Question 1
10 Points

Which of the following reactions are expected to go almost to completion (> 99% complete)? **Check all that apply.**
ASSUME ALL SPECIES in AQUEOUS SOLUTION, (aq), unless noted.

Yes $HCl + H_2O \rightarrow H_3O^+ + Cl^-$

No $NH_3 + H_2O \rightarrow OH^- + NH_4^+$

Yes $NaOH \rightarrow Na^+ + OH^-$

No $HCN + H_2O \rightarrow H_3O^+ + CN^-$

No $CH_3CO_2H + CH_3CO_2^- \rightarrow CH_3CO_2^- + CH_3CO_2H$

Yes $Fe^{2+} + 2\ OH^- \rightarrow Fe(OH)_2(s)$

No $Fe^{2+} + 2\ NO_3^- \rightarrow Fe(NO_3)_2(s)$

No $FeS(s) \rightarrow Fe^{2+} + S^{2-}$

Yes $Cu^{2+} + 4\ NH_3 \rightarrow Cu(NH_3)_4^{2+}$

No $Cu(CN)_4^{2-} \rightarrow Cu^{2+} + 4\ CN^-$

Question 2
6 Points

Calculate the pH of a 0.25 M solution of propanoic ($CH_3CH_2CO_2H$) acid.

$HA = CH_3CH_2CO_2H$, $A^- = CH_3CH_2CO_2^-$

	$HA(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + A^-(aq)$		
I	0.25	0	0
C	-x	+x	+x
E	0.25-x	x	x

$K_a = ([H_3O^+][A^-])/[HA]$

$1.3\times10^{-5} = x.x/(0.25-x)$

$1.3\times10^{-5} \approx x^2/0.25$

$x = 1.80\times10^{-3}$

pH = <u>2.74</u>

Question 3
6 Points

Calculate the pH of a solution prepared by mixing 0.35 mol propanoic acid and 0.25 mol sodium propanoate ($NaCH_3CH_2CO_2$) to create 1.00 liters of solution.

$HA = CH_3CH_2CO_2H$, $A^- = CH_3CH_2CO_2^-$

$K_a = ([H_3O^+][A^-])/[HA]$

$1.3\times10^{-5} = x(0.25+x)/(0.35-x)$

$1.3\times10^{-5} \approx x(0.25/0.35)$

$HA(aq) + H_2O(l) \Leftrightarrow H_3O^+(aq) + A^-(aq)$

	HA(aq)	$H_2O(l)$	$H_3O^+(aq)$	$A^-(aq)$
I	0.35	N/A	0	0.25
C	-x		+x	+x
E	0.35-x		x	0.25+x

$x = 1.82\times10^{-5}$

pH = <u>4.74</u>

Question 4
5 Points

Which of the following mixtures will result in a buffer solution. Check all that apply.

Yes — Mixing 0.20 mol formic acid (HCO_2H) and 0.80 mol sodium formate with 1 liter of water.

No — Mixing 0.20 mol formic acid and 0.80 mol HCl with 1 liter of water.

No — Mixing 0.20 mol formic acid and 0.80 mol NaOH with 1 liter of water.

Yes — Mixing 0.80 mol formic acid and 0.20 mol NaOH with 1 liter of water.

Yes — Mixing 0.20 mol HCl and 0.80 mol sodium formate with 1 liter of water.

Question 5
10 Points

For each of the following salts, indicate if a solution of the salt will be acidic (A), basic (B), or neutral (N).

B — $NaHCO_2$

B — NaCN

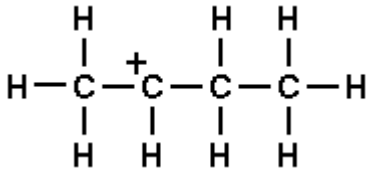
N — NaBr

A — NH_4NO_3

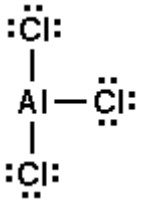
B — $(NH_4)_2SO_3$

Question 6
10 Points

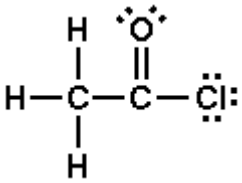
For each of the following indicate if the species could act as a Lewis acid (A), a Lewis basic (B), or neither (N). If something can act as either an acid or a base, indicate both.



A



AB



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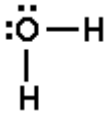
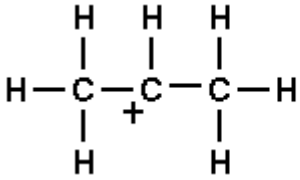


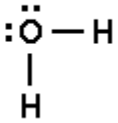
AB

B

Question 7
4 Points

Draw the product of the Lewis acid base reaction that occurs between these two species.





Attach OH_2 via a lone pair to the C^+ on the other molecule.

Question 8
7 Points

We have 1.00 L of a solution containing 0.45 M propanoic acid ($CH_3CH_2CO_2H$) and 0.30 M sodium propanoate ($NaCH_3CH_2CO_2$). To this solution we add 0.15 mol NaOH.

What is the pH of the resulting solution?

	OH^- +	$CH_3CH_2CO_2H$ =	$H_2O(l)$ +	$CH_3CH_2CO_2^-$
I	0.15	0.45	N/A	0.30
C	-0.15	-0.15		+0.15
F	0	0.30		0.45

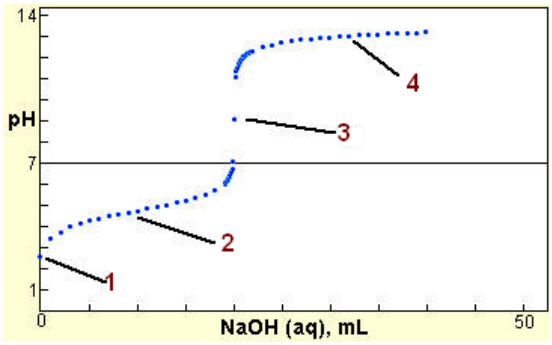
$[H_3O^+] = Ka\{[Acid]/[Base]\}$

$[H_3O^+] = 1.3\times10^{-5}(0.30/0.45) = 1.95\times10^{-5}$

pH = <u>5.06</u>

Question 9
12 Points

The below plot is a pH titration of an solution of an acid, **HA**, to which a solution of NaOH was added. Answer each of the questions about the titration.



a. Is the acid titrated a strong acid or a weak acid? Weak Acid

b. For each of the numbered points in the titration, indicate what the nature of the solution is (e.g. strong acid, strong base, buffer, weak acid, weak base, neutral salt).

1. Weak Acid
2. Buffer
3. Weak Base
4. Strong Base

c. What is the approximate value of K_a of the acid, HA? 1.58×10^{-5}

Question 10
6 Points

Use the K_{sp} value to estimate the solubility of CaF_2, in mol/L.
K_{sp} $CaF_2(s)$ @ 298K = 5.3×10^{-11}

	$CaF_2(s) \Leftrightarrow Ca^{2+}$	+	$2F^-$
I	0		0
C	x		2x
E	x		2x

$K_{sp} = [Ca^{2+}][F^-]^2$
$5.3 \times 10^{-11} = (x)(2x)^2$
$5.3 \times 10^{-11} = 4x^3$

$x = 2.37 \times 10^{-4}$ moles.L^{-1}

Question 11
7 Points

What is the solubility of CaF_2 in a solution that also contains 0.50 M NaF?

	$CaF_2(s) \Leftrightarrow Ca^{2+}$	+	$2F^-$
I	0		0.5
C	x		2x
E	x		0.5+2x

$K_{sp} = [Ca^{2+}][F^-]^2$
$5.3 \times 10^{-11} = (x)(0.5+2x)^2$
$5.3 \times 10^{-11} \approx (x)(0.5)^2$

$x = 2.12 \times 10^{-10}$ moles.L^{-1}

Question 12
10 Points

$Cu(OH)_2$ is a slightly soluble salt, as evidenced by its small value of Ksp. Suppose we had a saturated solution of copper(II) hydroxide with an excess of the solid at the bottom of the beaker. To this solution we add other chemicals. Indicate whether addition of each of the following species would increase (I) the solubility, decrease (D) the solubility, or have no (N) effect.

I HCl

D NaOH

I NH_3

N $NaNO_3$

N more $Cu(OH)_2$ solid

Question 13
7 Points

The bacterium Streptococcus pneumoniae has a radius of about 0.8 microns, or 8×10^{-5} cm. Use the formula for the volume of a sphere, volume = $4/3\pi r^3$ to calculate the volume of the bacterium.

Assuming the pH of the fluid in the cell is 7.6, calculate how many free H_3O^+ ions are present in one bacterium.

Avogadro's number = 6.023×10^{23}

Volume of the bacterium = $(4/3)x3.14x(8x10^{-5})^3$
= $2.14x10^{-12}$ cm^3

$[H_3O^+]$ = $2.51x10^{-8}$ $moles.L^{-1}$
H_3O^+ molecules = $2.51x10^{-8}(6.023x10^{23})$ L^{-1} = $1.61x10^{16}$ L^{-1} = $1.61x10^{13}$ cm^{-3}

$2.14x10^{-12}$ cm^3 x $1.61x10^{13}$ cm^{-3} ≈ 32