thermo practice **The answers are on the last page**

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

____ 1. Which of the following types of energy is not kinetic energy?
a. thermal energy
b. electrical energy
c. gravitational energy
d. mechanical energy
e. sound energy

____ 2. Of the following types of energy, which are potential energies?

1. thermal energy
2. chemical potential energy
3. mechanical energy
4. electrostatic energy

a. 1 only
b. 1 and 3
c. 2 only
d. 2 and 4
e. 1, 2, and 4

____ 3. All of the following statements are true EXCEPT
a. energy is neither created nor destroyed in chemical reactions.
b. spontaneous reactions are always exothermic.
c. kinetic energy is the energy associated with motion.
d. energy is the capacity to do work.
e. increasing the thermal energy of a gas increases the motion of its atoms.

____ 4. All of the following statements are true EXCEPT
a. In an endothermic process heat is transferred from the surroundings to the system.
b. The greater the specific heat of an object, the more thermal energy it can store.
c. The SI unit of specific heat capacity is joules per gram per kelvin.
d. Heat is transferred from the system to the surroundings in an exothermic process.
e. The temperature of a system is a state function.

____ 5. How many joules are equivalent to 158 calories?
a. 0.0265 J
b. 8.31 J
c. 22.1 J
d. 37.8 J
e. 661 J

____ 6. Specific heat capacity is
a. the quantity of heat required to melt 1.00 g of a substance.
b. the mass of a substance 1.00 J of energy will heat by 1.00 K.
c. the mass of a substance 1.00 cal of energy will heat by 1.00 K.
d. the temperature change undergone when 1.00 g of a substance absorbs 1.00 cal.
e. the quantity of heat needed to change 1.00 g of a substance by 1.00 K.

____ 7. Heat capacity is defined as
a. the amount of heat required to raise the temperature of a substance by 1 K.

b. the amount of heat required to raise the temperature of 1 gram of substance by 1 K.
c. 4.18 J/g·K.
d. 4.18 J/K.
e. 4.18 cal/g·K.

____ 8. If the same amount of heat is added to 50.0 g samples of each of the metals below, which metal will experience the largest temperature change?

Metal	Specific Heat (J/g·K)
Al	0.902
Cu	0.385
Fe	0.451
Au	0.128
K	0.753

a. Al
b. Cu
c. Fe
d. Au
e. K

____ 9. If 34.8 J is required to change the temperature of 10.0 g of mercury by 25 K, what is the specific heat of mercury?
a. 0.139 J/g·K
b. 0.338 J/g·K
c. 0.718 J/g·K
d. 0.870 J/g·K
e. 1.93 J/g·K

____ 10. If 1.00 mol H_2O at 25.0°C absorbs 1.00 kJ of heat, what is the final temperature of the water? The specific heat of water is 4.184 J/g·K.
a. 11.7°C
b. 32.9°C
c. 38.3°C
d. 52.1°C
e. 70.9°C

____ 11. How much energy is required to change the temperature of 15.0 g Fe from 18.5°C to 56.8°C? The specific heat of iron is 0.451 J/g·K.
a. 57.5 J
b. 127 J
c. 259 J
d. 385 J
e. 452 J

____ 12. If 25.0 g H_2O at 11.2°C is combined with 75.0 g H_2O at 87.2°C, what is the final temperature of the mixture? The specific heat of water is 4.184 J/g·K.
a. 43.1°C
b. 68.2°C
c. 73.2°C
d. 74.4°C
e. 87.0°C

____ 13. If 35.5 g Al at 20.0°C is placed in 90.0 g H_2O at 65.0°C, what is the final temperature of the mixture? The specific heats of water and aluminum are 4.184 J/g·K and 0.902 J/g·K, respectively.

a. 29.1°C
b. 42.5°C
c. 52.3°C
d. 57.4°C
e. 61.5°C

____ 14. When 18.0 g of an unknown metal at 79.0°C is placed in 112 g H_2O at 22.2°C, the final temperature of the water is 24.9°C. What is the specific heat capacity of the metal? The specific heat of water is 4.184 J/g·K.
a. 0.34 J/g·K
b. 0.72 J/g·K
c. 0.93 J/g·K
d. 1.0 J/g·K
e. 1.3 J/g·K

____ 15. When 175 g H_2O at 24.1°C is mixed with an unknown mass of H_2O at a temperature of 55.1°C, the final temperature of the mixture is 36.6°C. What is the mass of the second sample of H_2O? The specific heat of water is 4.184 J/g·K.
a. 32.8 g
b. 75.0 g
c. 102 g
d. 118 g
e. 259 g

____ 16. Calculate the amount of heat required to change 35.0 g ice at -25.0°C to steam at 125°C. (Heat of fusion = 333 J/g; heat of vaporization = 2260 J/g; specific heats: ice = 2.09 J/g·K, water = 4.18 J/g·K, steam = 1.84 J/g·K)
a. 22.0 kJ
b. 90.9 kJ
c. 109 kJ
d. 276 kJ
e. 3290 kJ

____ 17. 10.0 g of ice at 0.00°C is mixed with 50.0 g of water at 32.0°C. What is the final temperature of the mixture? (Heat of fusion = 333 J/g; specific heats: ice = 2.09 J/g·K, water = 4.184 J/g·K)
a. -4.59°C
b. 0.00°C
c. 4.59°C
d. 13.4°C
e. 23.8°C

____ 18. 75.0 g of ice at 0.00°C is combined with 125 g water at 20.0°C. The final temperature of the mixture is 0.00°C. What mass of ice melts? (Heat of fusion = 333 J/g; specific heats: ice = 2.09 J/g·K, water = 4.184 J/g·K)
a. 31.4 g
b. 43.6 g
c. 51.3 g
d. 75.0 g
e. 81.1 g

____ 19. The boiling point of benzene, C_6H_6, is 80.1°C. If 45.3 kJ of heat is required to vaporize 115 g benzene at its boiling point, what is the heat of vaporization of benzene?
a. 254 J/g
b. 333 J/g
c. 394 J/g
d. 521 J/g

e. 5210 J/g

____ 20. Calculate ΔE of a gas for a process in which the gas absorbs 42 J of heat and does 14 J of work on the surroundings (i.e. the gas expands)?
a. -56 J
b. -28 J
c. +28 J
d. +42 J
e. +56 J

____ 21. Calculate ΔE of a gas for a process in which the gas evolves 27 J of heat and does 24 J of work on the surroundings (i.e. the gas expands)?
a. -51 J
b. -3 J
c. +3 J
d. 24 J
e. +51 J

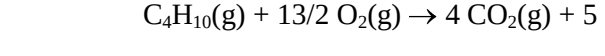
____ 22. For a particular process q = 25 kJ and w = -15 kJ. What conclusions may be drawn for this process?
a. ΔE = 40 kJ
b. ΔE = -40 kJ
c. This is a product favored reaction.
d. Work is done by the system on the surroundings.
e. Both answer b and d are correct.

____ 23. Which of the following statements is correct?
a. If a reaction occurs at constant pressure, $w = \Delta E$.
b. If a reaction occurs at constant volume, $q = w$.
c. If a reaction occurs at constant pressure, $q = \Delta E$.
d. If a reaction occurs at constant temperature, $\Delta E = 0$.
e. If a reaction occurs at constant volume, $q = \Delta E$.

____ 24. One statement of the first law of thermodynamics is that
a. the amount of work done on a system is independent of pathway.
b. the total energy flow in or out of a system is equal to the sum of the heat absorbed and the work done on the system.
c. the heat flow in or out of a system is independent of pathway.
d. the total work done on a system must equal the heat absorbed by the system.
e. in any chemical process the sum of the heat flow and the work must equal zero.

____ 25. Which of the following thermodynamic quantities are state functions: heat (q), work (w), enthalpy change (ΔH), and internal energy change (ΔE)?
a. ΔH and ΔE
b. ΔE only
c. ΔE and w
d. q and w
e. ΔH and q

____ 26. The standard molar enthalpy of combustion of butane is -2877 kJ.



$C_4H_{10}(g) + 13/2\ O_2(g) \rightarrow 4\ CO_2(g) + 5\ H_2O(g)$

What is the enthalpy change for the combustion of 15.00 g C_4H_{10}?
a. -4315kJ
b. -2219 kJ
c. -1114 kJ

d. -742.5 kJ
e. -491.2 kJ

____ 27. Methane, CH_4, reacts with excess oxygen to produce carbon dioxide, water, and heat. The standard molar enthalpy of combustion is -890.3 kJ.

$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(\ell)$

What is the enthalpy change for the following reaction?

$3\ CO_2(g) + 6\ H_2O(\ell) \rightarrow 3\ CH_4(g) + 6\ O_2(g)$

a. -2671 kJ
b. +296.8 kJ
c. +890.3 kJ
d. +1838 kJ
e. +2671 kJ

____ 28. Hydrazine, N_2H_4, is a liquid used as a rocket fuel. It reacts with oxygen to yield nitrogen gas and water.

$N_2H_4(\ell) + O_2(g) \rightarrow N_2(g) + 2\ H_2O(\ell)$

The reaction of 2.50 g N_2H_4 evolves 48.5 kJ of heat. Calculate the enthalpy change per mole of hydrazine combusted.

a. -3.90×10^3 kJ
b. -831 kJ
c. -622 kJ
d. -121 kJ
e. -3.77 kJ

____ 29. If 1.32 g MgO is combined with 100.0 mL of 1.00 M HCl in a coffee cup calorimeter, the temperature of the HCl solution increases from 24.2°C to 34.4°C. Calculate the enthalpy change for the reaction per mole of MgO. Assume that the specific heat of the HCl solution is 4.18 J/g·K and its density is 1.00 g/mL.

a. -409 kJ
b. -132 kJ
c. -105 kJ
d. -3.27 kJ
e. -1.65 kJ

____ 30. Commercial cold packs consist of solid ammonium nitrate and water. NH_4NO_3 absorbs 330. J of heat per gram dissolved in water. In a coffee-cup calorimeter, 3.00 g NH_4NO_3 is dissolved in 100.0 g of water at 24.0°C. What is the final temperature of the solution? Assume that the solution (whose total mass is 103.0 g) has a specific heat capacity of 4.18 J/g·K.

a. 11.0°C
b. 15.9°C
c. 19.1°C
d. 21.7°C
e. 35.9°C

____ 31. When 11.4 g KBr is dissolved in 100.0 g of water in a coffee-cup calorimeter, the temperature drops from 24.88°C to 20.34°C. What is the heat change per gram of KBr dissolved in the water? Assume that the solution (whose total mass is 111.4 g) has a specific heat capacity of 4.18 J/g·K.

a. 4.54 J/g
b. 76.9 J/g
c. 185 J/g

d. 444 J/g
e. 506 J/g

____ 32. A chemical reaction in a bomb calorimeter evolves 4.12 kJ of heat. If the temperature of the calorimeter increases from 18.20°C to 22.79°C, what is the heat capacity of the calorimeter?
a. 1.11 kJ/°C
b. 4.12 kJ/°C
c. 4.59 kJ/°C
d. 189 kJ/°C
e. 898 J/°C

____ 33. A 3.250 g sample of methanol, CH_3OH, is combusted in a bomb calorimeter. The temperature of the calorimeter increases by 12.55°C. If the heat capacity of the bomb is 850.0 J/°C and it contains 1.200 kg of water, what is the heat evolved per mole of ethanol combusted? The specific heat capacity of water is 4.184 J/g·K and the molar mass of methanol is 32.04 g/mol.
a. -1321 kJ
b. -726.4 kJ
c. -621.2 kJ
d. -105.2 kJ
e. -63.01 kJ

____ 34. The molar enthalpy of combustion of glucose, $C_6H_{12}O_6$, is -2803 kJ. A mass of 1.000 g glucose is combusted in a bomb calorimeter. If the calorimeter contains 875 g H_2O and the bomb has a heat capacity of 457 J/°C, what is the temperature increase of the bomb calorimeter? The specific heat capacity of water is 4.184 J/g·K and the molar mass of glucose is 180.2 g/mol.
a. 1.02°C
b. 2.03°C
c. 3.37°C
d. 3.78°C
e. 6.02°C

____ 35. Calculate the standard enthalpy of formation of carbon monoxide,

$C(s) + 1/2\ O_2(g) \rightarrow CO(g)$, given the enthalpies of the reactions below.

$C(s) + O_2(g) \rightarrow CO_2(g)$ ΔH = -393.5 kJ
$2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$ ΔH = -566.0 kJ

a. -959.6 kJ
b. -421.6 kJ°C
c. -172.5 kJ
d. -110.5 kJ
e. 172.5 kJ

____ 36. Calculate the enthalpy for the formation of calcium carbonate from calcium oxide and carbon dioxide,

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

given the enthalpies of the reactions below.

$2\ Ca(s) + O_2(g) \rightarrow 2\ CaO(s)$ ΔH = -1270.2 kJ
$C(s) + O_2(g) \rightarrow CO_2(g)$ ΔH = -393.5 kJ
$2\ Ca(s) + 2\ C(s) + 3\ O_2(g) \rightarrow 2\ CaCO_3(s)$ ΔH = -2413.8 kJ

a. -4077.3 kJ
b. -2235.5 kJ
c. -750.1 kJ
d. -350.2 kJ
e. -178.3 kJ

____ 37. Determine the heat of reaction for the oxidation of iron,

$4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$

given the enthalpies of the reactions below.

$2\ Fe(s) + 6\ H_2O(\ell) \rightarrow 2\ Fe(OH)_3(s) + 3\ H_2(g)$ $\Delta H = 321.8$ kJ
$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(\ell)$ $\Delta H = -571.7$ kJ
$Fe_2O_3(s) + 3\ H_2O(\ell) \rightarrow 2\ Fe(OH)_3(s)$ $\Delta H = 288.6$ kJ

a. -1648.7 kJ
b. -636.9 kJ
c. -505.3 kJ
d. 387.0 kJ
e. +1447.1 kJ

____ 38. Determine the heat of vaporization of titanium(IV) chloride given the enthalpies of reaction below.

$Ti(s) + 2\ Cl_2(g) \rightarrow TiCl_4(\ell)$ $\Delta H = -804.2$ kJ
$Ti(s) + 2\ Cl_2(g) \rightarrow TiCl_4(g)$ $\Delta H = -763.2$ kJ

a. -1567.4 kJ
b. 0.949 kJ
c. 41.0 kJ
d. 61.3 kJ
e. 1567.4 kJ

____ 39. Which of the following chemical equations corresponds to the standard enthalpy of formation of N_2O_5?
a. $N_2O_3(s) + O_2(g) \rightarrow N_2O_5(s)$
b. $NO_2(g) + NO(g) + O_2(g) \rightarrow N_2O_5(s)$
c. $2\ N_2(g) + 5\ O_2(g) \rightarrow 2\ N_2O_5(s)$
d. $2\ N(g) + 5\ O(g) \rightarrow N_2O_5(s)$
e. $N_2(g) + 5/2\ O_2(g) \rightarrow N_2O_5(s)$

____ 40. All of the following chemical equations correspond to a standard enthalpy of formation EXCEPT
a. $CaO(s) + C(s) + O_2(g) \rightarrow CaCO_3(s)$
b. $H_2(g) + 1/2\ O_2(g) \rightarrow H_2O(g)$
c. $H_2(g) + 1/2\ O_2(g) \rightarrow H_2O(\ell)$
d. $N_2(g) + 2\ O_2(g) \rightarrow N_2O_4(g)$
e. $C(s) + O_2(g) \rightarrow CO_2(g)$

____ 41. Calculate the molar enthalpy of combustion of $C_3H_6(g)$,

$C_3H_6(g) + 9/2\ O_2(g) \rightarrow 3\ CO_2(g) + 3\ H_2O(\ell)$

using standard enthalpies of formation.

molecule	ΔH_f^o (kJ)
$C_3H_6(g)$	+53.3
$CO_2(g)$	-393.5
$H_2O(\ell)$	-285.8

a. -2091.2 kJ
b. -1984.6 kJ
c. -187.8 kJ
d. -62.6 kJ
e. +732.3 kJ

____ 42. The standard enthalpy change for the combustion of propane is -2219.9 kJ.

$C_3H_8(g) + O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(\ell)$

Calculate the standard molar enthalpy of formation for propane based on the following standard enthalpies of formation.

molecule	ΔH_f^o (kJ)
$CO_2(g)$	-393.5
$H_2O(\ell)$	-285.8

a. -103.8 kJ
b. -102.8 kJ
c. -74.8 kJ
d. +52.1 kJ
e. +1540.6 kJ

____ 43. The standard enthalpy of formation of $CO_2(g)$ is -393.5 kJ. What is the enthalpy change if 4.49 g C(s) reacts with 9.21 $O_2(g)$ to form $CO_2(g)$?
a. -113 kJ
b. -92.8 kJ
c. -87.6 kJ
d. -42.7 kJ
e. -27.8 kJ

____ 44. Which fuel has the highest energy content per gram?
a. CH_4
b. C_8H_{18}
c. C_2H_2
d. C_2H_5OH
e. H_2

Completion
Complete each sentence or statement.

45. _____ gas is often called swamp gas or marsh gas.

46. A _____ calorimeter is often used to measure heat of combustion reactions under constant volume conditions.

47. The energy of motion is call _____ energy.

48. The _____ energy of a system is the sum of all its kinetic and potential energies.
49. When a hot piece of metal is submerged in water at a cooler temperature, heat is transferred from the metal to the water. When the temperature of the metal and the water are the same, we say that they have reached thermal _____.
50. The enthalpy change is the heat absorbed or evolved in a reaction that occurs at constant _____.

Essay

51. You can remove a piece of aluminum foil from a hot oven without using an oven mitt to protect your hand. Why do you not get burned?
52. What is one advantage and one disadvantage of using hydrogen gas as fuel?

thermo practice
Answer Section

MULTIPLE CHOICE

1. ANS: C
2. ANS: D
3. ANS: B
4. ANS: E
5. ANS: E
6. ANS: E
7. ANS: A
8. ANS: D
9. ANS: A
10. ANS: C
11. ANS: C
12. ANS: B
13. ANS: E
14. ANS: E
15. ANS: D
16. ANS: C
17. ANS: D
18. ANS: A
19. ANS: C
20. ANS: C
21. ANS: A
22. ANS: D
23. ANS: E
24. ANS: B
25. ANS: A
26. ANS: D
27. ANS: E
28. ANS: C
29. ANS: B
30. ANS: D
31. ANS: C
32. ANS: E
33. ANS: B
34. ANS: D
35. ANS: D
36. ANS: E
37. ANS: A
38. ANS: C
39. ANS: E
40. ANS: A
41. ANS: A

42. ANS: A
43. ANS: A
44. ANS: E

COMPLETION

45. ANS: Methane
46. ANS: bomb
47. ANS: kinetic
48. ANS: internal
49. ANS: equilibrium
50. ANS: pressure

ESSAY

51. ANS:
    Since the mass of the aluminum foil and the specific heat capacity of aluminum are small, the heat content of the aluminum is small. Thus, the hot aluminum does not transfer much heat to your hands.
52. ANS:
    Hydrogen has a higher energy content per gram than fossil fuels. Since hydrogen is a gas at room temperature, it is difficult to transport and store. (Additional advantage: hydrogen is non-polluting)