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39. ΔH must be multiplied by four ($\frac{1}{4} P_4O_{10}$ to P_4O_{10}) which means $\Delta H = -430.4\ kJ$

40. Because the coeffs. are reduced by 1/4 ΔH must be reduced by 1/4 so $\Delta H = -226.5\ kJ$

41. $P_{4(s)} + 5\ O_{2(g)} \rightarrow P_4O_{10(s)}$ $\Delta H = -2942\ kJ$

$1\ mol\ P_4 = 123.89\ g$

$$\frac{123.89\ g}{-2942\ kJ} = \frac{1\ g}{x} \qquad x = -23.75\ kJ \text{ per gram } P_4$$

42. $N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$ $\Delta H = 90.3\ kJ$

$1\ mol\ N_2 = 28.0\ g\ N_2$ $\qquad \frac{28.0\ g}{90.3\ kJ} = \frac{1\ g}{x} \qquad x = +3.23\ kJ$

43. $4NH_{3(g)} + 3O_{2(g)} \rightarrow 2N_{2(g)} + 6H_2O_{(g)}$ $\Delta H = -1267\ kJ$

$4\ mol\ NH_3 = 68.0\ g$

$$\frac{68.0\ g}{-1267\ kJ} = \frac{25.6\ g}{x} \qquad x = -476.99\ kJ$$

44. $2H_2S_{(g)} + 3O_{2(g)} \rightarrow 2SO_{2(g)} + 2H_2O_{(g)}$ $\Delta H = -1037\ kJ$

$2\ mol\ H_2S = 68.2\ g$

$$\frac{68.2\ g}{-1037\ kJ} = \frac{36.9\ g}{x} \qquad x = -561.0\ kJ$$

45. $q = mC_p\Delta T = (180.\text{g})(4.184)(96-15)$
$= (180.\text{g})(4.184)(81)$
$= 61002\text{J}$

46. $q = mC_p\Delta T = (1510\text{g})(.450)(178-21)$
$= (1510\text{g})(.450)(75-7)$
$= 106681\text{J}$

47. $q_{steam} = mC_p\Delta T$

steam: $(2.26\text{kJ/g})(124\text{g}) = 280.24\text{kJ}$
$= 280240\text{J}$

air:

$280240\text{J} = (6.44\times10^4)(1.015)(\Delta T)$

$\Delta T = 4.29^\circ\text{C}$

53. ① $H_2O_2(\ell) \rightarrow H_2O(\ell) + \frac{1}{2}O_2(g)$ $\Delta H = -98.0\text{kJ}$
② $2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$ $\Delta H = -571.6\text{kJ}$

① $\frac{1}{2}O_2 + H_2O \rightarrow H_2O_2$ $\Delta H = +98.0\text{kJ}$
① $O_2 + 2H_2O \rightarrow 2H_2O_2$ $\Delta H = +196.0\text{kJ}$
② $2H_2 + O_2 \rightarrow 2H_2O$ $\Delta H = -571.6\text{kJ}$

$2H_2 + 2O_2 \rightarrow 2H_2O_2$ $\Delta H = -375.6\text{kJ}$

$+ \quad H_2 + O_2 \rightarrow H_2O_2$ $\Delta H = -187.8\text{kJ}$

54. ① $N_2H_4 + O_2 \rightarrow N_2 + 2H_2O$ $\Delta H = -622.2\text{kJ}$
② $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ $\Delta H = -285.8\text{kJ}$

① $N_2 + 2H_2O \rightarrow N_2H_4 + O_2$ $\Delta H = +622.2\ kJ$

② $2H_2 + O_2 \rightarrow 2H_2O$ $\Delta H = -571.6\ kJ$

$N_2 + 2H_2 \rightarrow N_2H_4$ $\Delta H = +50.6\ kJ$

55. ① $N_2 + O_2 \rightarrow 2NO$ $\Delta H = +180.6\ kJ$

② $N_2 + 3H_2 \rightarrow 2NH_3$ $\Delta H = -91.8\ kJ$

③ $2H_2 + O_2 \rightarrow 2H_2O$ $\Delta H = -483.7\ kJ$

① $2N_2 + 2O_2 \rightarrow 4NO$ $\Delta H = +361.2\ kJ$

$2NH_3 \rightarrow N_2 + 3H_2$ $\Delta H = +91.8\ kJ$

② $4NH_3 \rightarrow 2N_2 + 6H_2$ $\Delta H = +183.6\ kJ$

③ $6H_2 + 3O_2 \rightarrow 6H_2O$ $\Delta H = -1451.1\ kJ$

Add ①, ②, ③

$(+361.2) + (183.6) + (-1451.1) = -906.3\ kJ$

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$ $\Delta H = -906.3\ kJ$

56. ① $N_2 + 3H_2 \rightarrow 2NH_3$ $\Delta H = -91.8\ kJ$

② $C + 2H_2 \rightarrow CH_4$ $\Delta H = -74.9\ kJ$

③ $H_2 + 2C + N_2 \rightarrow 2HCN$ $\Delta H = 270.3\ kJ$

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$2NH_3 \rightarrow N_2 + 3H_2$ $\Delta H = +91.8\ kJ$

① $NH_3 \rightarrow \frac{1}{2}N_2 + 1.5H_2$ $\Delta H = +45.9\ kJ$

② $CH_4 \rightarrow C + 2H_2$ $\Delta H = +74.9\ kJ$

③ $\frac{1}{2}H_2 + C + \frac{1}{2}N_2 \rightarrow HCN$ $\Delta H = +135.15\ kJ$

$CH_4 + NH_3 \rightarrow HCN + 3H_2$ $\Delta H = +255.95\ kJ$

57. ① $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ $\Delta H = -1401\ kJ$

② $C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O$ $\Delta H = -1550\ kJ$

③ $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ $\Delta H = -286\ kJ$

① $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$ $\Delta H = -1401\ kJ$

② $2CO_2 + 3H_2O \rightarrow C_2H_6 + 3\frac{1}{2}O_2$ $\Delta H = +1550\ kJ$

③ $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ $\Delta H = -286\ kJ$

$C_2H_4 + H_2 \rightarrow C_2H_6$ $\Delta H = -137\ kJ$

58. ① $CH_3COOH + 2O_2 \rightarrow 2CO_2 + 2H_2O$ $\Delta H = -871\ kJ$

② $C + O_2 \rightarrow CO_2$ $\Delta H = -394\ kJ$

③ $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ $\Delta H = -286\ kJ$

① $2H_2O + 2CO_2 \rightarrow 2O_2 + CH_3COOH$ $\Delta H = +871\ kJ$

② $2C + 2O_2 \rightarrow 2CO_2$ $\Delta H = -788\ kJ$

③ $2H_2 + O_2 \rightarrow 2H_2O$ $\Delta H = -572\ kJ$

$2C + 2H_2 + O_2 \rightarrow CH_3COOH$ $\Delta H = -489\ kJ$

59. $CCl_4(\ell) \rightarrow CCl_4(g)$

$\Delta H_{rxn} = \Delta H_{prod} - \Delta H_{rxts}$

$= [CCl_{4(g)} - CCl_{4(\ell)}]$

$= [(-96.0) - (-139)]$

$\Delta H_{rxn} = +43\ kJ$

60. $\Delta H_{rxn} = \Delta H_{C_2H_5OH(g)} - \Delta H_{C_2H_5OH(\ell)}$

$= [(-235.4) - (-277.6)]$

$= +42.2\ kJ$

61. $\Delta H_{rxn} = [(2\Delta H_{SO_2} + 2\Delta H_{H_2O(\ell)}) - (2\Delta H_{H_2S} + 3\Delta H_{O_2})]$

$= [2(-296.8) + 2(-285.840)] - [2(-20.2) + 3(0)]$

$= (-593.6 + -571.68) - (-40.4)$

$= -1124.88\ kJ$

$= [2\Delta H_{SO_2} + \Delta H_{CO_2(g)}] - [\Delta H_{CS_2(\ell)} + 3\Delta H_{O_2}]$

62. $\Delta H_{f\,rxn} = [2(-296.8) + (-393.5)] - [87.9 + 3(0)]$

$[-593.6 + -393.5] - (87.9)$

$(-987.1) - 87.9 =$ **-1075 kJ**

63. $\Delta H_{rxn} = [2\Delta H_{SO_2} + 2\Delta H_{PbO}] - [2\Delta H_{PbS} + 3\Delta H_{O_2}]$

$= [2(-296.8) + 2(-218)] - [2(-98.3) + 3(0)]$

$= [-593.6 + -436] - [-196.6 + 0]$

$= -833$ kJ

64. $\Delta H_{rxn} = [2\Delta H_{Fe} + 3\Delta H_{CO_2}] - [\Delta H_{Fe_2O_3} + 3\Delta H_{CO}]$

$= [2(0) + 3(-393.5)] - [-825.5 + 3(-110.5)]$

$= [0 + -1180.5] - [-825.5 + -331.5]$

$= -23.5$ kJ

65. $\Delta H_{rxn} = [\Delta H_{H^+} + \Delta H_{Cl^-}] - [\Delta H_{HCl(g)}]$

$= [0 + -167.46] - [-92.31]$

$= -167.46 + 92.31$

$= -75.15$ kJ

66. $\Delta H_{rxn} = [2\Delta H_{Ca^{2+}} + 2\Delta H_{HCO_3^-}] - [\Delta H_{CaCO_3} + \Delta H_{CO_2} + \Delta H_{H_2O(\ell)}]$

$= [-542.96 + 2(-691.11)] - [-1206.9 + -393.5 + -285.840]$

$= [-1925.18] - [-1886.24]$

$= -38.94$ kJ

67. $\Delta H_{rxn} = [5\Delta H_{H_2O(\ell)} + 4\Delta H_{CO_2}] - [\Delta H_{C_4H_{10}} + \frac{13}{2}\Delta H_{O_2}]$

$-2855 = [5(-285.840) + 4(-393.5)] - (\Delta H_{C_4H_{10}} + \frac{13}{2}(0))$

$-2855 = [-3003.2] - \Delta H_{C_4H_{10}} + 0$

$-2855 + 3003.2 = -\Delta H_{C_4H_{10}}$

$148.2 = -\Delta H_{C_4H_{10}}$

$\Delta H_{f\,C_4H_{10}} = -148.2$ kJ/mol

68. $\Delta H_{rxn} = [2\Delta H_{CO_2} + \Delta H_{SO_2} + 3\Delta H_{H_2O(\ell)}] - [\Delta H_{C_2H_5SH} + \frac{9}{2}\Delta H_{O_2}]$

$-1877 = [2(-393.5) + -296.8 + 3(-285.84)] - \Delta H_{C_2H_5SH} + 0$

$-1877 = [-787 + -296.8 + -857.52] - \Delta H_{C_2H_5SH}$

$-1877 = -1941.32 - \Delta H_{C_2H_5SH}$

$64.32 = -\Delta H_{C_2H_5SH}$ $\quad \boxed{\Delta H_{f\ C_2H_5SH} = -64.32 kJ}$

69. ~~$\frac{686\ Btu}{x\ cal} = \frac{1\ Btu}{252\ cal}$~~

~~$x = 172872$ calories~~ x

73. $\Delta H = 178.3 kJ$

$1 mol\ CaCO_3 = 100.1 g$

$\frac{178.3 kJ}{100.1 g} = \frac{x}{12.0 g}$

$\boxed{x = +21.37 kJ}$

74. $1 mol\ CaO = 56.1 g$

$\frac{-65.2 kJ}{56.1 g} = \frac{x}{28.1 g}$

$\boxed{x = -33.01 kJ}$

75. $\frac{5.48 g}{30.3 kJ} = \frac{46.0 g}{x}$

$1 mol\ HCHO_2 = 46.0 g$

$\boxed{x = 254.3 kJ}$

76. $\frac{52.0 kJ}{3.58 g} = \frac{x}{60.0 g}$

$1 mol\ HC_2H_3O_2 = 60.0 g$

$\boxed{x = 871.5 kJ}$

77. $q = m C_p \Delta T$

$235 = (121.6)(C_p)(35.5 - 20.4)$

$235 = (121.6)(C_p)(15.1)$

$\frac{235}{1836.16} = \frac{1836.16\, C_p}{1836.16}$

$C_p = .128 \text{ J/g°C}$

78. $q = m C_p \Delta T$

$47.0 = (35.4)(C_p)(3.45)$

$\frac{47.0}{122.13} = \frac{122.13\, C_p}{122.13}$

$C_p = .385 \text{ J/g°C}$

79. $m_{H_2O} C_{p\,H_2O} \Delta T_{H_2O} = m_{Zn} C_{p\,Zn} \Delta T_{Zn}$

$(50.0)(4.184)(100.00 - 96.68) = (25.3)(C_p)(96.68 - 25.00)$

$(50.0)(4.184)(3.32) = (25.3)(C_p)(71.68)$

$\frac{694.544}{1813.504} = \frac{1813.504\, C_p}{1813.504}$

$C_p = .383 \text{ J/g°C}$

80. $m_{metal} C_{p\,metal} \Delta T_{metal} = m_{H_2O} C_{p\,H_2O} \Delta T_{H_2O}$

$(19.6)(C_p)(61.67 - 30.00) = (26.7)(4.184)(30.00 - 25.00)$

$(19.6)(C_p)(31.67) = (111.7128)(5.00)$

$\frac{620.732\, C_p}{620.732} = \frac{558.564}{620.732}$

$C_p = .900 \text{ J/g°C}$

~~86.~~ (e)

85. $SO_{2(g)} + H_2O_{(g)} \rightarrow H_2S_{(g)} + \frac{3}{2}O_{2(g)}$ $\Delta H = +519\,kJ$

$\frac{1}{8}S_8 + O_{2(g)} \rightarrow SO_{2(g)}$ $\Delta H = -297\,kJ$

$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)}$ $\Delta H = -242\,kJ$

$H_{2(g)} + \frac{1}{8}S_{8(rhombic)} \rightarrow H_2S_{(g)}$ $\boxed{\Delta H = -20\,kJ}$

86. (a, b)

$C_2H_4O_{(g)} + \frac{5}{2}O_{2(g)} \rightarrow 2CO_{2(g)} + 2H_2O_{(l)}$ $\Delta H = -1306.1\,kJ$

$3H_2O_{(l)} + 2CO_{2(g)} \rightarrow HOCH_2CH_2OH_{(l)} + \frac{5}{2}O_{2(g)}$ $\Delta H = +1189.8\,kJ$

$C_2H_4O_{(g)} + H_2O_{(l)} \rightarrow HOCH_2CH_2OH_{(l)}$ $\boxed{\Delta H = -116.3\,kJ}$

Ch 11

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22. a. sublimation
b. evaporation
c. deposition
d. freezing
e. melting

26. $6.92 \text{ min} = 415.2 \text{ s}$

$$\frac{4.66 \text{ J}}{1 \text{ s}} = \frac{x}{415.2 \text{ s}} \qquad x = 1934 \text{ J}$$

$$\frac{35.8 \text{ g Cd}}{1934 \text{ J}} = \frac{112.4 \text{ g}}{x} \qquad x = 6072 \text{ J/mol}$$

$$= 6.072 \text{ kJ/mol}$$

28. $\frac{21.3 \text{ kJ}}{\text{mol}}$ $\quad 1 \text{ mol } C_4H_{10} = 58.0 \text{ g}$

$$\frac{21.3 \text{ kJ}}{58.0 \text{ g}} = \frac{x}{31.4 \text{ g}} \qquad x = 11.5 \text{ kJ}$$

30. $q_{lost} = q_{gained}$

$q_{water} = q_{ice}$

$m C_p \Delta T = m(\Delta H_{fus})$

$(36.2)(4.184)(21.0 - 0.0) = m(334)$

$3180.7 = 334m$

$9.52 \text{ g} = m$

$6.01 \text{ kJ/mol} = 6010 \text{ J/mol}$

$\frac{6010 \text{ J}}{18 \text{ g}} = \frac{x}{1 \text{ g}}$

$x = 334 \text{ J/g}$

32. $q_{lost} = q_{gained}$

$q_{steam} = q_{water}$

$m \Delta H_{vap} = n C_p \Delta T$

$m(2261) = (275)(4.184)(76-21)$

$2261m = 63283$

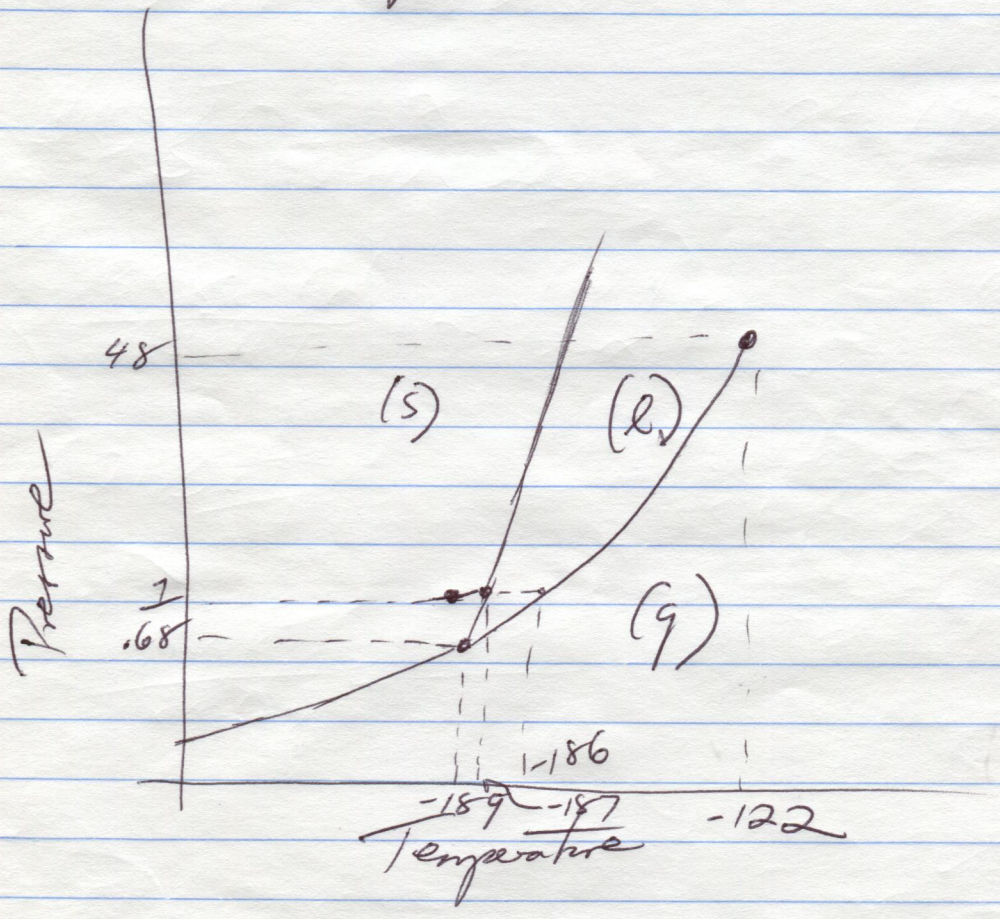
$\boxed{m = 27.9\ g}$

$40.7\ kJ/mol = 40700\ J/mol$

$\frac{40700\ J}{18\ g} = \frac{x}{1\ g}$

$\boxed{x = 2261\ J/g}$

38.



Pg 739-740, 743

22. $\Delta S = \frac{q}{T}$ $\quad 35.6°C = 308.6K$

$\frac{26.7kJ}{mol} = \frac{26700J}{mol}$ $\quad \frac{26700J}{50g} = \frac{x}{1g}$ $\quad x = \frac{534J}{g}$

$\Delta S = \frac{26700\frac{J}{mol}}{308.6K} = \boxed{86.5\frac{J}{mol \cdot K}}$

24. $\Delta S = \frac{q}{T}$ $\quad 25°C = 298K$

$\frac{-29kJ}{mol} = \frac{-29000J}{mol}$ $\quad \Delta S = \frac{-29000}{298} = \frac{-97.3J}{mol \cdot K}$

$\Delta S_{TOT} = (248 + -973) = \boxed{150.7\ J/mol \cdot k}$

26. a. + b. − c. − d. +

28. a. $[2(40)] - [2(41.6) + (205)]$

$80 - [83.2 + 205] = \boxed{-208.2\ J/mol \cdot k}$

b. $[186.3 + 2(205.7)] - [237.7 + 4(130.6)]$

$[186.3 + 411.4] - [237.7 + 522.4]$

$597.7 - 760.1 = \boxed{-162.4\ J/mol \cdot k}$

d. $[2(213.6) + 2(188.7)] - [219.3 + 3(205)]$

$[427.2 + 377.4] - [219.3 + 615]$

$804.6 - 834.3 = \boxed{-29.7\ J/mol \cdot k}$

32. $\Delta H = [2(-241.8) + 4(-393.5) + 2(0)] - [4(105) + 5(0)]$

$= (-483.6 + -1574) - (420)$

$= -2057.6 - 420 = \boxed{-2477.6 \text{ kJ/mol}}$

$\Delta S = [(2)(188.7)$ ~~$+188.7$~~

$= [2(188.7) + 4(213.6) + 2(191.5)] - [4(112.8) + 5(205)]$

$[377.4 + 854.4 + 383] - [451.2 + 1025]$

$1614.8 - 1476.2 = \boxed{138.6 \text{ J/mol} \cdot \text{K}}$

$\Delta G = \Delta H - T\Delta S$

$= -2477.6 - 298(.1386) = \boxed{-2518.9 \text{ kJ/mol}}$

36. $\Delta G = [2(-394.4) + 2(-228.6)] - [68.4 + 3(0)]$

$[-788.8 + -457.2] - 68.4$

$-1246 - 68.4 = \boxed{-1314.4 \text{ kJ/mol}}$

38. a. spontaneous
b. nonspontaneous
c. nonspontaneous
d. spontaneous
e. reversible

40. a. $\Delta H = [2(0) + 2(90.25)] - [2(-217.3) + 0]$

$= [0 + 180.50] - [-434.6]$

$180.50 + 434.6 = \boxed{615.1 \text{ kJ/mol / endothermic}}$

$\Delta G = [2(0) + 2(86.57)] - [2(-187.9) + 0]$

$= \boxed{548.94 \text{ kJ/mol / spontaneous}}$

b.

Pg. 743

66. ΔS will be positive due to increase in # moles of gases.

64. a. decrease → fewer moles gas produced
b. increase → 1 solid to 2 gases
c. decrease → 2 gases to 1 liquid
d. increase → greater disorder w/ ions in soln and gas produced

68. $\Delta S = [126.8] - [197.6 + 2(130.6)]$
$= -332 \text{ J/mol·K}$

76. $\Delta H = [-74.6 + 2(-20.6)] + [117.4 + 4(0)]$
$-115.8 - 117.4 = \boxed{-233.2 \text{ kJ/mol}}$
$\Delta S = [186.3 + 2(205.7)] - [237.7 + 4(130.6)]$
$= 597.7 - 760.1$
$= \boxed{-163 \text{ J/mol·K}}$

$\Delta G = -233.2 - 298(-.163)$
$\boxed{= -184.6 \text{ kJ/mol} / \text{spontaneous}}$

$\Delta G = -233.2 - 923(-.163)$
$\boxed{= -82.7 \text{ kJ/mol spontaneous (not as fast)}}$