10/17/2021

The Nature of Energy and Heat

PG 291 #8,10,11

8. The First Law of thermodynamics states that energy can neithe be created or destroyed: Δenergy $= 0$

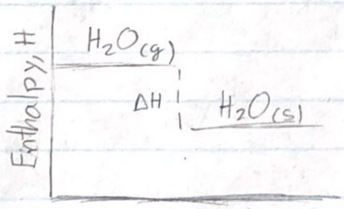
10. a) system: fire place sign: (−)
 ∴ energy is released in the form of heat when natural gas is burned

 b) system: pot sign: (+)
 ∴ energy is required to boil water and make particles move faster when energized

 c) system: couch sign (+)
 ∴ you require energy to stand up

 d) system: candle sign: (−)
 ∴ the candle is releasing energy while solidifying

11. $H_2O_{(s)} + \text{energy} \rightarrow H_2O_{(g)}$



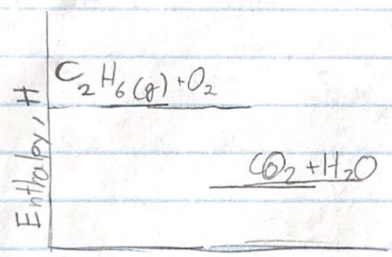
PG 295 #7-12

7. In a combustion reaction, energy is released. As a result, the enthalpy term is included as a product. The negative value indicates an exothermic reaction

8. Because energy is being released by the system, the products will have less potential energy than the reactants. As a result, the reactants will have more potential energy

9. $C_2H_{6(g)} + \frac{7}{2} O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(l)} + 1560.7 kJ/mol$

10.



11. -3228.2 kJ/mol

12. -1592.2 kJ/mol

PG 299 #11-20

11. $C_5H_{12(l)} + 8O_{2(g)} \longrightarrow 5CO_{2(g)} + 6H_2O_{(g)}$ $\Delta H = -3509.0\ kJ/mol$

a) $\frac{n_{C_{6}12}}{n_{O_2}} \times \frac{\Delta H}{n_{C_5H_{12}}} = \frac{1\ mol}{8\ mol} \times \frac{-3509\ kJ/mol}{1} = \frac{-3509\ kJ/mol}{8\ mol}$
$= -438.625\ kJ$

b) $\frac{n_{C_5H_{12}}}{n_{CO_2}} \times \frac{\Delta H}{n_{C_5H_{12}}} = \frac{1\ mol}{5\ mol} \times \frac{-3509\ kJ/mol}{1\ mol} = \frac{-3509\ kJ/mol}{5\ mol}$
$= -877.25\ kJ$

c) $\frac{n_{C_5H_{12}}}{n_{H_2O}} \times \frac{\Delta H}{n_{C_5H_{12}}} = \frac{1\ mol}{6\ mol} \times \frac{-3509\ kJ/mol}{1\ mol} = \frac{-3509\ kJ/mol}{6\ mol}$
$= -584.8\overline{3}\ kJ$

12. $m = 4.608\ g$

$n = \frac{m}{M} = \frac{4.608\ g}{46.08\ g/mol}$
$= 0.1\ mol$

$\Delta H_2 = (n)(H_{comb})$
$= (0.1\ mol)(-1336.8\ kJ/mol)$
$= -136.68\ kJ$

13. ΔH°_{comb} for hexane $= -4163.2\ kJ/mol$
ΔH°_{comb} for octane $= -5470.3\ kJ/mol$
ΔH°_{comb} for heptane $= -4817.0\ kJ/mol$

a) $m = 56.78\ g$; $n = \frac{m}{M} = \frac{56.78\ g}{86.2\ g/mol}$
$= 0.6587\ mol$

$\Delta H = (n)(\Delta H_{comb})$
$= (0.6587\ mol)(-4163.2\ kJ/mol)$
$= -2742.30\ kJ$

b) $m = 1.36\ kg$; $n = \frac{m}{M} = \frac{1360\ g}{114.26}$
$= 11.9\ mol$

$\Delta H = (n)(\Delta H_{comb})$
$= (11.9\ mol)(-5470.3\ \frac{kJ}{mol})$
$= -65\ 111.22\ kJ$

c) $m = 2.344 \times 10^4\ g$; $n = \frac{m}{M} = \frac{2.344 \times 10^4\ g}{100.23\ g/mol}$
$= 233.86\ mol$

$\Delta H = (n)(\Delta H_{comb})$
$= (233.86\ mol)(-4817.0\ kJ/mol)$
$= -1126513.818\ kJ$
$= -1.1 \times 10^6\ kJ$

14. $m = 1g$; $n = \frac{m}{M} = \frac{1g}{16.05\ g/mol}$
$= 0.0623 mol$

$\Delta H = n \Delta H_{comb}$
$= (0.0623 mol)(-890.8 kJ/mol)$
$= -55.501 kJ$

15. $\Delta H = n \Delta H_{comb} \rightarrow n = \frac{\Delta H}{\Delta H_{co}} = \frac{500 kJ}{5156 kJ/mol}$
$= 0.0969 mol$

$m = nm$
$= (0.0969 mol)(128.18\ g/mol)$
$= 12.42 g$

16. $\Delta H = n \Delta H_{comb} \rightarrow n = \frac{\Delta H}{\Delta H_{co}} = \frac{5.39 \times 10^5 kJ}{726.1 kJ/mol}$
$= 742.322 mol$

$m = nM$
$= (742.322)(32.05 g/mol)$
$= 23\ 791.4201 g$
$= 23.79 kg$

17. a) $-2058 kJ/mol$

b) $m = 5g$; $n = \frac{m}{M} = \frac{5g}{42.09}$
$= 0.11879 mol$

$\Delta H = n \Delta H_{comb}$
$= (0.11879 mol)(-2058 kJ/mol)$
$= 244.47 kJ$

18. a) $\Delta H_{comb} = \frac{\Delta H}{n} = \frac{-110.95 kJ/mol}{0.05 mol}$
$= -2219 kJ$

b) Propane

10/25/2021

Calorimetry Textbook

TB PG 305 #21-30

21. ① $m_{KOH} = 0.648g$

$n_{KOH} = \frac{m}{M} = \frac{0.648g}{56.11g/mol}$

$= 0.0115487$

② $\Delta T = T_f - T_i$

$= 27.8°C - 22.6°C$

$= 5.2°C$

③ $Q = mc\Delta T$

$= (40g)(4.184)(5.2°C)$

$= 870.272J$

$= 0.870272kJ$

④ $\Delta E_{system} = \Delta E_{surroundings}$

$\Delta H = -Q$

$\Delta H = -0.870272kJ$

⑤ $\Delta H_{soln} = \frac{\Delta H}{n} = \frac{-0.870272kJ}{0.0115487mol}$

$= -75.3567 kJ/mol$

22. ① $m_{NaHCO_3} = 5.022g$

$n_{NaHCO_3} = \frac{m}{M} = \frac{5.022g}{84.01g/mol}$

$= 0.059778mol$

② $\Delta T = t_f - t_i$

$= 28.4°C - 18.6°C$

$= 9.8°C$

③ $Q = mc\Delta T$

$= (80)(4.184)(9.8)$

$= 3280.256J$

$= 3.28kJ$

$m_b = 80.00g$

$n_b = \frac{m}{M} = \frac{80g}{60.06}$

$= 1.332mol$

④ $\Delta H_{sys} = -Q_{sol}$

$= -3.28kJ$

⑤ $\Delta H_r = \frac{\Delta H}{n}$

$= \frac{-3.28kJ}{0.059778mol}$

$= -54.870 kJ/mol$

23. ① $m_{Na} = 0.37g$

$n = \frac{m}{M} = \frac{0.37g}{22.99g/mol}$

$= 0.0160939mol$

② $\Delta t = t_f - t_i$

$= 25.70°C - 19.30°C$

$= 6.4°C$

③ $Q = mc\Delta t$

$= (175g)(4.184)(6.4)$

$= 4686.08J$

$= 4.686kJ$

④ $\Delta H_{sys} = -Q_{sol}$

$= -4.686kJ$

⑤ $\Delta H_r = \frac{\Delta H}{n} = \frac{-4.686kJ}{0.0160939mol}$

$= -291.166 kJ/mol$

Hilroy

24. ① $V_{total} = V_{BaCl_2} + V_{Na_2SO_4}$

$= 250.0mL + 150.0mL$

$= 400.0mL$

$= 400.0g$

② $n = cV$

$= (0.120\frac{mol}{L})(0.250L)$

$= 0.03\ mol$

③ $Q = mc\Delta t$

$= (400)(4.184)(0.49)$

$= 820.064\ J$

$= 0.820\ kJ$

④ $\Delta H_{sys} = -Q_{sol}$

$= -0.820kJ$

⑤ $\Delta H_r = \frac{\Delta H}{n} = \frac{-0.820kJ}{0.03mol}$

$= -27.3\ kJ/mol$

25. ① $n_{NH_3} = cV$

$= (0.2mol/L)(0.1L)$

$= 0.02mol$

$n_{HCl} = cV$

$= (0.2mol/L)(0.2L)$

$= 0.04mol$

$\therefore NH_3$ is the LR

② 1 : $-53.6kJ$

$0.02mol : -1.072kJ$

③ $Q_{sol} = -\Delta H_{sys}$

$= 1072J$

④ $Q = mc\Delta t \rightarrow \Delta t = \frac{Q}{mc} = \frac{1072J}{(300)(4.184)}$

$= 0.854°C$

26. ① $n_{NaOH} = cV$

$= (1\frac{mol}{L})(0.150L)$

$= 0.150\ mol$

$n_{HCl} = cV$

$= (1\frac{mol}{L})(0.150)$

$= 0.150\ mol$

② $\Delta t = t_f - t_i$

$= (30°C - 25°C)$

$= 5°C$

③ $Q = mc\Delta t$

$= (300mL)(4.184)(5)$

$= 6276J$

$= 6.276\ kJ$

④ $\Delta H_{sys} = -Q_{sol}$

$= -6.276\ kJ$

⑤ $\Delta H_r = \frac{\Delta H}{n} = \frac{-6.276kJ}{0.150mol}$

$= -41.84\ kJ/mol$

27. ① $n = cV$
$= (0.1\,\frac{mol}{L})(0.25L)$
$= 0.025\,mol$

② $\Delta H = n\Delta H_{sol}$
$= (0.025mol)(-55.0kJ/mol)$
$= -1.375kJ$
$= -1375J$

③ $Q_{sur} = -\Delta H$
$= 1375J$

④ $Q = mc\Delta t \rightarrow \Delta t = \frac{Q}{mc} = \frac{1375J}{(250)(4.184)}$
$= 1.3145°C$

28. ① $n_{LiOH} = cV$
$= (0.5\,\frac{mol}{L})(0.12L)$
$= 0.06\,mol$

$n_{HNO_3} = cV$
$= (0.375\,\frac{mol}{L})(0.16L)$
$= 0.06\,mol$

② $\Delta H = \Delta H_{sol}\,n$
$= (-53.1kJ/mol)(0.06mol)$
$= -3.186\,kJ/mol$

③ $Q_{sol} = -\Delta H_{sys}$
$= 3.186kJ$
$= 3186J$

④ $Q = mc\Delta t$
$\Delta t = \frac{Q}{mc} = \frac{3186J}{(280)(4.184)}$
$= 2.7195°C$

⑤ $2.7195°C = 24°C - t_i$
$t_i = 24°C - 2.7195°C$
$t_i = 21.28°C$

29. ① $m_{Na_2O_2} = 7.800g$

$n_{Na_2O_2} = \frac{m}{M} = \frac{7.800g}{77.98g/mol}$
$= 0.1000mol$

② $\frac{2mol\,Na_2O_2}{-285kJ} = \frac{0.1000mol\,Na_2O_2}{x}$

$x = \frac{(0.1000mol)(-285kJ)}{2mol}$

$x = -14.25kJ$
$\Delta H_r = -14.25kJ$

③ $Q_{sol} = -\Delta H_r$
$= 14\,250J$

④ $Q = mc\Delta t \rightarrow \Delta t = \frac{Q}{mc} = \frac{14\,250J}{(110g)(4.184)}$
$= 30.96°C$

30. ① $n_{KOH} = cV$

$= (1.00\ \frac{mol}{L})(0.200L)$

$= 0.200 mol$

$n_{H_2SO_4} = cV$

$= (1.00\ \frac{mol}{L})(0.200L)$

$= 0.200 mol$

② $H_2SO_4 : KOH$

$1 : 2$ *KOH is LR

$0.2 mol : 0.4 mol$

③ $Q_{sur} = mc\Delta t$

$= (400g)(4.184 J/g°C)(6.5°C)$

$= 10\,878.4 J$

$= 10.8784 kJ$

④ $\Delta H_r \stackrel{\Delta}{=} -Q_{sur}$

$= -10.878 kJ$

⑤ $\Delta H_r = \frac{\Delta H}{n} = \frac{-10.878 kJ}{0.2 mol}$

$= -54.39 kJ/mol$ of KOH

10/26/2021

Hess's Law Textbooook Questions

PG 323 #51–60

51. a) $C_2H_5OH_{(l)} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(g)}$

b) $\Delta H_{f_{C_2H_5OH}} = -277.6\,kJ/mol$; $\Delta H_{f_{O_2}} = 0\,kJ/mol$; $\Delta H_{f_{CO_2}} = -393.5\,kJ/mol$; $\Delta H_{f_{H_2O}} = -241.8\,kJ/mol$

$$\Delta H_{comb} = \sum(n\Delta H_f \text{ products}) - \sum(n\Delta H_f \text{ reactants})$$
$$= [2mol(-393.5kJ/mol) + 3mol(-241.8kJ/mol)] - [1mol(-277.6kJ/mol) + 3mol(0\tfrac{kJ}{mol})]$$

$$= [-787kJ - 725.4kJ] - [-277.6kJ]$$
$$= -787kJ - 725.4kJ + 277.6kJ$$
$$= \underline{-1234.8kJ}$$

52. $\Delta H_r = \sum(n\Delta H_f \text{ products}) - \sum(n\Delta H_f \text{ reactants})$
$$= [1mol(-314.4kJ/mol)] - [1mol(-45.9kJ/mol) + 1mol(-92.3kJ/mol)]$$

$$= -314.4kJ - (-45.9kJ - 92.3kJ)$$
$$= -314.4kJ - (-138.2kJ)$$
$$= -176.2kJ$$

53. $Zn_{(s)} + 2HCl_{(l)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$

a) $\Delta H_r = \sum(n\Delta H_f \text{ products}) - \sum(n\Delta H_f \text{ reactants})$
$$= [1mol(-488.2kJ/mol) + 1mol(0kJ/mol)] - [1mol(0kJ/mol) + 2mol(-167.2kJ/mol)]$$

$$= -488.2kJ + 334.4kJ$$
$$= -153.8kJ$$

b) ① $n = \frac{\Delta H}{\Delta H_r} = \frac{-123kJ}{-153.8kJ}$
$= 0.799739922mol$

② $m = nM$
$= (0.799739922mol)(65.38g/mol)$
$= 52.3g$

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

54. $\Delta H_r = \Sigma(n\Delta H_f \text{ products}) - \Sigma(n\Delta H_f \text{ reactants})$

$= [4mol(91.3 \frac{kJ}{mol}) + 6mol(-241.8 kJ/mol)] - [4mol(-45.9 kJ/mol) + 5mol(0 kJ/mol)$

$= (365.2kJ - 1450.8kJ) - (-183.6kJ + 0kJ)$

$= (-1085.6kJ + 183.6kJ$

$= -902kJ$

55. $\Delta H_r = \Sigma(n\Delta H_f \text{ products}) - \Sigma(n\Delta H_f \text{ reactants})$

$= [1mol(CHCl_3) + 3mol(-92.3kJ/mol)] - [1mol(-74.6 kJ/mol) + 3mol(0kJ/mol)]$

$-305.0kJ = \Delta H_f^\circ CHCl_3 - 276.9mol + 74.6kJ$

$\Delta H_f^\circ CHCl_3 = -305.0kJ + 276.9kJ - 74.6kJ$

$= -102.7 kJ/mol$

56. $\Delta H_r^\circ = \Sigma(n\Delta H_f \text{ products}) - \Sigma(n\Delta H_f \text{ reactants})$

$\Delta H^\circ_{comb} = (7mol(-393.5kJ/mol) + 8mol(-285.8kJ/mol)) - (1mol(\Delta H_f^\circ C_7H_{16}) + 11mol(0\frac{kJ}{mol}))$

$-4816.7kJ = (-2754.5kJ - 2284kJ) - (1mol(\Delta H_f^\circ C_7H_{16})$

$(1mol)(\Delta H_f^\circ C_7H_{16}) = -2754.5kJ - 2284kJ + 4816.7kJ$

$= -224.3 kJ/mol$

57. $\Delta H_r^\circ = \Sigma(n\Delta H_f \text{ products}) - \Sigma(n\Delta H_f \text{ reactants})$

$\Delta H_r^\circ = [(1mol)(-881.6\frac{kJ}{mol}) + (2mol)(-127.0kJ/mol)] - [(1mol)(-801.2kJ/mol) + (2mol)(-101.8kJ/mol)]$

$\Delta H_r^\circ = [-881.6kJ - 254kJ] - [-801.2kJ - 203.6kJ]$

$= -1135.6kJ + 1004.8kJ$

$= -130.8kJ$

10/27/2021

Chapter 5 Review

PG 343 - 349 #1-4, 7, 10, 13, 17, 18, 22, 28, 30, 32-39, 41-45, 47, 63

1. B 2. C 3. B 4. C 7. A 10. D 13. C

17. When water is heated to 110°C at standard pressure, its starts to build up energy. At the molecular lewel, molecules will be in the process of decomposing, some molecules will be released in the form of water vapor.

18. a) • the system is the wax candle
• the surroundings include everything else
b) $\Delta E_{universe} = 0$

22. a) product b) this indicates that extra energy is required in order to make a bond between between N_2 and O_2

28. The temperature of the solution starts to decrease because the reaction is endothermic. Thermal energy is absorbed from water in the beaker, which cools with the beaker. Water from air condenses on the cold beaker.

30. $\Delta H_f^\circ = \sum(\Delta H^\circ)$
$= (-65.2kJ + 178.1kJ - 16.2kJ)$
$= 96.7kJ$

32. a) $Cu(NO_3)_2\,(s) + 302.9kJ \longrightarrow Cu_{(s)} + N_{2(g)} + 3O_{2(g)}$

b) ① $n_{Cu} = \frac{m}{M} = \frac{37.9g}{63.55g/mol}$
$= 0.59638mol$

② $\frac{\Delta H}{Q} = \frac{302.9kJ}{Q} = \frac{1mol}{0.59638mol}$

$Q = 180.64kJ$

33. Because the equation has been reversed, the sign of ΔH changes and the arrow points in the opposite direction. Because both sides of the equation have also been divided by 2 to balance the equation, ΔH also needs to be divided by 2

34. a) $\Delta H_{melt} = \frac{\Delta H}{n} = \frac{98.1kJ}{0.3mol} = 327\ kJ/mol$

b) $Pb_{(l)} \rightarrow Pb_{(s)} + 327\ kJ/mol$

35. $\frac{1}{4}P_{4(s)} + \frac{3}{2}Cl_{2(g)} \longrightarrow PCl_3 \quad \Delta H_f^\circ = -23.2kJ$

~~36.~~
$$\cancel{H_2O_{(l)} \longrightarrow H_{2(g)} + \frac{1}{2}O_{2(g)} \quad \Delta H^\circ = +285.8kJ}$$
$$\cancel{C_3H_{4(g)} + 4O_{2(g)} \longrightarrow 3CO_{2(g)} + 2H_2O_{(l)} \quad \Delta H = -1936.8kJ}$$
$$\cancel{C_3H_{8(g)} + 5O_{2(g)} \longrightarrow 3CO_{2(g)} + 4H_2O_{(l)} \quad \Delta H = -2219.2kJ}$$

36. $H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O$

37. $\Delta H_{r} = \Sigma(n\Delta H_f\ products) - \Sigma(n\Delta H_f\ reactants)$

$= [1mol(Ni(CO)_4)] - [(1mol)(Ni) + (4mol)(CO)]$

$-159.6kJ = [(1mol)(Ni(CO)_4)] - [(1mol)(0kJ/mol) + (4mol)(-110.5\ kJ/mol)]$

$-159.6\ kJ = [(1mol)(Ni(CO)_4)] - [-442kJ/mol]$

$-(1mol)(Ni(CO)_4) = 159.6kJ + 442kJ/mol$

$\frac{-(1mol)(Ni(CO)_4)}{-(1mol)} = \frac{601.6\ kJ/mol}{-(1mol)}$

$Ni(CO)_4 = -601.6kJ$

38. $\Delta H_r = \sum(n\Delta H_f \text{ products}) - \sum(n\Delta H_f \text{ reactants})$

$= [(1mol)(\Delta H_f C_4H_6) + (2mol)(\Delta H_f H_2O) + (1mol)(\Delta H_f H_2)] - [(2mol)(\Delta H_f C_2H_5OH)]$

$= [(1mol)(-391.1kJ/mol) + (2mol)(-241.8kJ/mol) + (1mol)(0\frac{kJ}{mol})] - [(2mol)(-277.6kJ/mol)]$

$= [-391.1kJ - 483.6kJ] - [-555.2kJ]$

$= -874.7kJ + 555.2kJ$

$= -319.5kJ$

41. a) ① $Q = mc\Delta t$

$= (90g)(4.184J/g°C)(2.21°C)$

$= 832.1976J$

$= 0.8321976kJ$

② $\Delta H = -Q$

$= -0.8321976kJ$

③ $n = \frac{m}{M} = \frac{1.20g}{65.41g/mol}$

$= 0.0183458mol$

④ $\Delta H_r = \frac{\Delta H}{n} = \frac{-0.8321976kJ}{0.0183458mol}$

$= -45.36175037kJ/mol$

b) different aparatus can lead to different results.
Ex: paper cup VS styrofoam cup

c) $p.d. = \frac{exp}{act} \times 100\% = \frac{-45.3617kJ/mol}{-155kJ/mol} \times 100\%$

$= -0.292656 \times 100\%$

$= 29.2656\%$

42. ① $Q = mc\Delta t$

$Q = (1000)(4.184)(15.5)$

$Q = 64852J$

$= 64.852kJ$

② $\Delta H = -Q$

$= -64.852kJ$

③ $\frac{1mol\ CS_2}{-1077kJ/mol} = \frac{x}{-64.852}$

$x = 0.0602mol$

④ $m = nM$

$= (0.0602)(76.15)$

$= 4.58g$

43. a) $-1096 kJ/mol = (1mol)(\Delta C_2N_2) - (2mol)(CO_2)$

$(1mol)(\Delta H_f C_2N_2) = -1096 kJ/mol + 787 kJ/mol$

$$\frac{(1mol)(\Delta H_f C_2N_2)}{1mol} = \frac{-309 kJ/mol}{1mol}$$

$\Delta H_f C_2N_2 = -309 kJ/mol$

b) $C_2N_{2(g)} \rightarrow C_2N_{2(g)} + 309 kJ$

44. a) Before solving for ΔH_r you would need to determine ~~the~~ what the limiting reactant is. In addition, you would need to determine the number of moles. You woud also need to flip the sign because $\Delta H = -Q$

b) Yes, because your calculations need to be based on the values of the LR

45. ① $Q = mc\Delta t$

$= (50g)(4184 J/g°C)(-1.6°C)$

$= -334.72 J$

$= -0.33472 kJ$

② $\Delta H_{sol} = -Q$

$= 0.33472 kJ$

③ $n = \frac{m}{M} = \frac{1g}{97.95}$

$= 0.010209 mol$

④ $\Delta H_{soln} = \frac{\Delta H}{n} = \frac{0.33472 kJ}{0.010209 mol}$

$= 32.78675 kJ/mol$

47.