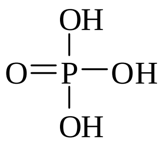
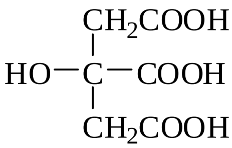
Marks
3

- Consider the two triprotic acids, phosphoric acid and citric acid.





Acid	Formula	K_{a1}	K_{a2}	K_{a3}
phosphoric	H_3PO_4	7.1×10^{-3}	6.3×10^{-8}	4.5×10^{-13}
citric	$C_6H_8O_7$	7.1×10^{-4}	1.7×10^{-5}	6.4×10^{-6}

Explain why $K_{a1} > K_{a2} > K_{a3}$ for both acids.

It is more difficult to remove a proton from a negatively charged species, so $K_{a1} > K_{a2} > K_{a3}$ for all acids. *i.e.* K_{a1}, K_{a2} and K_{a3} correspond to removal of H^+ from H_3PO_4, $H_2PO_4^-$ and HPO_4^{2-} respectively. This process gets harder and harder because a positively charged proton is having to be removed from a negatively charged molecule.

For phosphoric acid, the K_a values differ by about 5 orders of magnitude while for citric acid there is a much smaller difference. Explain.

The number of resonance structures for the various conjugate bases are:

2 for $H_2PO_4^-$; 3 for HPO_4^{2-}; and 4 for PO_4^{3-}
2 for $C_6H_7O_7^-$; 4 for $C_6H_6O_7^{2-}$; and 8 for $C_6H_5O_7^{3-}$

The conjugate bases for citric acid are more stable (because they have greater resonance stabilisation) so the corresponding acids are all stronger.

Alternatively, the increasing negative charges in the conjugate bases are being formed in different parts of the molecule in the case of citric acid, whereas they are all very close to each other in phosphoric acid. Again, the formation of the conjugate base series of citric acid is therefore easier and the acids are therefore stronger.