5. Strength of Acids and Bases

a) What is a Strong Acid?

i) 100% dissociated in water

ii) No reverse reaction. Not in equilibrium.

iii) Example:

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$ *(**no** undissociated HCl)*

1.0M 1.0M 1.0M

iv) There are **six** strong acids. Refer to "Relative Strengths of Acids and Bases" p.334 Hebden.

v) All six strong acids have the same net result when added to water:

$$H^+ + H_2O \rightarrow H_3O^+$$ *(line 7 on table)*

vi) Therefore, H_3O^+ is the strongest acid that can exist in water.

vii) And since, all six strong acids produce the same $[H_3O^+]$ in water, they have the same strength.

viii) This is called the **"Levelling Effect"** (the six strong acids are equal in producing H_3O^+)

ix) Strong acids do not have conjugate bases.

b) What is a Strong Base?

i) 100% dissociated in water

ii) No reverse reaction. Not in equilibrium.

iii) There are **two** strong *Bronsted-Lowry* bases. Refer to "Relative Strengths of Acids and Bases" p.334 Hebden.

iv) All metal hydroxides are also strong bases.

v) Examples:

$O^{-2} + H_2O \rightarrow 2OH^-$ (Bronsted-Lowry strong base)

1.0M 2.0M

$NH_2^- + H_2O \rightarrow OH^- + NH_3$ (Bronsted-Lowry strong base)

1.0M 1.0M 1.0M

$NaOH + H_2O \rightarrow OH^- + Na^+$ (Arrhenius strong base)

1.0M 1.0M

vi) All strong bases have the same net result when added to water:

$Base + H_2O \rightarrow OH^- + H^+$ *(line 3 from bottom of table)*

vii) Therefore, OH^- is the strongest base that can exist in water.

viii) And since, all strong bases produce the same $[OH^-]$ in water, they have the same strength.

ix) This is another instance of the **"Levelling Effect"**

x) Strong bases <u>do not</u> have conjugate acids

c) What is a Weak Acid?

i) Not 100% dissociated in water.

ii) They form an equilibrium.

iii) There are **29** weak acids. Refer to "Relative Strengths of Acids and Bases" p.334 Hebden on the left side of the equilibrium (HIO_3 to H_2O).

iv) The higher up in the table, the stronger the acid. Stronger = more dissociation!

v) Example: HF vs. CH_3COOH. Which is stronger?

1.0M CH_3COOH vs. 1.0M HF

$$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$$

0.996M 0.004M 0.004M

$$HF + H_2O \rightleftharpoons H_3O^+ + F^-$$

0.97M 0.03M 0.03M

vi) The stronger the acid, the weaker its conjugate base.

d) What is a Weak Base?

i) Not 100% dissociated.

ii) They form an equilibrium.

ii) There are **29** weak bases. Refer to "Relative Strengths of Acids and Bases" p.334 Hebden on the right side of the equilibrium (H_2O to PO_4^{-3}).

iii) The lower in the table, the stronger the base. Stronger = better ability to receive a proton.

iv) Example: NO_2^- vs. NH_3. Which is stronger?

NH_3 (lower in table)

v) The stronger the base, the weaker its conjugate acid.

e) Equilibrium Reactions with Table of Relative Strengths

Example: $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

Acid reaction: $H_2CO_{3\,(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + HCO_3^-{}_{(aq)}$

Base reaction: $HCO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3\,(aq)} + OH^-_{(aq)}$

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