

Acids and Bases

Overview of Acids and Bases

Indicators: Acids and Bases

Acids: Donates its proton to base (proton donor)

Base: Donates its lone pair to acid (LBP)



Remember: (1) only H atoms, (2) only OH is a base

What about organic indicators and indicators solution?

Acid-Base Indicators

Acids are proton donors, Bases are proton acceptors.



General acid-base reactions of acid-base reactions:

to find the strong base, the base gets protonated, charge of the base

and check for weak acids/bases of the acid.

to find the level of the hydrogen and more the electrons

in the other atom

Remember: -OH is a weak base, -OH- is a strong base

1. Acid: Donates and Proton: Donates, so: Proton Donor/Protonator

What if there is no proton transfer?

Acid-Base Reactions

Acids: Donates its proton to base (proton donor)

Base: Donates its lone pair to acid (LBP)



Acid-Base Reactions: Acids and Bases are described in terms of electron

transfer. The acid-base reaction involves the transfer of a proton

from the acid to the base. The acid is the proton donor and the base is the proton acceptor.

Acid Strength

What does it mean "strong acid"?

Relatively speaking, the more the acid donates its proton, the stronger it is.



The dissociation of the acid is a reversible reaction that is described by the equilibrium constant



Acid Strength and pK_a

The K_a values of weak acids (1) and weak bases (2) are shown below



The strength of an acid and base is the K_a value

To simplify the numbers, pK_a is used, which is the \log of the K_a value

$$pK_a = -\log K_a$$

$$pK_a = -\log K_a = 14 - pK_b = 14$$

So, the stronger the acid, the lower the pK_a value. (It's the opposite of the K_a)

Acids are pK_a values of weak acids (1) and weak bases (2)



What makes the Acid Strong?

The strength of the acid is determined by the stability of the conjugate base. The more stable the conjugate base, the stronger the acid.

The stronger the acid, the more stable the conjugate base.



Acids (1) and weak bases (2) are shown below. The stronger the acid, the more stable the conjugate base.

There are 14 factors in the calculation of the stability of the conjugate base.

1. The first and the last factor is the **charge** in which the hydrogen is connected. Usually, it is **positive** (1) and **negative** (2) and **neutral** (3).

2. The first and the last factor is the **charge** in which the hydrogen is connected. Usually, it is **positive** (1) and **negative** (2) and **neutral** (3).



3. When comparing the stability of the conjugate base, the more stable the base, the stronger the acid.

Large atoms have higher polarizability and transfer the negative charge better in the conjugate base.



There are 14 factors in the calculation of the stability of the conjugate base.

The more stable the base, the stronger the acid.

4. When comparing the stability of the conjugate base, the more stable the base, the stronger the acid.



5. The first factor in the calculation of the stability of the conjugate base is the **charge** in which the hydrogen is connected.

Inductive effect is the transmission of charge through atoms.

Electronegativity atoms pull the negative charge and help to stabilize the conjugate base.



The more electronegative, the more electron withdrawing, the stronger the acid.



The closer the electronegative atom to the hydrogen, the stronger the acid.



6. The first factor in the calculation of the stability of the conjugate base is the **charge** in which the hydrogen is connected.

The greater the positive difference of pK_a values of donors, donors, and acceptors.



7. The first factor in the calculation of the stability of the conjugate base is the **charge** in which the hydrogen is connected.

Therefore, for **acidic**, **basic**, **neutral**, **acidic**, **basic**, **neutral**.

The greater the positive difference of pK_a values of donors, donors, and acceptors.

8. The first factor in the calculation of the stability of the conjugate base is the **charge** in which the hydrogen is connected.

Remember: (1) only H atoms, (2) only OH is a base



The Position of Equilibrium for an Acid-Base Reaction

Is the following reaction reaction possible?



Acid-base reactions are reversible, so neither way of doing the reaction is

is the equilibrium of the reaction shifted to the right (products) or to the left (reactants)?

To answer this question, you need to remember: for the equilibrium of acids and bases

reaction is shifted towards the weaker acid and base.

So, you need to compare the pK_a of the acid and base and the conjugate acid and base.

The equilibrium will be shifted to the higher pK_a reaction with only.



Is the acid the pK_a of the conjugate acid is greater than the acid pK_a , or the

equilibrium is shifted to the right. Therefore, the right pointing arrow is shown larger.

Choosing a Base to Deprotonate a Given Compound

Suppose you need to deprotonate the following compound: H_2O

Deprotonate means remove the proton (acidic proton)

First, find the pK_a value: $\text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{OH}^-$

Find the chemical equation of the conjugate reaction with a conjugate base (1)



The pK_a of the conjugate acid must be higher than 14, so the reaction will be favored.

Find a conjugate base from a pK_a table with $pK_a > 14$. Acids are weak when $pK_a > 14$.



Choosing an Acid to Protonate a Given Compound

Suppose you need to protonate the following compound: H_2O (1) (2) (3) (4) (5) (6) (7) (8) (9) (10) (11) (12) (13) (14) (15) (16) (17) (18) (19) (20) (21) (22) (23) (24) (25) (26) (27) (28) (29) (30) (31) (32) (33) (34) (35) (36) (37) (38) (39) (40) (41) (42) (43) (44) (45) (46) (47) (48) (49) (50) (51) (52) (53) (54) (55) (56) (57) (58) (59) (60) (61) (62) (63) (64) (65) (66) (67) (68) (69) (70) (71) (72) (73) (74) (75) (76) (77) (78) (79) (80) (81) (82) (83) (84) (85) (86) (87) (88) (89) (90) (91) (92) (93) (94) (95) (96) (97) (98) (99) (100)

To do that, write the chemical equation of the reaction with a weak acid.



The pK_a of the acid must be lower than 14, so the reaction will be favored.

Find a weak acid from a pK_a table with $pK_a < 14$. Acids are weak when $pK_a < 14$.

Acids are weak when $pK_a < 14$. Acids are weak when $pK_a < 14$.



Hammett-Hansch Equation

The equation shows whether the compound with a given pK_a is an acid or base. (Deprotonated form is an anionic solution depending on the pK_a of the solution)

$$pK_a = pK_b + \log \frac{[\text{A}^-]}{[\text{HA}]}$$

But, given the equation of the Hammett-Hansch equation

1. If the $pK_a < pK_b$, 2. If the $pK_a > pK_b$, 3. If the $pK_a = pK_b$

1. $\log \frac{[\text{A}^-]}{[\text{HA}]} < 0$, 2. $\log \frac{[\text{A}^-]}{[\text{HA}]} > 0$, 3. $\log \frac{[\text{A}^-]}{[\text{HA}]} = 0$

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The pK_a of the conjugate acid is $pK_a + 14$. Therefore, it is usually the acid

that is shown in the reaction. $pK_a < 14$, which is the environment of the

acid $pK_a < 14$. So, the acid will be in the active form. There

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Jane M. Cram, Donald J. Cram



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