Answer on 45638, Chemistry, Other

Question

what is harness of water?explain various units and their relation.

Answer

Hard water is water that has high mineral content (in contrast with "soft water"). Water's hardness is determined by the concentration of multivalent cations in the water. Multivalent cations are cations (positively charged metal complexes) with a charge greater than 1+. Usually, the cations have the charge of 2+. Common cations found in hard water include Ca^{2+} and Mg^{2+}.

Temporary hardness is a type of water hardness caused by the presence of dissolved bicarbonate minerals (calcium bicarbonate and magnesium bicarbonate). When dissolved these minerals yield calcium and magnesium cations (Ca^{2+}, Mg^{2+}) and carbonate and bicarbonate anions (CO_3^{2-}, HCO_3^-). The presence of the metal cations makes the water hard. However, unlike the permanent hardness caused by sulfate and chloride compounds, this "temporary" hardness can be reduced either by boiling the water, or by the addition of lime (calcium hydroxide) through the softening process of lime softening. Boiling promotes the formation of carbonate from the bicarbonate and precipitates calcium carbonate out of solution, leaving water that is softer upon cooling.

Permanent hardness is hardness (mineral content) that cannot be removed by boiling. When this is the case, it is usually caused by the presence of calcium sulfate and/or magnesium sulfates in the water, which do not precipitate out as the temperature increases.

The **total water hardness** is the sum of the molar concentrations of Ca^{2+} and Mg^{2+}, in mol/L or mmol/L units. Although water hardness usually measures only the total concentrations of calcium and magnesium (the two most prevalent divalent metal ions), iron, aluminium, and manganese can also be present at elevated levels in some locations.

Water hardness is often not expressed as a molar concentration, but rather in various units, such as degrees of general hardness (dGH), German degrees (°dH), parts per million (ppm, mg/L, or American degrees), grains per gallon (gpg), English degrees (°e, e, or °Clark), or French degrees (°fH, °f or °F; lowercase f is used to prevent confusion with degrees Fahrenheit). The table below shows conversion factors between the various units.

Hardness unit conversion.

	mmol/L	**ppm, mg/L**	**dGH, °dH**	**gpg**	**°e, °Clark**	**°fH**
mmol/L	1	0.009991	0.1783	0.171	0.1424	0.09991
ppm, mg/L	100.1	1	17.85	17.12	14.25	10
dGH, °dH	5.608	0.05603	1	0.9591	0.7986	0.5603
gpg	5.847	0.05842	1.043	1	0.8327	0.5842
°e, °Clark	7.022	0.07016	1.252	1.201	1	0.7016
°fH	10.01	0.1	1.785	1.712	1.425	1

For example: 1 mmol/L = 100.1 ppm and 1 ppm = 0.056 dGH.

The various alternative units represent an equivalent mass of calcium oxide (CaO) or calcium carbonate ($CaCO_3$) that, when dissolved in a unit volume of pure water, would result in the same total molar concentration of Mg^{2+} and Ca^{2+}. The different conversion factors arise from the fact that equivalent masses of calcium oxide and calcium carbonates differ, and that different mass and volume units are used. The units are as follows:

- *Parts per million (ppm)* is usually defined as 1 mg/L $CaCO_3$ (the definition used below). It is equivalent to **mg/L** without chemical compound specified, and to **American degree**.
- *Grains per Gallon (gpg)* is defined as 1 grain (64.8 mg) of calcium carbonate per U.S. gallon (3.79 litres), or 17.118 ppm.
- a *mmol/L* is equivalent to 100.09 mg/L $CaCO_3$ or 40.08 mg/L Ca^{2+}.
- A *degree of General Hardness (dGH* or 'German degree (°dH, *deutsche Härte*))' is defined as 10 mg/L CaO or 17.848 ppm.
- A *Clark degree (°Clark)* or *English degrees (°e or e)* is defined as one grain (64.8 mg) of $CaCO_3$ per Imperial gallon (4.55 litres) of water, equivalent to 14.254 ppm.
- A *French degree (°fH or °f)* is defined as 10 mg/L $CaCO_3$, equivalent to 10 ppm.