# Speciation of inorganic carbon in aqueous solution

$CO_2$ dissolves in water:

**(a)** $CO_2(g) \rightarrow CO_2(aq)$ ($O_2(aq)$ is the same as $CO_2 \cdot H_2O$)

Dissolved $CO_2$ and water react to form carbonic acid:

**(b)** $CO_2(aq) + H_2O \rightarrow H_2CO3$ $\quad K=10^{-2.5}$ to $10^{-3}$

The small value of K means that equilibrium is far to the left in Reaction b. Thus most $CO_2(aq)$ stays as $CO_2(aq)$ - most remains as the hydrated linear $CO_2$ molecule (see right) rather than becoming a planar triangular $CO_3^{2-}$ ion complexed with two $H^+$s. Most geochemists simplify by lumping the hydrated $CO_2$ and the true $H_2CO_3$ as $H_2CO_3$*:

$$[H_2CO_3^*] = [CO_2(aq)] + [H_2CO_3]$$

Thus we usually write a third equation that combines (a) and (b):

At 20°C

**(c)** $CO_2(g) + H_2O \rightarrow H_2CO_3^*$ $\quad K_{CO2} = \dfrac{aH_2CO_3^*}{PCO_2} = 10^{-1.5}$

This carbonic acid can dissociate to give bicarbonate:

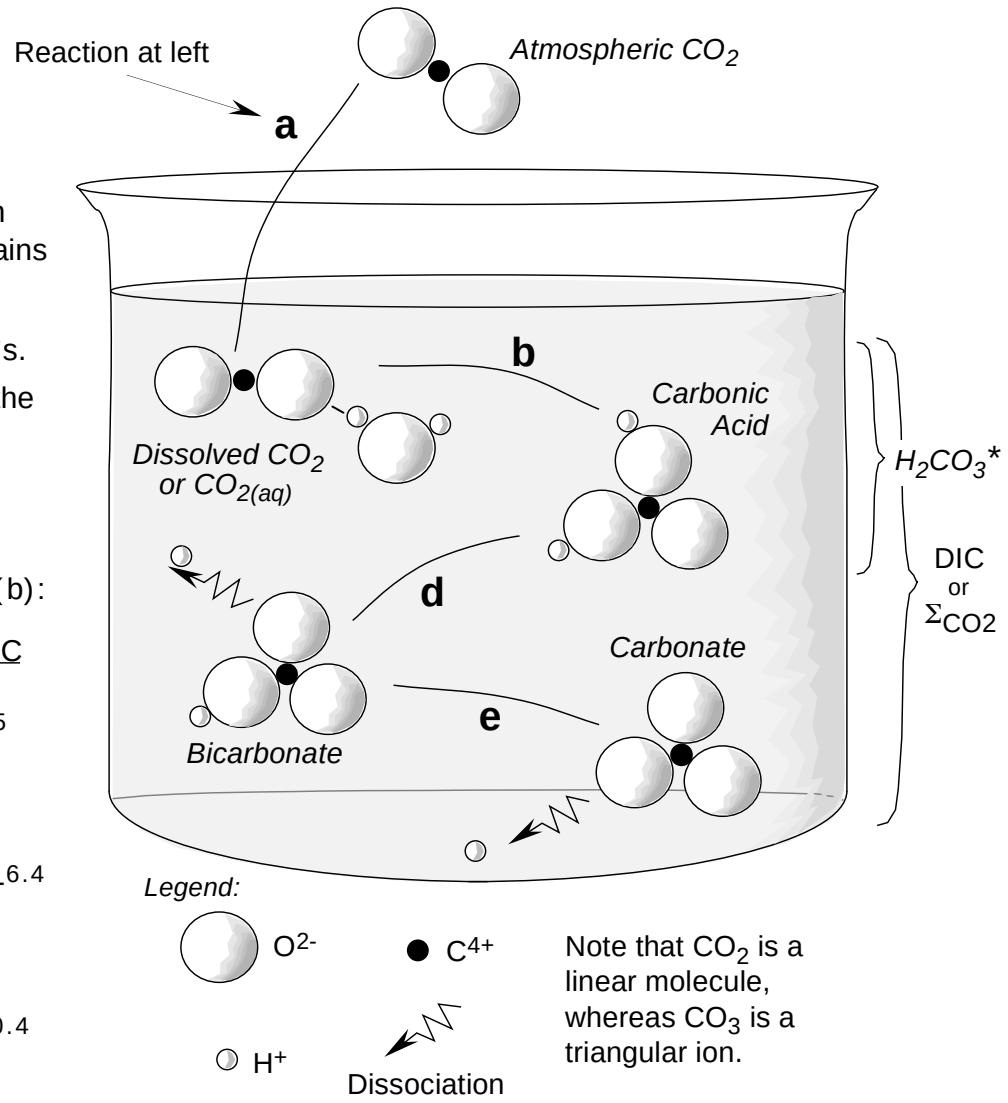
**(d)** $H_2CO_3^* \rightarrow H^+ + HCO_3^-$ $\quad K_1 = \dfrac{aH^+ \cdot aHCO_3^-}{aH_2CO_3^*} = 10^{-6.4}$

And bicarbonate can dissociate to give carbonate:

**(e)** $HCO_3^- \rightarrow H^+ + CO_3^{2-}$ $\quad K_2 = \dfrac{aH^+ \cdot aCO_3^{2-}}{aHCO_3^-} = 10^{-10.4}$

The presence of $H^+$ as a product in d and e means that both reactions proceed to the right much more at higher pH.

## A Graphic View of Carbonate Equilibria:




The size of the $H^+$ ion is greatly exaggerated relative to the other species.