Conjugate acid-base pairs

Acid-base reactions all involve the transfer of a proton from the acid (proton donor) to the base (proton acceptor). During this reaction the acid itself becomes the 'conjugate base' of the acid and the base becomes its 'conjugate acid'.

E.g. adding ethanoic acid to water ....

CH_3COO^- is the conjugate base of ethanoic acid

H_3O^+ is the conjugate acid of water

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(l)}$$

CH_3COOH is the acid because during the reaction it donates a proton (H^+) to water

water is the base because during the reaction it accepts a proton (H^+) forming H_3O^+

Since this is an equilibrium, the conjugate acid, H_3O^+, could donate a proton to the conjugate base, CH_3COO^-, and we would be back where we started.

There are essentially two conjugate acid-base pairs in this reaction - CH_3COOH / CH_3COO^- and H_3O^+ / H_2O.

Questions

1. Identify the conjugate pairs in each of these reactions

(a) $NH_{3\,(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$

(b) $HNO_{3\,(aq)} + OH^-_{(aq)} \rightleftharpoons NO_3^-{}_{(aq)} + H_2O_{(l)}$

(c) $H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$

(d) $HSO_3^-{}_{(aq)} + H_2O_{(l)} \rightleftharpoons SO_3^{2-}{}_{(aq)} + H_3O^+_{(aq)}$

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2. Write an equation to show each of the following behaving as a base in solution - the product of the reaction will be the conjugate acid.

(a) $OH^-_{(aq)}$ (b) $HSO_3^-{}_{(aq)}$ (c) $CO_3^{2-}{}_{(aq)}$ (d) $HCO_3^-{}_{(aq)}$

3. Write an equation to show the following behaving as an acid in solution - the product of the reaction will be the conjugate base.

(a) $HCO_2H_{(aq)}$ (b) $H_2O_{(l)}$ (c) $HCO_3^-{}_{(aq)}$ (d) $H_2S_{(aq)}$

Answers

1. (a) Base $NH_{3\,(aq)}$ / Conjugate acid $NH_4^+{}_{(aq)}$; Acid $H_2O_{(l)}$ / Conjugate base $OH^-_{(aq)}$

   (b) Base $OH^-_{(aq)}$ / Conjugate acid $H_2O_{(l)}$; Acid $HNO_{3\,(aq)}$ / Conjugate base $NO_3^-{}_{(aq)}$

   (c) Base $H_2O_{(l)}$ / Conjugate acid $H_3O^+_{(aq)}$; Acid $H_2O_{(l)}$ / Conjugate base $OH^-_{(aq)}$

   (d) Base $H_2O_{(l)}$/ Conjugate acid $H_3O^+_{(aq)}$; Acid $HSO_3^-{}_{(aq)}$ / Conjugate base $SO_3^{2-}{}_{(aq)}$

2. (a) $OH^-_{(aq)} + H^+_{(aq)} \rightleftharpoons H_2O_{(l)}$

   (b) $HCO_3^-{}_{(aq)} + H^+_{(aq)} \rightleftharpoons H_2SO_{4\,(aq)}$

   (c) $CO_3^{2-}{}_{(aq)} + H^+_{(aq)} \rightleftharpoons HCO_3^-{}_{(aq)}$

   (d) $HCO_3^-{}_{(aq)} + H^+_{(aq)} \rightleftharpoons H_2CO_{3\,(aq)}$

3. (a) $HCO_2H_{(aq)} \rightleftharpoons H^+_{(aq)} + HCO_2^-{}_{(aq)}$

   (b) $H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$

   (c) $HCO_3^-{}_{(aq)} \rightleftharpoons H^+_{(aq)} + CO_3^{2-}{}_{(aq)}$

   (d) $H_2S_{(aq)} \rightleftharpoons H^+_{(aq)} + HS^-_{(aq)}$