

**Key: Quiz Ch 17 Version A (33 points)**

1a.

	HCOOH $\leftrightarrow$	H <sup>+</sup> +	HCOO <sup>-</sup>
I	0.40	0	0.60
C	-x	+x	+x
E	0.40 - x	x	0.60 + x

$$K_a = 1.8 \times 10^{-4} = \frac{[H^+][HCOO^-]}{[HCOOH]}$$

$$(x(0.60+x))/(0.40-x) \approx (0.60x)/0.40$$

$$x = 3.0 \times 10^{-4}$$

$$pH = 3.92$$

1b. The ratio stays the same.

1c.

	HCOO <sup>-</sup> +	H <sup>+</sup> $\rightarrow$	HCOOH
I	0.60/0.105	0.0476	0
F			

$$pH = pK_a + \log \left( \frac{[base]}{[acid]} \right)$$

$$= -\log 1.8 \times 10^{-4} + \log \left( \frac{[0.055]}{[0.045]} \right)$$

$$= 3.74 + 0.079$$

$$= 3.82$$

1d.

$$0.800L \times 2.00M = 1.6 \text{ mol HCOOH}$$

$$0.200L \times 4.80M = 0.96 \text{ mol OH}^-$$

	HCOOH +	OH <sup>-</sup> $\rightarrow$	HCOO <sup>-</sup> +	H <sub>2</sub> O
I	1.6	0.96	0	
F	0.64	0	0.96	

$$pH = pK_a + \log \left( \frac{[base]}{[acid]} \right)$$

$$= -\log 1.8 \times 10^{-4} + \log (0.96/0.64)$$

$$= 3.74 + 0.18$$

$$= 3.92$$

2a.

$$0.0750L \times 0.020M = 0.0015 \text{ mol BaCl}_2 = 0.0015 \text{ mol Ba}^{2+}$$

$$0.125L \times 0.040M = 0.0050 \text{ mol Na}_2\text{SO}_4 = 0.0050 \text{ mol SO}_4^{2-}$$

$$K_{sp} = [Ba^{2+}][SO_4^{2-}]$$

$$= (0.0015/0.200)(0.0050/0.200)$$

$$Q = (0.075)(0.025)$$

$$= 1.9 \times 10^{-3}$$

$$Q > K_{sp}, \text{ so ppt!}$$

3a.

	B +	H <sub>2</sub> O ↔	BH <sup>+</sup> +	OH <sup>-</sup>
I	0.100		0	0
C	-x		+x	+x
E	0.100 - x		x	x

$$K_B = \frac{([\text{OH}^-][\text{BH}^+])}{[\text{B}]}$$

$$3.0 \times 10^{-6} = \frac{x^2}{(0.100 - x)}$$

$$\approx \frac{x^2}{0.100}$$

$$x^2 = 3.0 \times 10^{-7}$$

$$\text{pOH} = 3.26$$

$$\text{pH} = 10.74$$

3b.

$$0.200\text{M} \times (0.0200\text{L}/0.120\text{L}) = 0.0333\text{M H}^+$$

$$0.100\text{M} \times (0.100\text{L}/0.120\text{L}) = 0.0833\text{M H}_2\text{NNH}_2$$

	B +	H <sup>+</sup> →	BH <sup>+</sup>
I	0.0500	0.0333	0
C	-x	+ x	+x
E	0.0500 - x	0.0333 + x	x

$$\text{pOH} = \text{pK}_b + \log (0.0333/0.0500)$$

$$5.52 - 0.176$$

$$= 5.34$$

$$\text{pH} = 8.656$$

3c.

$$0.200\text{M} \times 0.0250\text{L} = 0.00500 \text{ mol H}^+$$

$$0.100\text{M} \times 0.100\text{L} = 0.100 \text{ mol B}$$

$$V = 0.125\text{L}$$

$$\text{pOH} = 5.52 + \log (0.00500/0.00500)$$

$$= 5.52$$

$$\text{pH} = 8.48$$

3d.

$$0.0400\text{L} \times 0.200\text{M} = 0.00800 \text{ H}^+$$

$$\text{pH} = 5.52 + \log (0.0080/0.002000)$$

$$= 5.52 + 0.602$$

$$= 6.12$$

$$\text{pH} = 7.88$$

3e.

$$0.0500 \times 0.200\text{M} = 0.0100 \text{ mol H}^+$$

$$[\text{BH}^+] = 0.0100/0.150 = 0.067 \text{ M}$$

	BH <sup>+</sup> ↔	B +	H <sup>+</sup>
I	0.067	0	0

C	-x	+ x	+x
E	0.067 - x	X	x

$$K_A = K_w/3.3 \times 10^{-9}$$

$$= x^2/0.067$$

$$x^2 = 2.2 \times 10^{-10}$$

$$[H^+] = x = 1.5 \times 10^{-5}$$

$$pH = 4.83$$

3f.

$$0.100 \times 0.200 = 0.0200 \text{ mol } H^+$$

	$BH^+ \leftrightarrow$	B	+	$H^+$
I	0.0100/0.2 = 0.0500	0		0.0500
C	-x	+ x		+x
E	0.0500 - x	X		0.0500 + x

$$K_a = 3.3 \times 10^{-9} = (x(0.01 + x))/(0.01 - x)$$

$$x = 3.3 \times 10^{-9}$$

$$[H^+] = x = 1.5 \times 10^{-5}$$

$$= 0.05$$

$$pH = 1.30$$

### Key: Quiz Ch 17 Version B (33 points)

1a.

	$HNO_2 \leftrightarrow$	$H^+$	+	$NO_2^-$
I	0.30	0		0.20
C	-x	+ x		+x
E	0.30 - x	X		0.20 + x

$$K_A = ([H^+][NO_2^-])/[HNO_2]$$

$$= 4.5 \times 10^{-4}$$

$$4.5 \times 10^{-4} = (x(0.20 + x))/(0.30 - x)$$

$$\approx 0.20x/0.30$$

$$x = 6.8 \times 10^{-4}$$

$$pH = 3.17$$

1b. The ratio stays the same.

$$1c. 0.01000L \times 0.800M HCl = 0.088 \text{ mol } H^+$$

$$0.100L \times 0.20M = 0.12 \text{ mol } HNO_2$$

$$0.100L \times 0.80 = 0.08$$

	$NO_2^-$	+	$H^+$	$\rightarrow$	$HNO_2$
I	0.080		0.008		0.120
C	- 0.008		- 0.008		+ 0.008

F	0.072	0	0.128
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	$\text{HNO}_2 \leftrightarrow$	$\text{H}^+ +$	$\text{NO}_2^-$
I	0.128	0	0.072
C	-x	+ x	+ x
E	$0.128 - x$	x	$0.072 + x$

$$\begin{aligned} \text{pH} &= \text{pK}_a + \log [\text{NO}_2^-]/[\text{HNO}_2] \\ &= -\log 4.5 \times 10^{-4} + \log (0.128/0.072) \\ &= 3.35 + -0.26 \\ &= 3.09 \end{aligned}$$

1d.  $0.700\text{L} \times 2.50\text{M HNO}_2 = 1.75 \text{ mol HNO}_2 - 0.624 = 1.13 \text{ mol HNO}_2$   
 $0.120\text{L} \times 5.20\text{M NaOH} = 0.624 \text{ mol OH}^- = 0$

	$\text{HNO}_2 \leftrightarrow$	$\text{H}^+ +$	$\text{NO}_2^-$
I	1.13	0	0.624
C	-x	+ x	+ x
E	$1.13 - x$	x	$0.624 + x$

$$\begin{aligned} \text{pH} &= \text{pK}_a + \log [\text{NO}_2^-]/[\text{HNO}_2] \\ &= -\log 4.5 \times 10^{-4} + \log ((0.678 + x)/6.23 - x) \\ &= 3.35 + -0.26 \\ &= 3.09 \end{aligned}$$

2.  $0.175\text{L} \times 0.040\text{M} = 0.0070 \text{ mol BaCl}_2 = 0.0070 \text{ mol Ba}^{2+}$   
 $0.210\text{L} \times 0.080\text{M} = 0.017 \text{ mol Na}_2\text{SO}_4 = 0.017 \text{ mol SO}_4^{2-}$

$$\begin{aligned} Q &= [\text{Ba}^{2+}][\text{SO}_4^{2-}] \\ &= (0.0070/0.85)(0.017/0.385) \\ &= 0.018 \times 0.044 \\ &= 7.92 \times 10^{-4} \\ Q &> K_{\text{sp}} \text{ so ppt.} \end{aligned}$$

3a.

	$\text{HONH}_2 +$	$\text{H}_2\text{O} \leftrightarrow$	$\text{HONH}_3^+ +$	$\text{OH}^-$
I	0.100 M		0	0
C	-x		+ x	+ x
E	$0.100 - x$		x	x

$$\begin{aligned} K_B &= [\text{OH}^-][\text{HB}^+]/[\text{B}] \\ &= 1.1 \times 10^{-8} \\ x^2/0.100 &= 1.1 \times 10^{-8} \\ x &= 3.3 \times 10^{-5} = [\text{OH}^-] \\ \text{pOH} &= 4.48 \\ \text{pH} &= 9.52 \end{aligned}$$

3b.  $0.015\text{L} \times 0.200\text{M} = 0.00300 \text{ mol H}^+$   
 $0.100\text{L} \times 0.100\text{M} = 0.0100 \text{ mol B} - 0.00300 = 0.00800 \text{ mol B}$

	HONH <sub>2</sub> +	H <sub>2</sub> O $\leftrightarrow$	HONH <sub>3</sub> <sup>+</sup> +	OH <sup>-</sup>
I	0.00700		0.00300	0
C	-x		+ x	+ x
E	0.00700 - x		0.00300 + x	x

$$\begin{aligned} \text{pOH} &= \text{pK}_B + \log \left( \frac{0.00300 + x}{0.00700 - x} \right) \\ &= -\log 1.1 \times 10^{-8} + \log 0.429 \\ \text{pOH} &= 7.96 + -0.368 \\ &= 7.59 \\ \text{pH} &= 6.41 \end{aligned}$$

3c.

$0.030\text{L} \times 0.200\text{M} = 0.00600 \text{ mol H}^+$

I	0.00400	0.00600	0
C	-x	+ x	+ x
E	0.00400 - x	0.00600 + x	x

$$\begin{aligned} \text{pOH} &= 7.96 + \log (0.00600/0.00400) \\ &= 7.96 + 0.176 \\ &= 8.14 \\ \text{pH} &= 5.86 \end{aligned}$$

3d.

$0.050\text{L} \times 0.200\text{M} = 0.0100 \text{ mol H}^+$

	HONH <sub>3</sub> <sup>+</sup> $\leftrightarrow$	HONH <sub>2</sub> +	H <sup>+</sup>
I	0.0100	0	0
C	- x	+ x	+ x
E	0.0100 - x	x	x

$$\begin{aligned} K_a &= K_w/K_b \\ &= ([\text{B}][\text{H}^+]/[\text{BH}^+]) \\ &= x^2/(0.0100 - x/0.150) \\ &= 9.1 \times 10^{-7} \\ &= x^2/0.0667 \\ x^2 &= 6.1 \times 10^{-8} \\ x &= 2.5 \times 10^{-4} \\ x &= [\text{H}^+] \\ \text{pH} &= 3.61 \end{aligned}$$

3e.

$0.070\text{L} \times 0.200\text{M} = 0.140 \text{ mol H}^+$   
 $0.0100 \text{ mol B}$

	HONH <sub>3</sub> <sup>+</sup> $\leftrightarrow$	HONH <sub>2</sub> +	H <sup>+</sup>
I	0.0588	0	0.0235
C	- x	+ x	+ x
E	(0.0100 - x)/0.170	x	0.023

$$\begin{aligned} K_a &= \frac{[\text{H}^+][\text{HONH}_2]}{[\text{HONH}_3^+]} = 9.1 \times 10^{-7} \\ &= \frac{((0.023 + x)x)/(0.0588 - x)}{0.170} \\ &\approx 9.1 \times 10^{-7} \\ x &= 2.3 \times 10^{-5} \end{aligned}$$

$$[\text{H}^+] = [0.002350]$$

$$\text{pH} = 1.63$$

3f.  $0.100\text{L} \times 0.200\text{M} = 0.0200 \text{ mol H}^+$

	HONH <sub>2</sub> +	H <sup>+</sup> ↔	HONH <sub>3</sub> <sup>+</sup>
I	0.0100 mol	0.0200	0
C	- 0.0100 mol	+ x	+ x
F	0	0.0100 mol H <sup>+</sup>	0.0100 mol

  

	HONH <sub>2</sub> +	H <sup>+</sup> ↔	HONH <sub>3</sub> <sup>+</sup>
I	0.0100/0.2	0	0.0100
C	- x	+ x	+ x
E	(0.0100 - x)/0.200	x	(0.0100 + x)/0.200

$$9.1 \times 10^{-7} = ((0.05+x)x) \cdot (0.05 - x)$$

$$\text{H}^+ = 0.0500 + 9.1 \times 10^{-7}$$

$$\text{pH} = 1.30$$