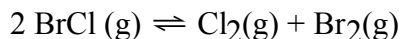


MULTIPLE CHOICE (2 pts each): Write the letter corresponding to the correct answer on the line next to each question. The LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION in order to receive full credit.

- 1) Which of the following is a strong base? 1) _____
a) $\text{CH}_3\text{CH}_2\text{NH}_2$ b) NH_3
c) $\text{Fe}(\text{OH})_3$ d) KOH
- 2) Which of the following statements about equilibrium is (are) true? 2) _____
(1) concentration of reactants and products are equal
(2) rate of the forward and reverse reactions are equal
a) Both statement 1 and Statement 2
b) Statement 2
c) Statement 1
- 3) If the K_{eq} value for a reaction is 5.77×10^{-4} , at equilibrium you would have 3) _____
a) all products, no reactants
b) the same concentration of products & reactants
c) more products than reactants
d) more reactants than products
- 4) You test a clear liquid, and it has a pH of 11.4. The liquid is 4) _____
a) acidic b) basic c) nonaqueous d) neutral
- 5) How many K_{a} values would phosphoric acid (H_3PO_4) have? 5) _____
a) 1 b) 4 c) 2 d) 3
- 6) A reaction was studied and found to have a K_{c} value of 3.95×10^{-3} . What is the K_{c} value for the reverse reaction? 6) _____
a) 2.53×10^2 b) 3.95×10^3 c) 6.28×10^{-2} d) 1.56×10^{-5}
- 7) Which of the following is a weak acid? 7) _____
a) acetic acid b) perchloric acid
c) nitric acid d) sulfuric acid
- 8) The K_{p} values for the reaction $\text{A}(\text{g}) + \text{B}(\text{g}) \rightarrow \text{C}(\text{g})$ are 3.71×10^{-8} at 0°C , 2.74×10^{-4} at 25°C and 4.5×10^{-6} at 45°C . If you want to maximize the yield of C, it is best to run the reaction at: 8) _____
a) 45°C b) 25°C c) 0°C d) 1000°C

SHORT ANSWER (14 pts each): Completely answer all of the following questions. Read all questions carefully!!! Show all work. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.

- 1) At 25°C, BrCl will dissociate into Br₂ and Cl₂ according to the following reaction, which has a K_c value of 0.45. You have placed 5.50x10⁻² mol of BrCl into a 250.0 mL container.



(a) Write the equilibrium expression for this reaction.

(b) What are the initial concentrations of the three gases?

BrCl: _____

Cl₂: _____

Br₂: _____

(c) What are the equilibrium concentrations of the three gases?

BrCl: _____

Cl₂: _____

Br₂: _____

- 2) Suppose there was a gas phase reaction $3\text{A(g)} + 2\text{B(g)} \rightleftharpoons 2\text{C(g)}$. Gases A and B were mixed in a 1.00L flask at 256K and allowed to reach equilibrium. At equilibrium, the flask contained:
A: 2.5x10⁻² moles; B: 3.8x10⁻² moles; and C: 1.6x10⁻³ moles.

(a) Write the equilibrium expression for this reaction.

(b) What is the value of K_c for this reaction?

K_c: _____

(c) What is the value of K_p for this reaction?

K_p: _____

3) A solution of the weak acid acetic acid (CH_3COOH) in water has a pH of 3.84. $K_a = 1.8 \times 10^{-5}$

(a) What is the formula of the conjugate base of this acid? Answer a: _____

(b) What is the hydronium ion concentration? Answer b: _____

(c) What is the molarity of the solution? Answer c: _____

(d) What is the % ionization? Answer d: _____

4) A solution of the weak base ethylamine ($\text{C}_2\text{H}_5\text{NH}_2$) was made by dissolving 0.140 moles in 1.00L of water. The K_b value for this base is 5.6×10^{-4} .

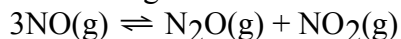
a.) What is the formula of the conjugate acid? Answer a: _____

b.) What is the equilibrium concentration of hydroxide ions? Answer b: _____

c.) What is the pOH? Answer c: _____

d.) What is the pH? Answer d: _____

- 5) Which way will the equilibrium of the following reaction shift (toward reactants or toward products) in response to each of the following stresses? $\Delta H = 155.5\text{kJ}$



a.) The volume of the reaction vessel is increased Answer a: _____

b.) Heat is added Answer b: _____

c.) $\text{N}_2\text{O}(\text{g})$ is added to the flask Answer c: _____

d.) $\text{NO}_2(\text{g})$ is removed from the flask Answer d: _____

e.) A catalyst is added to the reaction Answer e: _____

f.) $\text{NO}(\text{g})$ is added to the flask Answer f: _____

g.) Suggest a way to increase the yield of this reaction.

Answer g: _____

6) a.) What is the conjugate base of H_2PO_4^- ? Answer a: _____

b.) What is the pH when 0.258 mol of HCl (a strong acid) is dissolved in 1.00L of water?

Answer b: _____

c.) What is the conjugate acid of HCO_3^- ? Answer c: _____

d.) If the hydronium ion concentration in a given solution is $2.8 \times 10^{-7}\text{M}$, what is the hydroxide ion concentration?

Answer d: _____

e.) Is the solution in part d acidic or basic? Answer e: _____

f.) What is the K_b of aspirin ($K_a = 3.0 \times 10^{-4}$)? Answer f: _____

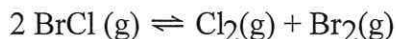
g.) What is the $\text{p}K_a$ of aspirin? Answer g: _____

MULTIPLE CHOICE (2 pts each): Write the letter corresponding to the correct answer on the line next to each question. The LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION in order to receive full credit.

- 1) Which of the following is a strong base? 1) D
a) $\text{CH}_3\text{CH}_2\text{NH}_2$ b) NH_3
c) $\text{Fe}(\text{OH})_3$ (d) KOH
- 2) Which of the following statements about equilibrium is (are) true? 2) B
(1) concentration of reactants and products are equal
(2) rate of the forward and reverse reactions are equal
a) Both statement 1 and Statement 2
(b) Statement 2
c) Statement 1
- 3) If the K_{eq} value for a reaction is 5.77×10^{-4} , at equilibrium you would have 3) D
a) all products, no reactants
b) the same concentration of products & reactants
c) more products than reactants
(d) more reactants than products
- 4) You test a clear liquid, and it has a pH of 11.4. The liquid is 4) B
a) acidic (b) basic c) nonaqueous d) neutral
- 5) How many K_{a} values would phosphoric acid (H_3PO_4) have? 5) D
a) 1 b) 4 c) 2 (d) 3
- 6) A reaction was studied and found to have a K_{c} value of 3.95×10^{-3} . What is the K_{c} value for the reverse reaction? 6) A
(a) 2.53×10^2 b) 3.95×10^3 c) 6.28×10^{-2} d) 1.56×10^{-5}
- 7) Which of the following is a weak acid? 7) A
(a) acetic acid b) perchloric acid
c) nitric acid d) sulfuric acid
- 8) The K_{p} values for the reaction $\text{A}(\text{g}) + \text{B}(\text{g}) \rightarrow \text{C}(\text{g})$ are 3.71×10^{-8} at 0°C , 2.74×10^{-4} at 25°C and 4.5×10^{-6} at 45°C . If you want to maximize the yield of C, it is best to run the reaction at: 8) B
a) 45°C (b) 25°C c) 0°C d) 1000°C

SHORT ANSWER (14 pts each): Completely answer all of the following questions. Read all questions carefully!!! Show all work. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.

- 1) At 25°C, BrCl will dissociate into Br₂ and Cl₂ according to the following reaction, which has a K_c value of 0.45. You have placed 5.50x10⁻² mol of BrCl into a 250.0 mL container.



- (a) Write the equilibrium expression for this reaction.

$$K_{eq} = \frac{[\text{Cl}_2][\text{Br}_2]}{[\text{BrCl}]^2}$$

- (b) What are the initial concentrations of the three gases?

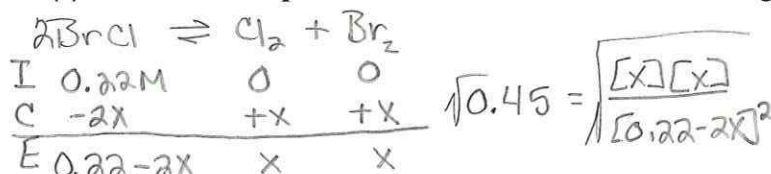
$$\text{BrCl: } \frac{5.50 \times 10^{-2} \text{ mol}}{0.250 \text{ L}} = 0.22 \text{ M}$$

$$\text{BrCl: } 0.220 \text{ M}$$

$$\text{Cl}_2: 0 \text{ M}$$

$$\text{Br}_2: 0 \text{ M}$$

- (c) What are the equilibrium concentrations of the three gases?



$$\text{BrCl: } 0.094 \text{ M}$$

$$\text{Cl}_2: 0.063 \text{ M}$$

$$\text{Br}_2: 0.063 \text{ M}$$

$$0.67082 = \frac{x}{0.22-2x} \quad \frac{0.14758}{2.34164} = \frac{2.34164x}{2.34164}$$

$$0.22 - 2(0.063) = 0.094 \text{ M}$$

$$0.14758 - 1.34164x = x \quad x = 0.0630$$

- 2) Suppose there was a gas phase reaction 3A(g) + 2B(g) ⇌ 2C(g). Gases A and B were mixed in a 1.00L flask at 256K and allowed to reach equilibrium. At equilibrium, the flask contained:

$$\text{A: } \frac{2.5 \times 10^{-2} \text{ moles}}{1 \text{ L}}; \text{ B: } \frac{3.8 \times 10^{-2} \text{ moles}}{1 \text{ L}}; \text{ and C: } \frac{1.6 \times 10^{-3} \text{ moles}}{1 \text{ L}}$$

- (a) Write the equilibrium expression for this reaction.

$$K_{eq} = \frac{[\text{C}]^2}{[\text{A}]^3 [\text{B}]^2}$$

- (b) What is the value of K_c for this reaction?

$$K_c: 1.13 \times 10^2$$

$$K_{eq} = \frac{[1.6 \times 10^{-3} \text{ M}]^2}{[2.5 \times 10^{-2} \text{ M}]^3 [3.8 \times 10^{-2} \text{ M}]^2} = \frac{2.56 \times 10^{-6}}{[1.5625 \times 10^{-5}] [1.444 \times 10^{-3}]} = \frac{2.56 \times 10^{-6}}{2.25625 \times 10^{-8}} = 1.1346 \times 10^2$$

- (c) What is the value of K_p for this reaction?

$$K_p: 1.22 \times 10^{-2}$$

$$K_p = K_c \cdot (RT)^{\Delta n} = (1.1346 \times 10^2) (0.0821 \cdot 256 \text{ K})^{-3} = 1.222 \times 10^{-2}$$

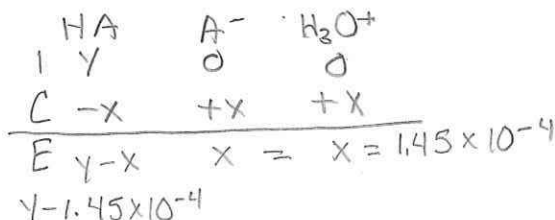
3) A solution of the weak acid acetic acid (CH_3COOH) in water has a pH of 3.84. $K_a = 1.8 \times 10^{-5}$

(a) What is the formula of the conjugate base of this acid? Answer a: CH_3COO^-

(b) What is the hydronium ion concentration? Answer b: $1.4 \times 10^{-4} \text{ M}$

$$[\text{H}_3\text{O}^+] = 10^{-3.84} = 1.4454 \times 10^{-4} \text{ M}$$

(c) What is the molarity of the solution? Answer c: $1.3 \times 10^{-3} \text{ M}$



$$1.8 \times 10^{-5} = \frac{[1.45 \times 10^{-4}][1.45 \times 10^{-4}]}{[Y - 1.45 \times 10^{-4}]}$$

$$1.8 \times 10^{-5} Y - 2.61 \times 10^{-9} = 2.1025 \times 10^{-8}$$

$$1.8 \times 10^{-5} Y = 2.3635 \times 10^{-8} \quad Y = 1.313 \times 10^{-3}$$

Answer d: 11%

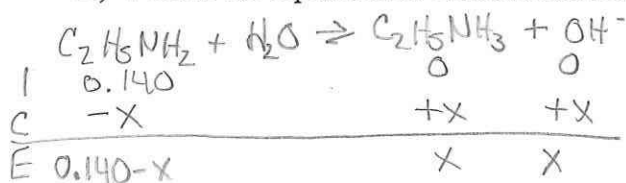
(d) What is the % ionization?

$$\frac{[A^-]}{[HA]} \times 100 = \frac{1.45 \times 10^{-4}}{1.313 \times 10^{-3}} \times 100 = 11.0684\%$$

4) A solution of the weak base ethylamine ($\text{C}_2\text{H}_5\text{NH}_2$) was made by dissolving 0.140 moles in 1.00L of water. The K_b value for this base is 5.6×10^{-4} . $\frac{0.140}{1\text{L}} = 0.140 \text{ M}$

a.) What is the formula of the conjugate acid? Answer a: $\text{C}_2\text{H}_5\text{NH}_3^+$

b.) What is the equilibrium concentration of hydroxide ions? Answer b: $8.9 \times 10^{-3} \text{ M}$



$$5.6 \times 10^{-4} = \frac{[x][x]}{[0.140-x]}$$

ignore

$$7.84 \times 10^{-5} = x^2$$

$$x = 8.8544 \times 10^{-3}$$

c.) What is the pOH? Answer c: 2.05

$$-\log [\text{OH}^-] = -\log [8.8544 \times 10^{-3}] = 2.053$$

d.) What is the pH? Answer d: 11.95

$$14 - 2.05 = 11.95$$

- 5) Which way will the equilibrium of the following reaction shift (toward reactants or toward products) in response to each of the following stresses? $\Delta H = 155.5 \text{ kJ}$



a.) The volume of the reaction vessel is increased

Answer a: reactants

b.) Heat is added

Answer b: products

c.) $\text{N}_2\text{O}(\text{g})$ is added to the flask

Answer c: reactants

d.) $\text{NO}_2(\text{g})$ is removed from the flask

Answer d: products

e.) A catalyst is added to the reaction

Answer e: no change

f.) $\text{NO}(\text{g})$ is added to the flask

Answer f: products

g.) Suggest a way to increase the yield of this reaction.

Possibilities:

Answer g: Remove a product, add more reactant, decrease size of flask
increase pressure, increase temperature

6) a.) What is the conjugate base of H_2PO_4^- ?

Answer a: HPO_4^{2-}

b.) What is the pH when $\frac{0.258 \text{ mol}}{1 \text{ L}}$ of HCl (a strong acid) is dissolved in 1.00L of water?

$$= 0.258 \text{ M}$$

complete dissociation $-\log(0.258) = 0.588$

Answer b: 0.588

c.) What is the conjugate acid of HCO_3^- ?

Answer c: H_2CO_3

d.) If the hydronium ion concentration in a given solution is $2.8 \times 10^{-7} \text{ M}$, what is the hydroxide ion concentration?

$$[\text{OH}^-] = \frac{1 \times 10^{-14}}{[\text{H}_3\text{O}^+]} = \frac{1 \times 10^{-14}}{2.8 \times 10^{-7}} = 3.57 \times 10^{-8}$$

Answer d: 3.6×10^{-8}

e.) Is the solution in part d acidic or basic?

$$-\log(2.8 \times 10^{-7}) = 6.55 = \text{acidic}$$

Answer e: acidic

f.) What is the K_b of aspirin ($K_a = 3.0 \times 10^{-4}$)?

Answer f: 3.3×10^{-11}

$$K_b = \frac{1 \times 10^{-14}}{K_a} = \frac{1 \times 10^{-14}}{3.0 \times 10^{-4}} = 3.33 \times 10^{-11}$$

g.) What is the $\text{p}K_a$ of aspirin?

Answer g: 3.52

$$-\log(K_a) = -\log(3.0 \times 10^{-4}) = 3.523$$