

Name: _____ Class: _____ Date: _____

[6 pt] 1. Answer the following questions about a 0.0250 M solution of HCN. $K_a = 4.9 \times 10^{-10}$.

(a) What is the pH of the solution? Explain. 1(a) _____

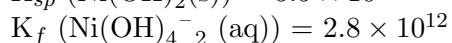
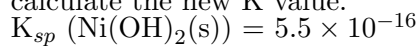
(b) Will the pH (D)ecrease, (I)ncrease, or (S)tay the same if 0.015 M NaCN is 1(b) _____ added? Explain

(c) Will the solubility (D)ecrease, (I)ncrease, or (S)tay the same if 0.025 M NaCl 1(c) _____ is added to the solution?

[10 pt] 2. Just like in lab, you titrate a 50.0 mL solution of 0.050 M $\text{Pb}(\text{NO}_3)_2$ with 2.50 mL of a 0.050 M solution of KI to form a PbI_2 precipitate. Answer the following questions about the experiment.(a) Write the K_{sp} equation(b) How many mols of I^- reacted? 2(b) _____(c) How many mols of Pb_2^+ reacted? 2(c) _____(d) What is the M of I^- in the final solution? 2(d) _____(e) What is the M of Pb_2^+ in the final solution? 2(e) _____(f) Calculate the value of K_{sp} for PbI_2 . 2(f) _____

(g) What is the %-Error compared to the theoretical value? 2(g) _____

[5 pt] 3. Write the reaction for each of the following values. Add the reactions together and 3. _____ calculate the new K value.



[5 pt] 4. Will a mixture of 600.0 mL of 0.020 M Na_2SO_4 and 700.0 mL of 0.001 M BaCl_2 produce a precipitate given the reaction $\text{Na}_2\text{SO}_4(\text{aq}) + \text{BaCl}_2(\text{aq}) \longrightarrow \text{BaSO}_4(\text{s}) + 2\text{NaCl}(\text{aq})$. Explain.

[8 pt] 5. Given a saturated solution of $\text{Al}(\text{OH})_3$ has $[\text{Al}^{+3}] = 5.0 \times 10^{-4} \text{ M}$ and $[\text{OH}^-] = 1.3 \times 10^{-3} \text{ M}$.

(a) Write the K_{sp} equation. 5(a) _____

(b) What is the value of K_{sp} ? 5(b) _____

(c) What is the $[\text{Al}^{+3}]$ concentration in a saturated solution that has $[\text{OH}^-] = 2.5 \times 10^{-4} \text{ M}$ 5(c) _____

(d) Would adding 0.25 M $\text{Al}(\text{NO}_3)_3$ or 0.25 M NaOH decrease the solubility the most. Explain. 5(d) _____

Equilibrium Constants at 25°C

Acid	Formula	K_{a1}	K_{a2}	K_{a3}
Acetic	CH ₃ CO ₂ H	1.8×10^{-5}		
Acetylsalicylic	C ₉ H ₈ O ₄	3.0×10^{-4}		
Arsenic	H ₃ AsO ₄	5.6×10^{-3}	1.7×10^{-7}	4.0×10^{-12}
Arsenious	H ₃ AsO ₃	6×10^{-10}		
Ascorbic	C ₆ H ₈ O ₆	8.0×10^{-5}		
Benzoic	C ₆ H ₅ CO ₂ H	6.5×10^{-5}		
Boric	H ₃ BO ₃	5.8×10^{-10}		
Carbonic	H ₂ CO ₃	4.3×10^{-7}	5.6×10^{-11}	
Chloroacetic	CH ₂ ClCO ₂ H	1.4×10^{-3}		
Citric	C ₆ H ₈ O ₇	7.1×10^{-4}	1.7×10^{-5}	4.1×10^{-7}
Formic	HCO ₂ H	1.8×10^{-4}		
Hydrazoic	HN ₃	1.9×10^{-5}		
Hydrocyanic	HCN	4.9×10^{-10}		
Hydrofluoric	HF	3.5×10^{-4}		
Hydrogen peroxide	H ₂ O ₂	2.4×10^{-12}		
Hydrosulfuric	H ₂ S	1.0×10^{-7}	$\sim 10^{-19}$	
Hypobromous	HOBr	2.0×10^{-9}		
Hypochlorous	HOCl	3.5×10^{-8}		
Hypoiodous	HOI	2.3×10^{-11}		
Iodic	HIO ₃	1.7×10^{-1}		
Lactic	HC ₃ H ₅ O ₃	1.4×10^{-4}		
Nitrous	HNO ₂	4.5×10^{-4}		
Oxalic	H ₂ C ₂ O ₄	5.9×10^{-2}	6.4×10^{-5}	
Phenol	C ₆ H ₅ OH	1.3×10^{-10}		
Phosphoric	H ₃ PO ₄	7.5×10^{-3}	6.2×10^{-8}	4.8×10^{-13}
Phosphorous	H ₃ PO ₃	1.0×10^{-2}	2.6×10^{-7}	
Saccharin	C ₇ H ₅ NO ₃ S	2.1×10^{-12}		
Selenic	H ₂ SeO ₄	Very large	1.2×10^{-2}	
Selenious	H ₂ SeO ₃	3.5×10^{-2}	5×10^{-8}	
Sulfuric	H ₂ SO ₄	Very large	1.2×10^{-2}	
Sulfurous	H ₂ SO ₃	1.5×10^{-2}	6.3×10^{-8}	
Tartaric	C ₄ H ₆ O ₆	1.0×10^{-3}	4.6×10^{-5}	
Water	H ₂ O	1.8×10^{-16}		

Cation	K_a	Cation	K_a
Fe ²⁺ (aq)	3.2×10^{-10}	Be ²⁺ (aq)	3×10^{-7}
Co ²⁺ (aq)	1.3×10^{-9}	Al ³⁺ (aq)	1.4×10^{-5}
Ni ²⁺ (aq)	2.5×10^{-11}	Cr ³⁺ (aq)	1.6×10^{-4}
Zn ²⁺ (aq)	2.5×10^{-10}	Fe ³⁺ (aq)	6.3×10^{-3}

Note: As an example, K_a for Fe²⁺(aq) is the equilibrium constant for the reaction



Figure 1

TABLE C.3 Base-Dissociation Constants at 25°C

Base	Formula	K_b
Ammonia	NH_3	1.8×10^{-5}
Aniline	$\text{C}_6\text{H}_5\text{NH}_2$	4.3×10^{-10}
Codeine	$\text{C}_{18}\text{H}_{21}\text{NO}_3$	1.6×10^{-6}
Dimethylamine	$(\text{CH}_3)_2\text{NH}$	5.4×10^{-4}
Ethylamine	$\text{C}_2\text{H}_5\text{NH}_2$	6.4×10^{-4}
Hydrazine	N_2H_4	8.9×10^{-7}
Hydroxylamine	NH_2OH	9.1×10^{-9}
Methylamine	CH_3NH_2	3.7×10^{-4}
Morphine	$\text{C}_{17}\text{H}_{19}\text{NO}_3$	1.6×10^{-6}
Piperidine	$\text{C}_5\text{H}_{11}\text{N}$	1.3×10^{-3}
Propylamine	$\text{C}_3\text{H}_7\text{NH}_2$	5.1×10^{-4}
Pyridine	$\text{C}_5\text{H}_5\text{N}$	1.8×10^{-9}
Strychnine	$\text{C}_{21}\text{H}_{22}\text{N}_2\text{O}_2$	1.8×10^{-6}
Trimethylamine	$(\text{CH}_3)_3\text{N}$	6.5×10^{-5}

TABLE C.4 Solubility Product Constants at 25°C

Compound	Formula	K_{sp}
Aluminum hydroxide	$\text{Al}(\text{OH})_3$	1.9×10^{-33}
Barium carbonate	BaCO_3	2.6×10^{-9}
Barium chromate	BaCrO_4	1.2×10^{-10}
Barium fluoride	BaF_2	1.8×10^{-7}
Barium hydroxide	$\text{Ba}(\text{OH})_2$	5.0×10^{-3}
Barium sulfate	BaSO_4	1.1×10^{-10}
Cadmium carbonate	CdCO_3	6.2×10^{-12}
Cadmium hydroxide	$\text{Cd}(\text{OH})_2$	5.3×10^{-15}
Calcium carbonate	CaCO_3	5.0×10^{-9}
Calcium fluoride	CaF_2	1.5×10^{-10}
Calcium hydroxide	$\text{Ca}(\text{OH})_2$	4.7×10^{-6}
Calcium phosphate	$\text{Ca}_3(\text{PO}_4)_2$	2.1×10^{-33}
Calcium sulfate	CaSO_4	7.1×10^{-5}
Chromium(III) hydroxide	$\text{Cr}(\text{OH})_3$	6.7×10^{-31}
Cobalt(II) hydroxide	$\text{Co}(\text{OH})_2$	1.1×10^{-15}
Copper(I) bromide	CuBr	6.3×10^{-9}
Copper(I) chloride	CuCl	1.7×10^{-7}
Copper(II) carbonate	CuCO_3	2.5×10^{-10}
Copper(II) hydroxide	$\text{Cu}(\text{OH})_2$	1.6×10^{-19}
Copper(II) phosphate	$\text{Cu}_3(\text{PO}_4)_2$	1.4×10^{-37}
Iron(II) hydroxide	$\text{Fe}(\text{OH})_2$	4.9×10^{-17}
Iron(III) hydroxide	$\text{Fe}(\text{OH})_3$	2.6×10^{-39}
Lead(II) bromide	PbBr_2	6.6×10^{-6}
Lead(II) chloride	PbCl_2	1.2×10^{-5}
Lead(II) chromate	PbCrO_4	2.8×10^{-13}
Lead(II) iodide	PbI_2	8.5×10^{-9}
Lead(II) sulfate	PbSO_4	1.8×10^{-8}
Magnesium carbonate	MgCO_3	6.8×10^{-6}
Magnesium fluoride	MgF_2	7.4×10^{-11}
Magnesium hydroxide	$\text{Mg}(\text{OH})_2$	5.6×10^{-12}
Manganese(II) carbonate	MnCO_3	2.2×10^{-11}
Manganese(II) hydroxide	$\text{Mn}(\text{OH})_2$	2.1×10^{-13}
Mercury(I) bromide	Hg_2Br_2	6.4×10^{-23}

Figure 2

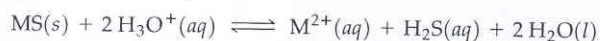
TABLE C.4 Solubility Product Constants at 25°C (continued)

Compound	Formula	K_{sp}
Mercury(I) chloride	Hg_2Cl_2	1.4×10^{-18}
Mercury(I) iodide	Hg_2I_2	5.3×10^{-29}
Mercury(II) hydroxide	$Hg(OH)_2$	3.1×10^{-26}
Nickel(II) hydroxide	$Ni(OH)_2$	5.5×10^{-16}
Silver bromide	$AgBr$	5.4×10^{-13}
Silver carbonate	Ag_2CO_3	8.4×10^{-12}
Silver chloride	$AgCl$	1.8×10^{-10}
Silver chromate	Ag_2CrO_4	1.1×10^{-12}
Silver cyanide	$AgCN$	6.0×10^{-17}
Silver iodide	AgI	8.5×10^{-17}
Silver sulfate	Ag_2SO_4	1.2×10^{-5}
Silver sulfite	Ag_2SO_3	1.5×10^{-14}
Strontium carbonate	$SrCO_3$	5.6×10^{-10}
Tin(II) hydroxide	$Sn(OH)_2$	5.4×10^{-27}
Zinc carbonate	$ZnCO_3$	1.2×10^{-10}
Zinc hydroxide	$Zn(OH)_2$	4.1×10^{-17}

TABLE C.5 Solubility Products in Acid (K_{spa}) at 25°C

Compound	Formula	K_{spa}
Cadmium sulfide	CdS	8×10^{-7}
Cobalt(II) sulfide	CoS	3
Copper(II) sulfide	CuS	6×10^{-16}
Iron(II) sulfide	FeS	6×10^2
Lead(II) sulfide	PbS	3×10^{-7}
Manganese(II) sulfide	MnS	3×10^{10}
Mercury(II) sulfide	HgS	2×10^{-32}
Nickel(II) sulfide	NiS	8×10^{-1}
Silver sulfide	Ag_2S	6×10^{-30}
Tin(II) sulfide	SnS	1×10^{-5}
Zinc sulfide	ZnS	3×10^{-2}

Note: K_{spa} for MS is the equilibrium constant for the reaction



We use K_{spa} for metal sulfides rather than K_{sp} because the traditional values of K_{sp} are now known to be incorrect since they are based on a K_{a2} value for H_2S that is generally in error (see R. J. Myers, *J. Chem. Educ.*, 1986, 63, 687–690).

TABLE C.6 Formation Constants for Complex Ions at 25°C

Complex Ion	K_f	Complex Ion	K_f
$Ag(CN)_2^-$	3.0×10^{20}	$Ga(OH)_4^-$	3×10^{39}
$Ag(NH_3)_2^+$	1.7×10^7	$Ni(CN)_4^{2-}$	1.7×10^{30}
$Ag(S_2O_3)_2^{3-}$	4.7×10^{13}	$Ni(NH_3)_6^{2+}$	2.0×10^8
$Al(OH)_4^-$	3×10^{33}	$Ni(en)_3^{2+}$	4×10^{17}
$Be(OH)_4^{2-}$	4×10^{18}	$Pb(OH)_3^-$	8×10^{13}
$Cr(OH)_4^-$	8×10^{29}	$Sn(OH)_3^-$	3×10^{25}
$Cu(NH_3)_4^{2+}$	5.6×10^{11}	$Zn(CN)_4^{2-}$	4.7×10^{19}
$Fe(CN)_6^{4-}$	3×10^{35}	$Zn(NH_3)_4^{2+}$	7.8×10^8
$Fe(CN)_6^{3-}$	4×10^{43}	$Zn(OH)_4^{2-}$	3×10^{15}

Figure 3