

Acid–Base Properties of Salts

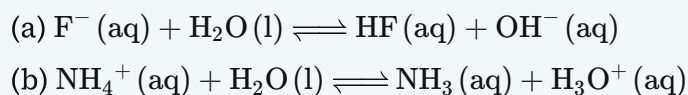
Answer key with worked solutions

A. Predicting

1. Acidic, basic or neutral.

(a) **neutral** (no ion hydrolyses) (b) **basic** (CO_3^{2-}) (c) **acidic** (NH_4^+) (d) **basic** (CH_3COO^-)
(e) **neutral** (f) **acidic** (NH_4^+)

2. Hydrolysis equations.



B. Ka and Kb

3. Ka and Kb.

(a) $K_b(\text{F}^-) = \frac{1.0 \times 10^{-14}}{6.8 \times 10^{-4}} = 1.5 \times 10^{-11}$
(b) $K_a(\text{NH}_4^+) = \frac{1.0 \times 10^{-14}}{1.8 \times 10^{-5}} = 5.6 \times 10^{-10}$
(c) $K_b(\text{CN}^-) = \frac{1.0 \times 10^{-14}}{4.9 \times 10^{-10}} = 2.0 \times 10^{-5}$

CN^- is the stronger base (larger K_b), because HCN is a much weaker acid than HF.

C. pH of salt solutions

4. 0.10 mol/L NaCN.

$[\text{OH}^-] \approx \sqrt{2.0 \times 10^{-5} \times 0.10} = 1.41 \times 10^{-3} \text{ mol/L}$ (1.4 % of 0.10 mol/L: approximation OK)
 $\text{pOH} = -\log(1.41 \times 10^{-3}) = 2.85$; $\text{pH} = 14.00 - 2.85 = 11.15$

5. 0.050 mol/L NH_4NO_3 .

$$[\text{H}_3\text{O}^+] \approx \sqrt{5.6 \times 10^{-10} \times 0.050} = 5.29 \times 10^{-6} \text{ mol/L}$$

$$\text{pH} = -\log(5.29 \times 10^{-6}) = \mathbf{5.28}$$

6. 0.25 mol/L CH_3COOK .

$$K_b(\text{CH}_3\text{COO}^-) = 5.6 \times 10^{-10}; [\text{OH}^-] \approx \sqrt{5.6 \times 10^{-10} \times 0.25} = 1.18 \times 10^{-5} \text{ mol/L}$$

$$\text{pOH} = 4.93; \text{pH} = 14.00 - 4.93 = \mathbf{9.07}$$

D. Titrations

7. Equivalence point.

(a) Same concentration, 1 : 1 reaction: **25.00 mL** of NaOH.

(b) Moles of ethanoate = $0.100 \text{ mol/L} \times 0.02500 \text{ L} = 2.50 \times 10^{-3} \text{ mol}$, in 0.05000 L: $c = \mathbf{0.0500 \text{ mol/L}}$

(c) $[\text{OH}^-] \approx \sqrt{5.6 \times 10^{-10} \times 0.0500} = 5.29 \times 10^{-6} \text{ mol/L}$; $\text{pOH} = 5.28$; $\text{pH} = \mathbf{8.72}$.

Phenolphthalein (changes colour at about pH 8.2–10) is suitable.

E. Challenge

8. Aluminium chloride.

In water, Al^{3+} is surrounded by six water molecules, $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$. The small, highly charged ion pulls electron density from the O–H bonds of these water molecules, so one of them can release a proton: $[\text{Al}(\text{H}_2\text{O})_6]^{3+} + \text{H}_2\text{O} \rightleftharpoons [\text{Al}(\text{H}_2\text{O})_5(\text{OH})]^{2+} + \text{H}_3\text{O}^+$. The H_3O^+ formed makes the solution **acidic**.