Acids and Bases Review, so far….

1. Acids are proton ______________. Complete the following chart for these **acids**:

Acid	Ionization Reaction in Water	Conjugate Base	Ka	Kb
H_2SO_3				
$HCHO_2$				
HPO_4^{2-}				
H_2O				
NH_4^{1+}				
HCO_3^{1-}				
H_2SO_4				
$C_5H_5NH^+$				

2. Bases are proton _____________. Complete the following chart for these **bases**:

Base	Ionization Reaction	Conjugate Acid	Ka	Kb
ClO-				
N_2H_4 (aq)				
CH_3COO^-				
HPO_4^{2-}				
F^{1-}				
H_2O				
NH_2OH				
NH_3				
C_5H_5N				
HCO_3^{1-}				

3. For nitrogen compounds, how can you recognize when they will behave as bases? As acids?
4. As a general rule for weak acids and bases, negative ions in solution will behave as __________.
5. Using your knowledge of trends for acid strengths, arrange the following acids in order from highest to lowest strength: HCl H_3PO_4 HI H_3PO_3
6. Using **Ka values**, arrange the following acids in order from highest to lowest strength:

   HNO_2 H_3PO_4 HF HCH_3COO H_2S H_2SO_3 H_2CO_3
7. Which of the acids in Q6 has the strongest conjugate base? ____________
8. Calculate the pH of the following solutions:

a) 15.4 g of potassium hydroxide in a total volume of 600.0 mL solution (13.660, 3 decimal places)
b) 125 mL of 15.0 M of nitric acid diluted to 1.00 litre of solution (-0.273, 3 decimal places)
c) a 0.0125 M solution of magnesium hydroxide (12.398, 3 decimal places)
d) a 1.35 M solution of acetic acid (2.31, 2 decimal places from K_a)
e) a 2.00 M solution of pyridine (C_5H_5N) (9.77, 2 decimal places from K_b)
f) 0.555 M solution of hypobromite ion (from sodium hypobromite) (11.15, 2 decimals from K_a)
g) 100.0 mL of 18.0 M H_2SO_4 diluted to 500.0 mL of solution (-0.556, 3 decimal places)

9. Complete the following chart. Include the correct number of sig digs in your answers:

pH	**pOH**	**[H3O+]**	**[OH-]**	**acid/base/neutral**
1.25				
		4.63×10^{-10}		
	9.10			
			0.750	
	5.00			

10. The following reaction strongly favours the reactants:

$$HCO_3^{1-}\,(aq) \quad + \quad HSO_4^{1-}\,(aq) \quad \leftrightarrow \quad CO_3^{2-}\,(aq) \quad + \quad H_2SO_4\,(aq)$$

a) the strongest acid in this system is: ___________________________

b) the strongest base in this system is: ___________________________

c) Will this reaction have a large or small value of K_{eq}? __________ Explain.

11. The pH of a 0.16 M solution of phenolic acid is 3.20.

a) What is the Ka for phenolic acid? ($K_a = 2.5 \times 10^{-6}$)

b) What is the percent dissociation of the acid in this solution? (only 0.39% dissociated)

12. Name the following substances and then predict whether their solutions will be acidic, basic or neutral:

a) $NaCH_3COO$ ____

b) NH_4Cl ____

c) Li_2O ____

d) $Sr(NO_3)_2$ ____

e) HBrO (HOBr) ____

f) $CoBr_2$ ____

g) $Cr(NO_3)_2$ ____

h) Na_3PO_4 ____

i) HSCN ____

j) CaC_2O_4 ____

k) $Mg(ClO_3)_2$ ____

l) K_3BO_3 ____

m) $SnCl_4$ ____

13. What are two tests or properties you could distinguish between the following solutions?

a) NaCl and NaClO ____

b) H_2O and Li_2O ____

c) $HClO_2$ and $HClO_3$ ____

d) H_2S and Na_2S ____

e) $Ca(OH)_2$ and $Co(OH)_2$ ____

14. Write the products of the following reactions (if any) and then balance each reaction:

a) $Mg\,(s) + CH_3COOH\,(aq) \rightarrow$

b) $NaOH\,(aq) + Ba\,(s) \rightarrow$

c) $HBrO_3\,(aq) + K_2CO_3\,(s) \rightarrow$

d) $K_2O\,(s) + H_2O\,(l) \rightarrow$

Acids and Bases Review, so far…. Answers

1. Acids are proton **donors**. Complete the following chart for these **acids**:

Acid	Ionization Reaction in Water	Conjugate Base	Ka	Kb
H_2SO_3	H_2SO_3 (l) + H_2O (l) ↔ HSO_3^{1-} (aq) + H_3O^+ (aq)	HSO_3^{1-}	1.4×10^{-2}	7.1×10^{-13}
$HCHO_2$	$HCHO_2$ (l) + H_2O (l) ↔ HCO_2^{1-} (aq) + H_3O^+ (aq)	HCO_2^{1-}	1.8×10^{-4}	5.6×10^{-11}
HPO_4^{2-}	HPO_4^{2-} (aq) + H_2O (l) ↔ PO_4^{3-} (aq) + H_3O^+ (aq)	PO_4^{3-}	4.8×10^{-13}	2.1×10^{-2}
H_2O	H_2O (l) + H_2O (l) ↔ OH^{1-} (aq) + H_3O^+ (aq)	OH^{1-}	1.0×10^{-14}	1.0
NH_4^{1+}	NH_4^+ (aq) + H_2O (l) ↔ NH_3 (aq) + H_3O^+ (aq)	NH_3	5.6×10^{-10}	1.8×10^{-5}
HCO_3^{1-}	HCO_3^{1-} (aq) + H_2O (l) ↔ CO_3^{2-} (aq) + H_3O^+ (aq)	CO_3^{2-}	4.7×10^{-11}	2.1×10^{-4}
H_2SO_4	H_2SO_4 (l) + H_2O (l) → HSO_4^{1-} (aq) + H_3O^+ (aq)	HSO_4^{1-}	1.0×10^{3}	1.0×10^{-17}
$C_5H_5NH^+$	$C_5H_5NH^+$ (aq) + H_2O (l) ↔ C_5H_5N (aq) + H_3O^+ (aq)	C_5H_5N	5.9×10^{-6}	1.7×10^{-9}

2. Bases are proton **acceptors**. Complete the following chart for these **bases**:

Base	Ionization Reaction	Conjugate Acid	Ka	Kb
ClO-	ClO^{1-} (aq) + H_2O (l) ↔ HClO (aq) + OH^- (aq)	HClO	4.0×10^{-8}	2.5×10^{-7}
N_2H_4 (aq)	N_2H_4 (aq) + H_2O (l) ↔ $N_2H_5^+$ (aq) + OH^- (aq)	$N_2H_5^+$	7.7×10^{-9}	1.3×10^{-6}
CH_3COO^{1-}	CH_3COO^{1-} (aq) + H_2O (l) ↔ CH_3COOH (aq) + OH^- (aq)	CH_3COOH	1.8×10^{-5}	5.6×10^{-10}
HPO_4^{2-}	HPO_4^{2-} (aq) + H_2O (l) ↔ $H_2PO_4^{1-}$ (aq) + OH^- (aq)	$H_2PO_4^{1-}$	6.2×10^{-8}	1.6×10^{-7}
F^{1-}	F^{1-} (aq) + H_2O (l) ↔ HF (aq) + OH^- (aq)	HF	6.3×10^{-4}	1.6×10^{-11}
H_2O	H_2O (l) + H_2O (l) ↔ H_3O^+ (aq) + OH^{1-} (aq)	H_3O^+	1.0×10^{-14}	1.0
NH_2OH	NH_2OH (aq) + H_2O (l) ↔ NH_3OH^+ (aq) + OH^- (aq)	NH_3OH^+	1.1×10^{-6}	8.8×10^{-9}
NH_3	NH_3 (aq) + H_2O (l) ↔ NH_4^+ (aq) + OH^- (aq)	NH_4^+	5.6×10^{-10}	1.8×10^{-5}
C_5H_5N	C_5H_5N (aq) + H_2O (l) ↔ $C_5H_5NH^+$ (aq) + OH^- (aq)	$C_5H_5NH^+$	5.9×10^{-6}	1.7×10^{-9}
HCO_3^{1-}	HCO_3^{1-} (aq) + H_2O (l) ↔ H_2CO_3 (aq) + OH^- (aq)	H_2CO_3	4.5×10^{-7}	2.2×10^{-8}

3. For nitrogen compounds, how can you recognize when they will behave as bases? As acids?
   - if a nitrogen compound is uncharged (neutral), it will probably behave as a base
   - if a nitrogen compound is positively charged, it will probably behave as an acid
4. As a general rule for weak acids and bases, negative ions in solution will behave as **bases**.

5. Using your knowledge of trends for acid strengths, arrange the following acids in order from highest to lowest strength:

HI is the strongest (it is closest to the bottom of the Periodic table),

HCl is the only other strong acid so it comes next

H_3PO_4 is a weak acid, but it is stronger than H_3PO_3 because it has more O atoms
H_3PO_3 is the weakest of these acids

6. Using Ka values, arrange the following acids in order from highest to lowest strength:

strongest:	H_2SO_3	(Ka = 1.4×10^{-2})
	H_3PO_4	(Ka = 6.9×10^{-3})
	HF	(Ka = 6.3×10^{-4})
	HNO_2	(Ka = 5.6×10^{-4})
	HCH_3COO	(Ka = 1.8×10^{-5})
	H_2CO_3	(Ka = 4.5×10^{-7})
weakest:	H_2S	(Ka = 8.9×10^{-8})

7. Which of the acids in Q6 has the strongest conjugate base? H_2S has the strongest conjugate base, HS^-

8. Calculate the pH of the following solutions:

a) 15.4 g of potassium hydroxide in 600.0 mL of distilled water (13.660, 3 decimal places)
b) 125 mL of 15.0 M of nitric acid diluted to 1.00 litre of solution (-0.273, 3 decimal places)
c) a 0.0125 M solution of magnesium hydroxide (12.398, 3 decimal places)
d) a 1.35 M solution of acetic acid (2.31, 2 decimal places from K_a)
e) a 2.00 M solution of pyridine (C_5H_5N) (9.77, 2 decimal places from K_b)
f) 0.555 M solution of hypobromite ion (from sodium hypobromite) (11.15, 2 decimals from K_a)
g) 100.0 mL of 18.0 M H_2SO_4 diluted to 500.0 mL of solution (-0.556, 3 decimal places)

9. Complete the following chart. Include the correct number of sig digs in your answers:

pH	**pOH**	**[H3O+]**	**[OH-]**	**acid/base/neutral**
1.25	12.75	5.6×10^{-2}	1.8×10^{-13}	acid
9.334	4.666	4.63×10^{-10}	2.16×10^{-5}	base
4.90	9.10	1.3×10^{-5}	7.9×10^{-10}	acid
13.875	0.125	1.33×10^{-14}	0.750	base
9.00	5.00	1.0×10^{-9}	1.0×10^{-5}	base

10. The following reaction strongly favours the reactants:

$$HCO_3^{1-}\ (aq) \quad + \quad HSO_4^{1-}\ (aq) \quad \leftrightarrow \quad CO_3^{2-}\ (aq) \quad + \quad H_2SO_4\ (aq)$$

a) the strongest acid in this system is: **H_2SO_4 (aq)**
b) the strongest base in this system is: **CO_3^{2-} (aq)**
c) Will this reaction have a large or small value of K_{eq}? Explain.
- the K_{eq} for this reaction will be very small in the forward direction. Because the products of the reaction include a very strong acid and strong base (the conjugate of a weak acid), these species will tend to drive the reaction strongly in reverse. There will be very little product formed, so the value of K_{eq} will be much less than one.

11. The pH of a 0.16 M solution of phenolic acid is 3.20.
a) What is the Ka for phenolic acid? ($K_a = 2.5 \times 10^{-6}$)
b) What is the percent dissociation of the acid in this solution? (only 0.39% dissociated)

12. Name the following substances and then predict whether their solutions will be acidic, basic or neutral:
a) $NaCH_3COO$: sodium acetate, basic
b) NH_4Cl: ammonium chloride, acidic
c) Li_2O: lithium oxide, basic
d) $Sr(NO_3)_2$: strontium nitrate, neutral
e) HBrO (HOBr): hypobromous acid, acidic
f) $CoBr_2$: cobalt (II) bromide, acidic
g) $Cr(NO_3)_2$: chromium (II) nitrate, acidic
h) Na_3PO_4 : sodium phosphate, basic
i) HSCN: thiocyanic acid, acidic
j) CaC_2O_4 : calcium oxalate, basic
k) $Mg(ClO_3)_2$: magnesium chlorate, neutral
l) K_3BO_3 : potassium borate, basic
m) $SnCl_4$: tin (IV) chloride, acidic

13. What are two tests or properties you could distinguish between the following solutions?
a) NaCl and NaClO: sodium chloride is a neutral salt while sodium hypochlorite is a basic salt

Test	**NaCl solution**	**NaClO solution**
skin feel	watery	slippery
colour with phenolphthalein	colourless	pink
colour with bromothymol blue	green	blue
colour with red litmus	red	blue

b) H_2O and Li_2O: water is neutral and covalent while lithium oxide will form a base in solution

Test	**H_2O solution (liquid)**	**Li_2O solution**
skin feel	watery	slippery
colour with phenolphthalein	colourless	pink
colour with bromothymol blue	green	blue
colour with red litmus	red	blue
conductivity	non-electrolyte	electrolyte

c) $HClO_2$ and $HClO_3$: both of these solutions are acids, but $HClO_2$ is a weak acid while $HClO_3$ is strong

Test	**$HClO_2$ solution**	**$HClO_3$ solution**
conductivity	weak electrolyte	strong electrolyte
pH (use same concentration of both solutions, eg. 1.0M of each)	pH of $HClO_2$ will be higher than pH of $HClO_3$	pH of $HClO_3$ will be lower than pH of $HClO_2$
rate of reaction with a metal	weak acid so reaction will be slow because the $[H_3O+]$ is low	strong acid so reaction will be fast because the $[H_3O+]$ is high
rate of reaction with a carbonate	weak acid so reaction will be slow because the $[H_3O+]$ is low	strong acid so reaction will be fast because the $[H_3O+]$ is high

13d) H_2S and Na_2S : in solution, H_2S is a weak acid and Na_2S is a basic salt

Test	**H_2S solution**	**Na_2S solution**
skin feel	watery	slippery
pH	less than 7.0	greater than 7.0
colour with phenolphthalein	colourless	pink
colour with bromothymol blue	yellow	blue
colour with red litmus	red	blue
colour with blue litmus	red	blue
reaction with metals	produce H_2 gas	no reaction
reaction with carbonates	produce CO_2 gas	no reaction

e) $Ca(OH)_2$ and $Co(OH)_2$: both solutions are bases, but $Ca(OH)_2$ is a strong base and $Co(OH)_2$ is weak

Test	**$Ca(OH)_2$ solution**	**$Co(OH)_2$ solution**
conductivity	strong electrolyte	weak electrolyte
pH (use same concentration of both solutions, eg. 1.0M of each)	pH of $Ca(OH)_2$ will be higher than pH of $Co(OH)_2$	pH of $Co(OH)_2$ will be lower than pH of $Ca(OH)_2$

14. Write the products of the following reactions (if any) and then balance each reaction:

a) $Mg\ (s) + 2\ CH_3COOH\ (aq) \rightarrow H_2\ (g) + Mg(CH_3COO)_2\ (aq)$

b) $NaOH\ (aq) + Ba\ (s) \rightarrow$ no reaction

c) $2\ HBrO_3\ (aq) + K_2CO_3\ (s) \rightarrow 2\ KBrO_3\ (aq) + H_2O\ (l) + CO_2\ (g)$

d) $K_2O\ (s) + H_2O\ (l) \rightarrow 2\ KOH\ (aq)$