Name: _____ 8 Digit ID Number: _____

Acid Name	Acid	K_a	Base	K_b	Base Name
Perchloric acid	$HClO_4$	large	ClO_4^-	very small	perchlorate ion
Sulfuric acid	H_2SO_4	large	HSO_4^-	very small	hydrogen sulfate ion
Hydrochloric acid	HCl	large	Cl^-	very small	chloride ion
Nitric acid	HNO_3	large	NO_3^-	very small	nitrate ion
Hydronium ion	H_3O^+	1	H_2O	1×10^{-14}	water
Sulfurous acid	H_2SO_3	1.2×10^{-2}	HSO_3^-	8.3×10^{-13}	hydrogen sulfite ion
Hydrogen sulfate ion	HSO_4^-	1.2×10^{-2}	SO_4^{2-}	8.3×10^{-13}	sulfate ion
Phosphoric acid	H_3PO_4	7.5×10^{-3}	$H_2PO_4^-$	1.3×10^{-12}	dihydrogen phosphate ion
Hexaaquairon(III) ion	$Fe(H_2O)_6^{3+}$	6.3×10^{-3}	$Fe(H_2O)_5OH^{2+}$	1.6×10^{-12}	pentaaquahydroxoiron(III) ion
Hydrofluoric acid	HF	7.2×10^{-4}	F^-	1.4×10^{-11}	fluoride ion
Nitrous acid	HNO_2	4.5×10^{-4}	NO_2^-	2.2×10^{-11}	nitrite ion
Formic acid	HCO_2H	1.8×10^{-4}	HCO_2^-	5.6×10^{-11}	formate ion
Benzoic acid	$C_6H_5CO_2H$	6.3×10^{-5}	$C_6H_5CO_2^-$	1.6×10^{-10}	benzoate ion
Acetic acid	CH_3CO_2H	1.8×10^{-5}	$CH_3CO_2^-$	5.6×10^{-10}	acetate ion
Propanoic acid	$CH_3CH_2CO_2H$	1.3×10^{-5}	$CH_3CH_2CO_2^-$	7.7×10^{-10}	propanoate ion
Hexaaquaaluminum ion	$Al(H_2O)_6^{3+}$	7.9×10^{-6}	$Al(H_2O)_5OH^{2+}$	1.3×10^{-9}	pentaaquahydroxoaluminum ion
Carbonic acid	H_2CO_3	4.2×10^{-7}	HCO_3^-	2.4×10^{-8}	hydrogen carbonate ion
Hexaaquacopper(II) ion	$Cu(H_2O)_6^{2+}$	1.6×10^{-7}	$Cu(H_2O)_5OH^+$	6.25×10^{-8}	pentaaquahydroxocopper(II) ion
Hydrogen sulfide	H_2S	1×10^{-7}	HS^-	1×10^{-7}	hydrogen sulfide ion
Dihydrogen phosphate ion	$H_2PO_4^-$	6.2×10^{-8}	HPO_4^{2-}	1.6×10^{-7}	hydrogen phosphate ion
Hydrogen sulfite ion	HSO_3^-	6.2×10^{-8}	SO_3^{2-}	1.6×10^{-7}	sulfite ion
Hypochlorous acid	HClO	3.5×10^{-8}	ClO^-	2.9×10^{-7}	hypochlorite ion
Hexaaqualead(II) ion	$Pb(H_2O)_6^{2+}$	1.5×10^{-8}	$Pb(H_2O)_5OH^+$	6.7×10^{-7}	pentaaquahydroxolead(II) ion
Hexaaquacobalt(II) ion	$Co(H_2O)_6^{2+}$	1.3×10^{-9}	$Co(H_2O)_5OH^+$	7.7×10^{-6}	pentaaquahydroxocobalt(II) ion
Boric acid	$B(OH)_3(H_2O)$	7.3×10^{-10}	$B(OH)_4^-$	1.4×10^{-5}	tetrahydroxoborate ion
Ammonium ion	NH_4^+	5.6×10^{-10}	NH_3	1.8×10^{-5}	ammonia
Hydrocyanic acid	HCN	4.0×10^{-10}	CN^-	2.5×10^{-5}	cyanide ion
Hexaaquairon(II) ion	$Fe(H_2O)_6^{2+}$	3.2×10^{-10}	$Fe(H_2O)_5OH^+$	3.1×10^{-5}	pentaaquahydroxoiron(II) ion
Hydrogen carbonate ion	HCO_3^-	4.8×10^{-11}	CO_3^{2-}	2.1×10^{-4}	carbonate ion
Hexaaquanickel(II) ion	$Ni(H_2O)_6^{2+}$	2.5×10^{-11}	$Ni(H_2O)_5OH^+$	4.0×10^{-4}	pentaaquahydroxonickel(II) ion
Hydrogen phosphate ion	HPO_4^{2-}	3.6×10^{-13}	PO_4^{3-}	2.8×10^{-2}	phosphate ion
Water	H_2O	1×10^{-14}	OH^-	1	hydroxide ion
Hydrogen sulfide ion*	HS^-	1×10^{-19}	S^{2-}	1×10^5	sulfide ion
Ethanol	C_2H_5OH	very small	$C_2H_5O^-$	large	ethoxide ion
Ammonia	NH_3	very small	NH_2^-	large	amide ion
Hydrogen	H_2	very small	H^-	large	hydride ion
Methane	CH_4	very small	CH_3^-	large	methide ion

Increasing Acid Strength ↑

Increasing Base Strength ↓

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.

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

_____ $NH_3 + H_2O \rightarrow OH^- + NH_4^+$

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

_____ $HCN + H_2O \rightarrow H_3O^+ + CN^-$

_____ $CH_3CO_2H + CH_3CO_2^- \rightarrow CH_3CO_2^- + CH_3CO_2H$

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

_____ $Fe^{2+} + 2\ NO_3^- \rightarrow Fe(NO_3)_2(s)$

_____ $FeS(s) \rightarrow Fe^{2+} + S^{2-}$

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

_____ $Cu(CN)_4^{2-} \rightarrow Cu^{2+} + 4\ CN^-$

Question 2
6 Points

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

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.

Question 4
5 Points

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

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

____ Mixing 0.20 mol formic acid and 0.80 mol HCl with 1 liter of water.

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

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

____ 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).

____ $NaHCO_2$

____ NaCN

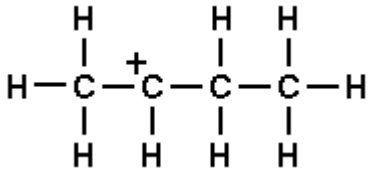
____ NaBr

____ NH_4NO_3

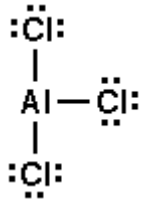
____ $(NH_4)_2SO_3$

Question 6
10 Points

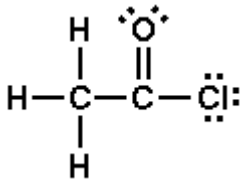
For each of the following indicate if the species could act as a Lewis acid (A), a Lewis basic (B), or neither (N). If something can act as either an acid or a base, indicate both.



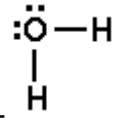
_____



_____



_____

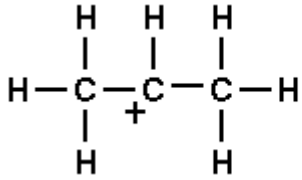


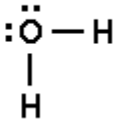
_____

_____

Question 7
4 Points

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





_____

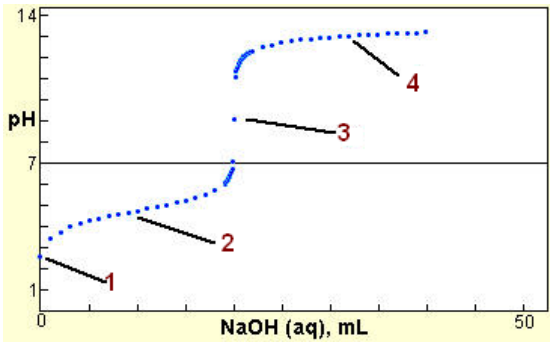
Question 8
7 Points

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?

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? _____

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. _____ 2. _____

3. _____ 4. _____

c. What is the approximate value of K_a of the acid, HA? _____

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}

Question 11
7 Points

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

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.

____ HCl

____ NaOH

____ NH_3

____ $NaNO_3$

____ 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}