4.6

Acids and Bases: General Principles

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Acids and Bases: General Principles

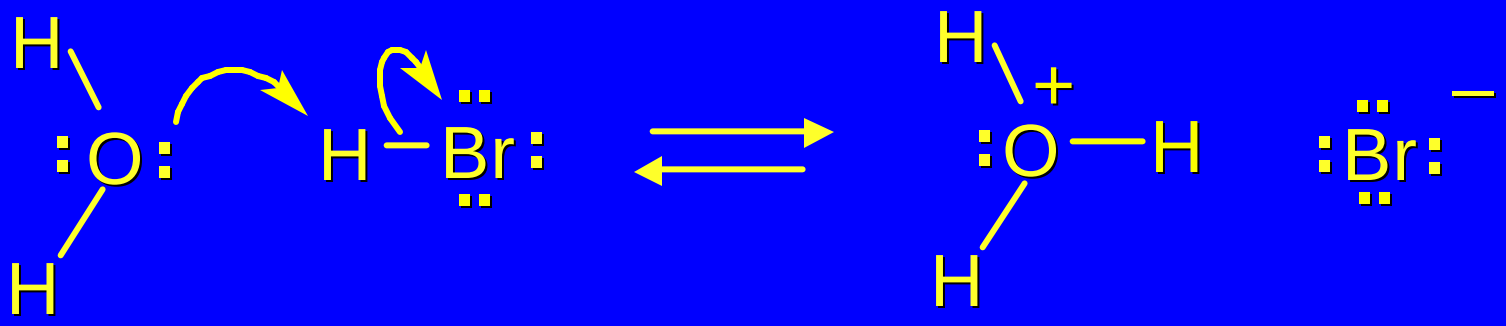
Brønsted-Lowry definition

an acid is a proton donor

a base is a proton acceptor

Proton Transfer from HBr to Water

hydronium ion



base acid conjugate acid conjugate base

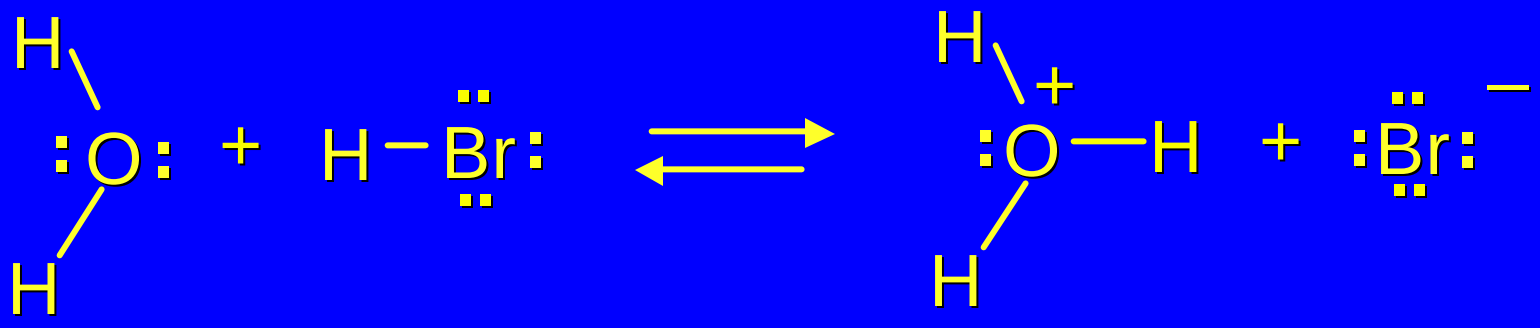
Acid Strength

A strong acid is one that is completely ionized in water.

A weak acid is one that ionizes in water to the extent of less than 100%.

Acid strength is measured by K_a or pK_a

Equilibrium constant for proton transfer



$$K = \frac{[H_3O^+][Br^-]}{[HBr]}$$

$$K_a = \frac{[H^+][Br^-]}{[HBr]}$$

$$pK_a = -\log K_a$$

Table 4.2 Strength of Some Brønsted Acids

Acid	K_a	pK_a	Conj. Base
HI	$\sim 10^{10}$	–10	I^-
HBr	$\sim 10^{9}$	–9	Br^-
HCl	$\sim 10^{7}$	–7	Cl^-
H_2SO_4	1.6×10^{5}	–4.8	HSO_4^-
H_3O^+	55.5	–1.7	H_2O

strong acids are stronger than hydronium ion

Table 4.2 Strength of Some Brønsted Acids

Acid	K_a	pK_a	Conj. Base
H_3O^+	55.5	–1.7	H_2O
HF	3.5×10^{-4}	3.5	F^-
CH_3CO_2H	1.8×10^{-5}	4.6	$CH_3CO_2^-$
NH_4^+	5.6×10^{-10}	9.2	NH_3
H_2O	1.8×10^{-16}	15.7	HO^-

weak acids are weaker than hydronium ion

Table 4.2 Strength of Some Brønsted Acids

Acid	K_a	pK_a	Conj. Base
H_2O	1.8×10^{-16}	15.7	HO^-
CH_3OH	$\sim 10^{-16}$	~16	CH_3O^-
CH_3CH_2OH	$\sim 10^{-16}$	~16	$CH_3CH_2O^-$
$(CH_3)_2CHOH$	$\sim 10^{-17}$	~17	$(CH_3)_2CHO^-$
$(CH_3)_3COH$	$\sim 10^{-18}$	~18	$(CH_3)_3CO^-$

alcohols resemble water in acidity; their conjugate bases are comparable to hydroxide ion in basicity

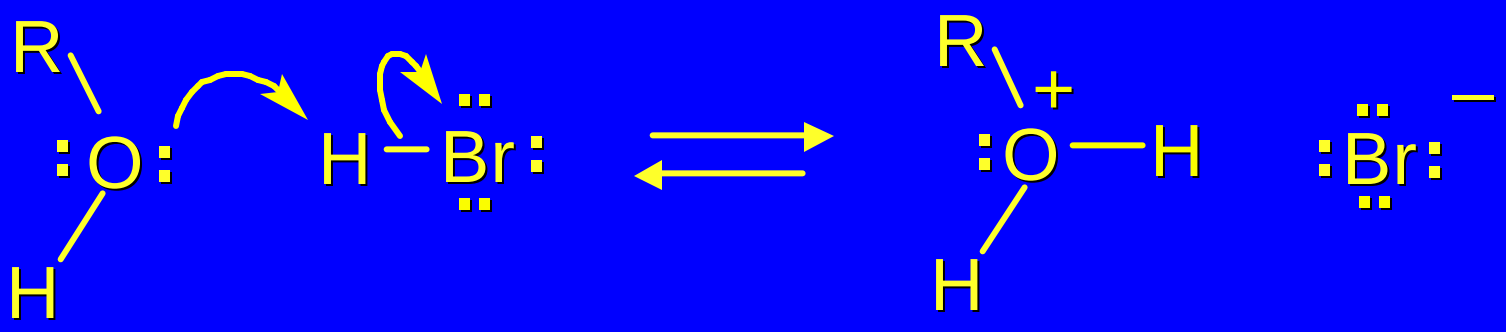
Table 4.2 Strength of Some Brønsted Acids

Acid	K_a	pK_a	Conj. Base
NH_3	$\sim 10^{-36}$	~36	NH_2^-
$(CH_3)_2NH$	$\sim 10^{-36}$	~36	$(CH_3)_2N^-$

ammonia and amines are very weak acids;
their conjugate bases are very strong bases

Proton Transfer to Alcohols

alkyloxonium ion



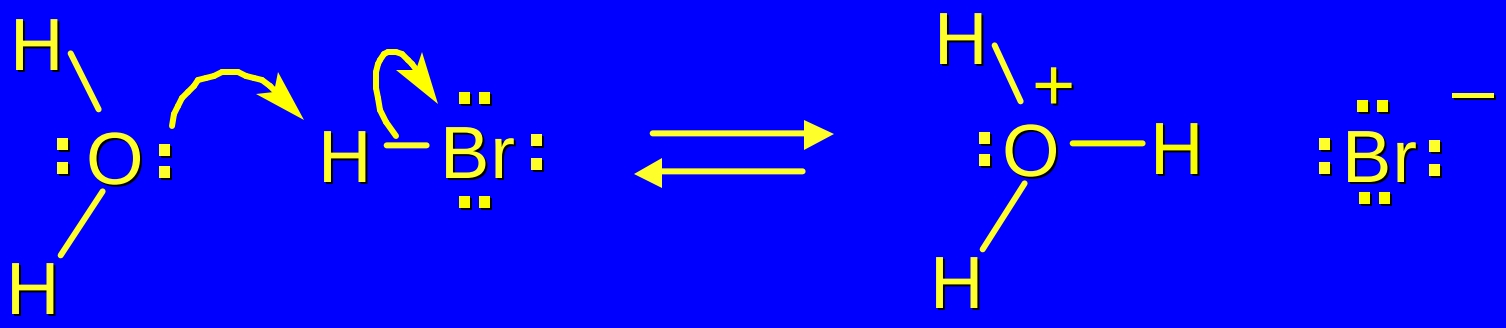
base acid conjugate acid conjugate base

4.7

Acid-Base Reactions:

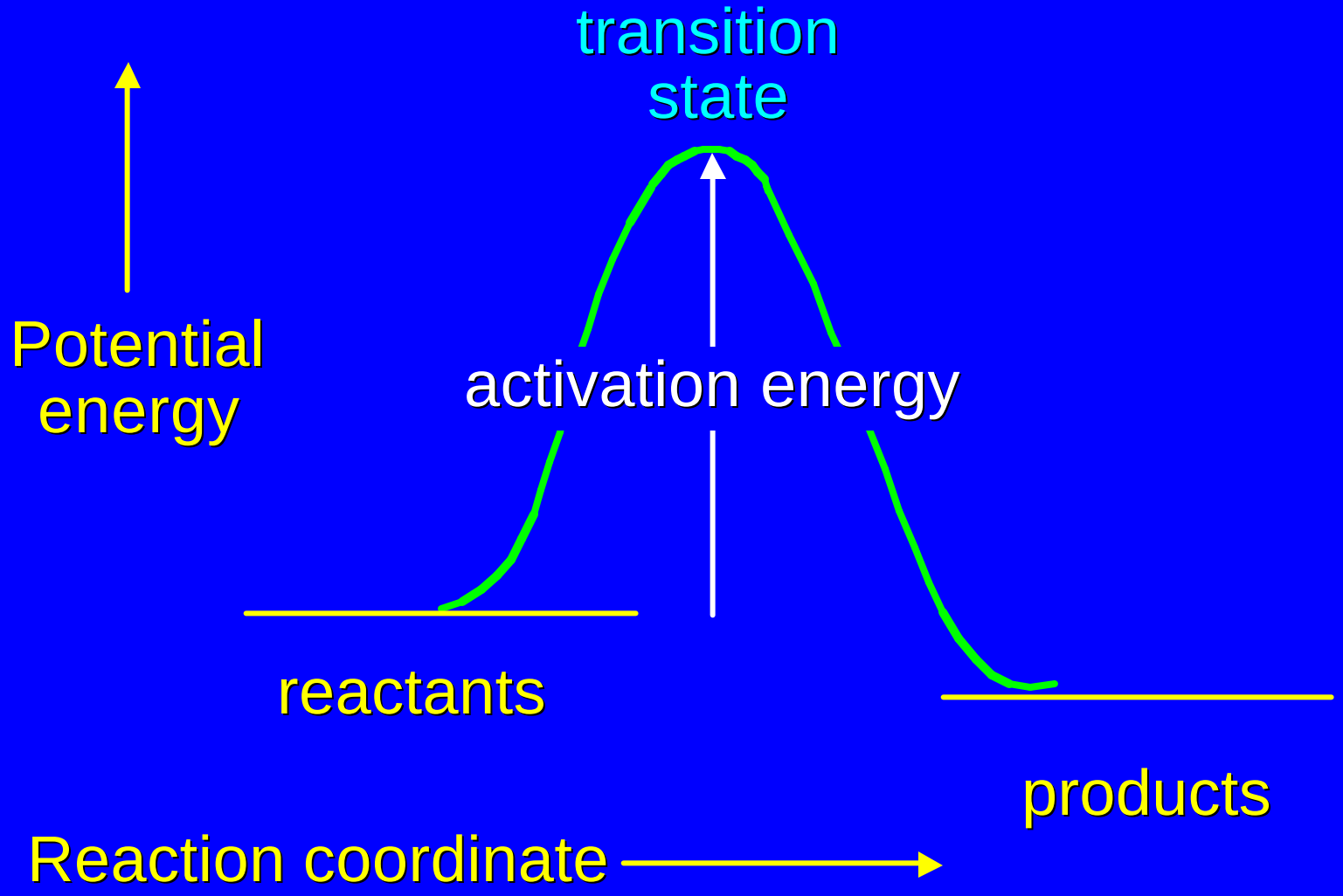
A Mechanism for Proton Transfer

Proton Transfer from HBr to Water

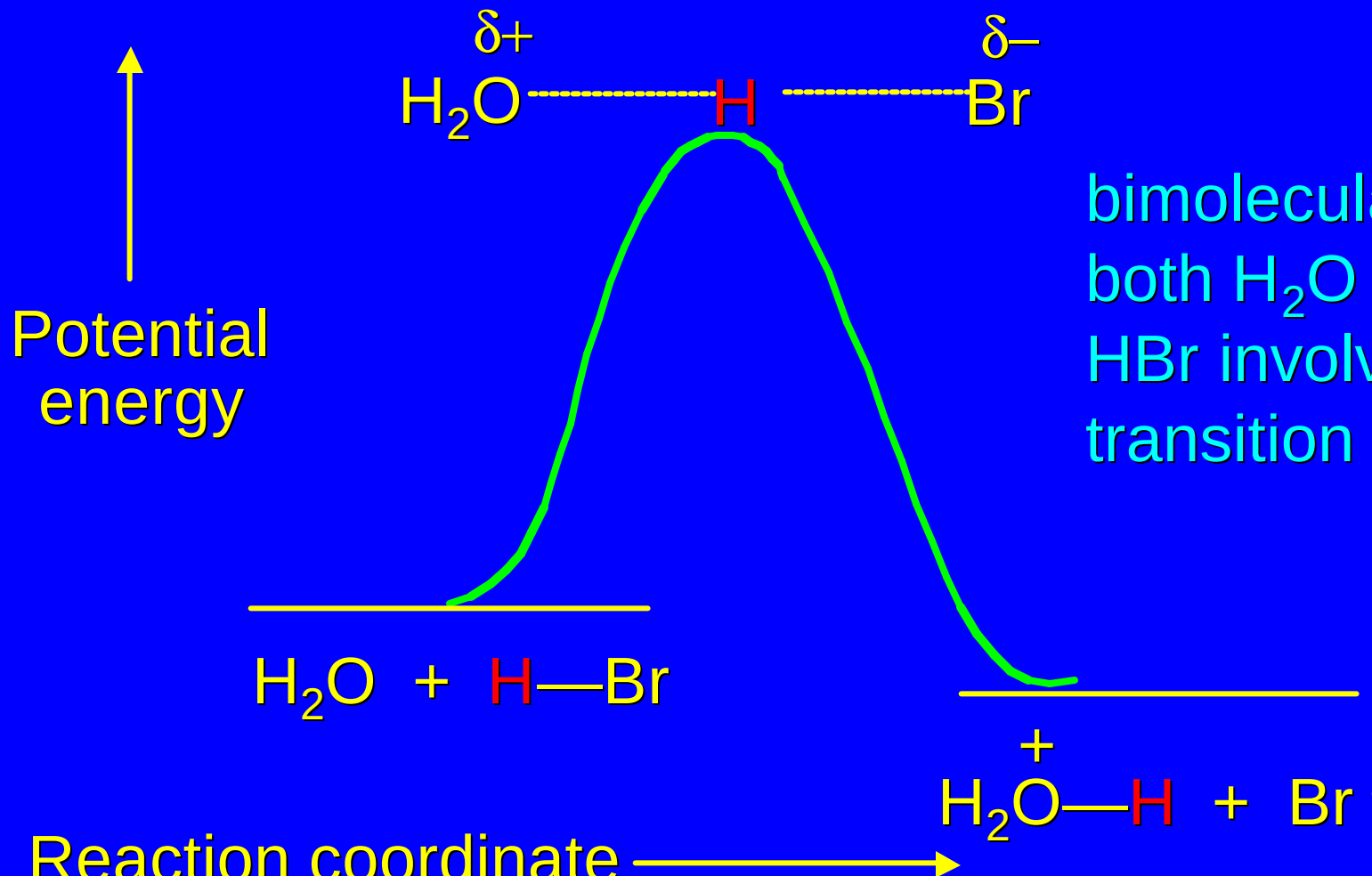


base acid conjugate acid conjugate base

Mechanism:
single step



Mechanism:
single step



bimolecular:
both H_2O and HBr involved at transition state