Non Sibi High School

Andover's Chem 550/580: Advanced Chemistry

Chapter 14, Review Quiz 1 Answers

1

Predict the sign of ΔS for each process:

a. Solid naphthalene dissolves in benzene.
b. Bromine vapor condenses.
c. $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$
d. Neon gas cools from 250°C to room temperature.
e. Solid arsenic sublimes.

a. Solid to solution, so $\Delta S > 0$.
b. Gas to liquid, so $\Delta S < 0$.
c. Although the total moles increase ($4 + 5 \longrightarrow 4 + 6$), the moles of gas decrease ($4 + 5 \longrightarrow 4$). Therefore, $\Delta S < 0$.
d. Temperature decreases, so $\Delta S < 0$.
e. Solid to gas, so $\Delta S > 0$.

2

Predict the sign of ΔS° and then calculate ΔS° for the reaction $2H_2S(g) + 3O_2(g) \longrightarrow 2H_2O(l) + 2SO_2(g)$ using the following information:

Compound	S° (J/mol · K)
$H_2O(l)$	70.
$H_2S(g)$	206
$O_2(g)$	205
$SO_2(g)$	248

ΔS° is expected to be negative because the moles of gas decrease during the reaction ($2 + 3 \longrightarrow 2$).

$$\Delta S^\circ = 2(70.) + 2(248) - 2(206) - 3(205) = -391\ \text{J/mol} \cdot \text{K}$$

3

For a certain reaction at 135°C, ΔH = -58 kJ/mol and ΔS = -185 J/mol·K. Calculate ΔG for the reaction at 135°C and determine if the reaction is spontaneous at this temperature.

$$\Delta G = -58\,\text{kJ/mol} - (135 + 273)\,\text{K}\left(-\frac{185}{1000}\,\text{kJ/mol}\cdot\text{K}\right) = 17\,\text{kJ/mol} > 0 = \text{nonspontaneous}$$

4

Determine whether reactions with the following ΔH and ΔS values will be spontaneous at all temperatures, nonspontaneous at all temperatures, spontaneous at high temperatures only, or spontaneous at low temperatures only. Also indicate the driving force for each spontaneous reaction:

a. ΔH = 82 kJ/mol, ΔS = 68 J/mol·K
b. ΔH = -326 kJ/mol, ΔS = 175 J/mol·K
c. ΔH = 592 kJ/mol, ΔS = -326 J/mol·K
d. ΔH = -97 kJ/mol, ΔS = -55 J/mol·K

a. spontaneous at high T only, entropy driven
b. spontaneous at all T, both enthalpy and entropy driven
c. nonspontaneous at all T
d. spontaneous at low T only, enthalpy driven

5

For a reaction with ΔH = -52.6 kJ/mol and ΔS = -125 J/mol·K, estimate the cutoff temperature in °C at which the reaction changes from spontaneous to nonspontaneous and also specify if the reaction is spontaneous above or below this cutoff temperature.

$$\Delta G = 0 = -52.6\,\text{kJ/mol} - \text{T}\left(-\frac{125}{1000}\,\text{kJ/mol}\cdot\text{K}\right)$$
$$\text{T} = 421\,\text{K}$$

Reaction is spontaneous below cutoff temperature 421 K - 273 = 148°C.

6

Calculate ΔG° for the reaction $N_2H_4(l) + 2H_2O_2(l) \longrightarrow N_2(g) + 4H_2O(g)$ using the following information:

$$\Delta G^\circ = 1(0) + 4(-228.6) - 1(149.3) - 2(-120.4) = -822.9\,\text{kJ/mol}$$

Compound	ΔG_f° (kJ/mol)
$H_2O(g)$	-228.6
$H_2O_2(l)$	-120.4
$N_2H_4(l)$	149.3

7

Given the reaction $Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$ $\Delta S^\circ = 15\,J/mol \cdot K$, use the information below to calculate S° for carbon monoxide gas:

Compound	S° (J/mol · K)
$CO_2(g)$	214
$Fe(s)$	27
$Fe_2O_3(s)$	87

$$\Delta S^\circ = 15\,J/mol \cdot K = 2(27\,J/mol \cdot K) + 3(214\,J/mol \cdot K) - 1(87\,J/mol \cdot K) - 3(S^\circ \text{ for } CO(g))$$

$$S^\circ \text{ for } CO(g) = 198\,J/mol \cdot K$$

8

Given the reaction $2NH_3(g) + 2O_2(g) \longrightarrow N_2O(g) + 3H_2O(l)$ $\Delta G^\circ = -575\,kJ/mol$, use the information below to calculate ΔG_f°, for $NH_3(g)$:

Compound	ΔG_f° (kJ/mol)
$H_2O(l)$	-237
$N_2O(g)$	104

$$\Delta G^\circ = -575\,kJ/mol = 104\,kJ/mol + 3(-237\,kJ/mol) - 2(\Delta G_f^\circ \text{ for } NH_3(g)) - 2(0\,kJ/mol)$$

$$\Delta G_f^\circ \text{ for } NH_3(g) = -16\,kJ/mol$$