4(\text{l})$	-814
$\text{H}_2\text{O}(\text{l})$	-286

A) -184

B) 60

C) -92

D) 30

E) Insufficient data are given.

64) A 5-ounce cup of raspberry yogurt contains 6.0 g of protein, 2.0 g of fat, and 26.9 g of carbohydrate. The fuel values for protein, fat, and carbohydrate are

17, 38, and 17 kJ/g, respectively. The fuel value of this cup of yogurt is _____ kJ.

A) 640

B) 830

C) 600

D) 720

E) 72

65) A 25.5-g piece of cheddar cheese contains 37% fat, 28% protein, and 4% carbohydrate. The respective fuel values for protein, fat, and carbohydrate are 17, 38, and 17 kJ/g, respectively. The fuel value for this piece of cheese is _____ kJ.

A) 450

B) 330

C) 790

D) 99

E) 260

66) The average fuel value of sugars is 17 kJ/g. A 2.0 L pitcher of sweetened Kool-Aid contains 400 g of sugar. What is the fuel value (in kJ) of a 500 mL serving of Kool-Aid? (Assume that the sugar is the only fuel source.)

A) 4.2×10^4

B) 1.7×10^3

C) 1.7×10^6

D) 1.7×10^2

E) 17

5.2 Multiple Choice Questions

1) At what velocity (m/s) must a 20.0 g object be moving in order to possess a kinetic energy of 1.00 J?

A) 1.00

B) 100×10^2

C) 10.0

D) 1.00×10^3

E) 50.0

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

2) Objects can possess energy as _____.

- (a) endothermic energy
- (b) potential energy
- (c) kinetic energy

- A) a only
- B) b only
- C) c only
- D) a and c
- E) b and c

3) The internal energy of a system is always increased by _____.

- A) adding heat to the system
- B) having the system do work on the surroundings
- C) withdrawing heat from the system
- D) adding heat to the system and having the system do work on the surroundings
- E) a volume compression

4) The internal energy of a system _____.

- A) is the sum of the kinetic energy of all of its components
- B) is the sum of the rotational, vibrational, and translational energies of all of its components
- C) refers only to the energies of the nuclei of the atoms of the component molecules
- D) is the sum of the potential and kinetic energies of the components
- E) none of the above

5) Which one of the following conditions would always result in an increase in the internal energy of a system?

- A) The system loses heat and does work on the surroundings.
- B) The system gains heat and does work on the surroundings.
- C) The system loses heat and has work done on it by the surroundings.
- D) The system gains heat and has work done on it by the surroundings.

E) None of the above is correct.

6) The value of ΔE for a system that performs 111 kJ of work on its surroundings and gains 89 kJ of heat is _____ kJ.

- A) -111
- B) -200
- C) 200
- D) -22
- E) 22

7) The value of ΔE for a system that performs 13 kJ of work on its surroundings and loses 9 kJ of heat is _____ kJ.

- A) 22
- B) -22
- C) -4
- D) 4
- E) -13

8) When a system _____, ΔE is always negative.

- A) absorbs heat and does work
- B) gives off heat and does work
- C) absorbs heat and has work done on it
- D) gives off heat and has work done on it
- E) none of the above is always negative.

9) Which one of the following is an endothermic process?

- A) ice melting
- B) water freezing
- C) boiling soup
- D) Hydrochloric acid and barium hydroxide are mixed at 25 °C: the temperature increases.
- E) Both A and C

10) Which one of the following is an exothermic process?

- A) ice melting
- B) water evaporating

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

- C) boiling soup
D) condensation of water vapor
E) Ammonium thiocyanate and barium hydroxide are mixed at 25 °C: the temperature drops.

11) Of the following, which one is a state function?

- A) H
B) q
C) w
D) heat
E) none of the above

12) Which of the following is a statement of the first law of thermodynamics?

- A) $E_k = \frac{1}{2}mv^2$
B) A negative ΔH corresponds to an exothermic process.
C) $\Delta E = E_{\text{final}} - E_{\text{initial}}$
D) Energy lost by the system must be gained by the surroundings.
E) 1 cal = 4.184 J (exactly)

13) The internal energy can be increased by _____.

- (a) transferring heat from the surroundings to the system
(b) transferring heat from the system to the surroundings
(c) doing work on the system

- A) a only
B) b only
C) c only
D) a and c
E) b and c

14) A _____ ΔH corresponds to an _____ process.

- A) negative, endothermic
B) negative, exothermic
C) positive, exothermic

- D) zero, exothermic
E) zero, endothermic

15) A _____ ΔH corresponds to an _____ process.

- A) negative, endothermic
B) positive, exothermic
C) positive, endothermic
D) zero, exothermic
E) zero, endothermic

16) ΔH for an endothermic process is _____ while ΔH for an exothermic process is _____.

- A) zero, positive
B) zero, negative
C) positive, zero
D) negative, positive
E) positive, negative

17) For a given process at constant pressure, ΔH is negative. This means that the process is _____.

- A) endothermic
B) equithermic
C) exothermic
D) a state function
E) energy

18) Which one of the following statements is true?

- A) Enthalpy is an intensive property.
B) The enthalpy change for a reaction is independent of the state of the reactants and products.
C) Enthalpy is a state function.
D) H is the value of q measured under conditions of constant volume.
E) The enthalpy change of a reaction is the reciprocal of the ΔH of the reverse reaction.

19) Which of the following statements is false?

- A) Internal energy is a state function.
B) Enthalpy is an intensive property.

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

- C) The enthalpy change for a reaction is equal in magnitude, but opposite in sign, to the enthalpy change for the reverse reaction.
D) The enthalpy change for a reaction depends on the state of the reactants and products.
E) The enthalpy of a reaction is equal to the heat of the reaction.

20) A chemical reaction that absorbs heat from the surroundings is said to be _____ and has a _____ ΔH at constant pressure.

- A) endothermic, positive
B) endothermic, negative
C) exothermic, negative
D) exothermic, positive
E) exothermic, neutral

21) The reaction

$4\text{Al(s)} + 3\text{O}_2\text{(g)} \rightarrow 2\text{Al}_2\text{O}_3\text{(s)}$ $\Delta H^\circ = -3351 \text{ kJ}$
is _____, and therefore heat is _____ by the reaction.

- A) endothermic, released
B) endothermic, absorbed
C) exothermic, released
D) exothermic, absorbed
E) thermoneutral, neither released nor absorbed

22) Under what condition(s) is the enthalpy change of a process equal to the amount of heat transferred into or out of the system?

- (a) temperature is constant
(b) pressure is constant
(c) volume is constant

- A) a only
B) b only
C) c only
D) a and b
E) b and c

23) The units of heat capacity are _____.

- A) K/J or $^\circ\text{C/J}$
B) J/K or J/ $^\circ\text{C}$

- C) J/g-K or J/g- $^\circ\text{C}$
D) J/mol
E) g-K/J or g- $^\circ\text{C/J}$

24) The units of specific heat are _____.

- A) K/J or $^\circ\text{C/J}$
B) J/K or J/ $^\circ\text{C}$
C) J/g-K or J/g- $^\circ\text{C}$
D) J/mol
E) g-K/J or g- $^\circ\text{C/J}$

25) The British thermal unit (Btu) is commonly used in engineering applications. A Btu is defined as the amount of heat required to raise the temperature of 1 lb of water by 1 $^\circ\text{F}$. There are _____ joules in one Btu. 1 lb = 453.59 g; $^\circ\text{C} = (5/9)(^\circ\text{F} - 32^\circ)$; specific heat of $\text{H}_2\text{O(l)} = 4.184 \text{ J/g-K}$.

- A) 3415
B) 60.29
C) 1054
D) 5.120×10^{-3}
E) Additional information is needed to complete the calculation.

26) A sample of calcium carbonate [$\text{CaCO}_3\text{(s)}$] absorbs 45.5 J of heat, upon which the temperature of the sample increases from 21.1 $^\circ\text{C}$ to 28.5 $^\circ\text{C}$. If the specific heat of calcium carbonate is 0.82 J/g-K, what is the mass (in grams) of the sample?

- A) 3.7
B) 5.0
C) 7.5
D) 410
E) 5.0×10^3

27) An 8.29 g sample of calcium carbonate [$\text{CaCO}_3\text{(s)}$] absorbs 50.3 J of heat, upon which the temperature of the sample increases from 21.1 $^\circ\text{C}$ to 28.5 $^\circ\text{C}$. What is the specific heat of calcium carbonate?

- A) .63

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

- B) .82
C) 1.1
D) 2.2
E) 4.2

28) A sample of iron absorbs 67.5 J of heat, upon which the temperature of the sample increases from 21.5 °C to 28.5 °C. If the specific heat of iron is 0.450 J/g-K, what is the mass (in grams) of the sample?

- A) 4.3
B) 11
C) 21
D) 1100
E) 1.1×10^3

29) A 22.44 g sample of iron absorbs 180.8 J of heat, upon which the temperature of the sample increases from 21.1 °C to 39.0 °C. What is the specific heat of iron?

- A) 0.140
B) 0.450
C) 0.820
D) 0.840
E) 0.900

30) Which of the following is a statement of Hess's law?

- A) If a reaction is carried out in a series of steps, the ΔH for the reaction will equal the sum of the enthalpy changes for the individual steps.
B) If a reaction is carried out in a series of steps, the ΔH for the reaction will equal the product of the enthalpy changes for the individual steps.
C) The ΔH for a process in the forward direction is equal in magnitude and opposite in sign to the ΔH for the process in the reverse direction.
D) The ΔH for a process in the forward direction is equal to the ΔH for the process in the reverse direction.
E) The ΔH of a reaction depends on the physical states of the reactants and products.

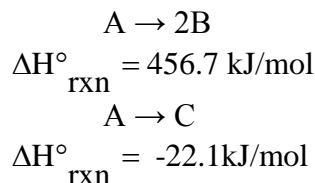
31) For which one of the following reactions is $\Delta H^\circ_{\text{rxn}}$ equal to the heat of formation of the product?

- A) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
B) $(1/2)\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{NO}_2(\text{g})$
C) $6\text{C}(\text{s}) + 6\text{H}(\text{g}) \rightarrow \text{C}_6\text{H}_6(\text{l})$
D) $\text{P}(\text{g}) + 4\text{H}(\text{g}) + \text{Br}(\text{g}) \rightarrow \text{PH}_4\text{Br}(\text{l})$
E) $12\text{C}(\text{g}) + 11\text{H}_2(\text{g}) + 11\text{O}(\text{g}) \rightarrow \text{C}_6\text{H}_{22}\text{O}_{11}(\text{g})$

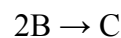
32) Of the following, ΔH_f° is not zero for _____.

- A) $\text{O}_2(\text{g})$
B) C (graphite)
C) $\text{N}_2(\text{g})$
D) $\text{F}_2(\text{s})$
E) $\text{Cl}_2(\text{g})$

33) Consider the following two reactions:

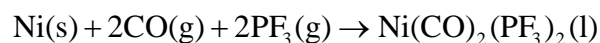


Determine the enthalpy change for the process:



- A) -478.8 kJ/mol
B) -434.6 kJ/mol
C) 434.6 kJ/mol
D) 478.8 kJ/mol
E) More information is needed to solve the problem.

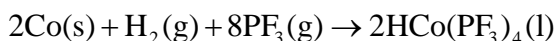
34) In the reaction below, ΔH_f° is zero for _____.



Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

- A) Ni(s)
- B) CO(g)
- C) PF₃(g)
- D) Ni(CO)₂(PF₃)₂(l)
- E) both CO(s) and PF₃(g)

35) For the species in the reaction below, ΔH_f° is zero for _____.



- A) Co(s)
- B) H₂(g)
- C) PF₃(g)
- D) HCo(PF₃)₄(l)
- E) both CO(s) and H₂(g)

36) For which one of the following equations is $\Delta H_{\text{rxn}}^\circ$ equal to ΔH_f° for the product?

- A) Xe(g) + 2F₂(g) → XeF₄(g)
- B) CH₄(g) + 2Cl₂(g) → CH₂Cl₂(l) + 2HCl(g)
- C) N₂(g) + O₃(g) → N₂O₃(g)
- D) 2CO(g) + O₂(g) → 2CO₂(g)
- E) C (diamond) + O₂(g) → CO₂(g)

37) For which one of the following reactions is the value of $\Delta H_{\text{rxn}}^\circ$ equal to ΔH_f° for the product?

- A) 2Ca(s) + O₂(g) → 2CaO(s)
- B) C₂H₂(g) + H₂(g) → C₂H₄(g)
- C) 2C (graphite) + O₂(g) → 2CO(g)
- D) 3Mg(s) + N₂(g) → Mg₃N₂(s)
- E) C (diamond) + O₂(g) → CO₂(g)

38) For which one of the following reactions is the value of $\Delta H_{\text{rxn}}^\circ$ equal to ΔH_f° for the product?

- A) 2C (s, graphite) + 2H₂(g) → C₂H₄(g)
- B) N₂(g) + O₂(g) → 2NO(g)
- C) 2H₂(g) + O₂(g) → 2H₂O(l)
- D) 2H₂(g) + O₂(g) → 2H₂O(g)
- E) H₂O(l) + 1/2 O₂(g) → H₂O₂(l)

39) For which one of the following reactions is the value of $\Delta H_{\text{rxn}}^\circ$ equal to ΔH_f° for the product?

- A) H₂O(l) + 1/2 O₂(g) → H₂O₂(l)
- B) N₂(g) + O₂(g) → 2NO(g)
- C) 2H₂(g) + O₂(g) → 2H₂O(l)
- D) 2H₂(g) + O₂(g) → 2H₂O(g)
- E) none of the above

40) For which one of the following reactions is the value of $\Delta H_{\text{rxn}}^\circ$ equal to ΔH_f° for the product?

- A) H₂(g) + 1/2 O₂(g) → H₂O(l)
- B) H₂(g) + O₂(g) → H₂O₂(l)
- C) 2C (s, graphite) + 2H₂(g) → C₂H₄(g)
- D) 1/2 N₂(g) + O₂(g) → NO₂(g)
- E) all of the above

41) With reference to enthalpy changes, the term standard conditions means _____.

- (a) P = 1 atm
- (b) some common temperature, usually 298 K
- (c) V = 1 L

- A) a only
- B) b only
- C) c only
- D) a and c
- E) a and b

42) The energy released by combustion of 1 g of a substance is called the _____ of the substance.

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

- A) specific heat
- B) fuel value
- C) nutritional calorie content
- D) heat capacity
- E) enthalpy

43) Fuel values of hydrocarbons increase as the H/C atomic ratio increases. Which of the following compounds has the highest fuel value?

- A) C_2H_6
- B) C_2H_4
- C) C_2H_2
- D) CH_4
- E) C_6H_6

44) Of the substances below, the highest fuel value is obtained from _____.

- A) charcoal
- B) bituminous coal
- C) natural gas
- D) hydrogen
- E) wood

45) Which one of the choices below is not considered a fossil fuel?

- A) anthracite coal
- B) crude oil
- C) natural gas
- D) hydrogen
- E) petroleum

46) The most abundant fossil fuel is _____.

- A) natural gas
- B) petroleum
- C) coal
- D) uranium
- E) hydrogen

5.3 Short Answer Questions

1) _____ is defined as the energy used to move

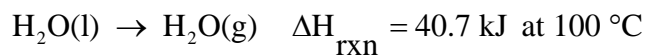
an object against a force.

2) Given the equation



Calculate the mass of liquid water (in grams) at 100°C that can be converted to vapor by absorbing 2.400 kJ of heat.

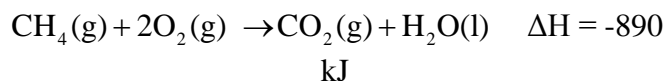
3) Given the equation



Calculate the heat required to convert 3.00 grams of liquid water at 100°C to vapor.

4) When 0.800 grams of NaOH is dissolved in 100.0 grams of water, the temperature of the solution increases from 25.00°C to 27.06°C . The amount of heat absorbed by the water is _____ J. (The specific heat of water is $4.18 \text{ J/g}\cdot^\circ\text{C}$.)

5) Given the equation:



The heat liberated when 34.78 grams of methane (CH_4) are burned in an excess amount of oxygen is _____ kJ.

6) The standard enthalpy change of a reaction is the enthalpy change when all reactants and products are at _____ pressure and a specific temperature.

7) Syngas is produced by treating _____ with superheated steam.

8) Coal contains hydrocarbons of high molecular weight as well as compounds containing _____, oxygen, or nitrogen.

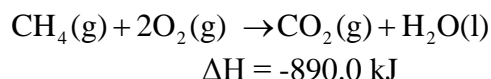
5.4 True/False Questions

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

- 1) Work equals force times distance.
- 2) One joule equals $1 \text{ kg} \cdot \text{m}^2/\text{s}^2$.
- 3) Units of energy include newtons, joules, and calories.
- 4) The primary component of natural gas is propane.
- 5) Renewable energy sources are essentially inexhaustible.
- 6) Petroleum is a liquid composed of hundreds of compounds.

5.5 Algorithmic Questions

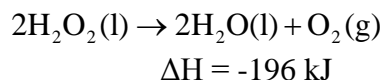
- 1) In the presence of excess oxygen, methane gas burns in a constant-pressure system to yield carbon dioxide and water:



Calculate the value of q (kJ) in this exothermic reaction when 1.70 g of methane is combusted at constant pressure.

- A) -94.6
- B) 0.0306
- C) -0.0106
- D) 32.7
- E) -9.46×10^4

- 2) Hydrogen peroxide decomposes to water and oxygen at constant pressure by the following reaction:

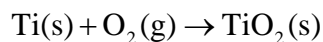


Calculate the value of q (kJ) in this exothermic reaction when 4.00 g of hydrogen peroxide decomposes at constant pressure?

- A) -23.1

- B) -11.5
- C) -0.0217
- D) 1.44
- E) -2.31×10^4

- 3) The combustion of titanium with oxygen produces titanium dioxide:



When 2.060 g of titanium is combusted in a bomb calorimeter, the temperature of the calorimeter increases from 25.00°C to 91.60°C . In a separate experiment, the heat capacity of the calorimeter is measured to be 9.84 kJ/K. The heat of reaction for the combustion of a mole of Ti in this calorimeter is _____ kJ/mol.

- A) 14.3
- B) 19.6
- C) -311
- D) -0.154
- E) -1.52×10^4

- 4) The specific heat capacity of liquid water is 4.18 J/g-K. How many joules of heat are needed to raise the temperature of 5.00 g of water from 25.1°C to 65.3°C ?

- A) 48.1
- B) 840
- C) 1.89×10^3
- D) 2.80×10^{-2}
- E) 54.4

- 5) The specific heat capacity of methane gas is 2.20 J/g-K. How many joules of heat are needed to raise the temperature of 5.00 g of methane from 36.0°C to 75.0°C ?

- A) 88.6
- B) 429
- C) 1221
- D) 0.0113
- E) 22.9

Chemistry, 11e (Brown/LeMay/Bursten/Murphy)
Chapter 5: Thermochemistry

6) The specific heat capacity of liquid mercury is $0.14 \text{ J/g}\cdot\text{K}$. How many joules of heat are needed to raise the temperature of 5.00 g of mercury from 15.0°C to 36.5°C ?

- A) 7.7×10^2
- B) 15
- C) 36
- D) 0.0013
- E) 1.7

7) The specific heat capacity of solid copper metal is $0.385 \text{ J/g}\cdot\text{K}$. How many joules of heat are needed to raise the temperature of a 1.55-kg block of copper from 33.0°C to 77.5°C ?

- A) 1.79×10^5
- B) 26.6
- C) 2.66×10^4
- D) 5.58×10^{-6}
- E) 0.00558

8) A 5.00-g sample of liquid water at 25.0°C is heated by the addition of 84.0 J of energy. The final temperature of the water is _____ $^\circ\text{C}$. The specific heat capacity of liquid water is $4.18 \text{ J/g}\cdot\text{K}$

- A) 95.2
- B) 25.2
- C) -21.0
- D) 29.0
- E) 4.02

9) A 50.0-g sample of liquid water at 25.0°C is mixed with 29.0 g of water at 45.0°C . The final temperature of the water is _____.

- A) 102
- B) 27.6
- C) 35.0
- D) 142
- E) 32.3

10) A 6.50-g sample of copper metal at 25.0°C is heated by the addition of 84.0 J of energy. The final temperature of the copper is _____ $^\circ\text{C}$. The

specific heat capacity of copper is $0.38 \text{ J/g}\cdot\text{K}$

- A) 29.9
- B) 25.0
- C) 9.0
- D) 59.0
- E) 34.0

11) What is the enthalpy change (in kJ) of a chemical reaction that raises the temperature of 250.0 ml of solution having a density of 1.25 g/ml by 7.80°C ? (The specific heat of the solution is $3.74 \text{ joules/gram}\cdot\text{K}$.)

- A) -7.43
- B) -12.51
- C) 8.20
- D) -9.12
- E) 6.51