**YEAR 12 CHEMISTRY – ATCHE**

**TEST 2 2022**

**Acids & Bases**

**Recommended time: 55 Minutes**

ANSWERS

This test is in two parts.

**/ 55**

**Part 1:** Multiple choice style consisting of (15) questions.

Each question is worth 1 mark.

**Part 2:** Short and/or Extended Answer questions worth 40 marks.

Write all answers in the spaces provided.

The marks allocated to each question are shown next to each question.

**Part 1: Multiple Choice Section. 15 MARKS**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | a □ b □ c □ d □ |  | 6 | a □ b □ c □ d □ |  | 11 | a □ b □ c □ d □ |
| 2 | a □ b □ c □ d □ |  | 7 | a □ b □ c □ d □ |  | 12 | a □ b □ c □ d □ |
| 3 | a □ b □ c □ d □ |  | 8 | a □ b □ c □ d □ |  | 13 | a □ b □ c □ d □ |
| 4 | a □ b □ c □ d □ |  | 9 | a □ b □ c □ d □ |  | 14 | a □ b □ c □ d □ |
| 5 | a □ b □ c □ d □ |  | 10 | a □ b □ c □ d □ |  | 15 | a □ b □ c □ d □ |

**Part 2: Short Answer and Calculation Section.**

**40 MARKS**

**Question 16**  **(8 marks)**

Malic acid (H2C4H4O5) is a weak diprotic acid with the structural formula HOOCCH2CH(OH)COOH.

Being diprotic it dissociates in two stages. The equation for the first stage dissociation of malic acid is shown below.

HOOCCH2CH(OH)COOH(aq) + H2O(ℓ) ⇌ HOOCCH2CH(OH)COO–(aq) + H3O+(aq)

1. Write the equation for the second stage ionisation of malic acid. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| HOOCCH2CH(OH)COO− (aq) + H2O(ℓ) ⇌ [OOCCH2CH(OH)COO]2− + H3O+ (aq) | 1 |
| Double arrow (⇌) must be present and the formula of C4H4O52– ion must be logical | 1 |
| **Total** | **2** |

1. Malic acid (H2C4H4O5) can react with a solution of potassium hydroxide to form a salt. Will the salt formed be acidic, neutral or basic? Justify your answer using chemical equations.

(4 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Salt formed is potassium malate (K2C4H4O5) 🡪 2K+ + C4H4O52– | 1 |
| The K+ ions are neutral and do ot undergo hydrolysis | 1 |
| The C4H4O52– ion undergoes hydrolysis  C4H4O52– + H2O(ℓ) ⇌ HC4H4O51– + OH1– (aq) | 1 |
| Salt formed is basic due to the increased concentration of OH1– ions from the equation above. (i.e. hydrolysis reactions cause [OH1–] > [H+] ; | 1 |
| **Total** | **4** |

1. Calculate the pH of the potassium hydroxide solution used in part (c) given that 25.0 mL of the KOH solution has a concentration of 0.0755 mol L–1.

Assume temperature of 25 oC, Kw = 10-14

(2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| [OH1–] = 0.0755mol L–1 therefore |  |
| [H+] = 10–14 / [OH1–] = 10–14 / 0.0755 mol L–1  = 1.32x10–13 mol L–1 | 1 |
| pH = – log [H+] = –log (1.32x10–13 mol L–1) = 12.88 = 12.9 (3 Sig.Fig.) | 1 |
| **Total** | **2** |

Alternative method:

p(OH-) = -log [OH-) = -log [ 0.0775] =1.112 ; hence pH = 14-1.112 = 12.9

**Question 17 (5 marks)**

The solubility of strontium hydroxide, Sr(OH)2, is 1.77 g in 100 mL water at 40°C.

1. Calculate the hydroxide ion concentration in the solution. (3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(Sr(OH)2) in 100 mL of water = 1.77 / (87.62 + 16 x 2 + 1.008 x 2)  = 0.01455 mol | 1 |
| n(OH-) in 100 mL of water = 0.01455 x 2 = 0.0291 mol | 1 |
| c(OH-) = 0.0291 / 0.1 = 0.291 mol L-1 | 1 |
| **Total** | **3** |

(b) Given that the Kw of water at this temperature is 2.916x10-14, calculate the pH of the solution. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| c(H+) = 2.916x10-14 / 0.291  = 1.00 x 10-13 mol L-1 | 1 |
| pH = -log(1.00 x 10-13)  = 13 | 1 |
| **Total** | **2** |

Can’t use pOH and 14-pOH here because the Kw value is not 1 x 10 -14

**Question 18 (3 marks)**

Calculate the amount of water that would need to be added to 50 mL of a 0.100 mol L-1 solution of nitric acid to raise its pH to 1.62.

**pH = 1.62, [H+] = 0.0240 molL-1 (1)**

**CV conc = CV dil**

**0.100 x 0.05 = 0.0240 x V (1)**

**V = 0.208L Vol added = 0.158L (158 mL) (1)**

**Question 19 (10 marks)**

Acids and bases exist as conjugate acid–base pairs. The term *conjugate* comes from the Latin stems meaning "joined together" and refers to things that are joined, particularly in pairs, such as Bronsted–Lowry acids and bases.

Below is a table showing the Ka value for a number of acids and the Kb for the corresponding conjugate bases.

|  |  |  |  |
| --- | --- | --- | --- |
| **Some Conjugate Acid–Base Pairs at 25 °C** | | | |
| **Acid** | **Ka** | **Base** | **Kb** |
| HNO3 | (Strong acid) | NO3– | (Negligible basicity) |
| HF | 6.8 x 10–4 | F– | 1.5 x 10–11 |
| CH3COOH | 1.8 x 10–5 | CH3COO– | 5.6 x 10–10 |
| H2CO3 | 4.3 x 10–7 | HCO3– | 2.3 x 10–8 |
| NH4+ | 5.6 x 10–10 | NH3 | 1.8 x 10–5 |
| HCO3– | 5.6 x 10–11 | CO32– | 1.8 x 10–4 |
| OH– | (Negligible acidity) | O2– | (Strong base) |

1. ‘The stronger the acid the stronger the conjugate base.’ Is this statement true or false? Explain how you came to your conclusion. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| False | 1 |
| Refer to data above to show that stronger acids with large Ka values produce weaker bases with small Kb values | 1 |
| **Total** | **2** |

An acidic buffer solution consists of a weak acid and one of its salts. The buffer can be prepared by reacting 40.0 mL of 1.00 mol L–1ethanoic acid with 20.0 mL of 1.00 mol L–1potassium hydroxide solution.

1. Calculate the concentration of potassium ions in this resulting buffer solution. (2 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| n(K+) = n (KOH) = cV = 1.00 mol L–1 x 0.02 L = 0.02 mol | 1 |
| [K+] = n/V = 0.02 mol / 0.06 L = 0.333 mol/L | 1 |
| **Total** | **2** |

1. Explain why the two quantities (specifically 40.0 mL of 1.00 mol L–1ethanoic acid and

20.0 mL of 1.00 mol L–1potassium hydroxide solution) were used to make this buffer.

(3 marks)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| This quantity of KOH solution converts half of the ethanoic acid into the salt (ethanoate ion) | 1 |
| The resulting mixture has equal moles of both ethanoic acid and ethanoate ions | 1 |
| High and equal concentrations of weak acid and conjugate base give rise to buffers with the highest buffering capacity. | 1 |
| **Total** | **3** |

1. Using the chemical equation below and the collision theory to explain how this buffer solution resists a change pH when a few drops of concentrated sodium hydroxide solution are added to it. (3 marks)

CH3COOH(aq) + H2O(ℓ) ⇌ H3O+(aq) + CH3COO–(aq)

|  |  |
| --- | --- |
| **Description** | **Marks** |
| Adding a few drops of concentrated sodium hydroxide solution increases [OH–] and this instantly reduces [H3O+] | 1 |
| This causes the frequency of collisions between H3O + and CH3COO– ions to decrease reducing rate of the reverse reaction | 1 |
| For a period of time the forward reaction rate is faster than the reverse and so the [H3O +] comes back up, resisting pH change | 1 |
| **Total** | **3** |

Stating H + instead of H3O + is ok.

**Question 20 (14 marks)**

Oxalic acid crystals (H2C2O4.2H2O) are commonly used as a primary standard in acid-base volumetric analysis.

(a) List **three** characteristics you expect oxalic acid crystals to have to justify this classification as a suitable primary standard. (3 marks)

One: High Purity

Two: Known Concentration

Three: Relatively high molecular mass (+ Known formula?!)

A number of 2.50 g samples of oxalic acid crystals had been carefully weighed, sealed and labelled H2C2O4.nH2O.

**Step 1:** One 2.50 g sample was very carefully dissolved in an empty beaker using distilled water. The resulting solution (H2C2O4 (aq)) was then transferred into a 250.00 mL volumetric flask and then made up to 250.00 mL.

**Step 2:** A burette was filled with this solution and was used to titrate a 25.00 mL sample of 0.100 mol L-1 NaOH using a suitable indicator.

1. (i) Name the substance used to rinse the burette immediately prior to its use. (1 mark)

**OXALIC ACID SOLUTION**

(ii) Explain the reason for your answer to (d) (i). (1 mark)

**Rinsing with the solution ensures concentration of the solution in burette does**

**not change, ie solution is not diluted with water.**

**Step 3:** Titrations were repeated until a consistent end point was obtained.

The student’s results were as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Final reading (mL)** | 20.65 | 19.60 | 20.75 | 21.85 |
| **Initial reading (mL)** | 4.45 | 3.90 | 4.95 | 5.95 |
| **Titration volume (mL)** | **16.2** | **15.7** | **15.8** | **15.9** |

1. Complete the table and determine the average titre value for the oxalic acid solution.

Average Titre: **15.8 mL** (0 marks for 159 mL, this uses 16.2mL) (1 mark)

1. Calculate the moles of oxalic acid which reacted with the NaOH. Note oxalic acid is a diprotic acid. (2 marks)

**Moles NaOH = 0.100 x 0.025 = 0.00250 mol (1)**

**Moles H2C2O4 =** **0.00250/2 = 0.00125 mol (1)**

1. Calculate the mass of oxalic acid in the 2.50g sample. (2 marks)

**Moles H2C2O4 in 250mL =** **250/15.8 x 0.00125 = 0.0198 mol (1)**

**Mass H2C2O4 = 0.0198 x 90.04 = 1.782g (1)**

1. Use your result to show that n = 2 in H2C2O4.**n**H2O. (3 marks)

**In 2.50 g sample, mass of water = 2.50 – 1.782 = 0.717g (1)**

**Moles water = 0.717/18 = 0.0398 mol (1)**

**Mole ratio: 0.0398 mol H2O / 0.0198 mol H2C2O4 = 2 (1)**