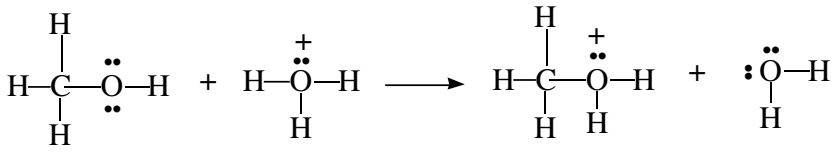
Acids and Bases

1. (4 points) In the following reaction from organic chemistry designate the Brønsted acid, the Brønsted base, and their conjugates.



(a) Brønsted base = _____ and its conjugate acid is _____

(b) Brønsted acid = _____ and its conjugate base is _____

2. (6 points) Equal amounts of the hydrogen phosphate ion (as Na_2HPO_4) ammonium ion (as NH_4Cl) are mixed in water. The net ionic equation for a possible reaction is

$$HPO_4^{2-}(aq) + NH_4^+(aq) \rightleftharpoons H_2PO_4^-(aq) + NH_3(aq)$$

(a) Circle the formulas of the two acids in the reaction.

$HPO_4^{2-}(aq)$ $NH_4^+(aq)$ $H_2PO_4^-(aq)$ $NH_3(aq)$

(b) Which of the acids is the stronger of the two? _____

(c) Does the equilibrium lie predominantly to the left or to the right? _____

3. (8 points) You have three different acids in separate beakers. All have a concentration of 0.05 M.

Beaker A: Boric acid Beaker B: Acetic acid Beaker C: H_3PO_4

Which beaker has the largest $[H_3O^+]$ concentration ? _____

Which beaker has the highest pH? _____

Which beaker has the highest concentration of OH^-? _____

Which acid has the strongest conjugate base? _____

4. (4 points) When the $[H_3O^+]$ in a solution increases by a factor of 10, the pH

(a) increases by 10 (b) does not change

(c) increases by 0.10 (d) increases by 1

(e) decreases by 10 (f) decreases by 1

(g) decreases by 0.1 (h) doubles

When the pH increases by 1.00, the $[OH^-]$ changes in the following manner:

(a) $[OH^-]$ decreases by a factor of 2

(b) $[OH^-]$ increases by a factor of 10

(c) $[OH^-]$ decreases by a factor of 10

(d) $[OH^-]$ increases by a factor of 1

5. (3 points) A solution has $[H_3O^+] = 6.8 \times 10^{-4}$ M. Which answer below is correct?

	pH	**pOH**	**$[OH^-]$**
(a)	3.17	10.83	1.47×10^{-11}
(b)	6.80	7.20	1.00×10^{-14}
(c)	10.83	3.17	1.47×10^{-11}
(d)	3.17	10.83	6.8×10^{-4}

6. (3 points) What is the pH of a 0.0423 M solution of HNO_3?

(a) 0.042

(b) 1.37

(c) 4.23

(d) 12.63

7. (3 points) What is the pH of a 0.015 M solution of acetic acid?

(a) 1.82

(b) 3.28

(c) 4.74

(d) 6.57

8. (3 points) What is the pH of a 0.015 M solution of the carbonate ion, CO_3^{2-} (with a cation that does not affect the pH)?

   (a) 2.75

   (b) 3.68

   (c) 10.32

   (d) 11.25

9. (7 points) Enough of each substance below is added to water to make a 0.10 M solution. Decide if each solution below is *acidic, basic,* or *neutral.*

Salt	**Acidity in Aqueous Solution**
(a) NaBr	_____
(b) K_2HPO_4	_____
(c) NH_4NO_3	_____
(d) $AlCl_3$	_____
(e) $(NH_4)_3PO_4$	_____
(f) Na_2SO_3	_____
(g) $NaH_2PO_4 + Na_2HPO_4$	_____

10. (2 points) Chloroacetic acid ($ClCH_2CO_2H$) has pK_a = 2.867. Chloroacetic acid is *(stronger)(weaker)* than acetic acid. _____

11. (3 points) The pH of 0.015 M benzilic acid (a weak acid) is 2.50. What is the value of K_a for the acid?

   (a) 0.015

   (b) 3.6×10^{-3}

   (c) 8.4×10^{-4}

   (d) 1.3×10^{-5}

12. (5 points) You have a buffer solution based on NH_3 and NH_4Cl. If the pH of the buffer is 9.00, which is present is larger amount in the solution, NH_3 or NH_4Cl?

    (a) NH_3

    (b) NH_4Cl

    Explain your answer in words and using appropriate calculations

12. (5 points) What mass of sodium acetate, $NaCH_3CO_2$ (molar mass = 82 g/mol) do you have to add to 1.00 L of 0.15 M acetic acid to prepare a buffer solution with a pH of 4.89?

    (a) 12.3 g $NaCH_3CO_2$

    (b) 17.2 g $NaCH_3CO_2$

    (c) 22.1 g $NaCH_3CO_2$

    (d) 82.0 g $NaCH_3CO_2$

    After you make the $NaCH_3CO_2$/acetic acid buffer solution, you add 500 mL of water. What happens to the pH of the buffer?

    (a) The pH increases

    (b) The pH decreases

    (c) The pH stays the same

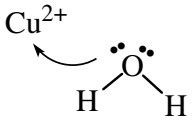
13. (6 points) Acid-base reactions

(a) A solution of formic acid (15 mL, 0.050 M) is mixed with 15 mL of 0.050 M NaOH. Is the resulting solution acidic, basic, or neutral? _____

(b) 50.0 mL of 0.40 M NH_3 is mixed with 50.0 mL of 0.40 M HCl. Is the resulting solution acidic, basic, or neutral? _____

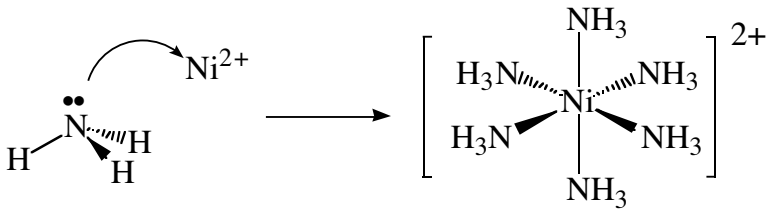
(c) 30 mL of 0.050 M acetic acid is mixed with 15 mL of 0.050 M NaOH. Is the resulting solution acidic, basic, or neutral? _____

14. (6 points) When placed in water, copper ions give the solution a beautiful blue color. The color comes from the interaction of Cu^{2+} with water.



In this reaction, Cu^{2+} is a (Lewis acid) (Lewis base) _____ and water is a (Lewis acid) (Lewis base). _____

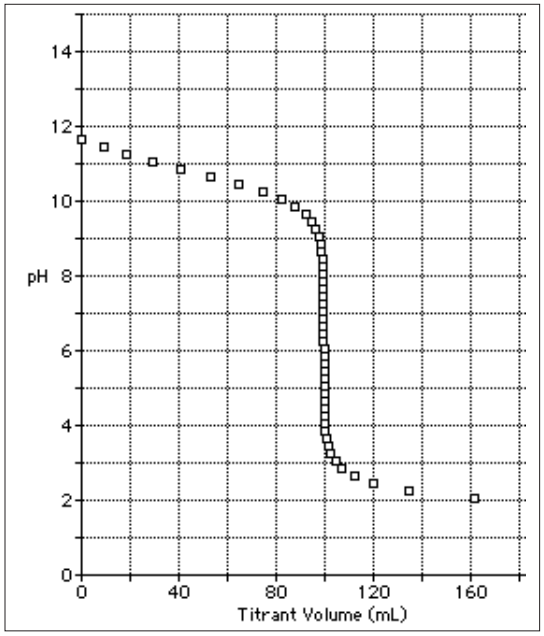
Nickel ion also interacts with ammonia to give a purple, octahedral complex ion.



The hybridization of the N in NH_3 is _____ and the hybridization of Ni^{2+} in the square planar $Ni(NH_3)_6^{2+}$ ion is _____ *(2 bonus points for the 2nd answer!)*

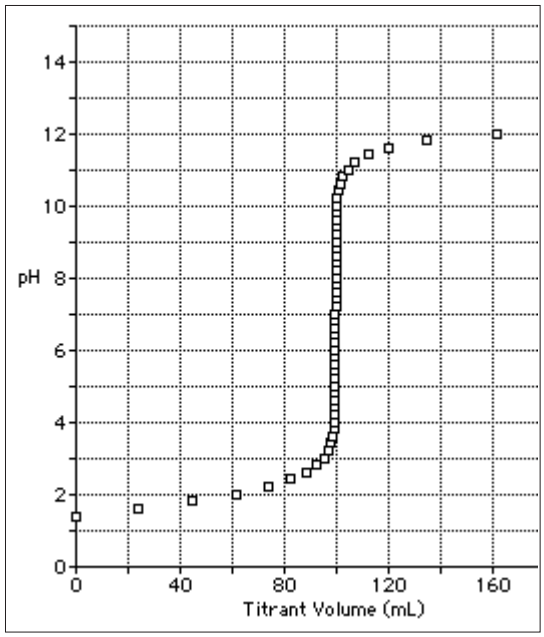
15. (4 points) Identify each of the two titration curves below as one of the following:

(a) a strong acid titrated with a strong base
(b) a strong acid titrated with a weak base
(c) a weak acid titrated with a strong base
(d) a strong base titrated with a strong acid
(e) a weak base titrated with a strong acid



Titration type:

_____



Titration type:

_____

16. 11 points) Suppose you titrate 50.0 mL of 0.050 M phenylacetic acid ($C_6H_5CH_2CO_2H$) with 0.050 M NaOH.

$$C_6H_5CH_2CO_2H(aq) + OH^-(aq) \rightarrow \text{products}$$

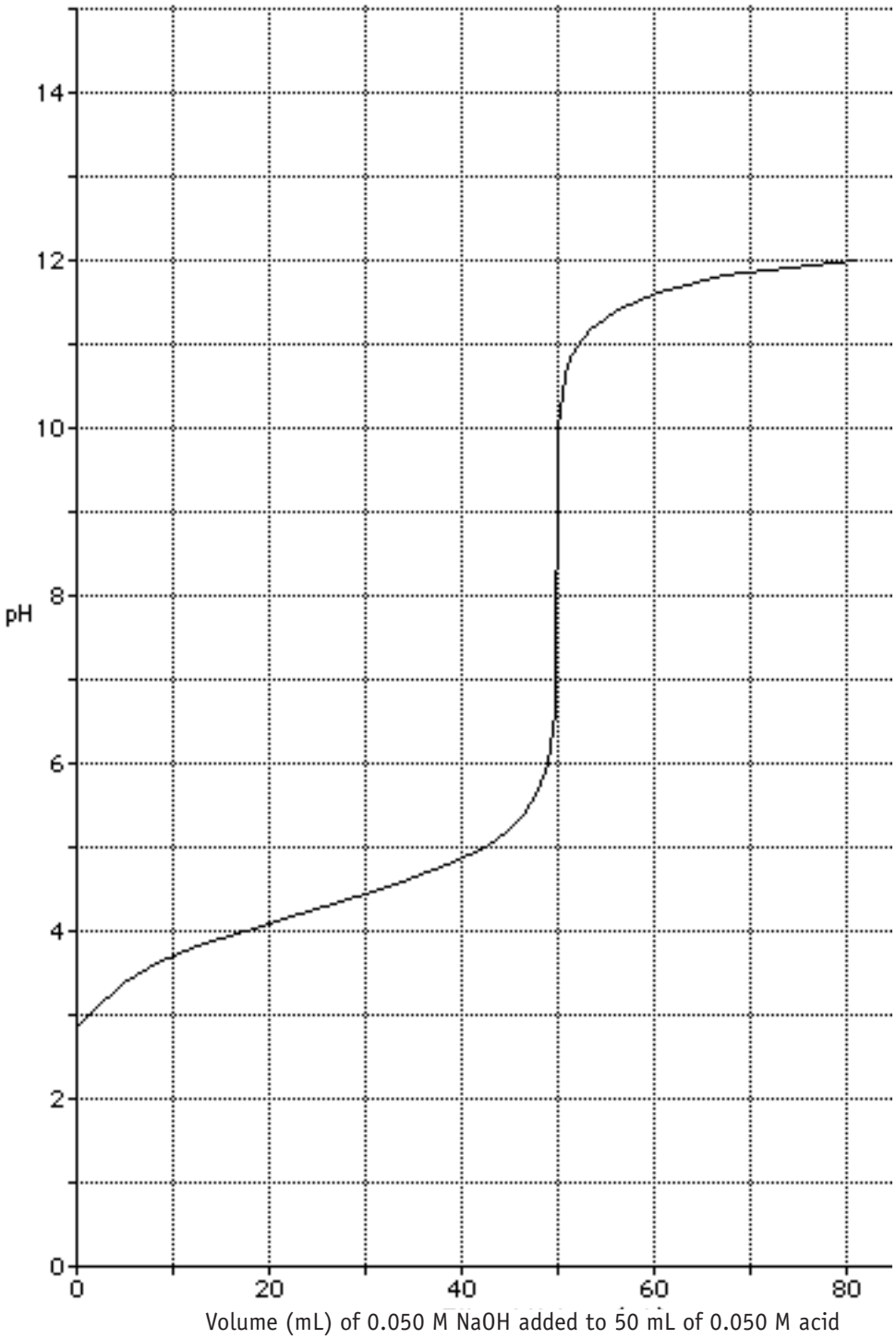
Use the titration curve on the next page to answer the following questions:

(a) What is the pH at the beginning of the titration? _____

(b) The pK_a of phenylacetic acid is about _____ and the K_a is about _____

(c) The pH at the equivalence point is _____

(d) Explain why the pH at the equivalence point is (*acidic*)(*basic*)(*neutral*).


14
12
10
8
6
4
2
0
pH
0
20
40
60
80
Volume (mL) of 0.050 M NaOH added to 50 mL of 0.050 M acid

VALENCE BOND THEORY AND HYBRIDIZATION

1. (7 points) Draw a Lewis electron dot structure for SO_3^{2-}, the sulfite ion.

Provide the following information:

The number of valence electrons in the ion _____

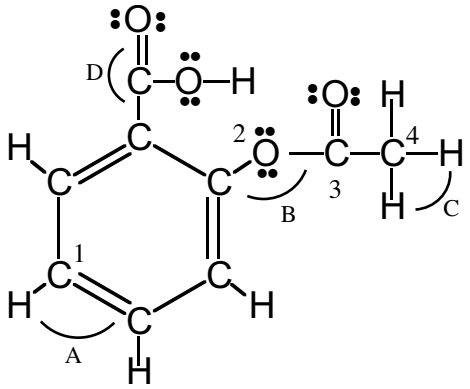
The electron pair geometry of the ion _____

The molecular geometry of the ion _____

The O—S—O bond angle _____

The S atom hybridization _____

2. (8 points) The structure of aspirin in shown here.



Bond angles:

Angle A = _____

Angle B = _____

Angle C = _____

Angle D = _____

Atom hybridizations:

C atom 1 = _____ C atom 3 = _____

O atom 2 = _____ C atom 4 = _____

3. (2 points) Give the hybridization used by each underlined atom.

(a) C in $\underline{C}O_2$ _____

(b) B in $\underline{B}H_4^-$ _____