Year 12 Chemistry

Volumetric Calculations Worksheet 1 ANSWERS

1. White wine contains a number of weak acids that contribute to the overall character of the wine. However, if too much acid is present, the white wine may become 'undrinkable'. In the analysis of one batch of white wine, a chemist titrated some wine with a standard sodium hydroxide solution using phenolphthalein as the indicator.
   The results of the experiment are summarised below.
   - Concentration of standard sodium hydroxide solution = 0.1030 mol L^{-1}
   - Aliquot of white wine used = 25.00 mL
   - Average of three concordant titres = 14.78 mL

   Determine the amount, in mole, of $H^+_{(aq)}$ available for reaction with a base in a 100 mL sample of this wine.

   $H^+_{(aq)} + NaOH_{(aq)} \rightarrow Na^+_{(aq)} + H_2O_{(l)}$
   n(NaOH) = cV = 0.1030 x 0.01478 = 0.00152234 mol
   SR = 1/1 = 1
   $n(H^+)$ = SR x n(NaOH) = 1 x 0.00152234 = 0.00152234 mol
   $c(H^+$ in wine) = n/V = 0.00152234 / 0.025 = 0.0608936 mol L^{-1}
   $n(H^+$ in 100 mL) = cV = 0.0608936 x 0.1 = 0.00608936 mol
   = 0.006089 mol (4 sf)

2. A particular brand of vinegar was analysed to determine the acetic acid content. A 22.17 g sample of the vinegar was diluted with distilled water to 250.0 mL in a volumetric flask. A 20.00 mL aliquot of 0.1146 mol L^{-1} sodium hydroxide was placed in a conical flask and titrated with the diluted vinegar solution to a phenolphthalein end point. The average of three concordant titres of diluted vinegar was 33.45 mL. Calculate the percentage by mass of acetic acid in the vinegar.

$CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow NaCH_3COO_{(aq)} + H_2O_{(l)}$
n(NaOH) = cV = 0.1146 x 0.020 = 0.002292 mol
SR = unknown/known = 1/1 = 1
n(CH_3COOH in titration) = SR x n(NaOH) = 1 x 0.002292 = 0.002292 mol
c(CH_3COOH in titration) = n/V = 0.002292 / 0.03345 = 0.0685202 mol L^{-1}
Therefore
c(CH_3COOH in volumetric flask after dilution) also = 0.0685202 mol L^{-1}
n(CH_3COOH in volumetric flask after dilution) = cV = 0.0685202 x 0.2500 = 0.01713 mol
m(CH_3COOH in volumetric flask) = nM = 0.01713 x ((2 x 12.01) + (2 x 16.00) + (4 x 1.008)) = 1.02869 g
% by mass = (1.02869 / 22.17) x 100 = 4.640 % (4 sf)

3. Hydrogen peroxide is used as a mild bleaching agent. Analysis of a sample of hydrogen peroxide can be carried out by using potassium permanganate in a redox reaction. While checking a sample of commercial peroxide bleach, a chemist transfers 10.00 mL of the peroxide solution to a 250.0 mL volumetric flask and makes it up to the calibrated mark with deionised water. A 25.00 mL aliquot of the diluted peroxide solution, mixed with acid, is titrated with a standardized solution of potassium permanganate of concentration 0.01894 mol L^{-1}. The average of three concordant titres of permanganate is 28.68 mL. Determine the concentration of hydrogen peroxide in the commercial bleach solution and the percentage by mass. Assume the density of the original peroxide bleach is 1 g mL^{-1}.
   The ionic equation for the reaction is
   $5H_2O_{2(aq)} + 2MnO_4^-{}_{(aq)} + 6H^+_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 8H_2O_{(l)} + 5O_{2(g)}$

   $n(KMnO_4) = n(MnO_4^-) = cV = 0.01894 \times 0.02868 = 0.0005431992$ mol
   SR = unknown/known = 5/2 = 2.5
   $n(H_2O_2) = SR \times n(KMnO_4) = 2.5 \times 0.0005431992 = 0.001357998$ mol
   c(diluted H_2O_2) = n / V = 0.001357998 / 0.025 = 0.05431992 mol L^{-1}
   $c_1V_1 = c_2V_2$
   c1 = c(undiluted H_2O_2) = c_2V_2/V_1 = 0.05431992 x 250/10 = 1.357998 mol L^{-1}
   = 1.358 mol L^{-1} (4 sf)
   Density = ρ = m / V
   Mass of 1 litre = ρV = 1 x 1000 = 1000 g
   m(H_2O_2 in 1 litre) = nM = 1.357998 x 34.016 = 46.193659968 g
   % composition by mass = (46.193659968 / 1000) x 100 = 4.6193659968 %
   = **4.619 % (4 sf)**