

Chem 1B Homework - Chapter 19 – Thermodynamics - 14th Edition

These problems can be found on pp. 838-847 of the textbook. Problems in parentheses are optional. Make sure to do the underlined problems.

4, 10, 16, 23, 31, 33, 35, 39, 41, 42, 43, 45, 47, 51ad, 55, 57c, 59a(c), 61, 63 (would each reaction be spontaneous at all temperatures, at no temperatures, at high temperatures, or at low temperatures? Explain.), 67, 69, 71, (experimental bp of benzene is 80°C), 73, 75, 77, 79ab, 81, 83, (96a, 97).

Additional Problems for Chapter 19

(See below for thermodynamic values to use for these problems.)

- The reaction: $\text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$ is nonspontaneous at room temperature but becomes spontaneous at a much higher temperature. What can you conclude from this about the signs of ΔH° and ΔS° ? Explain your reasoning.
 - Using thermodynamic data, estimate the temperature at which this reaction becomes spontaneous under standard conditions. What are standard conditions for this reaction?
 - At 500°C, is this reaction spontaneous or nonspontaneous under standard conditions?
 - At 500°C, if $P_{\text{CO}_2} = P_{\text{H}_2} = P_{\text{CO}} = 2.0 \text{ atm}$, what pressure of H_2O is needed to make this reaction spontaneous?
- Use thermodynamic data to determine the solubility of:
 - $\text{AgBr}(\text{s})$ at 40.°C
 - $\text{Na}_2\text{CO}_3(\text{s})$ at 75°C
- Using thermodynamic data, estimate the normal boiling point of ethanol, $\text{C}_2\text{H}_5\text{OH}$. Hint: the normal boiling point is the bp at 1.00 atm pressure. A liquid will boil when its vapor pressure equals the atmospheric pressure (or the external pressure, if it is not open to the atmosphere).
 - The actual boiling point of ethanol is 78 °C. Compare this with your result in part a.
- Estimate the vapor pressure of ethanol at 37 °C, using thermodynamic data. Express your result in mmHg.
- Estimate the temperature at which the vapor pressure of ethanol equals 500. mmHg. What is the approximate boiling point of ethanol at an external pressure of 500. mmHg?

6. The following reaction is nonspontaneous at room temperature.
 $\text{COCl}_2(\text{g}) \rightarrow \text{CO}(\text{g}) + \text{Cl}_2(\text{g})$
 To make it a spontaneous reaction, would you raise or lower the temperature?
 Explain, without doing a calculation. (Hint: what is the sign of ΔS ?)
7. The normal melting point of benzene is 5.5°C . For the melting of benzene at 1 atm, what is the sign of:
 a. ΔH° ? b. ΔS° ? c. ΔG° at 5.5°C ? d. ΔG° at 0.0°C ? e. ΔG° at 25.0°C ?
8. Sodium carbonate, an important chemical used in the production of glass, is made from sodium hydrogen carbonate by the reaction:
 $2\text{NaHCO}_3(\text{s}) \rightarrow \text{Na}_2\text{CO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$
 At $30.^\circ\text{C}$, $K_p = 1.66 \times 10^{-5}$ and at 100°C , $K_p = 0.231$.
 Estimate ΔH° and ΔS° for the above reaction from this data.

Thermodynamic Properties of Substances at 25°C

Substance	ΔH°_f , kJ/mol	ΔG°_f , kJ/mol	S° , J/K•mol
AgBr(s)	-100.4	-96.90	107
Ag ⁺ (aq)	105.6	77.11	72.68
Br ⁻ (aq)	-121.6	-104.0	82.4
Na ₂ CO ₃ (s)	-1131	-1044	135.0
Na ⁺ (aq)	-240.1	-261.9	59.0
CO ₃ ²⁻ (aq)	-677.1	-527.8	-56.9

Answers to additional problems, Ch. 19:

- ΔH and ΔS must both be +
 - 695°C
 - nonspontaneous
 - 0.6 atm
- 3×10^{-4} g/L (no sig figs)
 - 70 g/L (no sig figs)
- 76°C
 - close
- 100 mmHg
- 66°C , 66°C
- Raise temp
- a. + b. + c. 0 d. + e. -
- $\Delta H^\circ = 128$ kJ/mol, $\Delta S^\circ = 330$ J/mol•K