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) $CH_3CH_2NH_2$ b) NH_3

c) $Fe(OH)_3$ d) KOH

2) Which of the following statements about equallibrium 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 $A(g) + B(g) \rightarrow C(g)$ 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!!! <u>Show all work.</u> 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 Br_2 and Cl_2 according to the following reaction, which has a K_c value of 0.45. You have placed 5.50×10^{-2} mol of BrCl into a 250.0 mL container.

$$2\ BrCl\ (g) \rightleftharpoons Cl_2(g) + Br_2(g)$$

(a) Write the equilibrium expression for this reaction.

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

Cl_2:_____

Br_2:_____

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

Cl_2:_____

Br_2:_____

2) Suppose there was a gas phse reaction $3A(g) + 2B(g) \rightleftharpoons 2C(g)$. Gases A and B were mixed in a 1.00L flask at 256K and allowed to reach equilibrium. At equilibrium, the flask contained: A: 2.5×10^{-2} moles; B: 3.8×10^{-2}moles; and C: 1.6×10^{-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 conjuate 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 ($C_2H_5NH_2$) 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 conjuagate 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? $\triangle H = 155.5kJ$

$$3NO(g) \rightleftharpoons N_2O(g) + NO_2(g)$$

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

b.) Heat is added Answer b: _____

c.) $N_2O(g)$ is added to the flask Answer c: _____

d.) $NO_2(g)$ is removed from the flask Answer d: _____

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

f.) NO(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 $2.8x10^{-7}M$, 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 ($K_a = 3.0x10^{-4}$)? Answer f:_____

g.) What is the pK_a of aspirin? Answer g:_____

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1) Which of the following is a strong base? 1) D

a) $CH_3CH_2NH_2$ b) NH_3

c) $Fe(OH)_3$ d) KOH

2) Which of the following statements about equallibrium 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 $A(g) + B(g) \rightarrow C(g)$ 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 Br_2 and Cl_2 according to the following reaction, which has a K_c value of 0.45. You have placed 5.50×10^{-2} mol of BrCl into a 250.0 mL container.

$$2\ BrCl\ (g) \rightleftharpoons Cl_2(g) + Br_2(g)$$

(a) Write the equilibrium expression for this reaction.

$$K_{eq} = \frac{[Cl_2][Br_2]}{[BrCl]^2}$$

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

BrCl: 0.220 M

Cl_2: 0 M

Br_2: 0 M

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

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

BrCl: 0.094 M

Cl_2: 0.063 M

Br_2: 0.063 M

	$2BrCl$	$\rightleftharpoons Cl_2$	$+ Br_2$
I	0.22 M	0	0
C	$-2x$	$+x$	$+x$
E	$0.22-2x$	x	x

$$\sqrt{0.45} = \sqrt{\frac{[x][x]}{[0.22-2x]^2}}$$

$0.67082 = \frac{x}{0.22-2x}$ $\quad \frac{0.14758}{2.34164} = \frac{2.34164x}{2.34164}$ $\quad 0.22 - 2(0.063) = 0.094\ M$

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

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

A: 2.5×10^{-2} moles/1L; B: 3.8×10^{-2} moles/1L; and C: 1.6×10^{-3} moles/1L.

(a) Write the equilibrium expression for this reaction.

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

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

K_c: 1.13×10^2

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

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

K_p: 1.22×10^{-2}

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

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 conjuate base of this acid? Answer a: CH_3COO^-

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

$[H_3O^+] = 10^{-3.84} = 1.4454 \times 10^{-4}$ M

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

	HA	A^-	H_3O^+
I	Y	0	0
C	$-x$	$+x$	$+x$
E	$Y-x$	$x = 1.45 \times 10^{-4}$	$x = 1.45 \times 10^{-4}$

$Y - 1.45 \times 10^{-4}$

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

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

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

(d) What is the % ionization? Answer d: 11 %

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

4) A solution of the weak base ethylamine ($C_2H_5NH_2$) was made by dissolving 0.140 moles in 1.00L of water. The K_b value for this base is 5.6×10^{-4}.

$\frac{0.140 \text{ moles}}{1 \text{ L}} = 0.140 \text{ M}$

a.) What is the formula of the conjuagate acid? Answer a: $C_2H_5NH_3^+$

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

$C_2H_5NH_2 + H_2O \rightleftharpoons C_2H_5NH_3 + OH^-$

I	0.140	0	0
C	$-x$	$+x$	$+x$
E	$0.140 - x$	x	x

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

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

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

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

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

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? $\triangle H = 155.5kJ$

$$3NO(g) \rightleftharpoons N_2O(g) + NO_2(g)$$

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

b.) Heat is added — Answer b: products

c.) $N_2O(g)$ is added to the flask — Answer c: reactants

d.) $NO_2(g)$ is removed from the flask — Answer d: products

e.) A catalyst is added to the reaction — Answer e: no change

f.) NO(g) is added to the flask — Answer f: products

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

Answer g: Possibilities: 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 0.258 mol of HCl (a strong acid) is dissolved in 1.00L of water?

$\frac{0.258\ mol}{1L} = 0.258M$

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 $2.8 \times 10^{-7}M$, what is the hydroxide ion concentration?

$[OH^-] = \frac{1 \times 10^{-14}}{[H_3O^+]} = \frac{1 \times 10^{-14}}{2.8 \times 10^{-7}} = 3.57 \times 10^{-8}$ Answer d: 3.6×10^{-8}

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

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

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 pK_a of aspirin? Answer g: 3.52

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