B.Sc. (Honours) Part-I

Paper-IA

Topic: Equilibrium constants

pKa, pKb, Ka, and Kb

(Ionic Equilibrium)

UG

Subject-Chemistry

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Equilibrium constants pKa, pKb, Ka, and Kb

(Ionic Equilibrium)

Anything Added to Water which raises $[H_3O]^+$ above 1.0 x 10^{-7} mol L^{-1}, causes $[OH]^-$ to immediately drop below 1,.Z0 x 10^{-7} mol L^{-1}, so keeping K_w constant at 1.01 x 10^{-14} mol L^{-1}

pH, pKa, pKb, Ka, and Kb are used in chemistry to describe how acidic or basic a solution is and to gauge the strength of acids and bases. The pH scale is the most familiar measure of acidity and basicity, but pKa, pKb, Ka, and Kb are better for predicting acid and base strength and their reactions. Here are definitions of each term, simple formulas used to calculate them, and an explanation of how they differ from one another.

What the “p” and “K” Mean

First, it’s helpful to understand the symbols. When you see a “p” in acid-base chemistry, the letter stands for “power.” So, pH is “power of hydrogen” where the H is the element symbol. A “p” in front of a value also indicates the -log of the value. So, pH is the negative log of hydrogen ion concentration, while pKa is the negative log of the Ka value. The capital letter “K” stands for a constant. In this case, it refers to the equilibrium constant. Upper and lower case letters “A” or “a” and “B or “b” stand for acid and base, respectively.

pH and the Equilibrium Constant

pKa, pKb, Ka, and Kb are all equilibrium constants. Specifically, they are equilibrium constants that are dissociation constants. Usually, they are expressed in units of moles per liter (mol/L). Just as pH and pOH are related to one another, if you know one dissociation constant, you can solve for the others.

pKa, Ka, pKb, and Kb are used to predict whether a chemical species will donate or accept protons (hydrogen cations) at a given pH value. In other words, the equilibrium constants indicate acid and base strength and describe the level of ionization of an acid or a base. pKa and Ka describe acids, while pKb and Kb describe bases. Like pH, the pKa and Ka values account for hydrogen ion concentration. Like pOH, the pKb and Kb values account for hydroxide ion concentration. When dealing with equilibrium constant, remember adding water to an aqueous acid or base solution does not change its equilibrium constant. Ka and Kb are related by the ion constant for water (K_w):

Kw = Ka x Kb

pH Definition and Formula

pH is a measure of hydrogen ion concentration [H+], which in turn is a gauge of how acidic or basic a chemical solution is. Ordinarily, the pH scale runs from 0 to 14, although it’s actually possible to get negative values and ones exceeding 14. A p^H value around 7 is neutral (neither acidic nor basic), a p^H value less than 7 is acidic, and a p^H value greater than 7 is basic. The pH value tells whether a chemical is an acid or a base, but it doesn’t indicate the strength of the acid or base. pH is related to pOH, which is the power of the hydroxide ion [OH-] and is used when discussing bases. The formulas to calculate pH and pOH are:

pH = – log [H+]

pOH = – log [OH-]

At 25 degrees Celsius:

pH + pOH = 14

pKa and Ka

Ka is the acid dissociation constant. pKa is just the -log of this constant. An acid dissociates according to the general equation:

$HA + H_2O \leftrightarrows A^– + H_3O^+$

Where:

Ka = [H+][A-]/ [HA]

pKa = – log Ka

at half the equivalence point, pH = pKa = -log Ka

A large Ka value indicates a strong acid because it means an acid largely dissociates into its ions. A large Ka value also means the reaction arrow favors the formation of production. In contrast, a small Ka value means only a small amount of acid dissociates, indicating a weak acid. A small Ka value means the reaction favors the reactants rather than the products. Most weak acids have Ka values between 10^{-2} to 10^{-14}.

pKa gives the same information, but in a different way. The smaller the pKa value, the stronger the acid Or, the larger the pKa value, the weaker the acid. Weak acids typically have pKa values between 2 and 14.

pKb and Kb

Kb is the base dissociation constant and pKb is the -log of this constant. A base dissociates according to the general equation:

$HB + H_2O \leftrightarrows B^+ + OH^-$

Where:

Kb = [B+][OH-]/[BOH]

pKb = -log Kb

The base dissociation constants are interpreted just like the acid dissociation constants. A large Kb value means a base has largely dissociated and indicates a strong base. A small pKb value indicates a strong base, while a large pKb value indicates a weak base.

pKa and pKb are related using a simple equation:

pKa + pKb = 14

What Is pI?

pI is another useful value. pI stands for the isoelectric point. It is the pH value where are molecule (usually a protein) is electrically neutral and has a net electrical charge of zero. For an amino acid containing one amine group and one carboxyl group, the pI is calculated from the average or mean of the pKa values for the molecule:

pI = (pKa1 + pKa2) / 2