8. CLASSIFYING SUBSTANCES AS ACIDIC BASIC OR NEUTRAL.

• the hydrolysis of salts of weak acids and weak bases can be represented using equations; the Brønsted-Lowry model can be applied to explain the acidic, basic and neutral nature of salts derived from bases and monoprotic and polyprotic acids	

8a. Ions you should know.

Below is a table of common ions classified as either acidic basic or neutral.

	Neutral	Basic	Acidic
Anions	derived from strong acids	derived from weak acids	derived from polyprotic acids*
	Cl^-, NO_3^-, Br^-, I^-	F^-, S^{2-}, SO_4^{2-}, ClO^-, CH_3COO^-, CO_3^{2-}, HCO_3^-, PO_4^{3-}, HPO_4^{2-}	HSO_4^-, $H_2PO_4^-$
Cations	derived from strong bases		
	Li^+, Mg^{2+}, Na^+, Ca^{2+}, K^+, Ba^{2+}	none	NH_4^+, Al^{3+}, Fe^{3+}

*Some anions derived from polyprotic acids (e.g. HCO_3^- and HPO_4^{2-}) are basic.

Worked example 1 - Is ammonium chloride an acidic, basic, or neutral salt?

- Step 1 – The salt dissociates into it's constituent ions

$$NH_4Cl \rightarrow NH_4^+{}_{(aq)} + Cl^{1-}{}_{(aq)}$$

- Step 2 - Consider the hydrolysis reaction of each of the ions
  - Cl^{1-} does not undergo hydrolysis
  - NH_4^+ undergoes the following hydrolysis reaction

$$NH_4^+ + H_2O \leftrightarrow NH_3 + H_3O^+$$

Therefore...the salt is acidic (when dissolved in water)

Worked example 2 – Is potassium ethanoate an acidic, basic, or neutral salt?

- Step 1 – The salt dissociates into it's constituent ions

$$KCH_3COO \rightarrow K^+{}_{(aq)} + CH_3COO^{1-}{}_{(aq)}$$

- Step 2 - Consider the hydrolysis reaction of each of the ions
  - K^+ does not undergo hydrolysis
  - CH_3COO^{1-} undergoes the following hydrolysis reaction

$$CH_3COO^{1-} + H_2O \leftrightarrow CH_3COOH + OH^{1-}$$

Therefore...the salt is basic. (when dissolved in water)

8b. Justifying pH of ions when told if it's acidic basic or neutral.

Worked example 1 - NH_4F is a neutral salt, use chemical equations to explain this observation.

- Step 1 – The salt dissociates into it's constituent ions

$$NH_4F \rightarrow NH_4^{+}{}_{(aq)} + F^{-}{}_{(aq)}$$

- Step 2 - Consider the hydrolysis reaction of each of the ions
  - F^{1-} undergoes the following hydrolysis reaction

$$F^{1-} + H_2O \leftrightarrow HF + OH^{1-}$$

  - NH_4^{+} undergoes the following hydrolysis reaction

$$NH_4^{+} + H_2O \leftrightarrow NH_3 + H_3O^{+}$$

Therefore...
Both hydrolysis reactions must occur to similar extents resulting in equal quantities of H_3O^{+} and OH^{1-} being produced...thus the resulting solution is neutral.

Worked example 2 – NaH_2PO_4 is an acidic salt, use chemical equations to explain this observation

- Step 1 – The salt dissociates into it's constituent ions

$$NaH_2PO_4 \rightarrow Na^{+}{}_{(aq)} + H_2PO_4^{1-}{}_{(aq)}$$

- Step 2 - Consider the hydrolysis reaction of each of the ions
  - Na^{+} does not undergo a hydrolysis reaction
  - $H_2PO_4^{1-}$ can act as both a proton donor and a proton receiver.

$$(1)\ H_2PO_4^{1-} + H_2O \leftrightarrow HPO_4^{2-} + H_3O^{+}$$

$$(2)\ H_2PO_4^{1-} + H_2O \leftrightarrow H_3PO_4 + OH^{1-}$$

Therefore...
Since the salt is said to be acidic we assume that the 1st hydrolysis reaction occurs to a great extent (i.e. larger K value) than the 2nd. In other words $H_2PO_4^{1-}$ has a greater tendency to act a proton donor than to act as a proton receiver. Therefore the $[H_3O^{+}]$ will be greater than the $[OH^{1-}]$

Lucarelli

Exercise:

By examining the nature of the ions decide whether the following ionic salts would be acidic, basic or neutral in aqueous solution. Explain your answers with the aid of a diagram and a ***HYDROLYSIS*** reaction.

1. $NaHSO_4$

2. KCl

3. $NaCH_3COO$

4. NH_4Cl

5. Na_2SO_4

6. NH_4CH_3COO *(hard)*

7. $FeCl_3$

8. K_2CO_3

$Na_2CO_3 \rightleftharpoons CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$

basic

Exercise:

By examining the nature of the ions decide whether the following ionic salts would be acidic, basic or neutral in aqueous solution. Explain your answers with the aid of a diagram and a ***HYDROLYSIS*** reaction.

1. $NaHSO_4$

$HSO_4^- + OH^- \rightarrow H_2O + SO_4^{2-} \rightleftharpoons HSO_4^- + OH^-$

Slightly acidic $HSO_4^- \rightarrow H^+ + SO_4^{2-}$

Na^+ no affinity for H_2O ionisation

2. KCl

neutral $KCl \rightarrow K^+ + Cl^-$

come from strong base / acid e.g. KOH & HCl.

3. $NaCH_3COO$

Slightly basic. $CH_3COO^- + H^+ \rightarrow CH_3COOH$

Na^+.

4. NH_4Cl

Slightly acidic $NH_4^+ \rightleftharpoons NH_3 + H^+$

5. Na_2SO_4

$SO_4^{2-} + H_2O \rightleftharpoons HSO_4^- + OH^-$

strong base

basic $Na_2SO_4 \rightleftharpoons SO_4^{2-}$ from strong acid

6. $NH_3^+CH_2COO^-$ *(hard)*

$NH_2CH_2COO^- + H_2O \rightleftharpoons NH_3^+CH_2COO^- \rightleftharpoons NH_3^+CH_2COOH$

(buffer) OH^- H^+

Zwitterion.

7. $FeCl_3$

acidic $Fe^{III} + H_2O \rightleftharpoons Fe(OH)_3 + 3H^+$

Precipitate

8. K_2CO_3 $CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$ basic

1. Explain why the salt of a strong acid and a strong base yields a neutral solution.

Both strong acids and strong bases produce ions in a complete, irreversable manner in water.

2. Explain why the salt of a strong acid and a weak base yields an acidic solution.

	Colour of universal indicator	pH	Acidic/ basic/ neutral	Equation to explain if solution is acidic or basic
Sodium chloride(aq)	Green	7	Neutral	
Potassium chloride(aq)	Green	7	Neutral	
Ammonium chloride(aq)	Yellow	6	Acidic	$NH_{4(aq)}^{+} + H_2O_{(l)} \rightleftarrows NH_{3(aq)} + H_3O^{+}_{(aq)}$
Calcium chloride(aq)	Green	7	Neutral	
Iron (III) chloride(aq)	Red	1	Acidic	$Fe^{3+}_{(aq)} + H_2O_{(l)} \rightleftarrows Fe(OH_2)_{(s)} + 3H^{+}_{(aq)}$
Sodium carbonate(aq)	Purple	11	Basic	$CO_{3(aq)}^{2-} + 2H_2O_{(l)} \rightleftarrows H_2CO_{3(aq)} + 2OH^{-}_{(aq)}$
Sodium ethanoate(aq)	Pale green	8	Basic	$CH_3COO^{-}_{(aq)} + H_2O_{(l)} \rightleftarrows CH_3COOH_{(aq)} + OH^{-}_{(aq)}$
Sodium hydrogencarbonate(aq)	Dark green	9	Basic	$HCO_{3(aq)}^{-} + H_2O_{(l)} \rightleftarrows H_2CO_{3(aq)} + OH^{-}_{(aq)}$
Sodium sulfate (aq)	Green	7	Neutral	
Sodium hydrogen sulfate (aq)	Red	1	Acidic	$HSO_{4(aq)}^{+} + H_2O_{(l)} \rightleftarrows SO_{4(aq)}^{2-} + H_3O^{+}_{(aq)}$
Sodium sulfite(aq)	Dark green	9	Basic	$SO_{3(aq)}^{2-} + H_2O_{(l)} \rightleftarrows HSO_{3(aq)}^{-} + OH^{-}_{(aq)}$
Sodium sulfide(aq)	Purple	11	Basic	$S^{2-}_{(aq)} + 2H_2O_{(l)} \rightleftarrows H_2S_{(aq)} + 2OH^{-}_{(aq)}$
Iron(II) sulfate(aq)	Red	1	Acidic	$Fe^{2+}_{(aq)} + 3H_2O_{(l)} \rightleftarrows Fe(OH_3)_{(s)} + 3H^{+}_{(aq)}$
Sodium oxalate(aq)	Pale green	8	Basic	$C_2O_4^{2-}{}_{(aq)} + 2H_2O_{(l)} \rightleftarrows H_2C_2O_{4(aq)} + 2OH^{-}_{(aq)}$
Ammonium sulfate(aq)	Yellow	6	Acidic	$NH_{4(aq)}^{+} + H_2O_{(l)} \rightleftarrows NH_{3(aq)} + H_3O^{+}_{(aq)}$
Aluminium sulfate(aq)	Red	1	Acidic	$Al^{3+}_{(aq)} + 3H_2O_{(l)} \rightleftarrows Al(OH)_{3(s)} + 3H^{+}_{(aq)}$
Aluminium chloride(aq)	Red	1	Acidic	$Al^{3+}_{(aq)} + 3H_2O_{(l)} \rightleftarrows Al(OH)_{3(s)} + 3H^{+}_{(aq)}$