Acids & Bases Worksheet

Part A Dissolving of Ionic Compounds in water to form electrolytic solutions

forward → Ionic Compound dissolves completely
Group 1A Cation Na^+, K^+, Li^+
acetate $C_2H_3O_2^-$ or Nitrate NO_3^-

Equilibrium ⇌ Ionic Compound dissolves some
anything else than above

Examples

$$Na_3PO_{4(s)} \xrightarrow{H_2O} 3\,Na^+_{(aq)} + PO_4^{3-}{}_{(aq)}$$

Product

$$MgBr_{2(s)} \overset{H_2O}{\rightleftharpoons} Mg^{2+}_{(aq)} + 2\,Br^-_{(aq)}$$

Reactant ⇌ Products

Part B Decide if a solution Contains Ions, Molecules or both.

a nonelectrolyte - Dissolving as a molecule

ethanol CH_3CH_2OH

$$CH_3CH_2OH_{(l)} \xrightarrow{H_2O} CH_3CH_2OH_{(aq)}$$ Ions, Molecules, both

A Strong electrolyte - Dissociates Completely

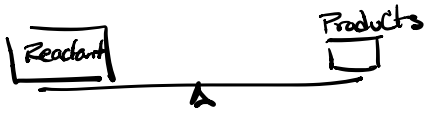
Sodium hydrogen Phosphate Na_2HPO_4, Strong electrolyte

$$Na_2HPO_{4(s)} \xrightarrow{H_2O} 2Na^+_{(aq)} + HPO_4^{2-}{}_{(aq)}$$ Ions, molecules, both

A weak electrolyte - Dissociates only slightly

Methylamine CH_3NH_2 a weak electrolyte

$$CH_3NH_{2(l)} \rightleftharpoons CH_3NH_3^+{}_{(aq)} + OH^-_{(aq)}$$ Ions, Molecules, both



Part C Characteristics of Acids & Bases

Acids

- Taste Sour
- They produce H^+ (hydrogen ions) in H_2O ↔ or H_3O^+ (hydronium ion)
- Acids neutralize bases
- Turn blue litmus paper → Red
- → They contain more H^+ (H_3O^+) than OH^-

Bases

- Taste bitter
- They produce OH^- (hydroxide ion) in H_2O
- Bases neutralize acids
- Turn red litmus paper → Blue
- → They contain more OH^- than H^+ (H_3O^+)

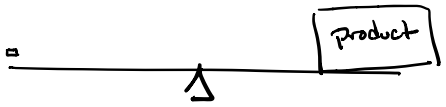
Part D Nomenclature

Names & formulas

Part E & F Writing the ionization equations for acids & Bases.

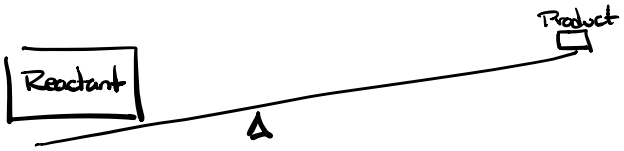
Strong acid or Strong base = Strong electrolyte

Dissociate Completely $\longrightarrow$



Weak acid or Weak base = Weak electrolyte

Dissociate little $\rightleftharpoons$ equilibrium



H_2SO_4, Strong acid

$$H_2SO_4 + 2\,H_2O_{(l)} \longrightarrow 2H_3O^+_{(aq)} + SO_4^{2-}{}_{(aq)}$$

$HC_2H_3O_2$, weak acid

$$HC_2H_3O_2 + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + C_2H_3O_2^-{}_{(aq)}$$

KOH, strong base

$$KOH_{(s)} \xrightarrow{H_2O} K^+_{(aq)} + OH^-_{(aq)}$$

Why is H_2O not a reactant?

$$KOH + H_2O \longrightarrow K^+ + OH^- + H_2O$$

NH_3, weak base

$$NH_{3\,(l)} + H_2O_{(l)} \rightleftharpoons NH_{3(aq)}^+ + OH^-_{(aq)}$$

$NaC_2H_3O_2$, weak base (Na^+ spectator ion)

$$C_2H_3O_2^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons HC_2H_3O_{2(aq)} + OH^-_{(aq)}$$

Part G Neutralization Reactions

Reaction of a strong acid & strong base to produce a "salt" (ionic compound) and water.

$$H_nA + n\,NaOH \rightarrow Na_nA + n\,H_2O$$

Acids	type	
HCl	monoprotic	protic = acidic H's
H_2SO_4	diprotic	
H_3PO_4	triprotic	

Bases	Type	
$NaOH$	monobasic	basic = # of OH's
$Mg(OH)_2$	dibasic	
$Al(OH)_3$	tribasic	

Example of Neutralization Rxns

$$HNO_{3(aq)} + NaOH_{(aq)} \rightarrow NaNO_{3(aq)} + H_2O_{(l)}$$

$$H_2SO_{4(aq)} + 2\,NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + 2\,H_2O_{(l)}$$

$$H_3PO_{4(aq)} + 3\,NaOH \rightarrow Na_3PO_{4(aq)} + 3\,H_2O_{(l)}$$

$2HCl_{(aq)} + Mg(OH)_{2(aq)} \rightarrow MgCl_{2(aq)} + 2H_2O$

Mg^{2+} | Cl^- Cl^- — 2^+ 2^-

H^+ | OH^- — $+$ $-$

$2HCl_{(aq)} + Mg(OH)_2 \rightarrow MgCl_2 + 2H_2O$

H	~~3~~ 4		H	~~4~~ ✓
Cl	~~x~~ 2		Cl	2 ✓
Mg	1		Mg	1 ✓
O	2		O	~~x~~ 2 ✓

Parts H → M $[OH^-]$, $[H^+]$, pH, pOH

[ ] = Concentration moles/L, M

Auto Ionization of Water

$$2\,H_2O \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

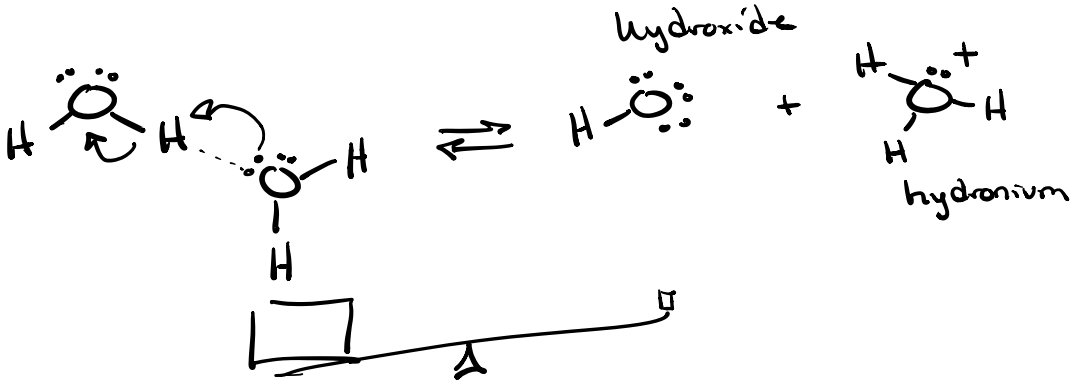
$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Acid

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

Base

H_2O is both an acid & a base



Equilibrium Constants

$$aA + bB \rightleftharpoons cC + dD$$

$$K = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

$$2H_2O \rightleftharpoons OH^-_{(aq)} + H_3O^+$$

$$K = \frac{[OH^-][H_3O^+]}{[H_2O]^2}$$

$$K[H_2O]^2 = K_w = [OH^-][H_3O^+] = 1 \times 10^{-14} \text{ moles}^2/L^2$$

K_w = ionization Constant for water

$$K = \frac{\text{Products}}{\text{Reactants}} \qquad K << 1 = \frac{\text{products}}{\text{Reactants}}$$

1×10^{-14} is a very small # $<< 1$

0.00000000000001 moles$^2/L^2$

Ex What is the $[H_3O^+]$ when $[OH^-]$ is 1.25×10^{-6} moles/L ?

$$[OH^-][H_3O^+] = 1 \times 10^{-14} \qquad 1.00 \times 10^{-14}$$

Solve eq for $[H_3O^+]$

$$[H_3O^+] = \frac{1 \times 10^{-14}}{[OH^-]}$$

$$= \frac{1.00 \times 10^{-14}}{1.25 \times 10^{-6}}$$

(3 sig figs)

= 1 EE (−) 14 ÷ 1.25 EE (−) 6 =

(E (±) 10^x)

$= 8 \times 10^{-9}$ moles/L (3)

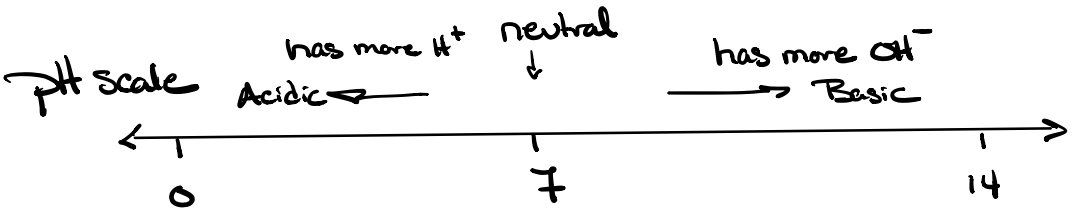
$= 8.00 \times 10^{-9}$ moles/L

pH = "power of hydrogen"

A measure of hydrogen ion concentration

p is a function that stands for $-\log$

$$pH = -\log[H^+] \text{ or } -\log[H_3O^+]$$



log function

value of x

$\text{Log } 10 = x$ $\qquad 10^x = 10$

$\text{Log } 10 = 1$

$\text{Log } 100 = 2$ $\qquad 10^x = 100$

$\text{Log } 10^{-6} = -6$ $\qquad 10^x = 10^{-6}$

$-\log 10^{-6} = -(-6) = 6$

$p10^{-6} = 6$

Ex Find the pH of a solution with $[H_3O^+] = 8.00 \times 10^{-3}$ moles/L

$$pH = -\log [H_3O^+]$$

$$= -\log 8.00 \times 10^{-3}$$

(−) Log (8.00 EE (−) 3) =
(±) 10^x

$$= 2.096\,91001301$$

sig figs in decimal

mantissa

$$pH = 2.097 \text{ unitless}$$

3 sig figs

Find the pH of a solution with a $[H^+]$ of 1.02×10^{-2} moles/L

$$pH = -\log H^+ = -\log 1.02 \times 10^{-2}$$

$$= 1.991\,39982824$$

$$pH = 1.991$$

How do I go backwards & find the $[H_3O^+]$ from a pH?

$$[H_3O^+] = 10^{-pH}$$

Ex what is the $[H_3O^+]$ of a solution with a pH of 6.92 ? (2 SF)

$$[H_3O^+] = 10^{-pH} = 10^{-6.92}$$

$$= 10 \text{ } ^{\wedge}(-)6.92 = 1.202264434 \times 10^{-7}$$

(x^n)

$$= \boxed{1.2 \times 10^{-7} \text{ moles/L}}$$

Exercise M Complete the table

$[H_3O^+]$	$[OH^-]$	pH	acidic / basic / Neutral
1×10^{-2}	1×10^{-12}	2	Acidic

$$[H_3O^+][OH^-] = 1 \times 10^{-14}$$

$$[H_3O^+] = \frac{1 \times 10^{-14}}{[OH^-]} = \frac{1 \times 10^{-14}}{1 \times 10^{-12}}$$

$$\frac{A^b}{A^c} = A^{b-c}$$

$$[H_3O^+] = 1 \times 10^{-2}$$

$$pH = -\log 1 \times 10^{-2} = 2$$

Buffer

A solution that resists a change in pH

⇒ A buffer is made from a weak acid & its conjugate base

Buffer example

$H_2PO_4^-$ & HPO_4^{2-} Phosphate buffer

weak acid — Conjugate base

$HC_2H_3O_2$ & Na^+ $C_2H_3O_2^-$

weak acid — Conjugate base

Strong Acid

HCl
HNO_3
H_2SO_4

} Cannot make a buffer solution from these

⇒ Do Not Do Exercise N problem # 5