titration and back titration Name_____

1. A solution containing ammonia requires 25.0 cm^3 of 0.100 mol dm^{-3} hydrochloric acid to reach the equivalence point of a titration.

   (i) Write an equation for the reaction of ammonia with hydrochloric acid

   (1)

   (ii) Calculate the amount (in mol) of hydrochloric acid and ammonia that react.

   (2)

   (iii) Calculate the mass of ammonia in the solution.

   (2)

2. The data below is from an experiment used to determine the percentage of iron present in a sample of iron ore. This sample was dissolved in acid and all of the iron was converted to Fe^{2+}. The resulting solution was titrated with a standard solution of potassium manganate(VII), $KMnO_4$. This procedure was carried out three times. In acidic solution, MnO_4^- reacts with Fe^{2+} ions to form Mn^{2+} and Fe^{3+} and the end point is indicated by a slight pink colour.

titre	**1**	**2**	**3**
initial burette reading / cm^3	1.00	23.60	10.00
Final burette reading / cm^3	24.60	46.10	32.50

Mass of iron ore / g	3.682×10^{-1}
concentration of $KMnO_4$ solution / mol dm^{-3}	2.152×10^{-2}

(a) Deduce the balanced redox equation for this reaction in **acidic** solution.

$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$

(b) Identify the reducing agent in the reaction.

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(1)

(c) Calculate the amount, in moles, of MnO_4^- used in the titration.

.....

(2)

(d) Calculate the amount, in moles, of Fe present in the 3.682×10^{-1} g sample of iron ore.

..... **(2)**

(e) Determine the percentage by mass of Fe present in the 3.682×10^{-1} g sample of iron ore.

.....

(2)

4. The percentage by mass of calcium carbonate in eggshell was determined by adding excess hydrochloric acid to ensure that all the calcium carbonate had reacted. The excess acid left was then titrated with aqueous sodium hydroxide.

(a) A student added 27.20 cm^3 of 0.200 mol dm^{-3} HCl to 0.188 g of eggshell. Calculate the amount, in mol, of HCl added.

.....

(1)

(b) The excess acid requires 23.80 cm^3 of 0.100 mol dm^{-3} NaOH for neutralization.
Calculate the amount, in mol, of acid that is in excess.

.....

(1)

(c) Determine the amount, in mol, of HCl that reacted with the calcium carbonate in the eggshell.

.....

(1)

(d) State the equation for the reaction of HCl with the calcium carbonate in the eggshell.

.....

(2)

(e) Determine the amount, in mol, of calcium carbonate in the sample of the eggshell.

.....

(2)

(f) Calculate the mass **and** the percentage by mass of calcium carbonate in the eggshell sample.

.....

(3)

(g) Deduce **one** assumption made in arriving at the percentage of calcium carbonate in the eggshell sample.

.....

(1)

(Total 11 marks)

50 0.558 grams of a monobasic aromatic carboxylic acid, HX, was dissolved in distilled water. A few drops of phenolphthalein indicator was added and the mixture was titrated with 0.100 mol dm^{-3} sodium hydroxide solution. It took 41.0 cm^3 of the alkali to obtain the end-point (with a permanent pink colour). Calculate the molar mass of the organic acid.

52 A 50.0 cm^3 sample of concentrated sulfuric acid was diluted to 1.00 dm^3. A sample of the diluted sulfuric acid was analysed by titrating with aqueous sodium hydroxide. In the titration, 25.00 cm^3 of 1.00 mol dm^{-3} aqueous sodium hydroxide required 20.0 cm^3 of the diluted sulfuric acid for neutralization. Determine the concentration of the original concentrated sulfuric acid solution through the following steps:

a Construct the equation for the complete neutralization of sulfuric acid by sodium hydroxide.

b Calculate the amount of sodium hydroxide that was used in the titration.

c Calculate the concentration of the diluted sulfuric acid.

d Calculate the concentration of the original concentrated sulfuric acid solution.

53 Magnesium oxide is not very soluble in water, and is difficult to titrate directly. Its purity can be determined by use of a 'back titration' method. 4.08 g of impure magnesium oxide was completely dissolved in 100 cm^3 of 2.00 mol dm^{-3} aqueous hydrochloric acid. The excess acid required 19.7 cm^3 of 0.200 mol dm^{-3} aqueous sodium hydroxide for neutralization. Work through the following steps to find out what the purity of the impure magnesium oxide is.

a Construct equations for the two neutralization reactions.

b Calculate the amount of hydrochloric acid added to the magnesium oxide.

c Calculate the amount of excess hydrochloric acid titrated.

d Calculate the amount of hydrochloric acid reacting with the magnesium oxide.

e Calculate the mass of magnesium oxide that reacted with the initial hydrochloric acid, and hence determine the percentage purity of the magnesium oxide.

54 Hydrated iron(II) sulfate has the formula $FeSO_4.xH_2O$. An experiment was performed to determine x, the amount of water of crystallization in hydrated iron(II) sulfate. 50.60 grams of hydrated iron(II) sulfate were dissolved in distilled water to make 250.00 cm^3 of solution. 20.00 cm^3 of this solution reacted completely with 24.00 cm^3 of 0.100 mol dm^{-3} potassium dichromate(VI) solution. Use this data to determine the value of x and hence the formula of hydrated iron(II) sulfate.

$$6Fe^{2+}(aq) + 14H^+(aq) + Cr_2O_7^{2-}(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l) + 6Fe^{3+}(aq)$$