Chapters 6 Questions

Section 6.1 & 6.2(a)

1) Suppose you toss a tennis ball upward.
a) Does the kinetic energy of the ball increase or decrease as it moves higher?
b) Does the potential energy of the ball increase or decrease as it moves higher?
c) At what point does the potential energy of the ball reach a maximum?

2a) What is meant by the term system in thermodynamics?
b) When a system loses heat to the surroundings, what kind of process is this?
c) A chemical reaction has a $+\Delta H$. In order for the reaction to proceed, what must happen?
d) A chemical reaction has a $-\Delta H$. Compare the enthalpy of the reactants compared to the products.

3) In a thermodynamic study, a scientist focuses on the properties of a solution in a flask that is sealed with a stopper.
a) What is the system in the study?
b) What are the surroundings in the study?
c) Is the system in this study a closed system?

4) Which of the following has the highest enthalpy at a given temperature and pressure: H_2O (s), H_2O (l) or H_2O (g)? Which has the lowest enthalpy?

5) Consider the following reaction, which occurs at room temperature and pressure:

$$2\ Cl\ (g) \rightarrow Cl_2\ (g)\quad \Delta H = -243.4\ kJ$$

a) Which has the higher enthalpy under these conditions, 2 Cl (g) or Cl_2 (g)?
b) Draw an enthalpy diagram for the reaction.

6) Given the reaction

$$SnO_2\ (s) + C\ (s) \rightarrow Sn\ (s) + CO_2\ (g)\quad \Delta H = +\ 360.0\ kJ$$

Draw an enthalpy diagram for the reaction.

7) The complete decomposition of liquid acetic acid to form H_2O (l) and CO_2 (g) at constant pressure releases 871.7 kJ if heat per mole of reactant.
a) Write a balanced thermochemical equation for this reaction.
b) Draw an enthalpy diagram for the reaction.

8) Consider the following reaction:
$2\ Mg\ (s) + O_2\ (g) \rightarrow 2\ MgO\ (s)\quad \Delta H = -1204\ kJ$
a) Is the reaction exothermic or endothermic?
b) Calculate the amount of heat transferred when 2.40 g of Mg (s) reacts at constant pressure.
c) How many grams of MgO are produced during an enthalpy change of 96.0 kJ?
d) How many kilojoules of heat are absorbed when 7.50 g of MgO (s) are decomposed into Mg (s) and O_2 (g) at constant pressure?

9) Consider the following reaction
$CH_3OH\ (g) \rightarrow CO\ (g) + 2\ H_2\ (g)\quad \Delta H = +90.7\ kJ$
a) Is the reaction exothermic or endothermic?
b) Calculate the amount of heat transferred when 45.0 g of CH_3OH (g) are decomposed at constant pressure.
c) If the enthalpy change is 16.5 kJ, how many grams of hydrogen gas are produced?
d) How many kilojoules of heat are released when 10.0 g of CO (g) reacts completely with hydrogen gas to form CH_3OH (g) at constant pressure?

Section 6.2(b)

10a) What is the specific heat of liquid water?
b) Pools are often cold until June and stay warm through September. Explain this in terms of specific heat.
c) Insulators have high specific heats and conductors have low specific heats. Explain why this is.

c) The specific heat of toluene, C_7H_8, is 1.13 J/gK. How many joules of heat are lost when 40.0 g of toluene is cooled from 28.0 ^{O}C to 10.4 ^{O}C?
d) How many kJ of heat are needed to raise the temperature of 10.00 kg of liquid water from 24.6 ^{O}C to 46.2 ^{O}C?

11a) How much energy does it take to heat the 500 g of water in your Keurig from 8.0 ^{O}C to 45.0 ^{O}C to make your coffee in the morning?
b) The specific heat of copper metal is 0.385 J/gK. How many joules of heat are necessary to raise the temperature of a 1.42 kg block of copper from 25.0 ^{O}C to 88.5 ^{O}C?

12a) A 54.7 g piece of aluminum at 15.7 OC is heated with 4440 J of energy. If aluminum has a specific heat of 0.890 J/gK, what temperature will the aluminum get to?
b) What is the mass of a piece of plastic (c = 1.76 J/gK) that is heated from 279 K to 313 K with 62.8 kJ of energy?

13) What is the specific heat of a 50.0 g piece of metal that is at 22.7 ^{O}C and is placed in 300 g of water at 47.2 ^{O}C and cools the water to 46.7 ^{O}C?

14) A 60 kg person drinks 750 g of water at 4.0 ^{O}C. If a person's specific heat is approximately 3.5 J/gK, at what temperature would the person's body and the water meet? Normal body temperature is 37.0 ^{O}C.

15) When a 6.50 g sample of solid sodium hydroxide dissolves in 100.0 g of water in a calorimeter, the temperature rises from 21.6 ^{O}C to 37.8 ^{O}C. Calculate ΔH (in kJ/mol NaOH) for the solution process

$NaOH (s) \rightarrow Na^{+} (aq) + OH^{-} (aq)$.

Assume that the specific heat of the solution is the same as that of pure water.

16) When a 4.25 g sample of solid ammonium nitrate dissolves in 60.0 g of water in a calorimeter, the temperature drops from 22.0 ^{O}C to 16.9 ^{O}C. Calculate the ΔH (in kJ/mol NH_4NO_3) for the solution process

$NH_4NO_3 (s) \rightarrow NH_4^{+} (aq) + NO_3^{-} (aq)$.

Assume that the specific heat of the solution is the same as that of pure water.

Section 6.3

17) Consider the following hypothetical reactions:

A --> B $\Delta H = +30$ kJ

B --> C $\Delta H = +60$ kJ

a) Use Hess's law to calculate the enthalpy change for the reaction A --> C.

b) Construct an enthalpy diagram for substances A, B and C and show how Hess's law applies.

18) Consider the following hypothetical reactions:

X --> Y $\Delta H = -40$ kJ

X --> Z $\Delta H = -95$ kJ

a) Use Hess's law to calculate the enthalpy change for the reaction Y --> Z.

b) Construct an enthalpy diagram for substances X, Y and Z and show how Hess's law applies.

19) Given the following enthalpies of reaction:

$P_4 (s) + 3 O_2 (g) \rightarrow P_4O_6 (s)$ $\Delta H = -1640.1$ kJ

$P_4 (s) + 5 O_2 (g) \rightarrow P_4O_{10} (s)$ $\Delta H = -2940.1$ kJ

Calculate the enthalpy change for the reaction:

$P_4O_6 (s) + 2 O_2 (g) \rightarrow P_4O_{10} (s)$

20) From the following enthalpies of reaction:

$H_2 (g) + F_2 (g) \rightarrow 2 HF (g)$ $\Delta H = -537.$ kJ

$C (s) + 2 F_2 (g) \rightarrow CF_4 (g)$ $\Delta H = -680.$ kJ

$2 C (s) + 2 H_2 (g) \rightarrow C_2H_4 (g)$ $\Delta H = +52.3$ kJ

Calculate ΔH for the reaction

$C_2H_4 (g) + 6 F_2 (g) \rightarrow 2 CF_4 (g) + 4 HF (g)$

21) From the following enthalpies of reaction:

$3 C (s) + 4 H_2 (g) \rightarrow C_3H_8 (g)$ $\Delta H = -103.85$ kJ

$C (s) + O_2 (g) \rightarrow CO_2 (g)$ $\Delta H = -393.5$ kJ

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

$H_2O (l) \rightarrow H_2O (g)$ $\Delta H = +44.0$ kJ

Calculate ΔH for the reaction

$C_3H_8 (g) + 5 O_2 (g) \rightarrow 3 CO_2 (g) + 4 H_2O (g)$

Section 6.4

22) Write balanced equations that describe the formation of the following compounds from their elements in the standard states, and use Appendix 4 to obtain the values of their standard enthalpies of formation.

a) HCl (g)
b) $NaNO_3$ (s)
c) Al_2O_3 (s)
d) CH_3OH (l)
e) NH_4ClO_4 (s)
f) UO_3 (s)

23) The following is known as the thermite reaction:

2 Al (s) + Fe_2O_3 (s) --> Al_2O_3 (s) + 2 Fe (s)

This highly exothermic reaction is used for welding massive units, such as propellers for large ships. Using enthalpies of formation in Appendix 4, Calculate ΔH^O for this reaction.

24) Using values from Appendix 4, calculate the standard enthalpy change for each of the following reactions:

a) 2 SO_2 (g) + O_2 (g) --> 2 SO_3 (g)
b) $Mg(OH)_2$ (s) --> MgO (s) + H_2O (l)
c) 4 FeO (s) + O_2 (g) --> 2 Fe_2O_3 (s)
d) $SiCl_4$ (l) + 2 H_2O (l) --> SiO_2 (s) + 4 HCl (g)
e) 2 AgI (s) + Cl_2 (g) --> 2 AgCl (s) + I_2 (g)
f) $CuCO_3$ (s) --> CuO (s) + CO_2 (g)

25) Calculate the standard enthalpy of formation of solid magnesium hydroxide, given the following data:

2 Mg (s) + O_2 (g) --> 2 MgO (s) ΔH^O = -1203.6 kJ

$Mg(OH)_2$ (s) --> MgO (s) + H_2O (l) ΔH^O = +37.1 kJ

2 H_2 (g) + O_2 (g) --> 2 H_2O (l)) ΔH^O = -571.7 kJ

Review

1) 25.0 mL of 0.400 M HNO_2 (K_a = 4.5 x 10^{-4}) is titrated with 0.100 M KOH.
a) What is the pH of the initial acid solution?
b) What is the pH of the initial base solution?
c) What volume of base will need to add to the acid to bring the acid to the equivalence point?
d) What would be the pH at the equivalence point?

2) Determine the pH of a 0.65 M solution of triethylamine, $(C_2H_5)_3N$ (K_b = 4.0 x 10^{-4}).

3) What volume of CO_2 is produced when 5.00 g of sodium bicarbonate neutralizes 30.0 mL of 0.100 M HCl when the temperature is 19 ^OC and the pressure in the room is 1.11 atm?

4) Write net ionic equations for the following reactions:
a) combustion of octane (C_8H_{18})
b) aqueous solutions of acetic acid and potassium hydroxide
c) solid calcium and aqueous lead (II) nitrate
d) Production of calcium chloride salt from it's parent acid and base.

5) Determine the moles of conjugate base needed to add to a 0.75 M solution of HClO (Ka = 3.5 x 10^{-8}) in order to make a buffer with a pH of 8.0.

6) Determine the oxidation state of chromium in the following compounds:
a) H_2CrO_4
b) $K_2Cr_2O_7$
c) $Cr(OH)_6^{-1}$
d) $CrCl_3$