Gibbs Free Energy Worksheet

Organic Chemistry Tutor

1. Which of the following statements is false?

A. The change in free energy is less than zero for a spontaneous process.

B. The change in free is equal to zero at equilibrium.

C. The maximum amount of work that can be obtained from a spontaneous process is equal to the change in free energy.

D. The change in free energy is greater than zero for a spontaneous process.

E. None of the above

2. The change in enthalpy and entropy for a certain reaction are -46.5 kJ/mol and 212 J/mol K. (a) Calculate the change in free energy at 25^0 C. (b) Is the reaction spontaneous, nonspontaneous, or at equilibrium?

A. -35.8 kJ/mol
B. +74.2 kJ/mol
C. -64.9 kJ/mol
D. -110 kJ/mol
E. +136 kJ/mol

3. Calculate the free energy change for the reaction shown below at 25^0 C.

$$H_{2\,(g)} + Cl_{2\,(g)} \rightarrow 2\ HCl_{(g)}$$

Substance	Enthalpy	Entropy
H_2 (g)	0 kJ/mol	131 J/mol K
Cl_2 (g)	0 kJ/mol	223 J/mol K
HCl (g)	-92 kJ/mol	187 J/mol K

A. -190 kJ
B. +125 kJ
C. -232 kJ
D. +146 kJ
E. -115 kJ

4. Calculate the free energy change of the reaction shown below using the standard free energy change of formation values in the data table.

$$4\ FeO_{(s)} + 1\ O_{2\,(g)} \rightarrow 2\ Fe_2O_{3\,(s)}$$

Substance	Free Energy Change
FeO (s)	-255 kJ/mol
Fe_2O_3 (s)	-740. kJ/mol

A. +265 kJ
B. -149 kJ
C. +365 kJ
D. -460 kJ
E. +785 kJ

5. Calculate the free energy change of the decomposition of Dinitrogen Pentoxide into Dinitrogen Tetroxide and Oxygen gas using the information shown below at 25^0 C.

$4\ NO_{2\,(g)} + O_{2\,(g)} \leftrightarrow 2\ N_2O_5$ $\Delta G = +60$ kJ

$2\ NO_{2\,(g)} \leftrightarrow N_2O_{4\,(g)}$ $\Delta G = -6$ kJ

$N_2O_{5\,(g)} \leftrightarrow N_2O_{4\,(g)} + \frac{1}{2}\ O_{2\,(g)}$ $\Delta G = ?$

A. -42 kJ
B. + 30 kJ
C. -36 kJ
D. +24 kJ
E. -30 kJ

6. The standard free energy change for a reaction under certain conditions is -65 kJ/mol. At this instant, which of the following events will occur?

A. The free energy change will increase as the reaction shifts to the left.

B. The free energy change will increase as the reaction shifts to the right.

C. The free energy change will decrease as the reaction shifts to the left.

D. The free energy change will decrease as the reaction shifts to the right.

E. The free energy change will remain the same since the reaction is at equilibrium.

7. Estimate the boiling point of Bromine. The enthalpy of vaporization of bromine is 30.9 kJ/mol. The standard entropy values for liquid and gaseous Bromine are 152 J/mol K and 245 J/mol K.

A. 25^0 C
B. 42^0 C
C. 59^0 C
D. 76^0 C
E. 94^0 C

8. Which of the following statements is false?

A. K is less than 1 for a spontaneous process.

B. For a nonspontaneous process, K is between 0 and 1.

C. If the standard free energy change is zero, then K is equal to 1.

D. The reaction is product favored when $K >> 1$.

E. The reaction is reactant favored when $K << 1$.

9. The equilibrium partial pressure constant is 1.4 x 10^{-5} at 298K for a certain reaction. Calculate the standard free energy change at 298K for that reaction.

A. -41.5 kJ/mol
B. +27.7 kJ/mol
C. +14.9 kJ/mol
D. -125 kJ/mol
E. +74.6 kJ/mol

10. The standard free energy change for a certain reaction at 298K is -215 kJ/mol. Calculate the value of the equilibrium constant for this reaction.

A. 1.4 x 10^{-22}
B. -3.6 x 10^{17}
C. 4.8 x 10^{37}
D. 9.3 x 10^{24}
E. 7.2 x 10^{-53}

11. Which of the following statements is true concerning the physical reaction shown below?

$$H_2O\ (l) \leftrightarrow H_2O\ (s)$$

A. The reaction is spontaneous at high temperatures.

B. The reaction is spontaneous at low temperatures.

C. The reaction is always spontaneous regardless of the temperature.

D. The reaction is never spontaneous.

E. The reaction is spontaneous at the freezing point.

12. Which of the following statements is true concerning the chemical reaction shown below?

$$H_{2\,(g)} \leftrightarrow 2\ H_{(g)}$$

A. The reaction is spontaneous at high temperatures.

B. The reaction is spontaneous at low temperatures.

C. The reaction is always spontaneous.

D. The reaction is never spontaneous.

E. None of the above.

13. The enthalpy and entropy change for a certain reaction is -140 kJ/mol and -350 J/mol K respectively. Which of the following statements is true concerning the reaction?

A. The reaction is spontaneous at temperatures above 400K.

B. The reaction is spontaneous at temperatures below 400K.

C. The reaction is spontaneous at temperatures above 300K.

D. The reaction is spontaneous at temperatures below 300K.

E. The reaction is at equilibrium at a temperature of 300K.

14. Calculate the free energy change for the reaction shown below at 298K when the partial pressures of SO_2, O_2, and SO_3 are 0.20 atm, 0.10 atm, and 0.01 atm.

$$2\ SO_{2\,(g)} + 1\ O_{2\,(g)} \rightarrow 2\ SO_{3\,(g)}$$

Substance	Free Energy Change
SO2 (g)	-300 kJ/mol
SO3 (g)	-371 kJ/mol

A. -275 kJ/mol
B. -151 kJ/mol
C. +342 kJ/mol
D. +121 kJ/mol
E. -199 kJ/mol

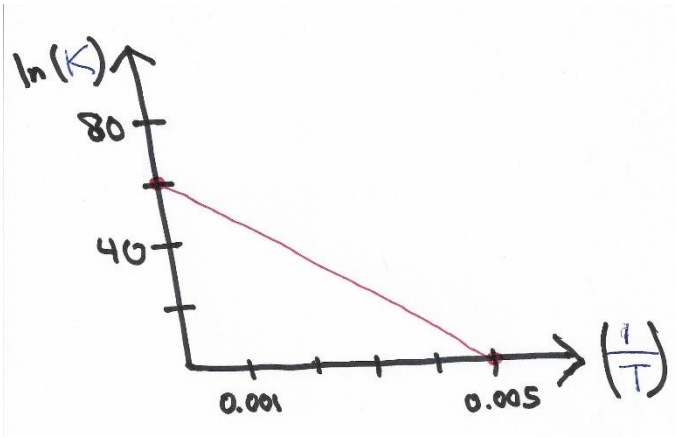
15. In what direction will the reaction shift if the partial pressure of Iodine is (a) 1 atm? (b) 2×10^{-7} atm? (c) What is the vapor pressure of Iodine at 298K at sea level?

$$I_{2\,(s)} \leftrightarrow I_{2\,(g)} \qquad \Delta G^0 = 19\ kJ/mol$$

16. The system below is currently at equilibrium. (a) What is the free energy change of the reaction shown below? Will the free energy change increase, decrease, or remain the same if (a) NO_2 is added to the system? (b) N_2O_4 is added to the system? (c) the temperature is increased? (d) the volume of the container increases?

$$2\ NO_{2\,(g)} \leftrightarrow N_2O_{4\,(g)} \qquad \Delta H = -58\ kJ$$

17. Determine the entropy change and enthalpy change for a reaction using the data plot shown below:



18. What is the maximum possible useful (in kJ) that can be obtained from the complete combustion of 80g of CH_4? (b) How much work can be generated from a combustion engine that uses natural gas such as methane in part (a) if the engine is 12% efficient?

19. What is the free energy change for the reaction shown below at 25^0C?

6C → 4A + 2D $K_1 = 2.8 \times 10^4$

2D + 2A → 4B + 2C $K_2 = 4.76 \times 10^{-5}$

1A + 2B → 2C $\Delta G^0 = ?$

20. The equilibrium partial pressures of NO, Br_2, and NOBr were measured to be 0.245 atm, 0.102 atm, and 0.817 atm at 25^0 C. Calculate the standard free energy change for the reaction shown below at 25^0 C.

$$2\ NO_{(g)} + 1\ Br_{2\ (g)} \leftrightarrow 2\ NOBr_{(g)}$$

Answers:

1. D

2a. D
2b. The reaction is spontaneous since ΔG is negative.

3. A
4. D
5. C
6. B
7. C
8. A
9. B
10. C
11. B
12. A
13. B
14. B

15a. It will shift to the left.
15b. It will shift to the right.
15c. 4.67×10^{-4} atm

16a. $\Delta G = 0$
16a. ΔG will decrease
16b. ΔG will increase
16c. ΔG will increase
16d. ΔG will increase

17. $\Delta H = +99.8$ kJ/mol, $\Delta S = 499$ J/mol K

18a. $W_{max} = -3{,}990$ kJ
18b. Work = -479 kJ

19. $\Delta G^0 = 360$ J/mol
20. $\Delta G = -11.6$ kJ/mol