HW03 - Chemical Equilibria

Question 1 — 1.5 pts

When the chemical reaction

A + B $\rightleftharpoons$ C + D

is at equilibrium, which of the following is true?

a. all four concentrations are equal
b. neither the forward nor the reverse reactions have stopped
c. the sum of the concentrations of A and B equals the sum of the concentrations of C and D
d. both the forward and reverse reactions have stopped

Question 2 — 1.5 pts

Explain why equilibrium constants are dimensionless.

a. They are dimensionless because the pressures or concentrations we put in are all for the substances in their standard states.
b. This is a trick question. Equilibrium constants have units that involve some multiple of atmospheres or moles per liter.
c. They are not really dimensionless, but we must treat them as such in order to be able to take ln(K) in the expression:

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

d. Every concentration or pressure that enters into K_c or K_p is really divided by the corresponding concentration or pressure of the substance in its standard state.

Question 3 — 1.5 pts

The expression for K_P for the reaction

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

at equilibrium is:

a. $\dfrac{P_{H_2O}^6 P_{NO}^4}{P_{O_2}^5 P_{NH_3}^4}$

b. $P_{NH_3}^4 P_{O_2}^5$

c. No answer text provided.

d. $\dfrac{P_{NH_3}^4 P_{O_2}^5}{P_{NO}^4 P_{H_2O}^6}$

e. $\dfrac{P_{NO} P_{H_2O}}{P_{NH_3} P_{O_2}}$

Question 4 — 1.5 pts

Consider the following reactions at 25°C:

$2NO(g) \rightleftharpoons N_2(g) + O_2(g)$ $K_P = 1\times10^{30}$

$2H_2O(g) \rightleftharpoons 2H_2(g) + O_2(g)$ $K_P = 5\times10^{-82}$

$2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$ $K_P = 3\times10^{91}$

Which compound is most likely to dissociate and give $O_2(g)$ at 25°C?

a. CO_2
b. NO
c. $\dfrac{P_{NO} P_{H_2O}}{P_{NH_3} P_{O_2}}$
d. H_2O

Question 5 — 1.5 pts

At 600°C, the equilibrium constant for the reaction

$2HgO\ (s) \longrightarrow 2Hg\ (\ell) + O_2\ (g)$

is 2.8. Calculate the equilibrium constant for the reaction

$0.5O_2\ (g) + Hg\ (\ell) \longrightarrow HgO\ (s)$.

a. 0.60
b. CO
c. 1.1
d. 1.7

Question 6 — 1.5 pts

Consider the reaction

$2HgO\ (s) \rightleftharpoons 2Hg\ (\ell) + O_2\ (g)$

What is the form of the equilibrium constant K_p for this reaction?

a. $\dfrac{P_{O_2}}{P_{HgO}^2}$

b. $\dfrac{P_{Hg}^2 P_{O_2}}{P_{HgO}^2}$

c. P_{O2}

d. $P_{Hg}^2 P_{O2}$

Question 7 — 1.5 pts

$K_p = 2.6 \times 10^8$ at 825 K for the reaction

$2H_2\ (g) + S_2\ (g) \rightleftharpoons 2H_2S\ (g)$

The equilibrium pressure of H_2 is 0.0020 atm and S_2 is 0.0010 atm. What is the equilibrium pressure of H_2S?

a. 0.10 atm
b. 1.0 atm
c. 0.0010 atm
d. 0.36

Question 8 — 1.5 pts

Consider the reaction below

$2SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g)$

At 1000 K the equilibrium pressures of the three gases in one mixture were found to be 0.562 atm SO_2, 0.101 atm O_2, and 0.332 atm SO_3. Calculate the value of K_p for the reaction.

a. 2.64
b. 0.298
c. 0.171
d. 3.46

Question 9 — 1.5 pts

Consider the following reaction:

$2NO\ (g) + Br_2\ (g) \rightleftharpoons 2NOBr\ (g)$ $K_p = 2.40$ @ 373 K

Calculate K_c for this reaction at 100 °C.

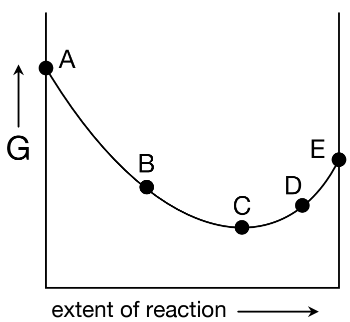
a. 10 atm
b. 73.5
c. 19.7
d. 0.0784

Question 10 — 1.5 pts

Calculate the equilibrium constant at 25°C for a reaction for which ΔG° = -4.22 kcal/mol. Include the sign if needed and round to the second decimal place.

Question 11 — 1.5 pts

The figure below represents a reaction at 298 K.



Based on the figure, which of the following statements (if any) are FALSE?

a. At point C, the system is at equilibrium.
b. None of the other statements are false.
c. For this reaction, ΔG° is negative.
d. At point D, the reaction will move toward the reactants to get to equilibrium.
e. At point B, Q < K.

Question 12 — 1.5 pts

Consider the reaction:

$C_{graphite}\ (s) + O_2\ (g) \rightleftharpoons CO_2\ (g)$ ΔG° = –400 kJ

Which of the following is a possible value of K for this reaction?

a. At point B, Q < K.
b. 10^{-70}
c. 10^{70}
d. 0.56

Question 13 — 1.5 pts

The reaction

$A + B \rightleftharpoons C + 2D$

has an equilibrium constant of 3.7×10^{-3}. Consider a reaction mixture with:

[A] = 2.0×10^{-2} M

[B] = 1.7×10^{-4} M

[C] = 2.4×10^{-6} M

[D] = 3.5×10^{-3} M

Which of the following statements is definitely true?

a. -0.56
b. The reverse reaction will occur to a greater extent than the forward reaction until equilibrium is established.
c. The system is at equilibrium.
d. The forward reaction will occur to a greater extent than the reverse reaction until equilibrium is established.

Question 14 — 1.5 pts

The reaction

$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$

has an equilibrium constant, K_p, of 4.0×10^8 at 25°C. What will eventually happen if 44.0 moles of NH_3, 0.452 moles of N_2, and 0.108 moles of H_2 are put in a 10.0 L container at 25°C.

a. More N_2 and H_2 will be formed.
b. No conclusions about the system can be made without additional information.
c. It is impossible to know what will happen unless we know what the equilibrium constant is at 298 K.
d. Nothing. The system is at equilibrium.

Question 15 — 1.5 pts

Given the hypothetical reaction:

$X(g) \rightleftharpoons Y(g)$

Predict what will happen when 1.0 mol Y is placed into an evacuated container.

a. Nothing. The products are already formed, so no reaction occurs.
b. More NH_3 will be formed.
c. As the reaction progresses, Q will increase until Q = K.
d. As the reaction progresses, ΔG° will decrease until ΔG° = 0.

Question 16 — 1.5 pts

What happens to the concentration of NO(g) when the total pressure on the reaction below is increased (by compression) when it is at equilibrium?

$3NO_2\ (g) + H_2O\ (\ell) \rightleftharpoons 2HNO_3\ (aq) + NO\ (g)$

a. it remains the same
b. it is impossible to tell
c. As the reaction progresses, Q will decrease until Q = K.
d. it increases

Question 17
1.5 pts

Consider the following reaction:

$2SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g)$

where $\Delta H_{rxn} = -198$ kJ. The amount of $SO_2(g)$ at equilibrium increases when...

a. the volume is increased.
b. the temperature is decreased.
c. SO_3 is removed.
d. it decreases

Question 18
1.5 pts

Suppose the reaction mixture

$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH_3\ (g)$

is at equilibrium at a given temperature and pressure. The pressure is then increased at constant temperature by compressing the reaction mixture, and the mixture is then allowed to reestablish equilibrium. At the new equilibrium...

a. there is the same amount of ammonia present as there was originally.
b. there is less ammonia present than there was originally.
c. more oxygen is added.
d. the nitrogen is used up completely.

Question 19
1.5 pts

Consider the system:

$2N_2O_5\ (g) \rightleftharpoons 2N_2O_4\ (g) + O_2\ (g)$

at equilibrium at 25°C. If this is an exothermic reaction and the temperature was raised, would the equilibrium be shifted to produce more N_2O_5 or more N_2O_4?

a. it is impossible to tell
b. more N_2O_5
c. there would be no change
d. more N_2O_4

Question 20
1.5 pts

The equilibrium constant K for the synthesis of ammonia is $6.8\text{x}10^{5}$ at 298 K. What will K be for the reaction at 375 K?

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H° = -92.22$ kJ/mol

a. there is more ammonia present than there was originally.
b. 1.42×10^9
c. 326
d. 6.85×10^5