1. (a) Aqueous XO_4^{3-} ions form a precipitate with aqueous silver ions, Ag^+. Write a balanced equation for the reaction, including state symbols.

$3Ag^+_{(aq)} + XO_4^{3-}{}_{(aq)} \rightarrow Ag_3XO_4\,(s)$

(b) When 41.18 cm^3 of a solution of aqueous silver ions with a concentration of 0.2040 mol dm^{-3} is added to a solution of XO_4^{3-} ions, 1.172 g of the precipitate is formed.

(i) Calculate the amount (in moles) of Ag^+ ions used in the reaction.

$n_{Ag^+} = 0.04118 \times 0.2040 = 8.4 \times 10^{-3}$ mol

(ii) Calculate the amount (in moles) of the precipitate formed.

$n_{Ag_3XO_4} = \frac{n_{Ag^+}}{3} = 2.8 \times 10^{-3}$ mol

(iii) Calculate the molar mass of the precipitate.

$M = \frac{1.172}{2.8 \times 10^{-3}} = 418.6$ g/mol

(iv) Determine the relative atomic mass of X and identify the element.

$X = M - 3M_{Ag} - 4M_O = 30.96 \approx 31$

$\therefore$ X = Phosphorus.

2. (a) (i) A solution of hydrochloric acid has a concentration of 0.10 mol dm^{-3} and a pH value of 1. The solution is diluted by a factor of 100. Determine the concentration of the acid **and** the pH value in the diluted solution.

HCl

$[HCl] = 0.001$ mol/L

pH = 3

(ii) Explain why 0.10 mol dm^{-3} ethanoic acid solution and the diluted solution in (a) (i) have similar $[H^+]$ values.

Because CH_3COOH solution has less ionized CH_3COO^- and H^+, more solute exist as molecule.

(b) Suggest **one** method, other than measuring pH, which could be used to distinguish between solutions of a strong acid and a weak acid of the same concentration. State the expected results.

Putting $CaCO_3$ in the two solutions, the one react faster is the strong acid.

3. (i) Calcium carbonate is added to separate solutions of hydrochloric acid and ethanoic acid of the same concentration. State **one** similarity and **one** difference in the observations you could make.

① The final amount of CO_2 formed at last are the same.

② HCl react with $CaCO_3$ at a higher speed compared to CH_3COOH.

(ii) Write an equation for the reaction between hydrochloric acid and calcium carbonate.

$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$

(iii) Determine the volume of 1.50 mol dm^{-3} hydrochloric acid that would react with exactly 1.25 g of calcium carbonate.

$M_{CaCO_3} = 40 + 12 + 3\times 16 = 100$

$\therefore n_{CaCO_3} = \frac{m_{CaCO_3}}{M_{CaCO_3}} = \frac{1.25}{100} = 0.0125$ mol

$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$

$\therefore n_{H^+} = 2n_{CaCO_3} = 0.025$ mol

$V = \frac{n_{H^+}}{[H^+]} = \frac{0.025}{1.5} = 0.0167\ L = 16.7\ cm^3$

(iv) Calculate the volume of carbon dioxide, measured at 273 K and 1.01×10^5 Pa, which would be produced when 1.25 g of calcium carbonate reacts completely with the hydrochloric acid.

$n_{CO_2} = n_{CaCO_3} = 0.0125$ mol

$V_{CO_2} = 0.0125 \times 22.7 = 0.5675\ L.$

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4. The pH values of solutions of three organic acids of the same concentration were measured.

acid X pH = 5 acid Y pH = 2 acid Z pH = 3

(i) Identify which solution is the least acidic.

(1)

(i) acid X

(ii) Deduce how the $[H^+]$ values compare in solutions of acids Y and Z.

(2)

(ii) $[H^+]$ in acid Y is 10 times of $[H^+]$ in Z

(iii) Arrange the solutions of the three acids in decreasing order of electrical conductivity, starting with the greatest conductivity, giving a reason for your choice.

(2)

(iii) Y > Z > X

when pH is lower, more free ions moving and greater conductivity.