Amphiprotic species

1) Using H_2O as an example, explain what is meant by an amphiprotic species.

2) Write equations for the following amphiprotic species reacting with the hydronium ion (H_3O^+) and the hydroxide ion (OH^-).

a) Hydrogen sulfate ion $HSO_4^-{}_{(aq)}$

(i) $HSO_4^-{}_{(aq)}$ reacting with $H_3O^+{}_{(aq)}$

(ii) $HSO_4^-{}_{(aq)}$ reacting with $OH^-{}_{(aq)}$

(iii) Identify the conjugate acid-base pairs in the above reactions.

b) Dihydrogen phosphate ion $H_2PO_4^-{}_{(aq)}$

(i) $H_2PO_4^-{}_{(aq)}$ reacting with $H_3O^+{}_{(aq)}$

(ii) $H_2PO_4^-{}_{(aq)}$ reacting with $OH^-{}_{(aq)}$

(iii) Identify the conjugate acid-base pairs in the above reactions.

3) Explain the difference between the terms amphiprotic and amphoteric.

Answers:

1) An amphiprotic species is able to donate or accept a proton therefore acting as a Bronsted-Lowry acid or a Bronsted-Lowry base. H_2O is able to donate a proton to form $OH^-_{(aq)}$ or accept a proton to form $H_3O^+_{(aq)}$, therefore acting as a Bronsted Lowry acid or a Bronsted-Lowry base.

2)

a)

(i) $HSO_4^-{}_{(aq)} + H_3O^+_{(aq)} \rightleftharpoons H_2SO_{4(aq)} + H_2O_{(l)}$

Conjugate acid-base pairs (differ by a H^+):

$HSO_4^-{}_{(aq)}$ and $H_2SO_{4(aq)}$ $H_3O^+_{(aq)}$ and $H_2O_{(l)}$

(ii) $HSO_4^-{}_{(aq)} + OH^-_{(aq)} \rightleftharpoons SO_4^{2-}{}_{(aq)} + H_2O_{(l)}$

Conjugate acid-base pairs:

$HSO_4^-{}_{(aq)}$ and $SO_4^{2-}{}_{(aq)}$ $OH^-_{(aq)}$ and $H_2O_{(l)}$

b)

(i) $H_2PO_4^-{}_{(aq)} + H_3O^+_{(aq)} \rightleftharpoons H_3PO_{4(aq)} + H_2O_{(l)}$

Conjugate acid-base pairs:

$H_2PO_4^-{}_{(aq)}$ and $H_3PO_{4(aq)}$ $H_3O^+_{(aq)}$ and $H_2O_{(l)}$

(ii) $H_2PO_4^-{}_{(aq)} + OH^-_{(aq)} \rightleftharpoons HPO_4^{2-}{}_{(aq)} + H_2O_{(l)}$

Conjugate acid-base pairs:

$H_2PO_4^-{}_{(aq)}$ and $HPO_4^{2-}{}_{(aq)}$ $OH^-_{(aq)}$ and $H_2O_{(l)}$

3) Amphiprotic is used to describe a species that can donate or accept a proton and is specific to the Bronsted-Lowry theory of acids and bases. All amphiprotic species are also amphoteric.

Amphoteric refers to substances that can act as acids and bases and can be used in other theories of acids and bases where there is no proton transfer.