Acid-Base properties of Salts

$Na_2S_{(s)} \rightarrow Na^+_{(aq)} + S^{2-}_{(aq)}$

Na^+ ↙ cation of Group 1 metal — no effect on pH

S^{2-} ↘ anion of weak acid acts as a conjugate base causing a hydrolysis rxn

$S^{2-}_{(aq)} + H_2O_{(l)} \rightleftharpoons HS^-_{(aq)} + OH^-_{(aq)}$

HS^- also anion of a weak acid, so

$HS^-_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2S_{(aq)} + OH^-_{(aq)}$

basic

$Na_3PO_4{}_{(s)} \rightarrow 3Na^+_{(aq)} + PO_4^{3-}{}_{(aq)}$

Na^+ ↙ cation of Group 1 metal — does not cause a hydrolysis rxn

PO_4^{3-} ↘ anion of a weak acid acts as a conjugate base causing a series of hydrolysis rxn

$PO_4^{3-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HPO_4^{2-}{}_{(aq)} + OH^-_{(aq)}$

$HPO_4^{2-}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2PO_4^-{}_{(aq)} + OH^-_{(aq)}$

$H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3PO_4{}_{(aq)} + OH^-_{(aq)}$

basic

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

Na^+ ↙ cation of group 1 metal — does not cause a hydrolysis rxn

$H_2PO_4^-$ ↘ anion of a weak acid acts as conjugate base causing a hydrolysis rxn

$H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3PO_4{}_{(aq)} + OH^-_{(aq)}$

but $H_2PO_4^-$ also has an acidic H

$H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HPO_4^{2-}{}_{(aq)} + H_3O^+_{(aq)}$

have to compare K_A & K_B to determine which predominates.

K_A for $H_2PO_4^- = 6.3 \times 10^{-8}$

K_B for $H_2PO_4 = \dfrac{K_w}{K_A \text{ for } H_3PO_4}$

$= \dfrac{1 \times 10^{-14}}{7.1 \times 10^{-3}}$

$= 1.4 \times 10^{-12}$.

$K_A > K_B$

∴ acidic properties dominate.

acidic

$NaF_{(s)} \rightarrow Na^+_{(aq)} + F^-_{(aq)}$

↓ cation of Group I metal does not cause a hydrolysis rxn

↳ anion of a weak acid, acts as a conjugate base

$F^-_{(aq)} + H_2O_{(l)} \rightleftharpoons HF_{(aq)} + OH^-_{(aq)}$

basic

$NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

↓ cation ~~anion~~ of Group I metal does not cause hydrolysis rxn

↳ anion of a strong acid, does not cause a hydrolysis rxn

neutral

$NaC_2H_3O_2{}_{(s)} \rightarrow Na^+_{(aq)} + C_2H_3O_2^-{}_{(aq)}$

↓ cation of Group I metal does not cause a hydrolysis rxn

↳ anion of a weak acid, causes a hydrolysis rxn

$C_2H_3O_2^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HC_2H_3O_2{}_{(aq)} + OH^-$

basic

$AlCl_3{}_{(s)} \rightarrow Al^{3+}_{(aq)} + 3Cl^-_{(aq)}$

↳ anion of a strong acid, does not cause a hydrolysis rxn

↓ combines w H_2O to form a complex ion which then causes a hydrolysis rxn

$Al^{3+}_{(aq)} + 6H_2O_{(l)} \rightleftharpoons [Al(H_2O)_6]^{3+}_{(aq)}$

$[Al(H_2O)_6]^{3+}_{(aq)} + H_2O_{(l)} \rightleftharpoons [Al(H_2O)_5(OH)]^{2+}_{(aq)} + H_3O^+_{(aq)}$

acidic

$NH_4NO_3{}_{(s)} \rightarrow NH_4^+{}_{(aq)} + NO_3^-{}_{(aq)}$

↓ cation of a weak base, acts as a conjugate acid

↳ anion of a weak acid, does not cause a hydrolysis rxn

$NH_4^+{}_{(aq)} + H_2O_{(l)} \rightleftharpoons NH_3{}_{(aq)} + H_3O^+_{(aq)}$

acidic

$Ca(NO_3)_2{}_{(s)} \rightarrow Ca^{2+}_{(aq)} + 2NO_3^-{}_{(aq)}$

↓ cation of a Group 2 metal, does not cause a hydrolysis rxn

↳ anion of a strong acid, does not cause a hydrolysis rxn

neutral

$NaC_3H_5O_2{}_{(s)} \rightarrow Na^+_{(aq)} + C_3H_5O_2^-{}_{(aq)}$

~~Cation~~ ↓ cation of group I metal does not cause a hydrolysis rxn

↳ anion of a weak base, acts as a conjugate base

$C_3H_5O_2^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HC_3H_5O_2{}_{(aq)} + OH^-{}_{(aq)}$

basic

$C_6H_5NH_3Cl_{(s)} \longrightarrow C_6H_5NH_3^+{}_{(aq)} + Cl^-{}_{(aq)}$

↓ cation of a weak base acts as conjugate acid

↳ anion of strong acid, does not cause a hydrolysis rxn

acid

$C_6H_5NH_3^+{}_{(aq)} + H_2O_{(l)} \rightleftharpoons C_6H_5NH_2{}_{(aq)} + H_3O^+{}_{(aq)}$

$N_2H_5Cl_{(s)} \rightarrow N_2H_5^+{}_{(aq)} + Cl^-{}_{(aq)}$

↓ cation of a weak base acts as a conjugate acid

↳ anion of strong acid, does not cause a hydrolysis rxn

acidic

$N_2H_5^+{}_{(aq)} + H_2O_{(l)} \rightleftharpoons N_2H_5{}_{(aq)} + H_3O^+{}_{(aq)}$

$BeCl_{2(s)} \longrightarrow Be^{2+}{}_{(aq)} + 2Cl^-{}_{(aq)}$

↓ cation which forms complex ion which then causes a hydrolysis rxn

↳ anion of strong acid, does not cause a hydrolysis rxn

acid

$Be^{2+}{}_{(aq)} + 2H_2O_{(l)} \rightleftharpoons [Be(H_2O)_2]^{2+}{}_{(aq)}$

$[Be(H_2O)_2]^{2+}{}_{(aq)} + H_2O_{(l)} \rightleftharpoons [Be(H_2O)(OH)]^+{}_{(aq)} + H_3O^+{}_{(aq)}$

$MgCl_{2(s)} \longrightarrow Mg^{2+}{}_{(aq)} + 2Cl^-{}_{(aq)}$

↓ cation of Group 2 metal does not cause hydrolysis rxn

↳ anion of a strong acid does not cause a hydrolysis rxn

neutral

$NaCN_{(s)} \longrightarrow Na^+_{(aq)} + CN^-_{(aq)}$

Na^+: cation of Group 1 metal does not cause hydrolysis rxn

CN^-: ↳ anion of a weak acid causes a hydrolysis rxn

	$CN^-_{(aq)}$	+ $H_2O_{(l)}$	⇌	$HCN_{(aq)}$	+ $OH^-_{(aq)}$
I	0.4408			0	(1×10^{-7})
C	$-x$			$+x$	$+y$
E	$0.4408-x$			x	x

$$[NaCN] = \frac{m}{MV} = 10.8\,g\ NaCN \times \frac{1\,mol\ NaCl}{49.00\,g\ NaCN} \times \frac{1}{0.500\,L}$$

$$= 0.4408\ \frac{mol\ NaCN}{L}$$

$$[Na^+] = [CN^-] = 0.4408\ \frac{mol}{L}$$

$$K_B = \frac{[HCN][OH^-]}{[CN^-]}$$

$$1.613\times10^{-5} = \frac{(x)(x)}{0.4408}$$

$$x = 2.666\times10^{-3}$$

$$K_B = \frac{K_W}{K_A}$$

$$= \frac{1\times10^{-14}}{6.2\times10^{-10}}$$

$$= 1.613\times10^{-5}$$

check

$$\frac{[\,]}{K_B} = \frac{0.4408}{1.613\times10^{-5}}$$

$$= 2.7\times10^4 > 100$$

proof

$$\frac{x}{[\,]_I} \times 100\% = \frac{2.666\times10^{-3}}{0.4408} \times 100\%$$

$$= 0.605\%$$

$$[OH^-] = [HCN] = 2.666\times10^{-3}\ mol/L$$

$$[H^+] = \frac{K_W}{[OH^-]} = \frac{1\times10^{-14}}{2.666\times10^{-3}} = 3.75\times10^{-12}\ \frac{mol}{L}$$