

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.

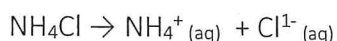
Below is a table of common ions classified as either acidic basic or neutral.

	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 ₃ COO ⁻ , CO ₃ ²⁻ , HCO ₃ ⁻ , PO ₄ ³⁻ , HPO ₄ ²⁻	HSO ₄ ⁻ , H ₂ PO 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. HCO₃⁻ and HPO₄²⁻) are basic.

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

- Step 1 – The salt dissociates into its constituent ions



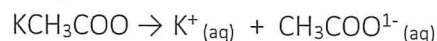
- Step 2 - Consider the hydrolysis reaction of each of the ions
 - Cl¹⁻ does not undergo hydrolysis
 - NH₄⁺ undergoes the following hydrolysis reaction



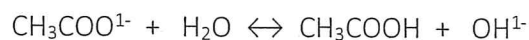
Therefore...the salt is acidic (when dissolved in water)

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

- Step 1 – The salt dissociates into its constituent ions



- Step 2 - Consider the hydrolysis reaction of each of the ions
 - K⁺ does not undergo hydrolysis
 - CH₃COO¹⁻ undergoes the following hydrolysis reaction

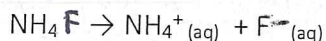


Therefore...the salt is basic. (when dissolved in water)

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 its constituent ions

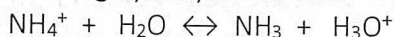


- Step 2 - Consider the hydrolysis reaction of each of the ions

- F^- undergoes the following hydrolysis reaction



- NH_4^+ undergoes the following hydrolysis reaction

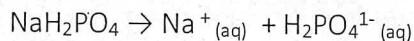


Therefore...

Both hydrolysis reactions must occur to similar extents resulting in equal quantities of H_3O^+ and OH^- 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

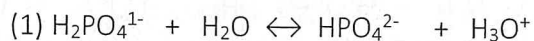
- Step 1 – The salt dissociates into its constituent ions



- Step 2 - Consider the hydrolysis reaction of each of the ions

- Na^+ does not undergo a hydrolysis reaction

- $\text{H}_2\text{PO}_4^{1-}$ can act as both a proton donor and a proton receiver.



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 $\text{H}_2\text{PO}_4^{1-}$ has a greater tendency to act a proton donor than to act as a proton receiver. Therefore the $[\text{H}_3\text{O}^+]$ will be greater than the $[\text{OH}^-]$

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

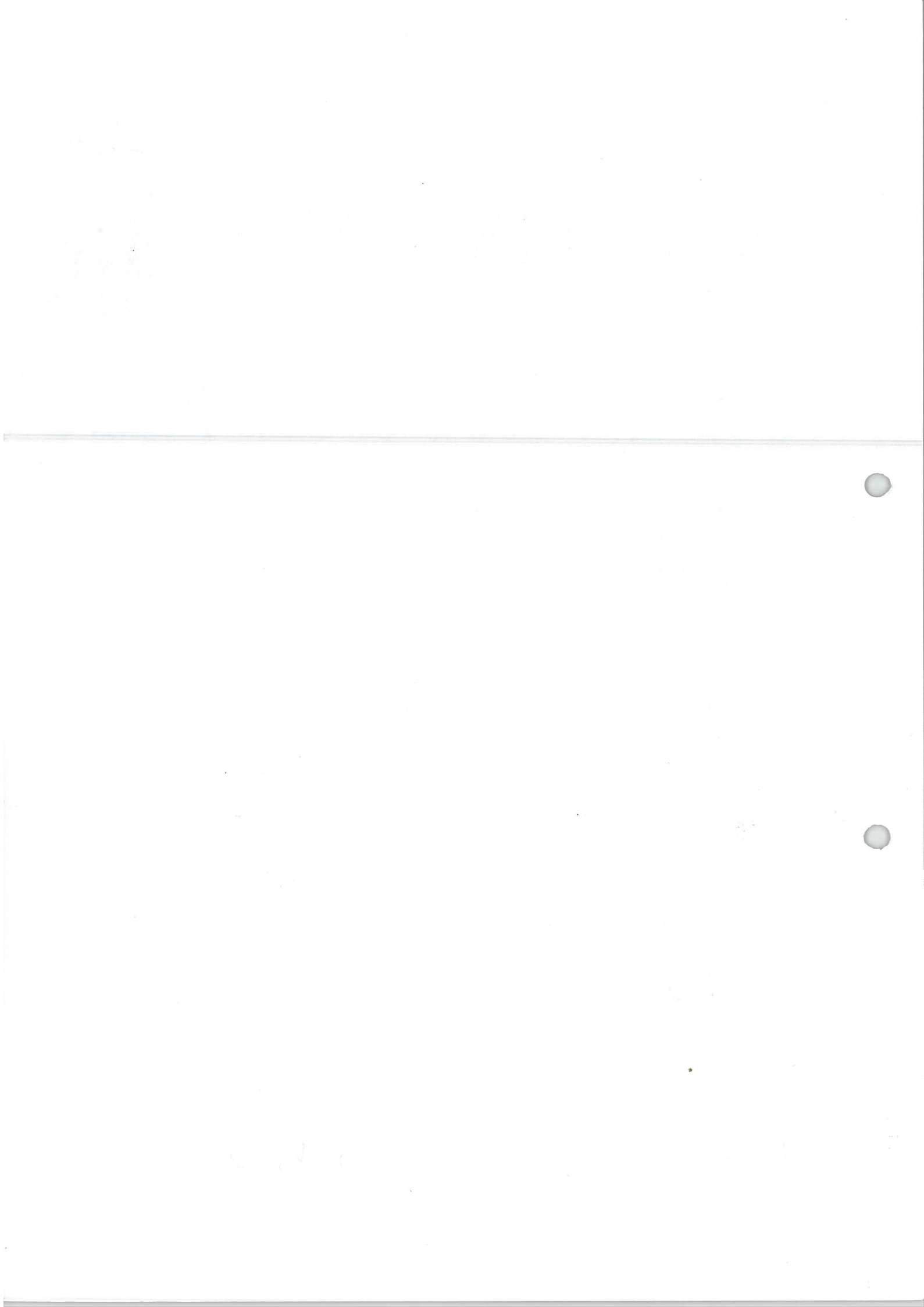
3. NaCH_3COO

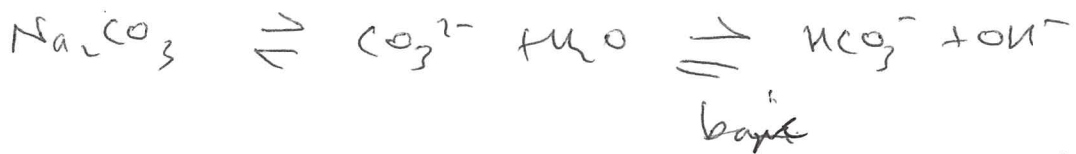
4. NH_4Cl

5. Na_2SO_4

6. $\text{NH}_4\text{CH}_2\text{COO}$ (hard)

7. FeCl_3 8. K_2CO_3



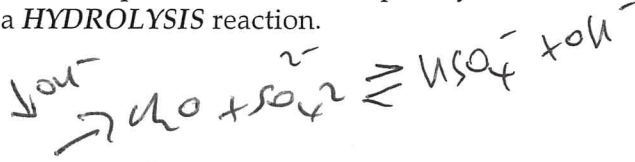


Exercise:

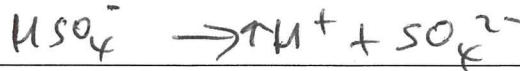
By examining the nature of the ions decide whether the following ionic salts would be acidic, basic or neutral in aqueous solution. Explain your answers with the aid of a diagram and a *HYDROLYSIS* reaction.



1. NaHSO₄



Slightly acidic



Na⁺ no affinity for H₂O ionization

2. KCl

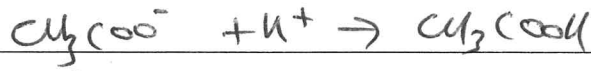
neutral



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

3. NaCH₃COO

Slightly basic



Na⁺:

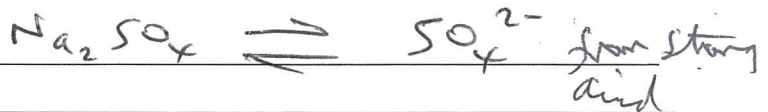
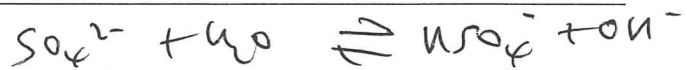
4. NH₄Cl

Slightly acidic

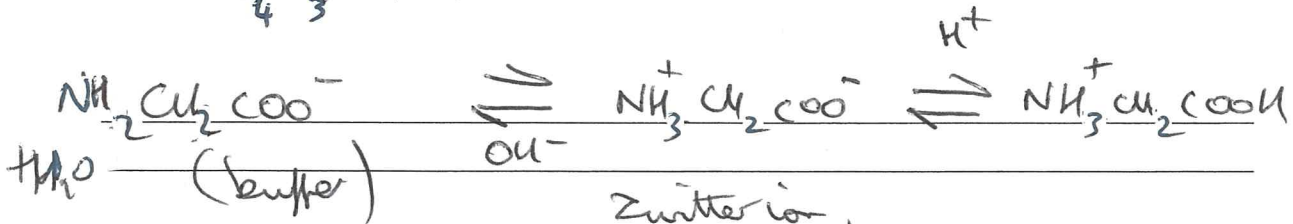


5. Na₂SO₄

strong base
basic

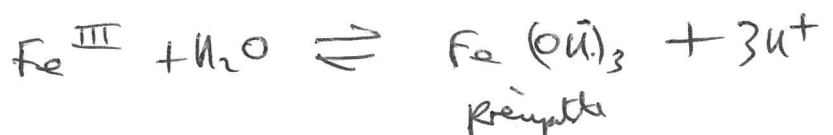


6. NH₄⁺CH₃COO⁻ (hard)

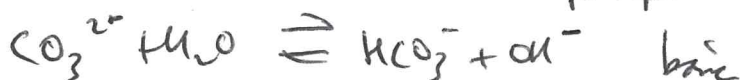


7. FeCl₃

acidic



8. K₂CO₃



2000

2001

$$f(x) = \frac{1}{x^2} = x^{-2}$$

$$f'(x) = -2x^{-3} = -\frac{2}{x^3}$$

The function $f(x) = \frac{1}{x^2}$ is a power function.

The derivative of $f(x) = \frac{1}{x^2}$ is $f'(x) = -\frac{2}{x^3}$.

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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, irreversible 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	$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$
Calcium chloride(aq)	Green	7	Neutral	
Iron (III) chloride(aq)	Red	1	Acidic	$Fe^{3+}(aq) + H_2O(l) \rightleftharpoons Fe(OH)_2(s) + 3H^+(aq)$
Sodium carbonate(aq)	Purple	11	Basic	$CO_3^{2-}(aq) + 2H_2O(l) \rightleftharpoons H_2CO_3(aq) + 2OH^-(aq)$
Sodium ethanoate(aq)	Pale green	8	Basic	$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$
Sodium hydrogencarbonate(aq)	Dark green	9	Basic	$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$
Sodium sulfate (aq)	Green	7	Neutral	
Sodium hydrogen sulfate (aq)	Red	1	Acidic	$HSO_4^-(aq) + H_2O(l) \rightleftharpoons SO_4^{2-}(aq) + H_3O^+(aq)$
Sodium sulfite(aq)	Dark green	9	Basic	$SO_3^{2-}(aq) + H_2O(l) \rightleftharpoons HSO_3^-(aq) + OH^-(aq)$
Sodium sulfide(aq)	Purple	11	Basic	$S^{2-}(aq) + 2H_2O(l) \rightleftharpoons H_2S(aq) + 2OH^-(aq)$
Iron(II) sulfate(aq)	Red	1	Acidic	$Fe^{2+}(aq) + 2H_2O(l) \rightleftharpoons Fe(OH)_2(s) + 2H^+(aq)$
Sodium oxalate(aq)	Pale green	8	Basic	$C_2O_4^{2-}(aq) + 2H_2O(l) \rightleftharpoons H_2C_2O_4(aq) + 2OH^-(aq)$
Ammonium sulfate(aq)	Yellow	6	Acidic	$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$
Aluminium sulfate(aq)	Red	1	Acidic	$Al^{3+}(aq) + 3H_2O(l) \rightleftharpoons Al(OH)_3(s) + 3H^+(aq)$
Aluminium chloride(aq)	Red	1	Acidic	$Al^{3+}(aq) + 3H_2O(l) \rightleftharpoons Al(OH)_3(s) + 3H^+(aq)$

