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

_____ 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.

$$H_2(g) + Br_2(g) \rightarrow 2HBr(g)$$

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?

$$2Na_2O_2(s) + 2H_2O(l) \rightarrow 4NaOH(s) + O_2(g)$$

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.

$$2Na_2O_2(s) + 2H_2O(l) \rightarrow 4NaOH(s) + O_2(g)$$

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.

$$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$$

A) 23
B) -23

C) -12
D) 12
E) -790

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

$$2C_6H_6(l)+15O_2(g)\rightarrow 12CO_2(g)+6H_2O(l)$$

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

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

$$2CO(g)+O_2(g)\rightarrow 2CO_2(g)$$

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

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

$$CH_4(g)+3Cl_2(g)\rightarrow CHCl_3(l)+3HCl(g)$$

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

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

$$H_2(g)+Cl_2\rightarrow 2HCl(g)$$

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:

$$2H_2(g)+O_2(g)\rightarrow 2H_2O(g)$$

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

$$4H_2(g)+2O_2(g)\rightarrow 4H_2O(g)$$

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

24) The value of $\Delta H°$ for the reaction below is +128.1 kJ:

$$CH_3OH(l)\rightarrow CO(g)+2H_2(g)$$

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 $\Delta H°$ for the reaction below is +128.1 kJ:

$$CH_3OH(l)\rightarrow CO(g)+2H_2(g)$$

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

26) The value of $\Delta H°$ for the reaction below is +128.1 kJ:

$$CH_3OH(l) \rightarrow CO(g) + 2H_2(g)$$

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 $\Delta H°$ for the reaction below is +128.1 kJ:

$$CH_3OH(l) \rightarrow CO(g) + 2H_2(g)$$

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 $\Delta H°$ for the reaction below is -1107 kJ:

$$2Ba(s) + O_2(g) \rightarrow 2BaO(s)$$

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 $\Delta H°$ for the reaction below is -1107 kJ:

$$2Ba(s) + O_2(g) \rightarrow 2BaO(s)$$

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 $\Delta H°$ for the reaction below is -1107 kJ:

$$2Ba(s) + O_2(g) \rightarrow 2BaO(s)$$

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 C_2H_6SO 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?

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

$$IF_5(g) \rightarrow IF_3(g) + F_2(g)$$

is _____ kJ, give the data below.

$$IF(g) + F_2(g) \rightarrow IF_3(g) \qquad \Delta H = -390 \text{ kJ}$$
$$IF(g) + 2F_2(g) \rightarrow IF_5(g) \qquad \Delta H = -745 \text{ kJ}$$

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

39) Given the following reactions

$Fe_2O_3(s) + 3CO(s) \rightarrow 2Fe(s) + 3CO_2(g)$
ΔH = -28.0 kJ
$3Fe(s) + 4CO_2(s) \rightarrow 4CO_2(g) + Fe_3O_4(s)$
ΔH = +12.5 kJ

the enthalpy of the reaction of Fe_2O_3 with CO

$$3Fe_2O_3(s) + CO(g) \rightarrow CO_2(g) + 2Fe_3O_4(s)$$

is _____ kJ.

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

40) Given the following reactions

$N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$ ΔH = 66.4 kJ
$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ ΔH = -114.2 kJ

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

$$N_2(g) + O_2(g) \rightarrow 2NO(g)$$

is _____ kJ.

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

41) Given the following reactions

(1) $2NO \rightarrow N_2 + O_2$ ΔH = -180 kJ

(2) $2NO + O_2 \rightarrow 2NO_2$ ΔH = -112 kJ

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

$$N_2 + 2O_2 \rightarrow 2NO_2$$

is _____ kJ.

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

42) Given the following reactions:

$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$ ΔH = -790 kJ

$S(s) + O_2(g) \rightarrow SO_2(g)$ ΔH = -297 kJ

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

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

is _____ kJ.

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

43) Given the following reactions

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ ΔH = 178.1 kJ

$C(s, graphite) + O_2(g) \rightarrow CO_2(g)$ ΔH = -393.5 kJ

the enthalpy of the reaction

$CaCO_3(s) \rightarrow CaO(s) + C(s, graphite) + O_2(g)$

is _____ kJ.

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

44) Given the following reactions

$H_2O(l) \rightarrow H_2O(g)$ ΔH = 44.01 kJ

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ ΔH = -483.64 kJ

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

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

is _____ kJ.

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

45) Given the following reactions

$N_2(g) + O_2(g) \rightarrow 2NO(g)$ ΔH = +180.7 kJ

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ ΔH = -113.1 kJ

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

$$2NO_2(g) \rightarrow N_2(g) + 2O_2(g)$$

is _____ kJ.

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

46) Given the following reactions

$N_2(g) + O_2(g) \rightarrow 2NO(g)$ ΔH = +180.7 kJ

$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ ΔH = -113.1 kJ
the enthalpy of reaction for
$4NO(g) \rightarrow 2NO_2(g) + N_2(g)$
is _____ kJ.

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

47) Given the following reactions
$N_2(g) + O_2(g) \rightarrow 2NO(g)$ ΔH = +180.7 kJ
$2N_2O(g) \rightarrow O_2(g) + 2N_2(g)$ ΔH = -163.2 kJ
the enthalpy of reaction for
$2N_2O(g) \rightarrow 2NO(g) + N_2(g)$
is _____ kJ.

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

48) The value of $\Delta H°$ for the reaction below is -186 kJ.
$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$
The value of $\Delta H_f°$ 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 $\Delta H°$ for the following reaction is -3351 kJ:
$2Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$
The value of $\Delta H_f°$ for $Al_2O_3(s)$ is _____ kJ.

A) -3351
B) -1676
C) -32.86
D) -16.43
E) +3351

50) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction
$Ca(OH)_2 + 2H_3AsO_4 \rightarrow Ca(H_2AsO_4)_2 + 2H_2O$
is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
$Ca(OH)_2$	-986.6
H_3AsO_4	-900.4
$Ca(H_2AsO_4)_2$	-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, $\Delta H°_{rxn}$ for the reaction
$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(l)$
is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
H_2O (l)	-286
NO (g)	90
NO_2 (g)	34
HNO_3 (aq)	-207
NH_3 (g)	-46

A) -1172
B) -150
C) -1540
D) -1892
E) The $\Delta H_f°$ of $O_2(g)$ is needed for the calculation.

52) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$C_2H_5OH(l) + O_2(g) \rightarrow CH_3CO_2H(l) + H_2O(l)$

is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
C_2H_4 (g)	52.3
C_2H_5OH (l)	-277.7
CH_3CO_2H (l)	-484.5
H_2O (l)	-285.8

A) -79.0
B) -1048.0
C) -476.4
D) -492.6
E) The value of $\Delta H_f°$ of $O_2(g)$ is required for the calculation.

53) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$3NO_2 + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$

is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
H_2O (l)	-286
NO (g)	90
NO_2 (g)	34
HNO_3 (aq)	-207
NH_3 (g)	-46

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

54) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$IF_5(g) + F_2(g) \rightarrow IF_7(g)$

is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
IF (g)	-95
IF_5 (g)	-840
IF_7 (g)	-941

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

55) Given the data in the table below, $\Delta H°$ for the reaction

$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
CO (g)	-110.5
CO_2 (g)	-393.7
$CaCO_3$ (s)	-1207.0

A) -566.4
B) -283.2
C) 283.2
D) -677.0
E) The $\Delta H°_f$ of $O_2(g)$ is needed for the calculation.

56) The value of $\Delta H°$ for the following reaction is 177.8 kJ. The value of $\Delta H°_f$ for CaO(s) is _____ kJ/mol.

$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

Substance	$\Delta H_f°$ (kJ/mol)
CO (g)	-110.5
CO_2 (g)	-393.7
$CaCO_3$ (s)	-1207.0

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

57) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$$2Ag_2S(s) + O_2(g) \rightarrow 2Ag_2O(s) + 2S(s)$$

is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
Ag_2O (s)	-31.0
Ag_2S (s)	-32.6
H_2S (g)	-20.6
H_2O (l)	-286

A) -1.6
B) +1.6
C) -3.2
D) +3.2
E) The $\Delta H°_f$ of S(s) and of $O_2(g)$ are needed for the calculation.

58) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$$Ag_2O(s) + H_2S(g) \rightarrow Ag_2S(s) + H_2O(l)$$

is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
Ag_2O (s)	-31.0
Ag_2S (s)	-32.6
H_2S (g)	-20.6
H_2O (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 $\Delta H°_{rxn}$ for the reaction

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
SO_2 (g)	-297
SO_3 (g)	-396
SO_2Cl_2 (g)	-364
H_2SO_4 (l)	-814
H_2O (l)	-286

A) -99
B) 99
C) -198
D) 198
E) The $\Delta H°_f$ of $O_2(g)$ is needed for the calculation.

60) Given the data in the table below $\Delta H°_{rxn}$ for the reaction

$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(l)$$

is _____ kJ.

Substance	$\Delta H_f°$ (kJ/mol)
SO_2 (g)	-297
SO_3 (g)	-396
SO_2Cl_2 (g)	-364
H_2SO_4 (l)	-814
H_2O (l)	-286

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

61) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$$3Cl_2(g) + PH_3(g) \rightarrow PCl_3(g) + 3HCl(g)$$

is _____ kJ.

Compound	$\Delta H_f°$ (kJ/mol)
PCl_3 (g)	-288.07
HCl (g)	-92.30
PH_3 (g)	5.40

A) -385.77
B) -570.37

C) 570.37
D) 385.77
E) The $\Delta H°_f$ of $Cl_2(g)$ is needed for the calculation.

62) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$$PCl_3(g) + 3HCl(g) \rightarrow 3Cl_2(g) + PH_3(g)$$

is _____ kJ.

Compound	$\Delta H_f°$ (kJ/mol)
PCl_3 (g)	-288.07
HCl (g)	-92.30
PH_3 (g)	5.40

A) -570.37
B) -385.77
C) 570.37
D) 385.77
E) The $\Delta H°_f$ of $Cl_2(g)$ is needed for the calculation.

63) Given the data in the table below and $\Delta H°_{rxn}$ for the reaction

$$SO_2Cl_2(g) + 2H_2O(l) \rightarrow H_2SO_4(l) + 2HCL(g)$$
$$\Delta H° = -62 \text{ kJ}$$

$\Delta H°_f$ of HCl(g) is _____ kJ/mol.

Substance	$\Delta H_f°$ (kJ/mol)
SO_2 (g)	-297
SO_3 (g)	-396
SO_2Cl_2 (g)	-364
H_2SO_4 (l)	-814
H_2O (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

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 <u>always</u> 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 <u>always</u> 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

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) $\Delta E = E_{final} - E_{initial}$
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.

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

$$4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s) \quad \Delta H° = -3351 \text{ kJ}$$

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 of heat capacity are _____.

A) K/J or °C/J
B) J/K or J/ °C
C) J/g-K or J/g- °C
D) J/mol
E) g-K/J or g- °C/J

24) The units of specific heat are _____.

A) K/J or °C/J
B) J/K or J/°C
C) J/g-K or J/g-°C
D) J/mol
E) g-K/J or g-°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 °F. There are _____ joules in one Btu. 1 lb = 453.59 g; °C = (5/9)(°F - 32 °); specific heat of H_2O (l) = 4.184 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 $[CaCO_3(s)]$ absorbs 45.5 J of heat, upon which the temperature of the sample increases from 21.1 °C to 28.5 °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 $[CaCO_3(s)]$ absorbs 50.3 J of heat, upon which the temperature of the sample increases from 21.1 °C to 28.5 °C. What is the specific heat of calcium carbonate?

A) .63

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 ΔH°_{rxn} equal to the heat of formation of the product?

A) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
B) $(1/2)N_2(g) + O_2(g) \rightarrow NO_2(g)$
C) $6C(s) + 6H(g) \rightarrow C_6H_6(l)$
D) $P(g) + 4H(g) + Br(g) \rightarrow PH_4Br(l)$
E) $12C(g) + 11H_2(g) + 11O(g) \rightarrow C_6H_{22}O_{11}(g)$

32) Of the following, ΔH_f° is <u>not</u> zero for _____.

A) $O_2(g)$
B) C (graphite)
C) $N_2(g)$
D) $F_2(s)$
E) $Cl_2(g)$

33) Consider the following two reactions:

$$A \rightarrow 2B \qquad \Delta H^\circ_{rxn} = 456.7 \text{ kJ/mol}$$
$$A \rightarrow C \qquad \Delta H^\circ_{rxn} = -22.1 \text{kJ/mol}$$

Determine the enthalpy change for the process:

$$2B \rightarrow C$$

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 _____.

$$Ni(s) + 2CO(g) + 2PF_3(g) \rightarrow Ni(CO)_2(PF_3)_2(l)$$

A) Ni(s)
B) CO(g)
C) $PF_3(g)$
D) $Ni(CO)_2(PF_3)_2(l)$
E) both $CO(s)$ and $PF_3(g)$

35) For the species in the reaction below, $\Delta H_f°$ is zero for _____.

$$2Co(s) + H_2(g) + 8PF_3(g) \rightarrow 2HCo(PF_3)_4(l)$$

A) Co(s)
B) $H_2(g)$
C) $PF_3(g)$
D) $HCo(PF_3)_4$ (l)
E) both $CO(s)$ and $H_2(g)$

36) For which one of the following equations is $\Delta H°_{rxn}$ equal to $\Delta H_f°$ for the product?

A) $Xe(g) + 2F_2(g) \rightarrow XeF_4(g)$
B) $CH_4(g) + 2Cl_2(g) \rightarrow CH_2Cl_2(l) + 2HCl(g)$
C) $N_2(g) + O_3(g) \rightarrow N_2O_3(g)$
D) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$
E) $C\ (diamond) + O_2(g) \rightarrow CO_2(g)$

37) For which one of the following reactions is the value of $\Delta H°_{rxn}$ equal to $\Delta H_f°$ for the product?

A) $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$
B) $C_2H_2(g) + H_2(g) \rightarrow C_2H_4(g)$
C) $2C\ (graphite) + O_2(g) \rightarrow 2CO(g)$
D) $3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$
E) $C\ (diamond) + O_2(g) \rightarrow CO_2(g)$

38) For which one of the following reactions is the value of $\Delta H°_{rxn}$ equal to $\Delta H°_f$ for the product?

A) $2C\ (s,\ graphite) + 2H_2(g) \rightarrow C_2H_4(g)$
B) $N_2(g) + O_2(g) \rightarrow 2NO(g)$
C) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
D) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
E) $H_2O(l) + 1/2O_2(g) \rightarrow H_2O_2(l)$

39) For which one of the following reactions is the value of $\Delta H°_{rxn}$ equal to $\Delta H°_f$ for the product?

A) $H_2O(l) + 1/2O_2(g) \rightarrow H_2O_2(l)$
B) $N_2(g) + O_2(g) \rightarrow 2NO(g)$
C) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$
D) $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
E) none of the above

40) For which one of the following reactions is the value of $\Delta H°_{rxn}$ equal to $\Delta H°_f$ for the product?

A) $H_2(g) + 1/2\ O_2(g) \rightarrow H_2O(l)$
B) $H_2(g) + O_2(g) \rightarrow H_2O_2(l)$
C) $2C\ (s,\ graphite) + 2H_2(g) \rightarrow C_2H_4(g)$
D) $1/2N_2\ (g) + O_2(g) \rightarrow NO_2(g)$
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.

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 <u>not</u> 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

$$H_2O(l) \rightarrow H_2O(g) \quad \Delta H_{rxn} = 40.7 \text{ kJ at } 100\ ^\circ\text{C}$$

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

3) Given the equation

$$H_2O(l) \rightarrow H_2O(g) \quad \Delta H_{rxn} = 40.7 \text{ kJ at } 100\ ^\circ\text{C}$$

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 J/g-°C.)

5) Given the equation:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + H_2O(l) \quad \Delta H = -890 \text{ kJ}$$

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

1) Work equals force times distance.

2) One joule equals $1\ \text{kg} \bullet \text{m}^2/\text{s}^2$.

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:

$$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$$
$$\Delta\text{H} = \text{-890.0 kJ}$$

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:

$$2\text{H}_2\text{O}_2(\text{l}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$$
$$\Delta\text{H} = \text{-196 kJ}$$

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:

$$\text{Ti}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{TiO}_2(\text{s})$$

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

6) The specific heat capacity of liquid mercury is 0.14 J/g-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 J/g-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 _____ °C. The specific heat capacity of liquid water is 4.18 J/g-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 _____ °C. The specific heat capacity of copper is 0.38 J/g-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 joules/gram-K.)

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