Thermochemistry Review

Multiple Choice Questions

____ 1. When the three types of energy changes are arranged in order of decreasing molar heat values, what is the correct order?

A. chemical, phase, nuclear
B. nuclear, chemical, phase
C. nuclear, phase, chemical
D. phase, chemical, nuclear

____ 2. The temperature remains constant as energy is added to a substance. How may the substance be changing?

A. from a gas to a solid
B. from a liquid to a gas
C. from a liquid to a solid
D. in the amount of kinetic energy

____ 3. Which metal requires the most energy to raise 1.00 g of it by 1.00°C?

A. aluminum B. copper C. lead D. nickel

____ 4. A substance has a molar heat of combustion of –810.4 kJ/mol. When 0.285 mol of the substance is burned in a calorimeter containing 8.60 kg of water, what is the increase of the water temperature?

A. 0.156°C B. 6.41°C C. 7.89°C D. 12.8°C

____ 5. The addition of 9.54 kJ of heat is required to raise the temperature of 225.0 g of a liquid hydrocarbon from 20.5°C to 45.0°C. What is the heat capacity of this hydrocarbon?

A. 0.94 J/g•°C B. 1.73 J/g•°C C. 1.88 J/g•°C D. 9.42 J/g•°C

____ 6. If the molar heat of fusion of sodium is 2.63 kJ/mol, how much energy is needed to melt 180.0 g of solid sodium at its melting point?

A. 2.63 kJ B. 2.93 kJ C. 20.6 kJ D. 473 kJ

____ 7. Which process is exothermic?

A. the boiling of liquid nitrogen
B. the freezing of water
C. the sublimation of dry ice
D. the vaporization of water

____ 8. If the heat of formation for the chemical reaction, $S_8(s) + 12O_2(g) \rightarrow 8SO_3(g)$, is –395.7 kJ/mol of SO_3, how can the equation be rewritten to include the heat term?

A. $S_8(s) + 12O_2(g) \rightarrow 8SO_3(g) + 3166$ kJ
B. $S_8(s) + 12O_2(g) \rightarrow 8SO_3(g) - 395.7$ kJ
C. $S_8(s) + 12O_2(g) \rightarrow 8SO_3(g) + 395.7$ kJ
D. $S_8(s) + 12O_2(g) + 3166$ kJ $\rightarrow 8SO_3(g)$

____ 9. Which statement correctly describes the energy changes that take place when a solid changes to a liquid at constant temperature?

A. The potential energy increases, and the kinetic energy remains constant.
B. The potential energy remains constant, and the kinetic energy increases.
C. The potential energy decreases, and the kinetic energy decreases.
D. The potential energy increases, and the kinetic energy decreases.

____ 10. Why does warm water have a more rapid rate of evaporation than cold water?

A. It has a higher viscosity.
B. Its molecules have a higher average kinetic energy.
C. Its molecules have more attraction for one another.
D. More of its molecules have nearly the same kinetic energy.

____ 11. If the heat of fusion of a substance is 20 kJ/mol, what heat is released when 1.0 mol of liquid at the melting point freezes?

A. 10 kJ B. 20 kJ C. 40 kJ D. 80 kJ

____ 12. The amount of 2.00 mol of a solid ionic compound was dissolved in 225 mL of water in an insulated container. The initial temperature of the water was 20.0°C and the final temperature of the water was 47.8°C. What is Hsoln?

A. –27.8 kJ/mol B. –26.2 kJ/mol C. –13.1 kJ/mol D. –6.26 kJ/mol

____ 13. What does it mean if the ΔH value for a chemical reaction is positive?

A. kinetic energy is increasing in the system
B. potential energy is decreasing in the system
C. products have less potential energy than reactants
D. reactants have less potential energy than products.

____ 14. Living plants produce glucose in the process of photosynthesis according to this equation:

$$6CO_2(g) + 6H_2O(l) + \text{energy} \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$$

Is this reaction endothermic or exothermic, and is the value of $\Delta H°$ positive or negative?

A. endothermic, positive B. endothermic, negative C. exothermic, positive D. exothermic, negative

____ 15. In order to produce 972 kJ of heat, how many grams of H_2 must burn?

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(g) + 243\ kJ$$

A. 0.250 g B. 4.04 g C. 8.08 g D. 16.0 g

____ 16. Use the equations to answer the question.

$$2A + B \rightarrow A_2B \qquad \Delta H = -217.3\ kJ$$
$$B + C \rightarrow BC \qquad \Delta H = -867.5\ kJ$$

What is the value of ΔH for the reaction $2A + BC \rightarrow A_2B + C$?

A. +1084.8 kJ B. +650.2 kJ C. –650.2 kJ D. –1084.8 kJ

____ 17. Consider this reaction: $LiH(s) + 90.5\ kJ \rightarrow Li(s) + \tfrac{1}{2}H_2(g)$

What amount of heat is necessary to decompose 15.9 g of LiH into Li and H_2 at standard conditions?

A. 15.9 kJ B. 90.5 kJ C. 181 kJ D. 1.44 MJ

____ 18. During the production of a small amount of material, there is a large decrease in the temperature of the water in the calorimeter. What is the ΔH for the reaction?

A. large and positive B. small and negative C. small and positive D. large and negative

____ 19. $C_2H_6(g) \rightarrow C_2H_2(g) + 2H_2(g) \qquad \Delta H = +3.2 \times 10^2$ kJ/mol (C_2H_6)

What is an alternate way to write this equation?

A. $C_2H_6(g) \rightarrow C_2H_2(g) + 2H_2(g) + 3.2 \times 10^2$ kJ
B. $C_2H_6(g) + 3.2 \times 10^2$ kJ $\rightarrow C_2H_2(g) + 2H_2(g)$
C. $C_2H_2(g) + 2H_2(g) + 3.2 \times 10^2$ kJ $\rightarrow C_2H_6(g)$
D. $C_2H_6(g) - 3.2 \times 10^2$ kJ $\rightarrow C_2H_2(g) + 2H_2(g)$

____ 20. What is 4.18 J?

A. The heat required to raise the temperature of one gram of water by one Celsius degree.
B. The heat required to raise the temperature of one mole of water by one Celsius degree.
C. The heat required to raise the temperature of one gram of substance by one Celsius degree.
D. The heat required to raise the temperature of one mole of substance by one Celsius degree.

____ 21. What is a positive molar heat of formation?

A. The heat absorbed when one mole of compound is formed from its elements.
B. The heat released when one mole of compound is formed from its elements.
C. The heat absorbed when one mole of elements is formed from the compound.
D. The heat released when one mole of elements is formed from the compound.

____ 22. What change is probably happening when energy is added to a substance, but the substance's temperature does not rise?

A. gas to liquid B. gas to solid C. liquid to gas D. liquid to solid

____ 23. What occurs when solid A (50°C) is placed in contact with solid B (80°C)?

A. Heat energy flows from A to B as the average kinetic energy of the particles in A decreases.
B. Heat energy flows from A to B as the average kinetic energy of the particles in A increase.
C. Heat energy flows from B to A as the average kinetic energy of the particles in B decreases.
D. Heat energy flows from B to A as the average kinetic energy of the particles in B increases.

____ 24. What characteristic(s) of water change(s) when its temperature is raised from 10°C to 110°C at standard pressure?

A. both kinetic and potential energy C. kinetic energy only
B. intramolecular bonding only D. potential energy only

____ 25. If 41.2 kJ of energy is needed to raise the temperature of 170.0 g of a liquid from 18.8°C to 65.2°C, what is the specific heat capacity of the solution?

A. 4.19 J/g•°C B. 5.22 J/g•°C C. 11.2 J/g•°C D. 12.0 J/g•°C

____ 26. What happens to the water in a calorimeter when an exothermic reaction occurs in it?

A. It absorbs heat, and a drop in temperature is observed.
B. It absorbs heat, and a rise in temperature is observed.
C. It releases heat, and a drop in temperature is observed.
D. It releases heat, and a rise in temperature is observed.

____ 27. Which is true for an exothermic reaction?

A. The ΔH is positive.
B. The products have less potential energy than the reactants.
C. The reactants have more kinetic energy than the products.
D. The reactants are below the products in the potential energy diagram.

____ 28. When $NH_4Cl(s)$ is added to water, the resulting solution feels cool to the touch. Which best describes this observation?

A. Heat is released as $NH_4Cl(s)$ dissolves.
B. $NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq) \qquad \Delta H = -33.6$ kJ
C. $NH_4Cl(s) + 33.6\ kJ \rightarrow NH_4^+(aq) + Cl^-(aq)$
D. $NH_4Cl(s) \rightarrow NH_4^+(aq) + Cl^-(aq) + 33.6$ kJ

____ 29. Use these thermochemical equations to answer the question.

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g)$ $\Delta H°comb = -1410.1$ kJ

$C_4H_8(g) + 6O_2(g) \rightarrow 4CO_2(g) + 4H_2O(g)$ $\Delta H°comb = -2698.3$ kJ

What is the heat of the reaction, $2C_2H_4(g) \rightarrow C_4H_8(g)$?

A. –5518.5 kJ B. –3986.5 kJ C. –1288.3 kJ D. –121.9 kJ

____ 30. What can be concluded from this thermochemical equation?

$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$ $\Delta H = -45$ kJ/mol

A. Sodium and hydroxide ions have more potential energy than solid sodium hydroxide.
B. Solid sodium hydroxide has less potential energy than aqueous sodium hydroxide.
C. The crystallization of sodium hydroxide is an exothermic process.
D. The temperature of the water would rise as solid sodium hydroxide dissolves.

____ 31. What is one result of a solid-liquid phase change?

A. A change in a substance's chemical bonding. C. A change in a substance's mass.
B. A change in a substance's kinetic energy. D. A change in a substance's potential energy.

___ 32. A sample of aluminum absorbed 9.86 J of heat and its temperature increased from 23.2°C to 30.5°C. What is the mass of the aluminum?

A. 1.5 g B. 8.1 g C. 65 g D. 72 g

____ 33. At standard pressure, which is an example of a change in kinetic energy ***only***?

A. carbon dioxide cooling from –80°C to –100°C
B. molten aluminum solidifying at 660°C
C. steam condensing at 100°C
D. water decomposing above 1×10^7°C

____ 34. In order for 10.0 g of NH_4Cl to dissociate in water, 2.77 kJ of energy is required. What is the molar enthalpy of solution for NH_4Cl?

A. 0.277 kJ/mol B. 2.77 kJ/mol C. 14.8 kJ/mol D. 19.8 kJ/mol

____ 35. Which statement is true?

A. An endothermic reaction is characterized by a negative value of ΔH.
B. An exothermic reaction transfers heat to the surroundings.
C. Heat is evolved when an endothermic reaction occurs.
D. The reaction vessel cools when an exothermic reaction occurs.

____ 36. Living plants produce glucose in the process of photosynthesis according to this equation:

$6CO_2(g) + 6H_2O(l) + \text{energy} \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$

Is this reaction endothermic or exothermic, and is the value of $\Delta H°$ positive or negative?

A. endothermic, positive B. endothermic, negative C. exothermic, positive D. exothermic, negative

____ 37. Using the thermochemical equation: $2Al(s) + \frac{3}{2}O_2(g) \rightarrow Al_2O_3(s)$ $\Delta H = -1676$ kJ

What is ΔH for the following reaction: $2Al_2O_3(s) \rightarrow 4Al + 3O_2(g)$?

A. –3352 kJ B. –838 kJ C. +838 kJ D. +3352 kJ

____ 38. What is the value of ΔH for the reaction, $S(s) \rightarrow S(g)$?

$S(s) + O_2(g) \rightarrow SO_2(g)$ $\Delta H = -395$ kJ

$S(g) + O_2(g) \rightarrow SO_2(g)$ $\Delta H = -618$ kJ

A. -1013 kJ B. -223 kJ C. + 223 kJ D. +1013 kJ

____ 39. What quantity of heat is evolved when 5.55 mol $H_2O(l)$ is formed from the combustion of $H_2(g)$ and $O_2(g)$?

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H = -285.8$ kJ

A. 51.44 kJ B. 285.8 kJ C. 1586 kJ D. 2297 kJ

____ 40. Which processes are exothermic?

1. boiling water 2. freezing water 3. condensation of steam 4. melting ice

A. 1 and 3 B. 1 and 4 C. 2 and 3 D. 2 and 4

____ 41. Which is correct for the process $H_2O(g) \rightarrow H_2O(l)$?

A. ΔH is negative and the process is endothermic. C. ΔH is positive and the process is endothermic.
B. ΔH is negative and the process is exothermic. D. ΔH is positive and the process is exothermic.

____ 42. If 1.0 mol of ammonia reacts to form nitrogen and hydrogen,

$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ $\Delta H = -92$ kJ

what heat energy is associated with the reaction?

A. 46 kJ and the reaction is endothermic C. 92 kJ and the reaction is endothermic
B. 46 kJ and the reaction is exothermic D. 92 kJ and the reaction is exothermic

____ 43. How might the reaction between $H_2(g)$ and $F_2(g)$ in a thermally insulated vessel be described?

$$H_2(g) + F_2(g) \rightarrow 2HF(g) \qquad \Delta H = -271 \text{ kJ}$$

A. It is endothermic, and the temperature of the reaction system would fall.
B. It is endothermic, and the temperature of the reaction system would rise.
C. It is exothermic, and the temperature of the reaction system would fall.
D. It is exothermic, and the temperature of the reaction system would rise.

____ 44. When graphite and diamond burn, the reactions can be represented by the thermochemical equations:

$$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -393 \text{ kJ}$$
$$C(\text{diamond}) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -395 \text{ kJ}$$

If 1.0 mol of graphite is converted into 1.0 mol of diamond under the same conditions, what is the heat energy change?

A. 2 kJ of heat are absorbed from the surroundings.
B. 2 kJ of heat are given off to the surroundings.
C. 788 kJ of heat are absorbed from the surroundings.
D. 788 kJ of heat are given off to the surroundings.

____ 45. Use the thermochemical equations:

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g) \qquad \Delta H = -26.8 \text{ kJ}$$
$$FeO(s) + CO(g) \rightarrow Fe(s) + CO_2(g) \qquad \Delta H = -16.5 \text{ kJ}$$

to calculate ΔH for this reaction:

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

A. –59.8 kJ B. –43.3 kJ C. -10.3 kJ D. +6.2 kJ

___ 46. Which one of the following processes is endothermic?

A. $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + H_2O(g)$
B. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$
C. $H_2O(g) \rightarrow H_2O(l)$
D. $H_2O(s) \rightarrow H_2O(l)$

___ 47. Which statement is true for the reaction between $HNO_3(aq)$ and $N_2H_4(l)$?

$$4HNO_3(aq) + 5N_2H_4(l) \rightarrow 7N_2(g) + 12H_2O(g) \qquad \Delta H = -24462.0 \text{ kJ}$$

A. 205.2 kJ are absorbed per mole of $H_2O(g)$ used.
B. 351.7 kJ are absorbed per mole of $N_2(g)$ formed.
C. 492.4 kJ are released per mole of $N_2H_4(l)$ formed.
D. 615.5 kJ are released per mole of $HNO_3(aq)$ used.

___ 48. Given the two reactions below, what is the ΔH for the reaction, $IF_5(g) \rightarrow IF_3(g) + F_2(g)$?

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

A. -1135 kJ B. 35 kJ C. 355 kJ D. 1135 kJ

___ 49. For which of the following equations is the enthalpy change 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. $2C(s) + O_2(g) \rightarrow 2CO(g)$
D. $3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$

___ 50. Given the following bond energies: C-C 349 kJ/mol C-H 416 kJ/mol
C-O 361 kJ/mol O-H 466 kJ/mol

What is the bonding energy for ethanol, $C_2H_5OH(g)$?

$$2C(g) + 6H(g) + O(g) \rightarrow \begin{array}{c} H\ H \\ |\ \ | \\ H\text{–}C\text{–}C\text{–}O\text{–}H \\ |\ \ | \\ H\ H \end{array}$$

A. 1.59×10^3 kJ/mol B. 2.01×10^3 kJ/mol C. 2.84×10^3 kJ/mol D. 3.26×10^3 kJ/mol

___ 51. Calculate the ΔH for the following reaction using the bond energies given below.

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

Bond Energies: H–H = 436 kJ/mol, I–I = 151 kJ/mol, H–I = 297 kJ/mol

A. +290 kJ B. -290 kJ C. +7 kJ D. -7 kJ

___ 52. Which statement correctly describes an endothermic chemical reaction?

A. The products have higher potential energy than the reactants, and ΔH is negative.
B. The products have higher potential energy than the reactants, and the ΔH is positive.
C. The products have lower potential energy than the reactants, and the ΔH is negative.
D. The products have lower potential energy than the reactants, and the Δ H is positive.

___ 53. The following decomposition reaction may occur in an air bag. $2NaN_3(s) \rightarrow 3N_2(g) + 2Na(s)$ $\Delta H = -43.5$ kJ
What is the heat of formation, ΔH_f, for NaN_3?

A. -43.5 kJ B. -21.8 kJ C. 21.8 kJ D. 43.5 kJ

___ 54. A small sample released 2.0×10^{10} kJ of energy while undergoing a change. What type of change most likely occurred?

A. chemical B. molecular C. nuclear D. physical