Revision-Aqueous Equilibria 1

This is the first revision lesson on aqueous equilibria and covers strong and weak acids and bases.

Watch the following clips and answer the questions that follow.

https://drive.google.com/file/d/1HezvUeE2T-L9T5iqstPY5Wl012AmSPgj/view?usp=sharing

https://drive.google.com/file/d/1YHP6p3yuzlcc_avruluegNypEwHuGOpo/view?usp=sharing

1. For each substance the in the following equations, write the acid, base, conjugate acid and conjugate base.
   a) $HNO_3\,(g) + H_2O(l) \rightleftharpoons H_3O^+\,(aq) + NO_3^-\,(aq)$
   b) $H_2O(l) + HF\,(g) \rightleftharpoons F^-\,(aq) + H_3O^+\,(aq)$
2. State whether the following salts are likely to acidic, neutral or basic.
   a) Calcium methanoate
   b) Ammonium nitrate
   c) Barium sulfate
   d) Potassium carbonate
3. Calculate the pH of a 0.01 mol l^{-1} solution of ethanoic acid.
4. Calculate the pH of a 0.240 mol l^{-1} solution of butanoic acid.
5. Calculate the concentration of propanoic acid that has a pH of 4.23.
6. Calculate the concentration of ethanoic acid that has a pH of 3.48.
7. Most commercial bleaches contain hypochlorous acid. This acid dissociates as follows:

$$HClO(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + ClO^-(aq)$$

   (a) Identify the conjugate base of hypochlorous acid.
   (b) Write the expression for the dissociation constant, K_a, for hypochlorous acid.
   (c) A solution of hypochlorous acid was titrated with sodium hydroxide solution.

   The solution at the end point was alkaline.

   Explain why the solution at the end point was alkaline.

8. When an ant bites, it injects methanoic acid (HCOOH).

(*a*) Methanoic acid is a weak acid.

$$HCOOH(aq) + H_2O(\ell) \rightleftharpoons HCOO^-(aq) + H_3O^+(aq)$$

(i) What is the conjugate base of methanoic acid?

(ii) Write the expression for the dissociation constant, K_a, of methanoic acid.

(*b*) (i) In a typical bite, an ant injects $3{\cdot}6 \times 10^{-3}$ g of methanoic acid.
Assuming that the methanoic acid dissolves in $1{\cdot}0\,cm^3$ of water in the body, calculate the concentration of the methanoic acid solution in $mol\,l^{-1}$.

(ii) Calculate the pH of this methanoic acid solution.

9. $5cm^3$ of a solution of hydrochloric acid was diluted to exactly $250cm^3$ with water. The pH of this diluted solution was 2.00. Calculate the concentration of the original undiluted solution, in mol l^{-1}.

10. $500cm^3$ of 0.022 mol l^{-1} hydrochloric acid is mixed with $500cm^3$ of 0.020mol l^{-1} sodium hydroxide solution.
Calculate the pH of the resulting solution.

11. The ionic product for water, Kw, is usually taken to be 1 x 10-14, but it varies with temperature. The following table shows this variation.

Temperature / Kelvin	Kw
273	0.114×10^{-14}
283	0.293×10^{-14}
298	1.008×10^{-14}
323	5.476×10^{-14}
373	51.3×10^{-14}

a) What is meant the term “ionic product” of water?
b) Calculate the pH of pure water at 373 Kelvin.
c) The ionisation of water is endothermic. Explain how the information in the table supports this statement.

12. Phosphoric acid, H_3PO_4, is triprotic. When neutralised by sodium hydroxide solution, it can form three different salts.
a) Give the formula of the three sodium salts of the acid.
b) The first stage in the ionisation of phosphoric acid has a dissociation constant of 7.08×10^{-3}, Calculate the approximate pH of a 0.1 mol l^{-1} solution of phosphoric acid.

Answers

1. a) Acid = HNO_3
   Base = H_2O
   Conjugate acid = H_3O^+
   Conjugate base = NO_3^-

   b) Acid = HF
   Base = H_2O
   Conjugate acid = H_3O^+
   Conjugate base = F^-

2. a) basic b) acidic c) neutral d) basic

3. 3.38

4. 2.72

5. 2.57×10^{-4}

6. 6.3×10^{-3}

7. a) ClO^-

   b) $K_a = \frac{[H_3O^+][ClO^-]}{[HClO^-]}$

   c) $ClO^-(aq) + H^+(aq) \rightleftharpoons HClO(aq)$

   or

   The $H^+(aq)$ are removed by the conjugate base from the water equilibrium
   (1 mark)

   and

   $H_2O(\ell) \rightleftharpoons H^+(aq) + OH^-(aq)$

   or

   This causes the water equilibrium to shift to the right hand side producing excess $OH^-(aq)$ and hence pH>7.

   or

   Produces an excess of hydroxide ions.
   (1 mark)

8. a)i) $HCOO^-$

ii) $$K_a = \frac{[HCOO^-][H_3O^+]}{[HCOOH]}$$

b)i) $$\text{moles of HCOOH} = \frac{3{\cdot}6\times10^{-3}}{46} = 7{\cdot}83\times10^{-5}\ \text{mol}$$

$$\text{Conc. of HCOOH} = \frac{7{\cdot}83\times10^{-5}}{0{\cdot}0010} = 0{\cdot}0783\ (\text{mol l}^{-1})$$

ii) pH=2.43

9. 5.0×10^{-1}

10. pH = 3

11.a) The product of $[H^+(aq)] \times [OH^-(aq)]$

b) pH = 6.14

c) An increase in temperature favours ΔH +ve. As the temperature increases so does the value of K_w and therefore more ions form. Thus the ionisation is endothermic.

12. a) NaH_2PO_4; Na_2HPO_4; Na_3PO_4

c) pH = 1.6