Chemistry 1A, Fall 2009

Midterm Exam #2
October 13, 2009
(90 min, closed book)

Name:_____KEY_____

SID:_____

GSI Name:_____

- The test consists of 6 short answer questions and 20 multiple choice questions.
- Put your written answers in the boxes provided. Answers outside the boxes may not be considered in grading.
- Write your name on every page of the exam.

Question	Page	Points	Score
Multiple Choice (1-20)	2-5	78	
Question 21	6	8	
Question 22-23	7	9	
Question 24	8	10	
Question 25	9	5	
Question 26	10	10	
Total		120	

Useful Equations and Constants:

$pH = - \log[H_3O^+]$
$pX = - \log X$
$X = 10^{-pX}$
$Kw = 1\times10^{-14}$

Strong acids and bases:

HCl	LiOH
HNO_3	NaOH
H_2SO_4	KOH
$HClO_4$	
HBr	
HI	

Acid dissociation constants (Ka)

CH_3COOH	1.75×10^{-5}
NH_4^+	5.70×10^{-10}
HCN	6.2×10^{-10}
$CH_3NH_3^+$	2.3×10^{-11}
H_2CO_3	4.45×10^{-7}
$(CH_3)_3NH^+$	1.58×10^{-10}

Name_____GSI_____

Multiple choice. Circle the BEST answer <u>and</u> bubble the choice on your scantron form.

1. How many moles of HCl must be added to 1 liter of water to make $[OH^-] = 10^{-9}$ M?
   A) 10^{-9} moles B) 10^{-5} moles C) 10^{-2} moles D) there is no OH^- in HCl (aq)

B) 3 points

2. What is the pH of a 0.020M HCl solution?
   A) 1.0 B) 0.020 C) 2.0 D) 1.7

D) 3 points C) 2 point

3. What is the pH of a 1.00M formic acid (HCOOH) solution? Ka = 1.80×10^{-4}
   A) 0.013 B) 0.00 C) 1.9 D) 3.7

C) 3 points A) 2 point

4. What is the solubility of the salt lead chloride, $PbCl_2$? Ksp = 1.7×10^{-5}
   A) 4.1×10^{-3}M B) 4.3×10^{-6} M C) 1.7×10^{-5}M D) 1.6×10^{-2} M

D) 3 points A) 2 point

5. Which solution requires the largest volume of 0.10 M HCl to reach the equivalence point?
   A) 50 mL 1.0 M NH_3
   B) 200 mL 2.0 M NaCl
   C) 100 mL 0.25 M NaOH
   D) 100 mL 0.40 M NaOH

A) 3 points D) 2 point

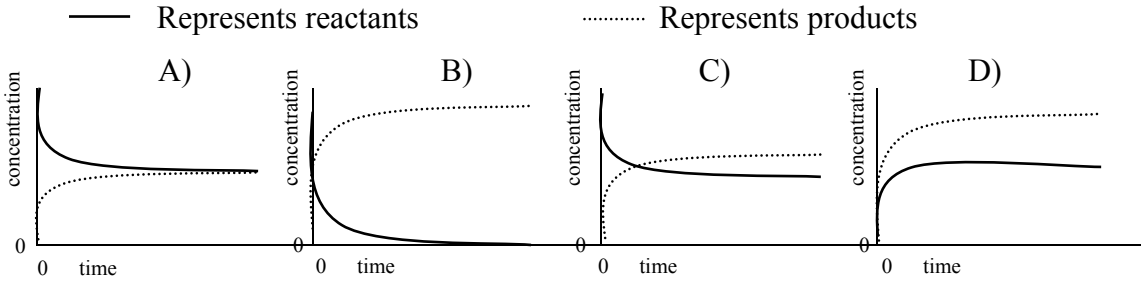
6. Which reaction is an oxidation-reduction reaction?
   A) $6FeCl_2(aq) + K_2Cr_2O_7(aq) + 14HCl \rightleftharpoons 6FeCl_3(aq) + 2CrCl_3(aq) + 2KCl(aq) + 7H_2O(l)$
   B) $AgNO_3(aq) + NaCl(aq) \rightleftharpoons AgCl(s) + NaNO_3(aq)$
   C) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$
   D) $SO_3(g) + H_2O(l) \rightleftharpoons H_2SO_4(aq)$

A) 3 points [Note: There is a small error in B). The A is missing for AgCl.

7. The solid $CaSO_4$ is dissolved in 1.0 L of water. The solution formed establishes an equilibrium with a large amount of solid $CaSO_4$. If you add 10 mL water and examine the solution after 10 minutes_____.
   A) the concentration decreases
   B) the equilibrium constant increases
   C) the solubility remains the same
   D) the solubility decreases

C) 3 points A) 2 point

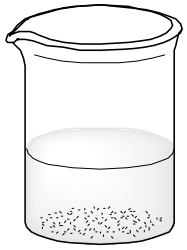
8. The diagrams shown below represent the concentration of reactants and products over time. Which of the graphs represent systems that have reached equilibrium? Why?



A) Graph A because the concentrations are equal
B) Graph B because the concentrations are constant
C) Graph C because the concentrations are constant
D) Graph D because the concentrations are constant

C) 3 points B) 2 point

9. What conclusion can you draw from the data in the table?



	Ksp	pH of saturated solution
$Mg(OH)_2$	2.0×10^{-13}	~10
$Ba(OH)_2$	2.6×10^{-4}	~13

A) $Mg(OH)_2$ is not an electrolyte.
B) $Mg(OH)_2$ is more soluble than $Ba(OH)_2$.
C) Both $Mg(OH)_2$ and $Ba(OH)_2$ are completely dissociated into ions in solution.
D) Molecules of $Mg(OH)_2$ in solution are only partially dissociated.
E) $Mg(OH)_2$ is a weak base.

C) 4 points E) 3 points D) 3 points

10. Equal moles of nitric acid, HNO_3, and sodium hydroxide, NaOH are mixed.

$$HNO_3\ (aq) + NaOH\ (aq) \rightleftharpoons NaNO_3\ (aq) + H_2O\ (l)$$

What happens to the equilibrium concentrations if you add solid sodium nitrate, $NaNO_3$ (s), to the solution?

A) The reaction proceeds to form more products.
B) The pH increases above 7.
C) The pH remains at 7.
D) There is less water in the solution.
E) The density of the solution increases.

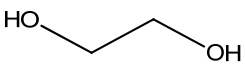
C) 4 points E) 3 points D) 3 points

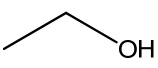
11. Which compound will form a solution with the lowest pH? (Data is on page 1)

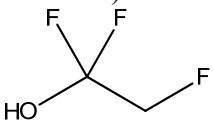
A) NH_4Cl B) Na_2CO_3 C) $N(CH_3)_3$ D) NaBr E) CH_3COONa

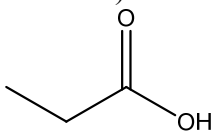
A) 4 points D) 2 point

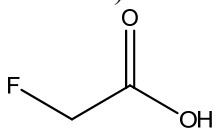
12. Which of the substances listed below is the strongest acid?

A) 

B) 

C) 

D) 

E) 

E) 4 points D) 3 points C) 2 points

13. An aqueous solution of 1 mole of NaOH (sodium hydroxide) was added to an aqueous solution of 1 mole of CH_3COOH (acetic acid). Which of the following statements is true about the solution?
    A) It contains *more* H_3O^+ ions that OH^- ions
    B) It contains *fewer* H_3O^+ ions than OH^- ions
    C) It contains *as many* H_3O^+ ions *as* OH^- ions
    D) It contains *neither* H_3O^+ ions *nor* OH^- ions
    E) It contains *as many* CH_3COO^- ions *as* Na^+ ions

B) 4 points E) 3 points C) 3 points

14. A 0.10 M solution of congo red indicator changes color from the blue-violet HIn molecule to the red In^- ion at a pH of 4. What is the equilibrium constant for the dissociation of congo red?
    A) 0.10 B) 0.00010 C) 10000 D) 4 E) 3.16×10^{-3}

B) 4 points E) 3 points

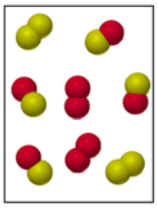
15. An equilibrium mixture of gases consists of $[CO] = 2.5\times10^{-3}$ M, $[O_2] = 1.6\times10^{-3}$ M, and $[CO_2] = 3.2\times10^{-2}$ M. Determine the equilibrium constant for the formation of CO_2.
    A) 8.0×10^{3} B) 1.0×10^{5} C) 1.3×10^{-7} D) 1.3×10^{-4} E) 1.0×10^{-5}

B) 5 points A) 4 points

16. Equal moles of HCl, CH_3COOH, and NH_3 are mixed in water. What are the three species in solution present in the highest concentrations?
    A) HCl, CH_3COOH, and NH_3
    B) H^+, CH_3COO^-, and NH_4^+
    C) H^+, NH_3, and CH_3COOH
    D) H^+, Cl^-, and NH_4^+
    E) Cl^-, NH_4^+, and CH_3COOH

E) 5 points B) 4 points

17. The illustration shows an equilibrium mixture for the reaction of A_2 and B_2.
$A_2\,(g) + B_2\,(g) \rightleftharpoons 2AB\,(g)$



How can you produce this equilibrium mixture?

A) Mix 4 molecules of A_2 and 4 molecules of B_2 and allow them to react.
B) Mix 6 molecules of A_2 and 6 molecules of B_2 and allow them to react.
C) Begin with 6 molecules of AB and allow some to decompose.
D) Begin with 8 molecules of AB and allow some to decompose.
E) Both (A) and (D)

E) 5 points A) 4 points D) 4 points

18. Silver chloride, AgCl, is less soluble than silver bromide, AgBr. Do you expect silver iodide ~~cyanide~~, AgI, to be more or less soluble than AgBr?

A) AgI is more soluble than AgBr because the trend is dominated by the decrease in lattice energy.
B) AgI is more soluble than AgBr because the trend is dominated by the increase in lattice energy.
C) AgI is less soluble than AgBr because the trend is dominated by the decrease in hydration energy.
D) AgI is less soluble than AgBr because the trend is dominated by the increase in hydration energy.
E) AgI is more soluble than AgBr because I^- is a stronger base than Br^-.

A) 5 points B) 4 points C) 4 points D) 4 points

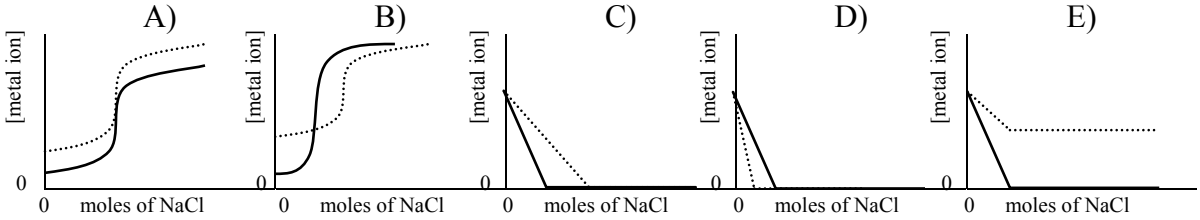
19. How much Ag^+ is left in solution if you mix 0.10 mole $AgNO_3$ with 0.20 mole NaOH to make a 1.0 liter solution? (Ksp for AgOH = 10^{-8})

A) 0 B) 10^{-4} C) 10^{-7} D) 10^{-8} E) 10^{-9}

C) 5 points B) 4 points D) 4 points

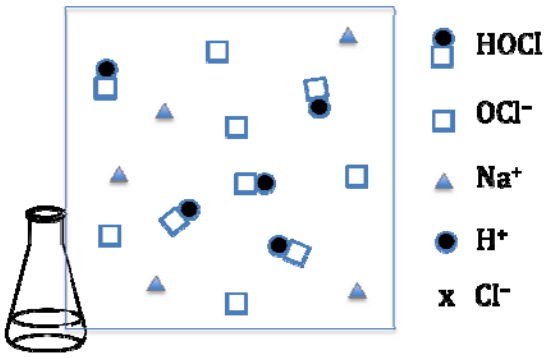
20. You have two solutions, one of 0.010M $AgNO_3$ (aq) and one of 0.010M $Pb(NO_3)_2$ (aq). To each solution you slowly add solid NaCl. Which graph best represents the concentration of the metal with the addition of NaCl? (Ksp for AgCl = 1.8×10^{-10}, Ksp for $PbCl_2$ = 1.7×10^{-8})

——— $[Ag^+]$ ····· $[Pb^{2+}]$



C) 5 points E) 4 points D) 4 points

21. An atomic scale view of a solution that is 0.50 M HOCl and 0.50 M NaOCl is shown. The squares represent OCl^- and the circles attached to the squares represent HOCl. Ka (HOCl) = 3.5×10^{-8}



Species	Numbers in Solution
HOCl	5
OCl^-	5
Na^+	5
Cl^-	0

a) Why are there no H^+ ions in the atomic scale view?

Ka is very small 2 points

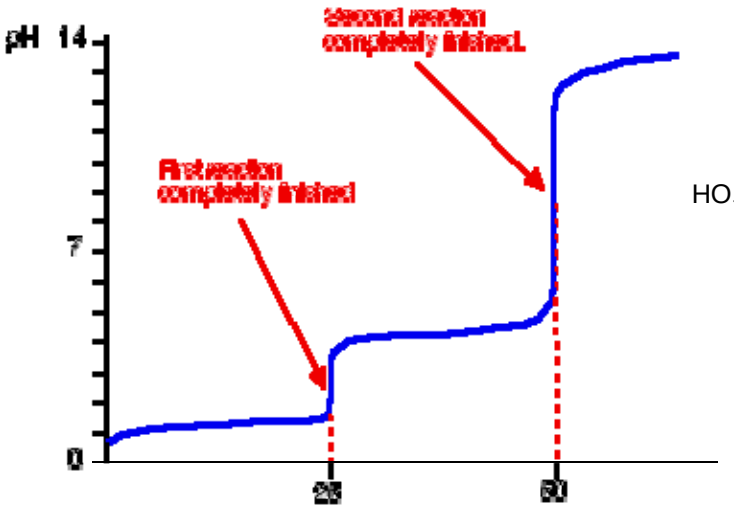
Since # HOCl = OCl^-, the H^+ is equal to Ka, so H^+ is only 10^{-8} M.
Each symbol in the illustration represents 0.1 M 2 points

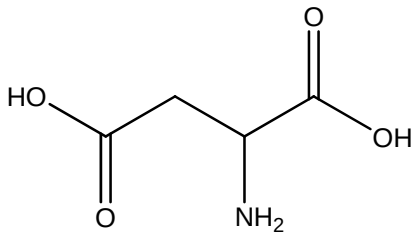
b) Draw an atomic view after addition of 0.30 moles HCl. Record the number of each species in your drawing in the table below.

Species	Numbers in Solution
HOCl	*8*
OCl^-	*2*
Na^+	*5*
Cl^-	*3*

1 point each

22. The titration of the amino acid aspartic acid with base is shown below.





Volume (mL) of 0.10M NaOH

How many moles of aspartic acid are in the sample being titrated? Show your work.

molarity of NaOH times any volume 2 points

(0.10 M)(0.025 mL) = 0.0025 moles 2 points

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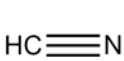
23. Explain why HCN is a weak acid.



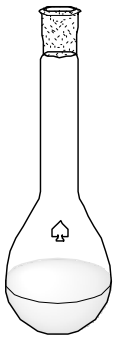
Show structures, 1 point

It is an acid because the N atoms draw electron density away from the C making the H-C bond polar enough for H^+ to dissociate.
2 points

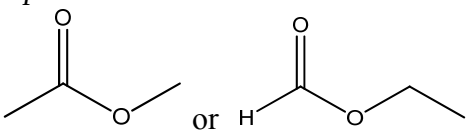
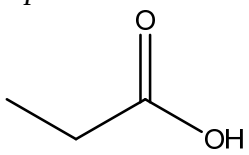
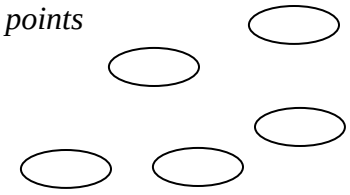
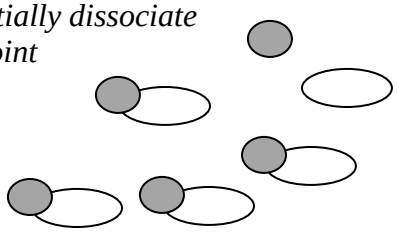
The H-CN bond is not very polar because of the small difference in electronegativity (or may mention the negative formal charge on the carbon will lead not the H^+ being attracted prone to dissociate.)
2 points

Name_____GSI_____

24. There are two bottles, both labeled $C_3H_6O_2$ (aq). The solution in Bottle A smells sweet, it does not conduct electricity, and does not change the color of purple cabbage juice. The solution in Bottle B smells putrid, it does conduct electricity (dim light bulb), and it turns cabbage juice pink.



Complete the table below by providing a detailed explanation including molecular structures and atomic views of the solutions to account for these observations.

	Bottle A	**Bottle B**
Smell	sweet	putrid
Conductivity	none	some, dim light bulb
Purple Cabbage Juice	stays purple	turns pink
Molecular Structure	*Ester or aldehyde* *2 points* 	*Acid* *2 points* 
Atomic View (show what five molecules in solution would look like)	*Not dissociate* *1 points* 	*Partially dissociate* *1 point* 
Explain your reasoning	*Does not conduct electricity = does not dissociate* *1 point* *Does not change color of cabbage juice = not an acid or base* *1 point*	*Dim light due to partial dissociation* *1 point* *Change color of cabbage juice indicating acid* *1 point*

25. Explain why adding vinegar (acetic acid, CH_3COOH) to fish reduces the fishy smell caused by molecules such as methyl amine, CH_3NH_2. Be specific about the products that form and why you no longer detect the smell.

$CH_3COOH\ (aq) + CH_3NH_2\ (aq) \rightleftharpoons CH_3COO^-\ (aq) + CH_3NH_3^+\ (aq)$
Acid-base reaction
2 points for writing this acid-base reaction

Correct products (technically = a salt)
1 point

Ions are not volatile so you do not smell them.
2 points

26. You have a mixture of three metal ions in a 1 liter solution: Ba^{2+}, Cu^{2+}, and Fe^{3+}. Use the information given below to design a two-step procedure to separate each metal ion from the solution. For each step, explain your procedure, write the net ionic equation and explain what you would observe. (Hint: No rigorous calculations are needed.)

There are three solutions available for your procedure (you do not need to use all three of these solutions).

1.0 M HNO_3 1.0 M NaOH 1.0 M K_2CrO_4

	K_{sp}
$Ba(OH)_2$	3.0×10^{-4}
$Cu(OH)_2$	1.0×10^{-19}
$Fe(OH)_3$	1.6×10^{-39}

	K_{sp}
$Ba\ CrO_4$	2.1×10^{-10}
$Cu\ CrO_4$	3.6×10^{-6}
$Fe_2(CrO_4)_3$	1.0×10^{-35}

Step 1:

- Explain what was added. 1 point
- Specify that you limited the amount if you only want 1 or 2 ions to precipitate or dissolve 1 point
- Filter to separate solid and liquid. 1 point
- Explain what happened. 2 points

Example
- Use NaOH to precipitate both $Cu(OH)_2$ (s) and $Fe(OH)_2$ (s). 1 point
- Do not add so much NaOH that you also precipitate $Ba(OH)_2$ (s). 1 point
- Filter solid. 1 point
- Ba^{2+} is still in solution after filtering the solid, so Ba^{2+} has been separated. 2 points

Step 2:

- Explain what was added. 1 point
- Specify that you limited the amount if you only want 1 or 2 ions to precipitate or dissolve 1 point
- Filter to separate solid and liquid 1 point
- Explain what happened. 2 points

Some possibilities
Scheme 1: Add just enough NaOH to ppt $Fe(OH)_3$. Add just enough K_2CrO_4 to ppt $BaCrO_4$.
Scheme 2: Add just enough NaOH to ppt both $Cu(OH)_2$ and $Fe(OH)_3$. Add just enough HNO_3 to dissolve $Cu(OH)_2$.
Scheme 3: Add just enough K_2CrO_4 to ppt $Fe_2(CrO_4)_3$. Add just enough NaOH to ppt $Cu(OH)_2$.