Exam 3
Chem 1142
Spring 2015

Name: KEY

MULTIPLE CHOICE. [3 pts ea.] Choose the best response on the scantron sheet. [**45 pts total.**]

Q1. The conjugate base of HPO_4^{2-} is:
a) H_3PO_4 b) $H_2PO_4^-$ c) HPO_4^{2-} d) PO_4^{3-} e) OH^-

Q2. An aqueous solution at 25 °C has a hydronium ion concentration of 2.4×10^{-8} M. What is the hydroxide concentration?
a) 2.4×10^{-8} M b) 7.6×10^{-6} M c) 1.0×10^{-7} M
d) 4.2×10^{-7} M e) 2.4×10^{6} M

Q3. Which of the following is NOT a strong acid?
a) HNO_2 b) H_2SO_4 c) $HClO_4$ d) HI e) HBr

Q4. A 0.10 M weak monoprotic acid undergoes 4.2 % dissociation in water. What is K_a for the acid?
a) 1.8×10^{-4} b) 0.042 c) 0.0042 d) 1.8×10^{-3} e) 5.1×10^{-5}

Q5. CH_3NH_2 is a weak base. Which chemical equation corresponds to the K_b reaction for CH_3NH_2?
a) $CH_3NH_2(aq) + OH^-(aq) \rightleftharpoons CH_3NH_3^+(aq) + O^{2-}(aq)$
b) $CH_3NH_2(aq) + H_2O(l) \rightleftharpoons CH_3NH_3^+(aq) + OH^-(aq)$
c) $CH_3NH_3^+(aq) + H_2O(l) \rightleftharpoons CH_3NH_2(aq) + H_3O^+(aq)$
d) $CH_3NH_2(s) \rightleftharpoons CH_2(aq) + NH_3(aq)$
e) $CH_3NH_2(aq) + H_3O^+(aq) \rightleftharpoons CH_3NH_3^+(aq) + H_2O(l)$

Q6. An example of an basic salt would be:
a) $NaNO_3$ b) NH_4Br c) LiF d) $Fe(ClO_4)_3$ e) KCl

Q7. A Lewis ACID is defined as:
a) A substance that forms H_3O^+ in water b) A substance that donates protons
c) A substance that is easily oxidized d) A substance with a low pH
e) A substance that can accept electrons

Q8. A few drops of concentrated HCl is added to a solution containing a mixture of HNO_3 and $NaNO_3$. The resultant pH change would be:
a) A small decrease in pH b) A small increase in pH
c) A large decrease in pH d) A large increase in pH e) A neutral pH would result

Q9. Which of the following weak acids could possibly be used to prepare a buffer with a pH of 7.50?
a) HF, $K_a = 7.2 \times 10^{-4}$ b) $C_6H_5CO_2H$, $K_a = 6.5 \times 10^{-5}$ c) HClO, $K_a = 3.5 \times 10^{-8}$
d) HBrO, $K_a = 2.0 \times 10^{-9}$ e) H_3BO_3, $K_a = 5.8 \times 10^{-10}$

Q10. K_{sp} for lead(II) fluoride is 4.1×10^{-8} at 25 °C. Its molar solubility is:
a) 0.0022 M b) 0.0028 M c) 2.0×10^{-4} M d) 3.5×10^{-3} M e) 6.7×10^{-5} M

Q11. If Q_{sp} for a ionic compound in solution is less than K_{sp}, we will observe:

a) Precipitation, and a solution that is unsaturated

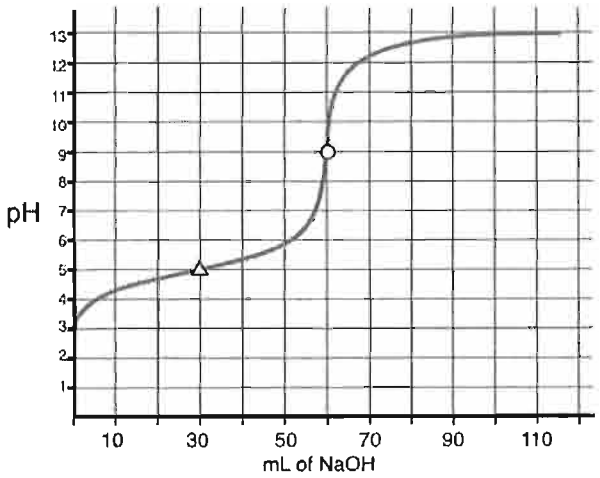
b) Precipitation, and a solution that is saturated

c) No precipitate, but a saturated solution

d) No precipitate, and an unsaturated solution

e) No precipitate, but a supersaturated solution that will eventually precipitate

Q12. Given the following pH titration curve:



which acid-base indicator would give us the most precise end-point?

Table 17.1 Some Common Acid-Base Indicators

	Color		
Indicator	**In Acid**	**In Base**	**pH Range***
Thymol blue	Red	Yellow	1.2–2.8
Bromophenol blue	Yellow	Bluish purple	3.0–4.6
Methyl orange	Orange	Yellow	3.1–4.4
Methyl red	Red	Yellow	4.2–6.3
Chlorophenol blue	Yellow	Red	4.8–6.4
Bromothymol blue	Yellow	Blue	6.0–7.6
Cresol red	Yellow	Red	7.2–8.8
Phenolphthalein	Colorless	Reddish pink	8.3–10.0

a) Thymol blue b) Methyl red c) Chlorophenol blue

d) Bromothymol blue e) Phenolphthalein

Q13. The pH of a 0.10 M solution of $Sr(OH)_2(aq)$ at 25 °C is:

a) 0.70 b) 1.00 c) 7.00 d) 13.00 e) 13.30

Q14. The molar solubility of $CaCO_3(s)$ would be GREATEST in which of the following solutions?

a) pure water b) 0.10 M $HNO_3(aq)$ c) 0.10 M $Ca(NO_3)_2(aq)$

d) saturated NaCl(aq) e) 0.10 M KCl(aq)

Q15. For a triprotic weak acid:

a) $K_{a1} < K_{a2} < K_{a3}$ b) $K_{a1} > K_{a2} > K_{a3}$ c) $K_{a1} \approx K_{a2} > K_{a3}$

d) $K_{a1} > K_{a2} \approx K_{a3}$ e) $K_{a1} \approx K_{a2} \approx K_{a3}$

$NaF \rightarrow Na^+(aq) + F^-(aq)$

0.100M 0.100M 0.100M

Short Response.
Show ALL work to receive credit.

Q16. [15 pts.] 25 mL of 0.100 M HF(aq) is poured into a beaker containing 15 mL of 0.100 M NaF(aq). The solution is stirred. The temperature is 25 °C. K_a (HF) = 7.1×10^{-4}.

i) What is the pH of this solution? $pKa(HF) = -\log(Ka) = 3.149$

[HF]

$M_1V_1 = M_2V_2$

$M_2 = \frac{M_1V_1}{V_2} = \frac{0.100M \times 25mL}{40.mL} = 0.0625M$

[F^-]

$M_2 = \frac{M_1V_1}{V_2} = \frac{0.100M \times 15mL}{40.mL} = 0.0375M$

H-H $pH = pKa + \log\frac{[F^-]}{[HF]}$

$= 3.149 + \log\left(\frac{0.0375M}{0.0625M}\right)$

$= \boxed{2.93}$

ii) 1.00 mL of 0.10 M HNO_3(aq) is added to this solution. Calculate the new pH.

$\#mol\ HNO_3 = \#mol\ H^+ = 1.00mL \times \frac{1L}{1000mL} \times \frac{0.10mol}{1L} = 0.00010mol\ H^+$

$\#mol\ F^- = 15mL \times \frac{1L}{1000mL} \times \frac{0.100mol}{1L} = 0.0015mol\ F^-$

$\#mol\ HF = 25mL \times \frac{1L}{1000mL} \times \frac{0.100mol}{1L} = 0.0025mol\ HF$

	$H^+(aq)$	+ $F^-(aq)$	⟶ $HF(aq)$
I(mol)	0.00010	0.0015	0.0025
C	−0.00010	−0.00010	+0.00010
E	0	0.0014	0.0026

new vol = 41mL = 0.041L

H-H $pH = pKa + \log\frac{[F^-]}{[HF]}$

$= 3.149 + \log\left(\frac{0.0014mol \div 0.041L}{0.0026mol \div 0.041L}\right)$

$= 2.88$

comment: drop of 0.05 units

10 pts

$Pb(NO_3)_2(aq) + 2LiF(aq) \rightarrow 2LiNO_3(aq) + PbF_2(s)$?

1 : 1

Q17. [~~15~~ pts.] 55 mL of 0.020 M $Pb(NO_3)_2$(aq) is mixed with 35 mL of 0.0050 M LiF(aq). Predict whether a precipitate will form. $K_{sp}(PbF_2) = 4.1 \times 10^{-8}$.

$PbF_2(s) \rightleftharpoons Pb^{2+}(aq) + 2F^-(aq)$.

$Q_{sp} = [Pb^{2+}]_i [F^-]_i^2$

$Q_{sp} = [0.0122][0.00194]^2$

$= 4.6 \times 10^{-8}$

$Q_{sp} > K_{sp} \Rightarrow$ will ppt!

$Pb(NO_3)_2 \rightarrow Pb^{2+}(aq) + 2NO_3^-(aq)$

$LiF \rightarrow Li^+(aq) + F^-(aq)$

1:1

$M_1V_1 = M_2V_2 \Rightarrow M_2 = \frac{M_1V_1}{V_2}$

$[Pb^{2+}] = \frac{0.020M \times 55mL}{90mL} = 0.0122M$

$[F^-] = \frac{0.0050M \times 35mL}{90mL} = 0.00194M$

10 pts

Q18. [~~15~~ pts.] The solubility of Ag_3PO_4 in 0.0010 M Na_3PO_4(aq) is 1.5×10^{-5} M. Calculate K_{sp} for silver phosphate. (molar)

$Na_3PO_4 \rightarrow 3Na^+ + PO_4^{3-}$

1:1

$\Rightarrow [PO_4^{3-}] = 0.0010M$

$Ag_3PO_4(s) \rightleftharpoons 3Ag^+(aq) + PO_4^{3-}(aq)$.

I	———	0	0.0010
C	"−s"	+3s	+s
E	———	(3s)	(0.0010+s)

$K_{sp} = [Ag^+]^3[PO_4^{3-}]$

$\Rightarrow K_{sp} = (3s)^3(0.0010+s)$

$= (3 \times 1.5 \times 10^{-5})^3 (0.0010 + 1.5 \times 10^{-5})$

$K_{sp} = 9.2 \times 10^{-17}$

10 pb

Q19. [~~15~~ pts.] Calculate the pH of 0.40 M $CH_3NH_3^+Cl^-(aq)$, given K_b (CH_3NH_2) = 4.4×10^{-4} at 25 °C.

$CH_3NH_3^+(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3NH_2(aq)$

	$CH_3NH_3^+$		H_3O^+	CH_3NH_2
I	0.40M	——	≈0	0
C	−x	——	+x	+x
E	(0.40−x)	——	(x)	(x)

$K_a = \frac{K_w}{K_b} = 2.27 \times 10^{-11} = \frac{x^2}{0.40-x} \approx \frac{x^2}{0.40}$ assume: $x \ll 0.40$

$\Rightarrow \sqrt{x^2} = \sqrt{0.40 \times 2.27 \times 10^{-11}}$

$\Rightarrow x = 3.015 \times 10^{-6}$ 5% ✓

3 ph $\Rightarrow pH = -\log_{10}[H^+] = -\log_{10}(x) =$ **5.52**

Q20. [~~15~~ pts.] Calculate the pH of the following solutions at 25 °C:
Be sure to show your work!

a) 0.25 M NaOH(aq) $\longrightarrow Na^+(aq) + OH^-(aq)$
0.25M

$pOH = -\log[OH^-] = 0.60$, $pH = 14.00 - pOH$
$= \boxed{13.40}$

b) 0.42 M $Sr(OH)_2$(aq) $\longrightarrow Sr^{2+}(aq) + 2OH^-(aq)$
0.84M

$pOH = -\log[OH^-] = 0.076$ $\Rightarrow pH = 14.00 - pOH$
$= \boxed{13.92}$

c) 12 M HCl(aq) $\longrightarrow H^+ + Cl^-$
12M 12M

$pH = -\log[H^+] = \boxed{-1.08}$

7 pts

Q21. [15 pts.] i) Write out the chemical equation for the reaction corresponding to K_w.

$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$ or $H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$

ii) Set up an ICE-Chart for this reaction, and solve for the equilibrium concentrations of products at 25 °C.

$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$

I	———	0	0
C	"-2x"	+x	+x
E	———	(x)	(x)

$K_w = 1.0\times10^{-14} = x^2 \Rightarrow x = 1.0\times10^{-7} \Rightarrow [H_3O^+] = [OH^-] = 1.0\times10^{-7}\,M$

iii) If K_w is equal to 2.4×10^{-14} at 37 °C (body temperature), what will the pH be for a **NEUTRAL** solution of water at this temperature?

$K_w = 2.4\times10^{-14} = x^2 \Rightarrow x = \sqrt{K_w} = 1.55\times10^{-7}$

$pH = -\log[H_3O^+] = -\log(x) = \boxed{6.81}$

BONUS Question:

Give an example of an:

i) Acid salt NH_4Cl

ii) Basic salt NaF

iii) Neutral salt $NaCl$

Useful Information

Periodic Table of the Elements

IA	IIA											IIIA	IVA	VA	VIA	VIIA	VIIIA
1																	2
H																	He
1.01	2											13	14	15	16	17	4.00
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
6.94	9.01											10.81	12.01	14.01	16.00	19.00	20.18
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
22.99	24.31	3	4	5	6	7	8	9	10	11	12	26.98	28.09	30.97	32.07	35.45	39.95
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.10	40.08	44.96	47.87	50.94	52.00	54.94	55.85	58.93	58.69	63.55	65.39	69.72	72.61	74.92160	78.96	79.90	83.80
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
85.47	87.62	88.91	91.22	92.91	95.94	[98]	101.07	102.91	106.42	107.87	112.41	114.82	118.71	121.76	127.60	126.90	131.29
55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba*	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
132.91	137.33	174.97	178.49	180.95	183.84	186.21	190.23	192.22	195.08	196.97	200.59	204.38	207.20	208.98	[210]	[210]	[222]
87	88	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr	Ra**	Lr	Rf	Db	Sg	Bh	Hs	Mt									
[223]	[226]	[262]	[261]	[262]	[266]	[264]	[265]	[268]	[269]	[272]	[277]		[285]		[289]		[293]

*	57	58	59	60	61	62	63	64	65	66	67	68	69	70
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
	138.91	140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04
**	89	90	91	92	93	94	95	96	97	98	99	100	101	102
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No
	[227]	232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]

$N_A = 6.022 \times 10^{23}\ \text{mol}^{-1}$

$$R = 8.3145\frac{\text{J}}{\text{mol}\cdot\text{K}} = 0.08206\frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}} \qquad M_1V_1 = M_2V_2$$

$\text{pH} = -\log_{10}[\text{H}^+]$ $\qquad$ $\text{pH} + \text{pOH} = 14.00$ (25 °C)

$K_w = 1.0 \times 10^{-14}$ (25 °C) $\qquad$ $K_a \cdot K_b = K_w$

$$\text{pH} = \text{p}K_a + \log\frac{[\text{Base}]}{[\text{Acid}]}$$

$K_p = K_c(RT)^{\Delta ng}$

Given: $ax^2 + bx + c = 0$, then $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$