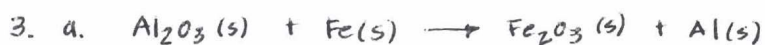


Thermodynamic Homework Key

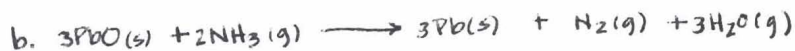
1. a. + c. +
b. - f. +
c. - g. -
d. - h. +

2. a, b, c



$$\Delta G^\circ = [(-742.2 \text{ kJ/mol} + 0)] - [(-1582.3) + (0)]$$

$$\Delta G^\circ = 840.1 \text{ kJ/mol}$$



$$\Delta G^\circ = [(3)(-228.72) + 0 + 0] - [(3)(-217.3) + (2)(-16.4)] = -1.46 \text{ kJ/mol}$$

↳ spontaneous



$$\Delta G^\circ = [(1)(-32) + (0)] - [(2)(50.5)] = 69 \text{ kJ/mol}$$

4. A - largest atom

5. C - largest molecule

6. C

7. $\Delta S_{\text{sys}} = \frac{\Delta H_{\text{sys}}}{T} = \frac{-6.00 \text{ kJ}}{273} = -0.022 \text{ kJ/mol}\cdot\text{K}$ or $-22 \text{ J/mol}\cdot\text{K}$

8. $\Delta S_{\text{sys}} = \frac{\Delta H_{\text{sys}}}{T} = \frac{38.7 \text{ kJ/mol}}{351.15} = 110 \text{ J/mol}\cdot\text{K}$

9. $\Delta S_{\text{sys}} = \frac{\Delta H_{\text{sys}}}{T}$

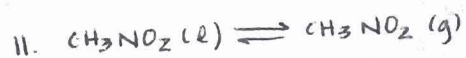
$$0.00950 \text{ kJ/mol}\cdot\text{K} = \frac{10.0 \text{ kJ/mol}}{T}$$

$$T = 1052 \text{ K}$$

$$10. \Delta S_{\text{sys}} = \frac{\Delta H_{\text{sys}}}{T}$$

$$0.099 \text{ kJ} = \frac{60.7 \text{ kJ/mol}}{T}$$

$$T = 613 \text{ K}$$



$$\Delta S_{\text{sys}} = \frac{\Delta H_{\text{sys}}}{T}$$

$$\begin{array}{r} \Delta H \quad -113.1 \quad \quad -74.73 \\ \Delta S \quad 171.76 \quad \quad 274.42 \end{array}$$

$$0.10266 \text{ kJ/mol} = \frac{38.37 \text{ kJ/mol}}{T}$$

$$T = 373 \text{ K}$$

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

$$0 = \Delta H - T\Delta S$$

$$T = \frac{\Delta H}{\Delta S}$$

$$12. \Delta G^\circ = [(2)(-372)] - [(2)(301) + (0)]$$

$$\Delta G^\circ = -142 \text{ kJ/mol}$$

$$13. \text{D} \quad \Delta G = \Delta H - T\Delta S$$

$$\underbrace{\quad - \quad + \quad}_{\text{always negative}}$$

always negative

$$4. \Delta G^\circ = [(1)(-204.6)] - [(1)(-137.168) + (0)]$$

$$\Delta G^\circ = -67.43 \text{ kJ/mol}$$



spontaneous

5. E

$$6. \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta H^\circ = [(2)(-285.83) + (82.05)] - [(-385.56)] = -124.05 \text{ kJ/mol}$$

$$\Delta S^\circ = [(2)(69.91) + (219.85)] - [(131.08)] = 0.20859 \text{ kJ/mol} \cdot \text{K}$$

$$\Delta G^\circ = -124.05 - (298)(0.20859)$$

$$\Delta G^\circ = -186 \text{ kJ/mol}$$

$$17. \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta H^\circ = [0 + 0] - [(2)(-90.83)] = 181.66 \text{ kJ/mol}$$

$$\Delta S^\circ = [(205.14) + (2)(76.02)] - [(2)(70.29)] = 0.2166 \text{ kJ/mol}\cdot\text{K}$$

$$\Delta G^\circ = 181.66 \text{ kJ/mol} - (298 \text{ K})(0.2166 \text{ kJ/mol}\cdot\text{K})$$

$$\Delta G^\circ = 117 \text{ kJ/mol}$$

$$18. \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G^\circ = (-92 \text{ kJ}) - (298 \text{ K})(-0.065)$$

$$\Delta G^\circ = -73 \text{ kJ/mol}$$

$$19. \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G^\circ = (-87.0 \text{ kJ}) - (400 \text{ K})(0.047)$$

$$\Delta G^\circ = -106 \text{ kJ/mol}$$

$$20. \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G^\circ = (-206) - (773 \text{ K})(-0.363)$$

$$\Delta G^\circ = 74.6 \text{ kJ/mol}$$

$$21. \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta G^\circ = 92.22 \text{ kJ} - (x)(0.19875)$$

$$x = 464 \text{ K}$$

$$22. \Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta H^\circ = [(-110.525) + (0)] - [(-218.8)] = 108.28 \text{ kJ/mol}$$

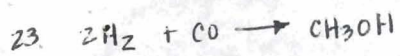
$$\Delta S^\circ = [(197.674) + (223.066)] - [283.53] = 137.21 \text{ J/mol}\cdot\text{K}$$

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

$$+ \quad - \quad \uparrow (+)$$

↑ temp spontaneous

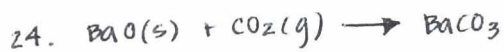
↓ temp nonspontaneous



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

$$\Delta G = (-128.13 \text{ kJ}) - (373 \text{ K})(-0.33223 \text{ kJ/mol}\cdot\text{K})$$

$$\Delta G = -4.21 \text{ kJ}$$



$$\Delta H^\circ = [(-1216.3)] - [(-553.3) + (-393.509)] = -269.29 \text{ kJ/mol}$$

$$\Delta S^\circ = [(112.1)] - [(70.42 + 213.74)] = -172.06 \text{ J/mol}\cdot\text{K}$$

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

$$\Delta G = -269.29 - (370 \text{ K})(-0.17206 \text{ kJ/mol}\cdot\text{K})$$

$$\Delta G = -205.63 \text{ kJ/mol}$$

$$25. \quad \Delta G = \Delta G^\circ + RT \ln Q$$

$$\Delta G = 6.2 \text{ kJ} + (8.314 \text{ J/mol}\cdot\text{K})(298 \text{ K}) \ln (.0263 \text{ atm})$$

$$\Delta G = -2.81 \text{ kJ/mol}$$

$$26. \quad \Delta G^\circ = -RT \ln K$$

$$\Delta G^\circ = - (8.314 \text{ J/mol}\cdot\text{K})(298) \ln (1.75 \times 10^{-5})$$

$$\Delta G^\circ = 27.1 \text{ kJ/mol}$$

$$27. \quad \Delta G^\circ = [(-202.87)] - [(-16.45) + (-95.3)]$$

$$\Delta G^\circ = -91.12 \text{ kJ/mol}$$

$$e^{-\Delta G^\circ/RT} = K$$

$$e^{-(-91.12)/(8.314)(298)} = K$$

$$K = 9.39 \times 10^{15}$$

$$28. \Delta G = \Delta G^\circ + RT \ln Q$$

$$\Delta G = (-41.0 \text{ kJ}) + (0.008314)(298) \ln \left[\frac{(0.002)^2 (0.001)}{0.1} \right]$$

$$\Delta G = -83.2 \text{ kJ}$$

$$29. \Delta G^\circ = -RT \ln K$$

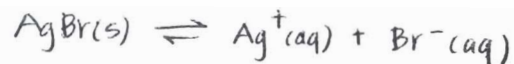
$$\Delta G^\circ = -(0.008314)(298) \ln (7.7 \times 10^{-13})$$

$$\Delta G^\circ = 69 \text{ kJ}$$

$$\Delta G = \Delta G^\circ + RT \ln Q$$

$$\Delta G = 69 \text{ kJ} + (0.008314)(298) \ln [(0.1)(0.1)]$$

$$\Delta G = 57.6 \text{ kJ}$$



$$Q = [\text{Ag}^+][\text{Br}^-]$$

$$Q = (0.1)(0.1)$$

$$30. \Delta G^\circ = -RT \ln K$$

$$27.1 = -(0.008314)(298) \ln K$$

$$-10.94 = \ln K$$

$$K = 1.78 \times 10^{-5}$$

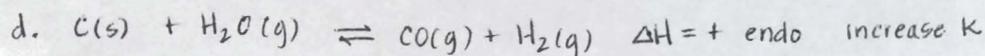
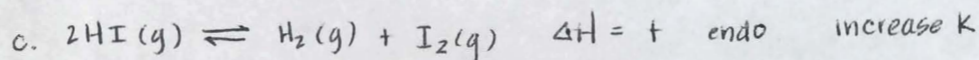
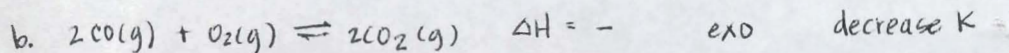
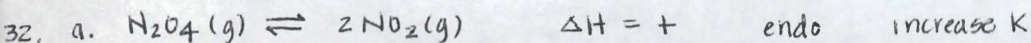
$$31. \Delta G = \Delta G^\circ + RT \ln Q$$

$$\Delta G = -8.686 \text{ kJ} + (0.008314)(304.8 \text{ K}) \ln 1.85 \times 10^{-7}$$

$$\Delta G = -47.96 \text{ kJ}$$

$$Q = (3.5 \times 10^{-2})(2.3 \times 10^{-3})^2$$

$$Q = 1.85 \times 10^{-7}$$



33. (a) $A \rightarrow C$ is melting

b. $A \rightarrow B \rightarrow C$ sublime to condense

c. cause it to sublime

(d) none are correct

34. all three phases co-exist.

35. $D \rightarrow B$ answer: b

solid \rightarrow gas sublimates

gas \rightarrow solid deposition