Homework 03 Chemical Equilibria

Question 1 — 1.2 pts

When the chemical reaction

A + B $\rightleftharpoons$ C + D

is at equilibrium, which of the following is true?

- both the forward and reverse reactions have stopped
- the sum of the concentrations of A and B equals the sum of the concentrations of C and D
- neither the forward nor the reverse reactions have stopped
- all four concentrations are equal

Question 2 — 1.2 pts

Explain why equilibrium constants are dimensionless.

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

Question 3 — 1.2 pts

The expression for K_c for the reaction

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

at equilibrium is:

- $\frac{[NH_3]^4[O_2]^5}{[NO]^4[H_2O]^6}$
- $[NH_3]^4[O_2]^5$
- $\frac{[NO]^4[H_2O]^6}{[NH_3]^4[O_2]^5}$
- $\frac{[NO][H_2O]}{[NH_3][O_2]}$

Question 4 — 1.2 pts

Consider the following reactions at 25°C:

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

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

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

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

- CO_2
- NO
- H_2O
- CO

Question 5 — 1.2 pts

At 600°C, the equilibrium constant for the reaction

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

is 2.8. Calculate the equilibrium constant for the reaction

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

- 0.60
- 1.7
- 0.36
- 1.1

Question 6 — 1.2 pts

Consider the reaction

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

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

- $\frac{[Hg]^2[O_2]}{[HgO]^2}$
- $[Hg]^2\,[O_2]$
- $\frac{[O_2]}{[HgO]^2}$
- $[O_2]$

Question 7 — 1.2 pts

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

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

The equilibrium concentration of H_2 is 0.0020 M and S_2 is 0.0010 M. What is the equilibrium concentration of H_2S?

- 10 M
- 1.0 M
- 0.10 M
- 0.0010 M

Question 8 — 1.2 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.

- 2.64
- 0.171
- 0.289
- 3.46

Question 9 — 1.2 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.

- 19.7
- 0.0784
- 73.5
- 7440

Question 10 — 1.2 pts

Calculate the equilibrium constant at 25°C for a reaction for which ΔG° = -4.22 kcal/mol.

- -1240.51
- 1240.51
- 620.254
- 2481.02

Question 11 — 1.2 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?

- No conclusions about the system can be made without additional information.
- The forward reaction will occur to a greater extent than the reverse reaction until equilibrium is established.
- The system is at equilibrium.
- The reverse reaction will occur to a greater extent than the forward reaction until equilibrium is established.

Question 12 — 1.2 pts

The reaction

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

has an equilibrium constant 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°

- It is impossible to know what will happen unless we know what the equilibrium constant is at 298 K.
- Nothing. The system is at equilibrium.
- More NH_3 will be formed.
- More N_2 and H_2 will be formed.

Question 13 — 1.2 pts

Consider the reaction:

$Ni(CO)_4(g) \longrightarrow Ni(s) + 4CO(g)$

If the initial concentration of $Ni(CO)_4(g)$ is 1.0 M and x is the equilibrium concentration of CO(g), what is the correct equilibrium relation?

- $K_c = \frac{x^5}{\left(1.0 - \frac{x}{4}\right)}$
- $K_c = \frac{256x^4}{(1.0 - 4x)}$
- $K_c = \frac{x^4}{\left(1.0 - \frac{x}{4}\right)}$
- $K_c = \frac{4x}{(1.0 - 4x)}$

Question 14 — 1.2 pts

Suppose the reaction

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

has an equilibrium constant $K_c = 49$ and the initial concentrations of H_2 and I_2 is 0.5 M and of HI is 0.0M. Which of the following is the correct value for the final concentration of HI(g)?

- 0.219 M
- 0.599 M
- 0.250 M
- 0.778 M

Question 15 — 1.2 pts

The system

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

is at equilibrium at a fixed temperature with a partial pressure of H_2 of 0.200 atm, a partial pressure of I_2 of 0.200 atm, and a partial pressure of HI of 0.100 atm. An additional 0.26 atm pressure of HI is admitted to the container, and it is allowed to come to equilibrium again. What is the new partial pressure of HI?

- 0.360 atm
- 0.152 atm
- 0.104 atm
- 0.464 atm

Question 16 — 1.2 pts

At 990°C, $K_c = 1.6$ for the reaction

$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g)$

How many moles of $H_2O(g)$ are present in an equilibrium mixture resulting from the addition of 1.00 mole of H_2, 2.00 moles of CO_2, 0.75 moles of H_2O, and 1.00 mole of CO to a 5.00 liter container at 990°C?

- 1.7 mol
- 1.0 mol
- 0.60 mol
- 1.1 mol

Question 17 — 1.2 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?

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

- it decreases
- it is impossible to tell
- it increases
- it remains the same

Question 18 — 1.2 pts

Consider the following reaction:

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

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

- the volume is increased.
- SO_3 is removed.
- the temperature is decreased.
- more oxygen is added.

Question 19 — 1.2 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...

- there is more ammonia present than there was originally.
- the nitrogen is used up completely.
- there is the same amount of ammonia present as there was originally.
- there is less ammonia present than there was originally.

Question 20 — 1.2 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?

- it is impossible to tell
- there would be no change
- more N_2O_4
- more N_2O_5

Question 21 — 1.2 pts

The system

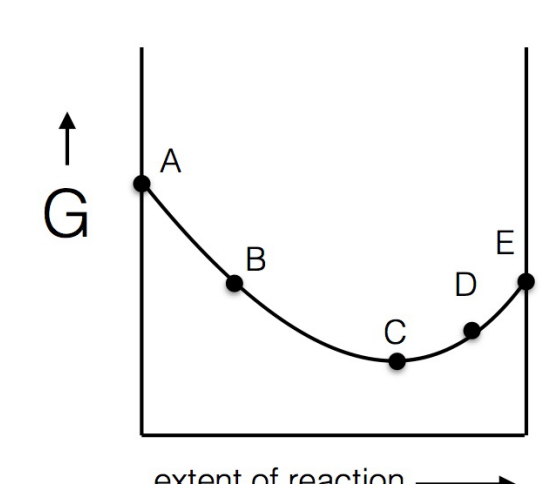
$CO_2(g) + H_2(g)\ \ H_2O(g) + CO(g)$

is at equilibrium at some temperature. At equilibrium, a 4.00L vessel contains 1.00 mole CO_2, 1.00 mole H_2, 2.40 moles H_2O, and 2.40 moles CO. How many moles of CO_2 must be added to this system to bring the equilibrium CO concentration to 0.669 mol/L?

- 0.429 moles
- 0.993 moles
- 0.069 moles
- 0.498 moles

Question 22 — 1.2 pts

The figure below represents a reaction at 298 K.



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

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

Question 23 — 1.2 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.

- ΔG° will decrease until ΔG° = 0.
- Nothing. The products are already formed, so no reaction occurs.
- Q will increase until Q = K.
- Q will decrease until Q = K.

Question 24 — 1.2 pts

Consider the reaction:

$C_{graphite}(s) + O_2(g)\ \ CO_2(g)$ $\Delta G^\circ = -400\ kJ \times mol^{-1} \times K^{-1}$

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

- 10^{70}
- -0.56
- 0.56
- 10^{-70}

Question 25 — 1.2 pts

The equilibrium constant K for the synthesis of ammonia is 6.8×10^5 at 298 K. What will K be for the reaction at 375 K?

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H^\circ = -92.22\ kJ \cdot mol^{-1}$

- 6.75×10^5
- 1.42×10^9
- 326
- 6.85×10^5