WTS TUTORING

WTS

ACIDS AND BASES

GRADE : 12

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PAST PAPERS

QUESTION 7 (Start on a new page.)

7.1 A salt reacts with water according to the balanced net (overall) equation:

$CO_3^{2-}(aq) + H_2O(\ell) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$ $K_b = 2{,}13 \times 10^{-4}$ at 25 °C

7.1.1 Write down a term for *the reaction of a salt with water*. (1)

7.1.2 Is the carbonate ion (CO_3^{2-}) a STRONG or WEAK base? Support the answer by referring to the given K_b value. (2)

7.1.3 Are the two substances (H_2O and HCO_3^-) acting as ACIDS or BASES in the reaction?

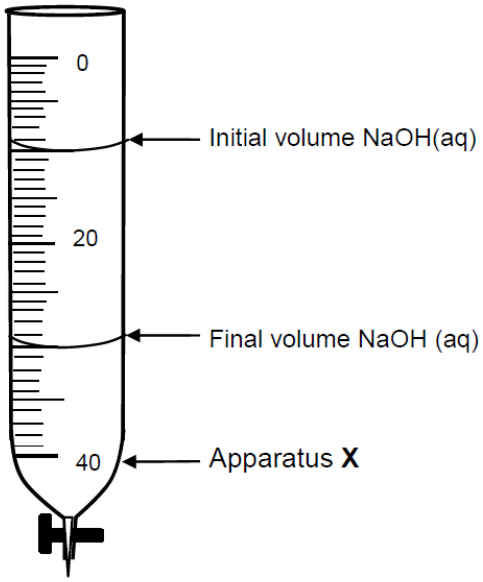
Give a reason. (2)

7.2 In a titration exactly 40 cm^3 of a strong diprotic acid (H_2X) of unknown concentration is neutralised by a sodium hydroxide solution (NaOH) of concentration 0,1 $mol.dm^{-3}$.

The reaction is represented by the balanced equation given below.

$$H_2X(aq) + 2NaOH(aq) \longrightarrow Na_2X(aq) + 2H_2O(\ell)$$

Apparatus **X** shown below is used to measure the initial and final volume of sodium hydroxide used during the titration.



7.2.1 Write down the NAME of apparatus **X**. (1)

7.2.2 Write down the volume of sodium hydroxide used in the titration in cm^3. (1)

7.2.3 Calculate the number of moles of sodium hydroxide that reacted during the titration. (3)

7.2.4 Calculate the pH of the diprotic acid H_2X, before it was used in the titration. (5)

7.2.5 Is the solution at the endpoint ACIDIC, ALKALINE or NEUTRAL? Give a reason for your answer. (2)

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QUESTION 6

6.1 Define *an acid* according to the Brønsted-Lowry theory. (2)

6.2 An acid-base reaction is shown below.

$$H_2PO_4^- + HAsO_4^{2-} \rightarrow HPO_4^{2-} + H_2AsO_4^-$$

Write down the name of the conjugate base of $H_2PO_4^-$. (1)

6.3 In a titration, a 20 cm^3 potassium hydroxide solution was neutralized by 15 cm^3 dilute sulfuric acid with a concentration of 0,1 $mol{\cdot}dm^{-3}$.

$$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$$

6.3.1 Which indicator will be most suitable for this titration? Choose from:

phenolphthalein
methyl orange
bromothymol blue (1)

6.3.2 Give a reason for your choice of indicator in Question 6.3.1. (2)

6.3.3 Calculate the concentration of the potassium hydroxide solution. (5)

6.3.4 Calculate the pH of the potassium hydroxide solution in Question 6.3.3. (5)

6.4 The salt ammonium chloride (NH_4Cl) reacts with water.

$$NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+$$

6.4.1 What do we call this type of reaction? (1)

6.4.2 What will the approximate pH of the salt solution be? Choose from EQUAL TO, SMALLER THAN 7 or GREATER THAN 7. (1)

6.4.3 Give a reason for the answer to Question 6.4.2. (1)

[19]

QUESTION 8 (Start on a new page.)

8.1 Concentrated hydrochloric acid with a concentration of 10 mol·dm^{-3} is diluted to form 500 cm^3 of a 0,25 mol·dm^{-3} solution.

8.1.1 Is the diluted hydrochloric acid a strong acid or a weak acid? (1)

8.1.2 Calculate the volume, in cm^3, of the concentrated hydrochloric acid that must be used. (5)

8.1.3 Calculate the pH of the 0,25 mol·dm^{-3} solution of HCl. (3)

8.2 Calcium carbonate forms a large percentage of sea shells. In order to determine percentage purity of the calcium carbonate in sea shells, learners react 5 g of powered sea shells with the 500 cm^3 of the diluted hydrochloric acid prepared in QUESTION 8.1. The reaction that takes place is represented by the following balanced equation.

$$CaCO_3\,(s) + 2HCl\,(aq) \longrightarrow CaCl_2\,(aq) + H_2O\,(l) + CO_2\,(g)$$

The excess HCl is then titrated with 140 cm^3 of a 0,2 mol·dm^{-3} solution of sodium hydroxide.

8.2.1 Calculate the mass of $CaCO_3$ present in the sample of sea shells. (8)

8.2.2 Calculate the percentage purity of the calcium carbonate in the in the sea shells. (3)

[20]

QUESTION 7 (Start on a new page)

7.1 The hydrogen carbonate ion (HCO_3^-) can act as both an acid and a base.

7.1.1 Define an acid and a base in terms of the Lowry-Bronsted theory. (2)

7.1.2 What are substances, which can act as both an acid and a base, called? (1)

Consider the following equations:

A. $H_2CO_3 + H_2O \rightleftharpoons H_3O^+ + HCO_3^-$

B. $HCO_3^- + H_2O \rightleftharpoons H_3O^+ + CO_3^{2-}$

7.1.3 In which of the above reactions does HCO_3^- acts as an acid? Answer only A or B. (2)

7.1.4 Give the conjugate base of H_2CO_3. (1)

7.1.5 Why is H_2CO_3 a diprotic acid? (1)

7.2 60 cm^3 of a 0,50 $mol \cdot dm^{-3}$ solution of hydrochloric acid is added to 0,8 g of solid calcium carbonate ($CaCO_3$). The $CaCO_3$ reacts completely. The balanced equation for the reaction is as follows:

$$2HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2O$$

7.2.1 Calculate the number of moles of HCl that have reacted with the $CaCO_3$. (5)

7.2.2 Calculate the pH of the solution when the reaction is completed. (9)

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QUESTION 7 (Start on a new page)

7.1 Given the equation

$$HPO_4^{2-} + H_2O \rightleftharpoons H_3O^+ + PO_4^{3-}$$

7.1.1 By referring to the Brønsted-Lowry theory, explain why the H_3O^+ ion is regarded as an acid. (2)

7.1.2 Select another acid from the equation. (1)

7.1.3 Give a single term for a substance which can act as both an acid and a base. (1)

7.2 In a reaction, 25 cm^3 of a $Ba(OH)_2$ with a pH of 13,6 are added to 40 cm^3 of 0,15 $mol \cdot dm^{-3}$ H_2SO_4. The following reaction takes place:

$$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(aq) + 2H_2O(\ell)$$

7.2.1 Calculate the concentration of the solution of $Ba(OH)_2$ used in the reaction. (4)

7.2.2 Calculate the number of moles of $Ba(OH)_2$ used in the reaction. (3)

7.2.3 Calculate the pH of the final solution. (7)

7.3 The salt $BaSO_4$ undergoes hydrolysis.

7.3.1 Define the term *hydrolysis*. (2)

7.3.2 Will an aqueous $BaSO_4$, the solution be ACIDIC, NEUTRAL or BASIC. (1)

[21]

QUESTION 8 (Start on a new page.)

A learner takes 20 cm^3 of sodium hydrogen carbonate ($NaHCO_3$) solution of unknown concentration and titrate it against a standard solution of sulphuric acid with a pH of 1.

8.1 Define a *standard solution*. (2)

8.2 Write down the formula of the conjugate base for sulphuric acid. (1)

The balanced chemical equation for the titration is given below:

$$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2CO_2 + 2H_2O$$

8.3 Calculate the concentration of the sodium hydrogen carbonate solution if it neutralizes 12 cm^3 of the sulphuric acid solution. (7)

8.4 What mass of the sodium hydrogen carbonate is needed to prepare a 250 cm^3 solution that the learner used in the titration? (3)

8.5 Which indicator would be best to use during this titration? Explain your choice. (2)

[15]

QUESTION 7 (Start on a new page.)

7.1 The hydrogen phosphate ion (HPO_4^{2-}) can act as an ampholyte.

7.1.1 Define the term *ampholyte*. (2)

7.1.2 Consider the following reaction:

$$HPO_4^{2-}(aq) + H_2O(\ell) \rightleftharpoons PO_4^{3-}(aq) + H_3O^+(aq)$$

Is the HPO_4^{2-} ion in this reaction acting as a Brønsted-Lowry acid or a base? Give a reason for the answer. (2)

7.1.3 Write down the FORMULA of the substance which forms a conjugate acid-base pair with the HPO_4^{2-} ion. (1)

7.2 A container holds an unknown solution. On the label is written: pH = 13,3.

7.2.1 Is the solution acidic, basic or neutral? (1)

7.2.2 Determine the concentration of the hydroxide ions (OH^-) in the solution. (5)

7.2.3 Exactly 25 cm^3 of the solution in QUESTION 7.2.2 is titrated with a sulphuric acid solution of unknown concentration. At the end point it is found that 17,85 cm^3 of the sulphuric acid was used. The balanced equation for the reaction is:

$$H_2SO_4(aq) + 2XOH(aq) \rightarrow X_2SO_4(aq) + 2H_2O(\ell)$$

Calculate the concentration of the sulphuric acid solution. (5)

7.2.4 Use a calculation to identify element X if the molar mass of compound XOH is 56 $g \cdot mol^{-1}$. (2)

[18]

QUESTION 7 (Start on a NEW PAGE.)

Learners perform a titration to standardise a dilute sodium hydroxide (NaOH) solution. They use standard oxalic acid ($H_2C_2O_4.2H_2O$) solution of concentration 0,02 mol·dm^{-3}. The titration is repeated three times after which the average volume readings are calculated as shown in the table below:

Titrations	Volume of oxalic acid solution (cm^3)	Volume NaOH solution (cm^3)
1	25	20,24
2	25	19,80
3	25	19,87
Average	**25**	**19,97**

7.1 What does the term *standard solution* mean? (2)

7.2 Give a reason why the titration is repeated three times. (1)

7.3 The balanced equation for the reaction taking place is:

$$H_2C_2O_4.2H_2O(aq) + 2NaOH(aq) \rightarrow Na_2C_2O_4(aq) + 4H_2O(\ell)$$

Calculate the number of moles of oxalic acid reacting. (3)

7.4 The dilute solution of sodium hydroxide used in the titration was obtained by adding 90 cm^3 of water to 10 cm^3 of a sodium hydroxide solution.

Calculate the pH of the sodium hydroxide solution BEFORE dilution. (8)

[14]

QUESTION 7 (Start on a new page.)

7.1 Hydrochloric acid is a highly corrosive strong acid with many industrial uses. When 0,02 dm^3 of sodium hydroxide is added to 0,15 dm^3 of diluted hydrochloric acid of concentration 0,03 mol.dm^{-3}, the pH of the mixture changes to 4.

7.1.1 Give a reason why hydrochloric acid is classified as a strong acid. (2)

7.1.2 Write down a balanced chemical equation to show the dissociation of HCℓ in water. (3)

7.1.3 Will the final mixture be acidic or basic? Give a reason for your answer by referring to the pH of the mixture. (2)

7.1.4 Calculate the final concentration of the H^+ ion in the mixture. (3)

7.1.5 Calculate the original concentration of the sodium hydroxide solution. (6)

7.2 Calcium carbonate solutions provide living organisms with the substance they need to grow their protective shells and skeletons. For example, eggshells are composed of calcium carbonate. Grade 12 learners decide to calculate the percentage calcium carbonate in eggshells at STP.

They take 5 g of crushed eggshells and react it with excess hydrochloric acid according to the following equation:

$$CaCO_3(s) + 2\ HC\ell(aq) \rightarrow CaC\ell_2(aq) + CO_2(g) + H_2O(\ell)$$

The carbon dioxide gas produced is collected and found to be 1,06 dm^3 after all the calcium carbonate has reacted. Calculate the percentage calcium carbonate in the 5 g eggshells. Show all the calculations. (6)

[22]

QUESTION 10

10.1 A factory accidentally spills sulphuric acid into a nearby river. The fish species in the river CANNOT survive in water with a pH LOWER THAN 5,8.

Analysis of water samples from the river shows that the hydrogen ion concentration is $5,6 \times 10^{-6}$ $mol \cdot dm^{-3}$. Show with the aid of a calculation that the fish will not survive in the river. (3)

10.2 A sample of seawater is treated with 500 cm^3 of a 2,5 $mol \cdot dm^{-3}$ sodium hydroxide solution to remove the magnesium ions. The reaction that takes place is represented by the following balanced equation:

$$Mg(NO_3)_2(aq) + 2NaOH(aq) \rightarrow Mg(OH)_2(s) + 2NaNO_3(aq)$$

After removal of the precipitate, the excess NaOH(aq) is titrated with 95 cm^3 of a 0,2 $mol \cdot dm^3$ sulphuric acid solution. The balanced equation for the reaction is:

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(\ell)$$

Calculate the:

10.2.1 Number of moles sodium hydroxide added to the seawater. (3)

10.2.2 Original mass of magnesium nitrate in the seawater. (6)

[12]

QUESTION 7 (Start on a new page.)

7.1 Magnesium hydroxide ($Mg(OH)_2$) is often used to relieve an upset stomach.
The pH of the $HC\ell(aq)$ in a person's stomach is 1.

7.1.1 Calculate the concentration of the hydrochloric acid in the person's stomach. (3)

7.1.2 Will the pH in the stomach **INCREASE, DECREASE** or **STAY THE SAME** after taking a dose of $Mg(OH)_2$? (1)

7.1.3 A person takes a dose of $Mg(OH)_2$. Write down the balanced equation for the reaction that takes place in the stomach. (3)

7.2 Explain what is meant by a neutralization reaction. (2)

7.3 12 cm^3 of NaOH of concentration 0,1 $mol \cdot dm^{-3}$ and 48 cm^3 of $Ba(OH)_2$ of unknown concentration are mixed in a large flask, and the solution is homogenized.
This solution is completely neutralized by 54 cm^3 of a 0,05 $mol \cdot dm^{-3}$ H_2SO_4 solution.
Calculate the concentration of the $Ba(OH)_2$ solution. (8)

[17]

QUESTION 7 (Start on a New Page)

7.1 A laboratory technician prepares the following two dilute nitric acid solutions:

0,20 mol·dm^{-3} HNO_3 solution .....(**I**)
0,30 mol·dm^{-3} HNO_3 solution .....(**II**)

7.1.1 Distinguish between a *concentrated acid* and a *dilute acid*. (2)

7.1.2 Give a reason why nitric acid is classified as a strong acid. (2)

7.1.3 Determine the pH of solution (**I**) at 25 °C . (3)

7.2 A few crystals of sodium carbonate are added to water in a test tube.

7.2.1 Is the solution in the test tube ACIDIC, BASIC or NEUTRAL? (1)

7.2.2 Use a balanced ionic equation to explain the answer in QUESTION 7.2.1 (3)

7.3 A 25 g mass of impure sodium carbonate(Na_2CO_3) is treated with EXCESS dilute sulphuric acid.

The balanced chemical equation for the reaction is:

$$Na_2CO_3(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4\ (aq) + H_2O\ (\ell) + CO_2(g)$$

During the reaction, 4.48 dm^3 of carbon dioxide gas is collected at STP.

Calculate the:

7.3.1 Percentage purity of the sodium carbonate (5)

7.3.2 Mass of the impurity (2)

[18]

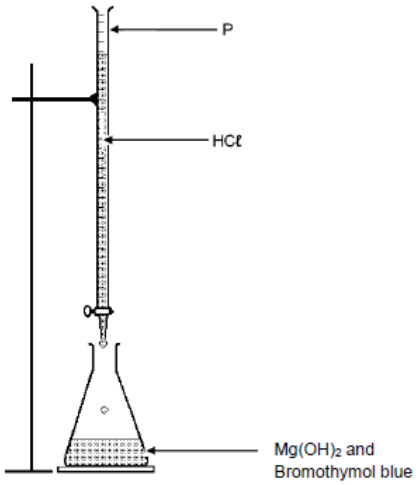
QUESTION 7 (START ON A NEW PAGE)

27 g of $Mg(OH)_2$ is dissolved in 2 ℓ of water at 25 °C. A drop of bromothymol blue is added to the solution and it turns blue.

7.1 Explain why $Mg(OH)_2$ is classified as a strong base. (2)

7.2 Calculate the pH of the $Mg(OH)_2$ solution (7)

HCℓ with a concentration of 2,5 mol·dm^{-3} is added to the $Mg(OH)_2$-solution as shown in the sketch below.



The balanced equation for this reaction is

$$Mg(OH)_2 + 2HC\ell \rightarrow MgC\ell_2 + 2H_2O$$

7.3 Write down the name of the apparatus labelled **P**. (1)

7.4 Write down the Lowry-Brønsted definition of an acid. (2)

7.5 Calculate the minimum volume of HCℓ that must be added to the reaction so that it just changes colour from blue to yellow. (4)

7.6 Explain why bromothymol blue is a better choice than phenolphthalein to indicate the neutralization in the reaction above. (2)

7.7 What would happen to the colour of the solution if 20 cm^3 water is added after the HCℓ was added and the solution turned yellow? Write only REMAINS YELLOW or CHANGES TO BLUE. (1)

[19]

QUESTION 7 (Start on a new page.)

7.1 Ethanoic acid is a weak monoprotic acid.

Give the definition for:

7.1.1 an acid in terms of th Lowry-Brønsted theory. (1)

7.1.2 a weak acid. (2)

7.2 During titration, 15 cm^3 of a 0,25 $mol \cdot dm^{-3}$ acetic acid solution is neutralised by 20 cm^3 sodium hydroxide solution, according to the following balanced equation below:

$$CH_3COOH(aq) + Na^+(aq) + OH^-(aq) \rightarrow CH_3COO^-(aq) + Na^+(aq) + H_2O(\ell)$$

7.2.1 Write down two conjugate acid base pairs that occurs in this equation. (4)

7.2.2 Which indicator (bromothymol blue or phenolphthalein) is suitable to use in this titration reaction? (1)

7.2.3 Will the pH at the endpoint of the titration be LARGER THAN, SMALLER THAN or EQUAL TO 7? Give a reason for your answer (2)

7.2.4 Calculate the concentration of the NaOH solution. (4)

7.2.5 Calculate the pH of the original acetic acid solution. (3)

[17]

QUESTION 7 (Start on a new page.)

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7.2.4 Calculate the concentration of the NaOH solution. (4)

7.2.5 Calculate the pH of the original acetic acid solution. (3)

[17]

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