Chemistry 112-2014, Exam #4, VERSION 2

**1.** Which of the following will create a buffer solution when equal volumes of each solution are mixed? Choose all that apply—there may be more than one correct answer.

(a)  $0.20 \text{ M} \text{HNO}_3$  +  $0.10 \text{ M} \text{H}_2\text{CO}_3$ (b)  $0.20 \text{ M} \text{HCO}_2\text{H}$  +  $0.10 \text{ M} \text{NaHCO}_2$ (c) 0.20 M HF +  $0.20 \text{ M} \text{CaF}_2$ (d)  $0.10 \text{ M} \text{HNO}_3$  +  $0.30 \text{ M} \text{NaCH}_3\text{CO}_2$ (e)  $0.20 \text{ M} \text{NaNO}_2$  +  $0.10 \text{ M} \text{NH}_3$ 

**2.** Which of the following acid-base pairs would be used to create a buffer of pH = 9.8, and which species would be present in higher concentration?

Weak Acid	Conjugate Base	K <sub>a</sub>	pКa					
HC <sub>2</sub> O <sub>4</sub> -	C <sub>2</sub> O <sub>4</sub> <sup>2-</sup>	6.4 x 10 <sup>-5</sup>	4.19					
H <sub>2</sub> PO <sub>4</sub> <sup>-</sup>	HPO42-	6.2 x 10 <sup>-8</sup>	7.21					
HCO3-	CO32-	4.8 x 10 <sup>-11</sup>	10.32					
a) HC <sub>2</sub> (	$O_4^{-}/C_2O_4^{-2-}$	$HC_2O_4^-$ in	greater conce	entration				
b) HC <sub>2</sub>	$O_4^{-}/C_2O_4^{-2-}$	$C_2 O_4^{2-}$ in greater concentration						
c) H <sub>2</sub> P(	D <sub>4</sub> <sup>-</sup> /HPO <sub>4</sub> <sup>2-</sup>	$H_2PO_4$ in	greater conce	entration				

d)  $H_2PO_4^{-}/HPO_4^{-2-}$   $HPO_4^{-2-}$  in greater concentration

e)  $HCO_3^{-7}/CO_3^{-2-}$ f)  $HCO_3^{-7}/CO_3^{-2-}$ HCO\_3^{-2-} in greater concentration  $CO_3^{-2-}$  in greater concentration

**3.** Calculate the pH after 0.0200 mol of NaC<sub>6</sub>H<sub>5</sub>CO<sub>2</sub> are added to 175 mL of a 0.180 M solution of C<sub>6</sub>H<sub>5</sub>CO<sub>2</sub>H.

a) 3.82 b) 4.00 c) 4.20 d) 4.40 e) 5.86

4. Under which circumstances will PbCl<sub>2</sub> be most soluble?

a) in pure water
b) in a solution of 0.10 M Pb(NO<sub>3</sub>)<sub>2</sub>
c) in a solution of 0.10 M NaCl
d) none of these- PbCl<sub>2</sub> is insoluble

5. What is the solubility of AgBr, in grams per liter? Molar mass = 187.8 g/mol.

a)  $1.38 \times 10^{-4}$  g/L b)  $1.01 \times 10^{-10}$  g/L c)  $5.07 \times 10^{-11}$  g/L d)  $7.35 \times 10^{-7}$  g/L e)  $1.38 \times 10^{-4}$  g/L

6. What is the molar solubility of CaF<sub>2</sub> in a 0.50 M solution of KF?

a) 5.3 x 10<sup>-11</sup> M b) 1.06 x 10<sup>-10</sup> M c) 2.12 x 10<sup>-10</sup> M d) 2.37 x 10<sup>-4</sup> M e) 0.25 M

7. Which of the following can water (H<sub>2</sub>O) not act as?
a) Bronsted acid b) Bronsted base c) Lewis acid d) Lewis base

**8.** Consider the following pair of reaction steps. Add the following labels to the species they represent. Point to the species and add the label. You label four things in total. If something is both Lewis and Bronsted, label it Bronsted. For example, find something that is acting as a Lewis Acid and draw and arrow to it labeled with "LA."







a. which species is mainly prevalent at pH = 8?

b. What is  $\mathsf{pK}_{\mathsf{a}}$  of HA?

c. What is K<sub>a</sub> of HA?

d. If this acid-base pair were a pH indicator, would it be suitable for the titration of  $\rm NH_4^+$  with NaOH?

Yes or No

**10.** A saturated solution of chromium(III) hydroxide,  $Cr(OH)_3$ , is found to have a pH of 10.63. What is  $K_{sp}$  for  $Cr(OH)_3$  dissolution?

**11.** The reaction below takes place in an electrochemical cell using compartments containing  $Zn/ZnSO_4(aq)$  and  $Cu/CuSO_4(aq)$ .

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

a) write the oxidation half-reaction:

b) write the reduction half-reaction:

c) label the following: anode, cathode, salt bridge, direction of electrons, direction of sulfate ions



## 12.

Consider the titration curve below involving a weak acid (HA) and a weak base (A<sup>-</sup>).



a. Which does this titration represent? Circle it.

weak acid being titrated with NaOH or

weak base being titrated with HCl

b. What is the approximate value of  $K_{\text{a}}$  for the acid

form (HA) of the studied acid-base pair?

K<sub>a</sub> = \_\_\_\_\_

c. What acid-base species is/are mainly in solution at point A?

d. What acid-base species is/are mainly in solution at point B?\_\_\_\_\_

e. What acid-base species is/are mainly in solution at point C? \_\_\_\_\_\_

**13.** a) What is the pH of a buffer composed of 1.0 L of 0.30 M  $HCO_2H$  and 0.50 M  $HCO^{2-}$ ?

b) What is the pH of this buffer after 0.080 mol NaOH have been added?

**14.** The Henderson-Hasselbalch equation has a built-in assumption that is not completely valid. Determine the percent error use of the Henderson-Hasselbalch equation leads to when predicting the pH of a buffer containing 0.010 M HF + 0.010 M NaF.

**15.** What is the concentration of free Ni<sup>2+</sup> in a 0.200 M solution of Ni(NH<sub>3</sub>)<sub>6</sub><sup>2+</sup>?  $K_f = 5.5 \times 10^8$ 

What is the concentration of  $Ni^{2+}$  if  $NH_3$  is added to the solution so  $[NH_3] = 0.100$  M?

		K <sub>a</sub> an	nd K <sub>b</sub> Values						
Name of Acid	Acid	Ka	Name of Base	Base	Kb				
Hydrogen sulfate ion	HSO4-	1.2 × 10 <sup>-2</sup>	sulfate ion	504 <sup>2-</sup>	8.3 × 10 <sup>-13</sup>				
Phosphoric acid	H <sub>3</sub> PO <sub>4</sub>	7.5 × 10 <sup>-3</sup>	dihydrogen phosphate ion	H <sub>2</sub> PO <sub>4</sub> -	1.3 x 10 <sup>-12</sup>				
Hexaaquairon(III)ion	Fe(H <sub>2</sub> O) <sub>6</sub> 3+	6.3 x 10 <sup>-3</sup>	pentaaquahydroxoiron(III) ion	Fe(H <sub>2</sub> O) <sub>5</sub> OH <sup>2+</sup>	1.6 x 10 <sup>-12</sup>				
Hydrofluoric acid	HF	7.4 x 10 <sup>-4</sup>	fluoride ion	F	1.4 × 10 <sup>-11</sup>				
Formic acid	HCO <sub>2</sub> H	1.8 × 10 <sup>-4</sup>	formate ion	HCO2-	5.6 x 10 <sup>-11</sup>				
Benzoic acid	C <sub>6</sub> H <sub>5</sub> CO <sub>2</sub> H	6.3 × 10 <sup>-5</sup>	benzoate ion	C <sub>6</sub> H <sub>5</sub> CO <sub>2</sub> -	1.6 x 10 <sup>-10</sup>				
Acetic acid	CH3CO2H	1.8 × 10 <sup>-5</sup>	acetate ion	CH3CO2	5.6 x 10 <sup>-10</sup>				
Hexaaquaaluminum ion	A1(H <sub>2</sub> O) <sub>6</sub> 3+	7.9 × 10 <sup>-6</sup>	pentaaquahydroxoaluminum ion	A1(H <sub>2</sub> O) <sub>5</sub> OH <sup>2+</sup>	1.3 x 10 <sup>-9</sup>				
Carbonic acid	H <sub>2</sub> CO <sub>3</sub>	4.2 x 10 <sup>−7</sup>	hydrogen carbonate ion	HCO3	2.4 x 10 <sup>-8</sup>				
Hydrogen sulfide	H <sub>2</sub> S	1 × 10 <sup>-7</sup>	hydrogen sulfide ion	HS <sup>-</sup>	1 × 10 <sup>-7</sup>				
Dihydrogen phosphate ion	H <sub>2</sub> PO <sub>4</sub> -	6.2 × 10 <sup>-8</sup>	hydrogen phosphate ion	HPO4 <sup>2-</sup>	1.6 × 10 <sup>-7</sup>				
Hypochlorous acid	HC1O	3.5 × 10 <sup>-8</sup>	hypochlorite ion	C10 <sup>-1</sup>	2.9 x 10 <sup>-7</sup>				
Ammonium ion	NH4+	5.6 x 10 <sup>-10</sup>	ammonia	NH <sub>3</sub>	1.8 × 10 <sup>-5</sup>				
Hydrocyanic acid	HCN	4.0 x 10 <sup>-10</sup>	cyanide ion	CN <sup>2</sup>	2.5 x 10 <sup>-5</sup>				
Hexaaquairon(II) ion	Fe(H <sub>2</sub> O) <sub>6</sub> 2+	$3.2 \times 10^{-10}$	pentaaquahydroxoiron(II) ion	Fe(H <sub>2</sub> O) <sub>5</sub> OH+	$3.1 \times 10^{-5}$				
Hydrogen carbonate ion	HCO3-	4.8 x 10 <sup>-11</sup>	carbonate ion	CO32-	2.1 x 10 <sup>-4</sup>				
Hydrogen phosphate ion	HPO42-	3.6 × 10 <sup>-13</sup>	phosphate ion	PO4 <sup>3-</sup>	$2.8 \times 10^{-2}$				

	<b>(</b> _	and K <sub>h</sub>	values for	Common	Weak	Acids an	d Base
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K <sub>so</sub> Value	es for Some				
Insolu	ıble Salts				
Compound	K <sub>sp</sub> at 25 °C				
CaCO3	3.4 × 10 <sup>-9</sup>		GROUP		Ρ
SrCO <sub>3</sub>	5.6 × 10 <sup>-10</sup>		1 1.0079		-
BaCO <sub>3</sub>	2.6 × 10 <sup>-9</sup>	PEF	HYDROGEN	2 IA	1
BaSO <sub>4</sub>	1.1 × 10 <sup>-10</sup>	2	Li	Be	
CaF <sub>2</sub>	5.3 × 10 <sup>-11</sup>		LITHIUM 11 22.990	BERYLLIUM 12 24.305	-
- FeCO <sub>2</sub>	3.1 × 10 <sup>-11</sup>	3	Na sodium		3
Fe(OH)	4.9 × 10 <sup>-17</sup>	4	19 39.098 K	<sup>20</sup> 40.078 Ca	21 44.9 Sc
AgC1	1.8 × 10 <sup>-10</sup>		POTASSIUM 37 85.468	CALCIUM 38 87.62	SCAND 39 88.
AgBr	5.4 × 10 <sup>-13</sup>	5	RUBIDIUM	Sr strontium	YTTRI
Agl	8.5 × 10 <sup>-17</sup>	6	55 132.91 CS	56 137.33 Ba	57-7 La-L
AgoCrO4	$1.1 \times 10^{-12}$		CAESIUM 87 (223)	BARIUM 88 (226)	Lantha
PhC1 <sub>2</sub>	1.7 × 10 <sup>-5</sup>	7	Fr	Ra	Ac-I Actini
PbCrO <sub>4</sub>	2.8 × 10 <sup>-13</sup>		FRANCIUM	RADIUM	
PbBr <sub>5</sub>	6.6 × 10 <sup>-6</sup>				
PbSO <sub>4</sub>	2.5 × 10 <sup>-8</sup>				

	GROUP		PF	RI	OD	IC	ΤΔ	BI	FC	)F <sup>-</sup>	тн	FF	ΙF	MF	-N1	ſS		10 1/1114
	1 1.0079												http:	//www.ktf-sj	olit.hr/perio	odni/e n/		2 4.0026
1	Н				CROUPN	TIMDERS		CROFT	NUMBERS									Не
	HYDROGEN	2 IIA		п	UPAC RECON	MENDATION	i c	HEMICAL AL	BSTRACT SEF	RVICE			13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	HELIUM
	3 6.941	4 9.0122			(1)		13 IIA		(1980)				5 10.811	6 12.011	7 14.007	8 15.999	9 18.998	10 20.180
2	Li	Be			ATOMIC	NUMBER —	5 10.811	- RELATIV	EATOMIC M/	ASS (1)			В	C	N	0	F	Ne
	LITHIUM	BERYLLIUM				SYMBOL -	-B						BORON	CARBON	NITROGEN	OXYGEN	FLUORINE	NEON
	11 22.990	12 24.305					BORON	ELEMEN	<b>FNAME</b>				13 26.982	14 28.086	15 30.974	16 32.065	17 35.453	18 39.948
3	Na	Mg							1.000				Al	Si	Р	S	CI	Ar
	SODIUM	MAGNESIUM	3    B	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIIIB -	10	11 B	12 IB	ALUMINUM	SILICON	PHOSPHORUS	SULPHUR	CHLORINE	ARGON
	19 39.098	20 40.078	21 44.956	22 47.867	23 50.942	24 51.996	25 54.938	26 55.845	27 58.933	28 58.693	<b>29</b> 63.546	30 65.39	31 69.723	32 72.64	33 74.922	34 78.96	35 79.904	36 83.80
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Со	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	POTASSIUM	CALCIUM	SCANDIUM	TITANIUM	VANADIUM	CHROMIUM	MANGANESE	IRON	COBALT	NICKEL	COPPER	ZINC	GALLIUM	GERMANIUM	ARSENIC	SELENIUM	BROMINE	KRYP TON
	37 85.468	38 87.62	<b>39</b> 88.906	40 91.224	41 92.906	42 95.94	43 (98)	44 101.07	45 102.91	46 106.42	47 107.87	48 112.41	49 114.82	50 118.71	51 121.76	<b>52</b> 127.60	53 126.90	54 131.29
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
	RUBIDIUM	STRONTIUM	YTTRUM	ZIRCONIUM	NIOBIUM	MOLYBDENUM	TECHNETIUM	RUTHENIUM	RHODIUM	PALLADIUM	SILVER	CADMIUM	INDIUM	TIN	ANTIMONY	TELLURIUM	IODINE	XENON
	55 132.91	56 137.33	57-71	72 178.49	73 180.95	74 183.84	75 186.21	76 190.23	77 192.22	78 195.08	79 196.97	80 200.59	81 204.38	82 207.2	83 208.98	84 (209)	85 (210)	86 (222)
6	Cs	Ba	La-Lu	Hf	Та	W	Re	Os	Ir	Pt	Au	Hg	TI	Pb	Bi	Po	At	Rn
	CAESIUM	BARIUM	Lanthanide	HAFNUM	TANTALUM	TUNGSTEN	RHENIUM	OSMIUM	RIDIUM	PLATINUM	GOLD	MERCURY	THALLIUM	LEAD	BISMUTH	POLONIUM	ASTATINE	RADON
	87 (223)	88 (226)	89-103	104 (261)	105 (262)	106 (266)	107 (264)	108 (277)	109 (268)	110 (281)	111 (272)	112 (285)		114 (289)				
7	Fr	Ra	Ac-Lr	Rf	Db	Sg	Bh	Hs	Mt	Uum	Uuu	Uub		Uuq				
	FRANCIUM	RADIUM	Actinide	RUTHERFORDIUM	DUBNUM	SEABORGUM	BOHRIUM	HASSIUM	MEITNERIUM	UNUNNILIUM	UNUNUNUM	UNUNBIUM		UNUNQUADUM				

$$pH = pK_a + log \frac{[base]}{[acid]}$$