Question #1

Which statement best describes dynamic equilibrium?

A. No reactants react.
B. No products are formed.
C. The rate of the forward reaction is faster than the rate of the reverse reaction.
D. The rate of the reverse reaction is faster than the rate of the forward reaction.
E. The rate of the forward reaction equals the rate of the reverse reaction.

Question #2

What is the direction of the reaction if \( K >> 1 \)?

A. The forward reaction is favored.
B. The reverse reaction is favored.
C. Neither direction is favored.
D. If the temperature is raised, then the forward reaction is favored.
E. If the temperature is raised, then the reverse reaction is favored.
**Question #: 3**

The equilibrium constant is given for one of the reactions below. Determine the value of the missing equilibrium constant.

\[ \text{H}_2(g) + \text{Br}_2(g) \Leftrightarrow 2\text{HBr}(g) \quad K_c = 3.8 \times 10^4 \]

\[ 4\text{HBr}(g) \Leftrightarrow 2\text{H}_2(g) + 2\text{Br}_2(g) \quad K_c = ? \]

A. 1.9 \times 10^4  
B. 5.1 \times 10^{-3}  
C. 2.6 \times 10^{-5}  
D. 6.9 \times 10^{-10}

---

**Question #: 4**

The equilibrium constant is given for two of the reactions below. Determine the value of the missing equilibrium constant.

\[ 2\text{A}(g) + \text{B}(g) \Leftrightarrow \text{A}_2\text{B}(g) \quad K_c = ? \]

\[ \text{A}_2\text{B}(g) + \text{B}(g) \Leftrightarrow \text{A}_2\text{B}_2(g) \quad K_c = 16.4 \]

\[ 2\text{A}(g) + 2\text{B}(g) \Leftrightarrow \text{A}_2\text{B}_2(g) \quad K_c = 28.2 \]

Report your answer with **three** significant figures. Do **NOT** use scientific notation.

\[ K_c = \underbrace{1}_{\text{three significant figures}} \]

1. ________

---

**Question #: 5**

The reaction below has a \( K_p \) value of \( 3.3 \times 10^{-5} \). What is the value of \( K_c \) for this reaction at 700 K?

\[ 2\text{SO}_3(g) \Leftrightarrow 2\text{SO}_2(g) + \text{O}_2(g) \]

A. 5.7 \times 10^{-7}  
B. 1.7 \times 10^6  
C. 3.3 \times 10^{-5}  
D. 3.0 \times 10^4
Question #: 6

Determine the value of $K_c$ for the following reaction if the equilibrium concentrations are as follows: 

\[ [P_4O_{10}]_{eq} = 2.000 \text{ moles}, [P_4]_{eq} = 3.000 \text{ moles}, [O_2]_{eq} = 4.000 \text{ M} \]

\[ P_4O_{10}(s) \rightleftharpoons P_4(s) + 5 O_2(g) \]

Report your answer with four significant figures. Do **NOT** use scientific notation.

\[ K_c = \Box \]

1. \_\_\_\_

Question #: 7

Calculate the value of $[N_2]_{eq}$ if $[H_2]_{eq} = 2.0 \text{ M}$, $[NH_3]_{eq} = 0.5 \text{ M}$, and $K_c = 2$.

\[ N_2(g) + 3 \text{ H}_2(g) \rightleftharpoons 2 \text{ NH}_3(g) \]

Report your answer with two significant figures. Do **NOT** include units in your answer. Do **NOT** use scientific notation.

\[ [N_2]_{eq} = \Box \]

1. \_\_\_\_

Question #: 8

In a reaction mixture containing only reactants, what is the value of $Q$?

A. -1  
B. 1  
C. $\infty$  
D. 0  
E. It cannot be determined without concentrations.
Question #: 9
Which statement is true?

A. If \( Q < K \), it means the reverse reaction will proceed to form more reactants.
B. If \( Q > K \), it means the forward reaction will proceed to form more products.
C. If \( Q = K \), it means the reaction is at equilibrium.
D. All of the above are true.
E. None of the above are true.

Question #: 10
Consider the following reaction:

\[
Xe(g) + 2F_2(g) \rightleftharpoons XeF_4(g)
\]

A reaction mixture initially contains 2.24 atm Xe and 4.27 atm \( F_2 \). If the equilibrium pressure of Xe is 0.34 atm, find the equilibrium constant \( (K_p) \) for the reaction.

A. 25
B. 0.12
C. 0.99
D. 8.3

Question #: 11
Which statement best describes Le Chatelier's Principle?

A. When a chemical system at equilibrium is disturbed, the system shifts in a direction that maximizes the disturbance
B. A system will always change if the pressure changes.
C. When a chemical system at equilibrium is disturbed, the system shifts in a direction that equals the disturbance.
D. When a chemical system at equilibrium is disturbed, the system shifts in a direction that minimizes the disturbance.
E. A system will always change if the volume changes.
Question #: 12

Consider the following reaction at equilibrium. What will happen if FeS₂ is added to the reaction?

\[ 4\text{FeS}_2(s) + 11\text{O}_2(g) \rightleftharpoons 2\text{Fe}_2\text{O}_3(s) + 8\text{SO}_2(g) \]

A. The equilibrium constant will increase.
B. The equilibrium will change in the direction of the reactants.
C. The equilibrium will change in the direction of the products.
D. No change in equilibrium is observed.
E. The equilibrium constant will decrease.

Question #: 13

The following reaction is exothermic. Which change will shift the equilibrium to the left?

\[ 2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \]

A. increasing the temperature
B. removing \(\text{SO}_3\)
C. adding \(\text{O}_2\)
D. decreasing the temperature

Question #: 14

Consider the following reaction and its equilibrium constant:

\[ \text{SO}_2(g) + \text{NO}_2(g) \rightleftharpoons \text{SO}_3(g) + \text{NO}(g) \quad K_c = 0.33 \]

A reaction mixture contains 0.41 M \(\text{SO}_2\), 0.13 M \(\text{NO}_2\), 0.11 M \(\text{SO}_3\) and 0.13 M NO. Which statement is true concerning this system?

A. The reaction will shift in the direction of reactants.
B. The equilibrium constant will decrease.
C. The reaction will shift in the direction of products.
D. The reaction quotient will decrease.
E. The system is at equilibrium.
**Question #: 15**

The Brønsted-Lowry model focuses on the transfer of _______ in an acid-base reaction.

A. neutrons  
B. electrons  
C. orbitals  
D. OH\(^-\)  
E. H\(^+\)

**Question #: 16**

What is the conjugate base of H\(_2\)PO\(_4\)\(^-\) ?

A. HPO\(_4\)^{2-}\)  
B. PO\(_4\)^{3-}\)  
C. H\(_3\)PO\(_4\)  
D. H\(_3\)O\(^+\)  
E. OH\(^-\)

**Question #: 17**

Which one is **NOT** a conjugate acid-base pair?

A. NH\(_4\)^+/NH\(_3\)  
B. H\(_3\)O\(^+\)/OH\(^-\)  
C. H\(_2\)SO\(_3\)/HSO\(_3\)^{-}  
D. C\(_2\)H\(_3\)O\(_2\)^{-}/HC\(_2\)H\(_3\)O\(_2\)
**Question #**: 18

The stronger the acid, the ______________.

A. stronger the conjugate acid  
B. stronger the conjugate base  
C. weaker the conjugate base  
D. weaker the conjugate acid

**Question #**: 19

Which solution would have the highest pH? Assume that they are all 0.10 M in acid at 25°C.

A. HF, $K_a = 3.5 \times 10^{-4}$  
B. HCN, $K_a = 4.9 \times 10^{-10}$  
C. HNO$_2$, $K_a = 4.6 \times 10^{-4}$  
D. HClO$_2$, $K_a = 1.1 \times 10^{-2}$

**Question #**: 20

Which statement is true?

A. A neutral solution contains $[\text{H}_2\text{O}] = [\text{H}_3\text{O}^+]$.  
B. A neutral solution does not contain any $\text{H}_3\text{O}^+$ or $\text{OH}^–$.  
C. An acidic solution has $[\text{H}_3\text{O}^+] > [\text{OH}^–]$.  
D. A basic solution does not contain $\text{H}_3\text{O}^+$.
Question #: 21

Calculate the concentration of H_3O^+ in a solution that contains 5.5 \times 10^{-5} M OH^- at 25^\circ C. Identify the solution as acidic, basic, or neutral.

A. 1.8 \times 10^{-10} M, basic
B. 1.8 \times 10^{-10} M, acidic
C. 5.5 \times 10^{-10} M, neutral
D. 9.2 \times 10^{-1} M, acidic

Question #: 22

Determine the pH of a 0.023 M HNO_3 solution. Report your answer with two decimal points. Do NOT use scientific notation.

pH = \underline{1. \_\_\_\_\_\_}

1. \underline{\_\_\_\_\_\_}

Question #: 23

Determine the pH of a 0.461 M C_6H_5CO_2H M solution if the K_a of C_6H_5CO_2H is 6.5 \times 10^{-5}.

A. 2.26
B. 4.52
C. 11.74
D. 9.48

Question #: 24

Determine the pH of a 0.227 M C_5H_5N solution at 25^\circ C. The K_b of C_5H_5N is 1.7 \times 10^{-9}. Report your answer with two decimal points. Do NOT use scientific notation.

pH = \underline{1. \_\_\_\_\_\_}

1. \underline{\_\_\_\_\_\_}
Question #: 25

Determine the $K_a$ for $\text{CH}_3\text{NH}_3^+$ at 25°C. The $K_b$ for $\text{CH}_3\text{NH}_2$ is $4.4 \times 10^{-4}$.

A. $2.3 \times 10^{-11}$
B. $5.6 \times 10^{-10}$
C. $6.8 \times 10^{-11}$
D. $3.1 \times 10^{-10}$

Question #: 26

Which one is the strongest acid?

A. $\text{H}_2\text{O}$
B. $\text{H}_2\text{S}$
C. $\text{H}_2\text{Se}$
D. $\text{H}_2\text{Te}$

Question #: 27

Which one will form an acidic solution in water?

A. $\text{NH}_4\text{Cl}$
B. $\text{LiF}$
C. $\text{NaI}$
D. $\text{KNO}_3$
E. None of the above solutions will be acidic.
Question #: 28

If the pKₐ of HCHO₂ is 3.74 and the pH of an HCHO₂/NaCHO₂ solution is 3.11, which of the following is true?

A. [HCHO₂] < [NaCHO₂]
B. [HCHO₂] = [NaCHO₂]
C. [HCHO₂] << [NaCHO₂]
D. [HCHO₂] > [NaCHO₂]
E. It is not possible to make a buffer of this pH from HCHO₂ and NaCHO₂

Question #: 29

A 1.00 L buffer solution is 0.250 M in HF and 0.250 M in LiF. Calculate the pH of the solution after the addition of 0.150 moles of solid LiOH. Assume no volume change upon the addition of base. The Kₐ for HF is $3.5 \times 10^{-4}$.

A. 3.46
B. 4.06
C. 2.85
D. 3.63
Question #1

Which statement best describes dynamic equilibrium?

A. No reactants react.
   ✓ B. No products are formed.
C. The rate of the forward reaction is faster than the rate of the reverse reaction.
D. The rate of the reverse reaction is faster than the rate of the forward reaction.
E. The rate of the forward reaction equals the rate of the reverse reaction.

Question #2

What is the direction of the reaction if $K >> 1$?

✓ A. The forward reaction is favored.
B. The reverse reaction is favored.
C. Neither direction is favored.
D. If the temperature is raised, then the forward reaction is favored.
E. If the temperature is raised, then the reverse reaction is favored.

Question #: 3

The equilibrium constant is given for one of the reactions below. Determine the value of the missing equilibrium constant.

\[ \text{H}_2(g) + \text{Br}_2(g) \leftrightarrow 2\text{HBr}(g) \quad K_c = 3.8 \times 10^4 \]

\[ 4\text{HBr}(g) \leftrightarrow 2\text{H}_2(g) + 2\text{Br}_2(g) \quad K_c = ? \]

A. \(1.9 \times 10^4\)
B. \(5.1 \times 10^{-3}\)
C. \(2.6 \times 10^{-5}\)
D. \(6.9 \times 10^{-10}\)

Question #: 4

The equilibrium constant is given for two of the reactions below. Determine the value of the missing equilibrium constant.

\[ 2\text{A}(g) + \text{B}(g) \leftrightarrow \text{A}_2\text{B}(g) \quad K_c = ? \]

\[ \text{A}_2\text{B}(g) + \text{B}(g) \leftrightarrow \text{A}_2\text{B}_2(g) \quad K_c = 16.4 \]

\[ 2\text{A}(g) + 2\text{B}(g) \leftrightarrow \text{A}_2\text{B}_2(g) \quad K_c = 28.2 \]

Report your answer with three significant figures. Do NOT use scientific notation.

\[ K_c = \frac{1}{1.72} \]

Question #: 5
The reaction below has a $K_p$ value of $3.3 \times 10^{-5}$. What is the value of $K_c$ for this reaction at 700 K?

$$2 \text{SO}_3(g) \rightleftharpoons 2 \text{SO}_2(g) + \text{O}_2(g)$$

A. $5.7 \times 10^{-7}$  
B. $1.7 \times 10^6$  
C. $3.3 \times 10^{-5}$  
D. $3.0 \times 10^4$

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**Question #6**

Determine the value of $K_c$ for the following reaction if the equilibrium concentrations are as follows: $[\text{P}_4\text{O}_{10}]_{eq} = 2.000$ moles, $[\text{P}_4]_{eq} = 3.000$ moles, $[\text{O}_2]_{eq} = 4.000$ M

$$\text{P}_4\text{O}_{10}(s) \rightleftharpoons \text{P}_4(s) + 5 \text{O}_2(g)$$

Report your answer with **four** significant figures. Do **NOT** use scientific notation.

$K_c = \boxed{1.1024}$

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**Question #7**

Calculate the value of $[\text{N}_2]_{eq}$ if $[\text{H}_2]_{eq} = 2.0$ M, $[\text{NH}_3]_{eq} = 0.5$ M, and $K_c = 2$.

$$\text{N}_2(g) + 3 \text{H}_2(g) \rightleftharpoons 2 \text{NH}_3(g)$$

Report your answer with **two** significant figures. Do **NOT** include units in your answer. Do **NOT** use scientific notation.

$[\text{N}_2]_{eq} = \boxed{0.016}$
Question #: 8

In a reaction mixture containing only reactants, what is the value of Q?

A. -1
B. 1
C. ∞
D. 0
E. It cannot be determined without concentrations.

Question #: 9

Which statement is true?

A. If Q < K, it means the reverse reaction will proceed to form more reactants.
B. If Q > K, it means the forward reaction will proceed to form more products.
C. If Q = K, it means the reaction is at equilibrium.
D. All of the above are true.
E. None of the above are true.

Question #: 10

Consider the following reaction:

\[ \text{Xe}(g) + 2\text{F}_2(g) \leftrightarrow \text{XeF}_4(g) \]

A reaction mixture initially contains 2.24 atm Xe and 4.27 atm F\(_2\). If the equilibrium pressure of Xe is 0.34 atm, find the equilibrium constant (K\(_p\)) for the reaction.

A. 25
B. 0.12
C. 0.99
D. 8.3

Question #: 11
Which statement best describes Le Chatelier's Principle?

A. When a chemical system at equilibrium is disturbed, the system shifts in a direction that maximizes the disturbance
B. A system will always change if the pressure changes.
C. When a chemical system at equilibrium is disturbed, the system shifts in a direction that equals the disturbance.
✓D. When a chemical system at equilibrium is disturbed, the system shifts in a direction that minimizes the disturbance.
E. A system will always change if the volume changes.

Question #: 12

Consider the following reaction at equilibrium. What will happen if FeS₂ is added to the reaction?

\[ 4\text{FeS}_2(s) + 11\text{O}_2(g) \rightleftharpoons 2\text{Fe}_2\text{O}_3(s) + 8\text{SO}_2(g) \]

A. The equilibrium constant will increase.
B. The equilibrium will change in the direction of the reactants.
C. The equilibrium will change in the direction of the products.
✓D. No change in equilibrium is observed.
E. The equilibrium constant will decrease.

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The following reaction is exothermic. Which change will shift the equilibrium to the left?

\[ 2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \]

✓A. increasing the temperature
B. removing \text{SO}_3
C. adding \text{O}_2
D. decreasing the temperature
Question #: 14

Consider the following reaction and its equilibrium constant:

\[ \text{SO}_2 (g) + \text{NO}_2(g) \rightleftharpoons \text{SO}_3(g) + \text{NO}(g) \quad K_c = 0.33 \]

A reaction mixture contains 0.41 M SO₂, 0.13 M NO₂, 0.11 M SO₃ and 0.13 M NO. Which statement is **true** concerning this system?

A. The reaction will shift in the direction of reactants.
B. The equilibrium constant will decrease.
✓ C. The reaction will shift in the direction of products.
D. The reaction quotient will decrease.
E. The system is at equilibrium.

Question #: 15

The Brønsted-Lowry model focuses on the transfer of _______ in an acid-base reaction.

A. neutrons
B. electrons
C. orbitals
D. OH⁻
✓ E. H⁺

Question #: 16

What is the conjugate base of \( \text{H}_2\text{PO}_4^- \)?

✓ A. HPO₂⁻
B. PO₃³⁻
C. \( \text{H}_3\text{PO}_4 \)
D. \( \text{H}_3\text{O}^+4 \)
E. OH⁻
Question #: 17

Which one is **NOT** a conjugate acid-base pair?

A. NH₄⁺/NH₃
✓ B. H₃O⁺/OH⁻
C. H₂SO₃/HSO₃⁻
D. C₂H₃O₂⁻/HC₂H₃O₂

Question #: 18

The stronger the acid, the ______________.

A. stronger the conjugate acid
B. stronger the conjugate base
✓ C. weaker the conjugate base
D. weaker the conjugate acid

Question #: 19

Which solution would have the highest pH? Assume that they are all 0.10 M in acid at 25°C.

A. HF, $K_a = 3.5 \times 10^{-4}$
✓ B. HCN, $K_a = 4.9 \times 10^{-10}$
C. HNO₂, $K_a = 4.6 \times 10^{-4}$
D. HClO₂, $K_a = 1.1 \times 10^{-2}$

Question #: 20

Which statement is **true**?

A. A neutral solution contains $[H_2O] = [H_3O^+]$.
B. A neutral solution does not contain any $H_3O^+$ or $OH$–.
✓ C. An acidic solution has $[H_3O^+] >[OH^-]$. 
D. A basic solution does not contain $\text{H}_3\text{O}^+$. 

**Question #: 21**

Calculate the concentration of $\text{H}_3\text{O}^+$ in a solution that contains 5.5 $\times$ 10$^{-5}$ M OH$^-$ at 25°C. Identify the solution as acidic, basic, or neutral.

- ✓ A. 1.8 $\times$ 10$^{-10}$ M, basic
  - B. 1.8 $\times$ 10$^{-10}$ M, acidic
  - C. 5.5 $\times$ 10$^{-10}$ M, neutral
  - D. 9.2 $\times$ 10$^{-1}$ M, acidic

**Question #: 22**

Determine the pH of a 0.023 M $\text{HNO}_3$ solution. Report your answer with two decimal points. Do NOT use scientific notation.

pH = 1.64

**Question #: 23**

Determine the pH of a 0.461 M $\text{C}_6\text{H}_5\text{CO}_2\text{H}$ M solution if the $K_a$ of $\text{C}_6\text{H}_5\text{CO}_2\text{H}$ is 6.5 $\times$ 10$^{-5}$. 

- ✓ A. 2.26
  - B. 4.52
  - C. 11.74
  - D. 9.48

**Question #: 24**

Determine the pH of a 0.227 M $\text{C}_5\text{H}_5\text{N}$ solution at 25°C. The $K_b$ of $\text{C}_5\text{H}_5\text{N}$ is 1.7 $\times$ 10$^{-9}$ Report your answer with two decimal points. Do NOT use scientific notation.
pH = 1

1. 9.29

**Question #**: 25

Determine the $K_a$ for CH$_3$NH$_3^+$ at 25°C. The $K_b$ for CH$_3$NH$_2$ is 4.4×10$^{-4}$.

A. 2.3×10$^{-11}$
B. 5.6×10$^{-10}$
C. 6.8×10$^{-11}$
D. 3.1×10$^{-10}$

**Question #**: 26

Which one is the **strongest** acid?

A. H$_2$O
B. H$_2$S
C. H$_2$Se
D. H$_2$Te

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Which one will form an acidic solution in water?

A. NH$_4$Cl
B. LiF
C. NaI
D. KNO$_3$
E. None of the above solutions will be acidic.

**Question #**: 28
If the pKₐ of HCHO₂ is 3.74 and the pH of an HCHO₂/NaCHO₂ solution is 3.11, which of the following is true?

A. [HCHO₂] < [NaCHO₂]
B. [HCHO₂] = [NaCHO₂]
C. [HCHO₂] << [NaCHO₂]
D. [HCHO₂] > [NaCHO₂]
E. It is not possible to make a buffer of this pH from HCHO₂ and NaCHO₂

Question #: 29

A 1.00 L buffer solution is 0.250 M in HF and 0.250 M in LiF. Calculate the pH of the solution after the addition of 0.150 moles of solid LiOH. Assume no volume change upon the addition of base. The Kₐ for HF is 3.5×10⁻⁴.

A. 3.46
B. 4.06
C. 2.85
D. 3.63