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# 

# 1. Generic Matrix Chemistry

|  |  |  |  |
| --- | --- | --- | --- |
| Question | competence | Weight in % | Weight in points |
| Question A1  inorganic chemistry | Knowledge and Comprehension | 25 | 5-8 |
| Application | 50 | 10-15 |
| Analysis and Evaluation | 25 | 5-8 |
| Total A1 | | **25** |
| Question A2  inorganic chemistry | Knowledge and Comprehension | 25 | 5-8 |
| Application | 50 | 10-15 |
| Analysis and Evaluation | 25 | 5-8 |
| Total A2 | | **25** |
| Question B1  organic chemistry | Knowledge and Comprehension | 25 | 5-8 |
| Application | 50 | 10-15 |
| Analysis and Evaluation | 25 | 5-8 |
| Total B1 | | **25** |
| Question B2  organic chemistry | Knowledge and Comprehension | 25 | 5-8 |
| Application | 50 | 10-15 |
| Analysis and Evaluation | 25 | 5-8 |
| Total B2 | | **25** |
| Total exam | | | 100 |

# 2. Paper-specific Matrix

|  |  |  |  |
| --- | --- | --- | --- |
| Question | competence | Weight in % | Weight in points |
| Question A1  inorganic chemistry | Knowledge and Comprehension | 28 | 7 |
| Application | 52 | 13 |
| Analysis and Evaluation | 20 | 5 |
| Total A1 | | **25** |
| Question A2  inorganic chemistry | Knowledge and Comprehension | 24 | 6 |
| Application | 55 | 13 |
| Analysis and Evaluation | 24 | 6 |
| Total A2 | | **25** |
| Question B1  organic chemistry | Knowledge and Comprehension | 24 | 6 |
| Application | 48 | 12 |
| Analysis and Evaluation | 28 | 7 |
| Total B1 | | **25** |
| Question B2  organic chemistry | Knowledge and Comprehension | 24 | 6 |
| Application | 52 | 13 |
| Analysis and Evaluation | 24 | 6 |
| Total B2 | | **25** |
| Total exam | | | 100 |

# 3. Sample Bac written examinations

CHEMISTRY

DATE: 2 June 2020

**DURATION OF EXAMINATION:**

3 hours (180 minutes)

PERMITTED EQUIPMENT:

Calculator: TI-Nspire in ‘Press-to-Test’ mode

INSTRUCTIONS:

* Answer both A questions and both B questions
* Use a different page for each of the four questions
* **All relative atomic mass values are given in the periodic table of the elements provided. These values are the same as the molar mass values in g mol–1**.

|  |  |  |  |
| --- | --- | --- | --- |
| **Question A1** | | | |
| **Page 1/3** | | | **Marks** |
| a) | Lactic acid, C3H6O3, is a monoprotic “Brønsted acid”. When exercising, lactic acid can be produced in the muscles.  If a concentration of 3.00 x 10–3 mol dm–3 (mol L–1) is reached in one’s blood, the muscles can hurt and cramp. It is suggested that drinking a lot of water helps to reduce the high concentration of lactic acid in the body.  **Given**:Ka for lactic acid | |  |
|  | i. | Define the term “Brønsted acid”. | 1 mark |
|  | ii. | Give the formula of the conjugate base of the lactic acid molecule. | 1 mark |
|  | iii. | Write the equation for the reaction of lactic acid with water. | 1 mark |
|  | iv. | Write the expression for the acid ionisation constant, *K*a, of a **generic** acid AH. | 1 mark |
|  | After intense training an athlete’s blood was analysed. The lactic acid mass concentration was 1.85 x 10–1 g dm–3 (g L–1). | |  |
|  | v. | Justify by calculation that the athlete drank enough water to avoid cramps caused by lactic acid. | 2 marks |
|  | More concentrated aqueous solutions of lactic acid are used in a research project. | |  |
|  | vi. | State the mathematical formula used to calculate the [H+] of a weak acid. | 1 mark |
|  | vii. | Calculate the pH of a solution of lactic acid with an initial concentration of 1.00 x 10–1 mol dm–3 (mol L–1) at 25°C. | 2 marks |
|  | **Given**: *K*a(C3H6O3(aq)) = 1.38 x 10–4 at 25°C | |  |
| **Question A1** | | | |
| **Page 2/3** | | | **Marks** |
| b) | The molar concentration of lactic acid in a sample of volume 25.0 cm3 (mL) was determined using titration with a 5.00 x 10–2 mol dm–3 (mol L–1) aqueous solution of sodium hydroxide, NaOH(aq).    volume of NaOH(aq) added in cm3(mL) | |  |
|  | i. | Write the equation for this titration reaction. | 1 mark |
|  | ii. | State two features of the titration curve of a weak acid. | 1 mark |
|  | iii. | Using the titration curve above, find the pH value at the equivalence point for this titration. | 1 mark |
|  | iv. | Show by calculation, using the equivalence point, that the initial molar concentration of the lactic acid was approximately 5.6 x 10–2 mol dm–3 (mol L–1). | 2 marks |
|  | v. | Show by calculation and with reference to the initial pH value of the lactic acid sample from the titration curve, that lactic acid is not a strong acid. | 3 marks |
|  | vi. | Determine the p*K*a of lactic acid from the titration curve. Justify your answer using the *K*a expression. | 2 marks |
|  | vii. | Define what is the pH range of colour change of an indicator. | 1 mark |
|  | viii. | Justify why phenolphthalein is the most suitable indicator for this titration.   |  |  | | --- | --- | | **Indicator** | **pH range of colour change** | | Crystal violet | 0.0 – 1.8 | | Methyl orange | 3.1 – 4.4 | | Phenolphthalein | 8.2 – 10.0 | | 2 marks |
| **Question A1** | | | |
| **Page 3/3** | | | **Marks** |
| c) | Human blood normally has a pH value of 7.4 at 37 oC. This value is kept constant by a buffer solution which contains, amongst other species, carbonic acid, H2CO3(aq), and the hydrogen carbonate ion, HCO 3(aq). | |  |
|  | i. | Explain how this buffer system works. Include in your answer two relevant equations. | 3 marks |
|  | ii. | Assuming that carbonic acid is a monoprotic acid, calculate the ratio: [HC03(aq)] at pH = 7.4 at 37 oC.  [H2C03(aq)] | 2 marks |
|  | **Given**: p*K*a(H2CO3(aq)) = 6.1 at 37 oC | |  |
| **Question A2** | | | |
| **Page 1/2** | | | **Marks** |
| a) | An electrochemical cell was constructed using the couples:    I2 (aq), / I-(aq) Eo   =  +  0.54 V  Fe3+(aq), /  Fe2+(aq) Eo   =  +  0.77 V | |  |
|  | i. | Write the oxidation half equation. | 1 mark |
|  | ii. | Write the reduction half equation. | 1 mark |
|  | iii. | Write the overall balanced equation when the cell is operating. | 1 mark |
|  | iv. | Calculate the emf that the cell would generate under standard conditions. | 1 mark |
|  | v. | Draw a clearly labeled diagram of the electrochemical cell. Indicate on your diagram the polarity of the electrodes, the direction of electron flow and of ion flow. | 4 marks |
|  | vi. | List what are ‘standard conditions’ as described in part (iv) above. | 2 marks |
| b) | Sodium nitrite, NaNO2, and sodium nitrate, NaNO3, are used to preserve meat.  In order to determine the quantity of sodium nitrite in a preservative, 5.00 g of the preservative were dissolved in water and the resulting solution reacted with a 3.00 x 10-1 mol dm-3 solution of acidified potassium dichromate, K2Cr2O7.  During the reaction, the Cr2O72-(aq) ions are converted into Cr3+(aq) ions while the NO2-(aq) ions are converted into NO3-(aq) ions.  10.8 cm3 of the K2Cr2O7 solution are required to react with all the sodium nitrite present in the sample. | |  |
|  | i. | Write the half-equations for the reduction and oxidation processes. | 2 marks |
|  | ii. | Write the overall balanced equation for the reaction. | 2 marks |
|  | iii. | Show that  the amount, in moles, of nitrite ions present in the initial solution equals … | 3 marks |
| **Question A2** | | | |
| **Page 2/2** | | | **Marks** |
| c) | Given the following standard electrode potentials at 25oC:  K+ (aq) / K(s) Eo    =   -  2.92 V  H2O(aq) / H2(g), Eo    =   -  0.41 V  O2(g), / H2O(aq) Eo    =   + 0.81 V  Br2(aq)  / Br- (aq) Eo    =    + 1.07 V | |  |
|  | i. | Write the chemical equations for the reactions occurring at the positive and negative electrode during the electrolysis of molten potassium bromide. | 2 marks |
|  | ii. | In an experiment, a current of 3.00 A was passed through molten potassium bromide for 30 minutes. Calculate the mass of product formed at the positive electrode. **Given**: Faraday constant, *F* = 9.65 x 104 C mol-1 | 3 marks |
|  | iii. | State what species you would expect to be formed at each electrode during the electrolysis of an aqueous solution of potassium bromide. Justify your answer by referring to the electrode potentials given. | 3 marks |
| **Question B1** | | | |
| **Page 1/2** | | | **Marks** |
| Eucalyptus oil and aspirin are often used to treat the symptoms of the common cold.  Eucalyptus oil has anti-bacterial properties and contains a number of esters, one of which is 3-methylbutyl butanoate. This ester is formed from 3-methylbutan-1-ol and butanoic acid.  Aspirin has anti-inflammatory properties and contains the active ingredient acetylsalicylic acid which can be formed from salicylic acid.  The structural formulas of 3-methylbutyl butanoate, 3-methylbutan-1-ol, acetyl salicylic acid and salicylic acid are given below: | | |  |
| **3-methylbutyl butanoate 3-methylbutan-1-ol** | | |  |
| **acetylsalicylic acid** **salicylic acid** | | |  |
| a) | A student mixes 3-methylbutyl butanoate with water in the laboratory and observes the formation of two layers. | |  |
|  | i. | Explain the observation. | 1 mark |
|  | ii. | Write the equation for the formation of 3-methylbutyl butanoate using structural formulas. | 2 marks |
|  | iii. | State and explain the effect of replacing concentrated sulfuric acid with dilute sulfuric acid in the reaction. | 2 marks |
|  | iv. | Describe the role of the sulfuric acid in the esterification reaction. | 1 mark |
|  | v. | Identify the compound which provides the oxygen labeled X on structure 1. | 1 mark |
|  | vi. | Explain one piece of experimental evidence for this mechanism. | 2 marks |
| b) | 3-methylbutan-1-ol is a primary alcohol. | |  |
|  | i. | Draw and name the structural formula of a secondary alcohol and tertiary alcohol which are isomers of this primary alcohol. | 4 marks |
|  | ii. | ii. Identify the type of reaction which can be used to distinguish between the secondary and tertiary isomers in **b) i.** Justify your response. | 2 marks |
| **Question B1** | | | |
| **Page 2/2** | | | **Marks** |
|  | iii. | Give the balanced equation for the reaction in **b) ii.** | 2 marks |
|  | In the eucalyptus plant 3-methylbutan-1-ol can be converted to 3-methylbutanoic acid. | |  |
|  | iv. | Give the structural formula of 3-methylbutanoic acid. | 1 mark |
|  | The p*K*a value of butanoic acid is 4.82 and that of 3-methylbutanoic acid is 5.01. | |  |
|  | v. | Explain the difference in these p*K*a values and why this difference is relatively small. | 2 marks |
|  | Salicylic acid has a p*K*a value of 2.97. | |  |
|  | vi. | With reference to the structure of salicylic acid, explain, why the p*K*a is much lower than that of butanoic acid and 3-methylbutanoic acid. | 2 marks |
| c) | Aspirin helps to prevent inflammation by reacting with the amino acid serine, HO-Ser530, which is part of a particular protein, as shown below (the number 530 refers to the position of serine in the protein): | |  |
|  | i. | Give the structural formula of the reaction product using O—Ser530. | 1 mark |
|  | In the laboratory salicylic acid can be formed from the hydrolysis of acetylsalicylic acid. | |  |
|  | ii. | Write the equation for the reaction using structural formulas. | 2 marks |
| **Question B2** | | | |
| **Page 1/4** | | | **Marks** |
| a) | Lysine and phenylalanine are essential amino acids for humans.  Glutamic acid and serine can be formed by human cell metabolism.  Tyrosine can be enzymatically formed from phenylalanine. Glycine can  be formed from serine. The structural formulas of the six amino acids are given below: | |  |
|  |  | |  |
|  | i. | Explain, which of the two amino acids lysine or phenylalanine you would expect to be the most water-soluble. | 2 marks |
|  | ii. | Copy the structural formula of tyrosine and circle all hydrogen atoms which could react with water in an acid-base-reaction. | 2 marks |
|  | iii. | Define the term isoelectric point of an amino acid. | 1 mark |
| **Question B2** | | | |
| **Page 2/4** | | | **Marks** |
|  | iv. | Give the structural formula of the predominant species of glycine at the isoelectric point. | 1 mark |
|  |  | The isoelectric point for serine is 5.68 at 25 °C. |  |
|  | v. | Give the structural formula of the predominant species of serine in an aqueous solution with a pH = 3.0. | 1 mark |
|  |  | Consider the following table:   |  |  |  | | --- | --- | --- | | **Compound** | **Molar mass in g mol-1** | **Melting point in °C** | | Serine | 105 | 246 | | Hexan-1-ol | 102 | -45 | |  |
|  | vi. | Explain the significant difference in the melting points of the two given compounds. | 2 marks |
|  | **Compound M** can be formed when two of the amino acids given in question a) react with one another. The structural formula is: | |  |
|  | vii. | Name the functional group linking the two amino acids. | 1 mark |
|  | viii. | Identify the two amino acids which reacted to form compound M. | 2 marks |
|  | Glycine and phenylalanine can react with one another to form two different dipeptides. | |  |
|  | ix. | Give the structural formulas of both dipeptides. | 2 marks |
| **Question B2** | | | |
| **Page 3/4** | | | **Marks** |
| b) | During the last decades, several substances used as food dyes have been banned in Europe. The structural formula of one formerly used as a yellow dye is shown below: | |  |
|  | i. | Name the functional group linking the two aromatic rings. | 1 mark |
|  | ii. | Explain why this compound is coloured. | 2 marks |
|  | The dye above is hydrogenated under appropriate conditions. The structural formula of the product obtained is shown below: | |  |
|  | iii. | Give the common name of a long chain composed of amino acids. | 1 mark |
|  | iv. | Explain, whether the compound obtained can be used as a dye or not. | 1 mark |
|  | The yellow dye is produced from two aromatic Compounds A and B: | |  |
|  | v. | Calculate the minimum mass of **Compound A** required to produce 1.00 x 102 g of the dye. | 3 marks |
|  | **Given**: Molar masses in g mol-1: Compound A: 110, Compound B: 195 | |  |
| **Question B2** | | | |
| **Page 4/4** | | | **Marks** |
| c) | Kevlar, Poly(p-phenylene terephthalamide) is a very strong material used, for example, in puncture resistant tyres and bullet proof clothing. It is produced in a polycondensation reaction. The secondary product is hydrogen chloride, HCl.  ***Kevlar*** structure: | |  |
|  | i. | By referring to the structure given above, explain the strength of ***Kevlar*** fibres. | 2 marks |
|  | The structural formula of one of the two monomers used to produce ***Kevlar*** is shown below: | |  |
|  | ii. | Name the bond found between the two monomers in ***Kevlar***. | 1 mark |

# 4. Marking scheme

CHEMISTRY

DATE: 2 June 2020

**ANSWERS AND MARK SCHEME**

**The following are the suggested answers together with the mark scheme for the correction of the papers. The answers are not necessarily 'model' answers. Where a candidate has given a correct alternative answer or used a different correct method to arrive at an answer full credit should be given.**

**The use of state symbols (i.e. (aq), (s), (l) and (g)) in the answers is optional. Accept either H+ or H3O+ for a proton in water.**

**Numerical answers have been given to three significant figures.**

**A suggested breakdown showing the minimum needed for each marking point has been given.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Question A1** | | | | | | | | | | | | | | **COMPETENCES** | | | | | |
| **Page 1/2** | | | | | | | | | | **Marks** | | | | **KC** | **AP** | | **AE** | | |
| a) | | | i. | | | | Proton donor **[1]** | | | 1 mark | | | | 1 |  | |  | | |
|  | | | ii. | | | | C3H5O3¯(aq) **[1]** | | | 1 mark | | | |  | 1 | |  | | |
|  | | | iii. | | | | C3H6O3(aq) + H2O(l) C3H5O3¯(aq) + H3O+(aq) **[1]** | | | 1 mark | | | |  | 1 | |  | | |
|  | | | iv. | | | | *K*a(HX(aq)) = [X¯(aq)] x [H3O+(aq)] / [HX(aq)] [1] | | | 1 mark | | | | 1 |  | |  | | |
|  | | | v. | | | | *M*(C3H6O3) = 90.1 g mol–1 **[1]**  [C3H6O3(aq)]  = 1.85 x 10–1 / 90.1 = 2.05 x 10–3 mol dm–3 (mol L–1) **[1]**  ( [C3H6O3(aq)] < 3.00 x 10–3 mol dm–3 (mol L–1) so the athlete drank enough water. )  () *not required* | | | 2 marks | | | |  |  | | | 2 | |
|  | | | vi. | | | | **[H3O+(aq)] = (CaKa)1/2** | | | 1 mark | | | | 1 |  | | |  | |
|  | | | vii. | | | | ( [C3H5O3¯(aq)] = [H3O+(aq)]  weak acid: [C3H6O3(aq)] = 1.00 x 10–1 mol dm–3 (mol L–1) )  [H3O+(aq)]2 = *K*a(C3H6O3(aq)) x [C3H6O3(aq)]  [H3O+(aq)] = (1.38 x 10–4 x 1.00 X 10–1)1/2 **[1]**  = 3.71 x 10–3 mol dm–3 (mol L–1)  pH = 2.43 **[1]**  () not required | | | 2 marks | | | |  | 2 | | |  | |
| b) | | | i. | | | | | | C3H6O3(aq) + OH¯(aq)  C3H5O3¯(aq) + H2O(l) **[1]** | 1 mark | | | |  | 1 | | |  | |
|  | | | ii. | | | | | | presence of a buffer zone and pH at equivalence higher than 7 | 1 mark | | | | 1 |  | | |  | |
|  | | | iii. | | | | | | pH = 8.0 **[1]** (*accept pH between 7.5 and 8.5*) | 1 mark | | | |  | 1 | | |  | |
|  | | | iv. | | | | | | *n*(OH¯(aq)) = ( [OH¯(aq)] x *V*(OH¯(aq)) )  = 5.00 x 10-2 x 28 x 10-3  = 1.4 x 10-3 mol *= n*(C3H6O3(aq)) **[1]**  [C3H6O3(aq)] = ( *n*(C3H6O3(aq)) / (C3H6O3(aq)) )  = 1.4 x 10-3 / 25 x 10-3 **[1]**  = 5.6 x10-2 mol dm-3 (mol L-1) **(*given*)**  () *not required* | 2 marks | | | |  | 2 | | |  | |
|  | | | v. | | | | | | If C3H6O3(aq) was a strong acid then the initial pH would be pH = -log (5.6 x10–2) = 1.3 **[1]**, but according to the graph, the initial value is pH = 2.6 > 1.3 **[1]** | 2 marks | | | |  |  | | | 2 | |
| **Question A1** | | | | | | | | | | | | | | **COMPETENCES** | | | | | |
| **Page 2/2** | | | | | | | | | | **Marks** | | | | **KC** | **AP** | | **AE** | | |
|  | | | vi. | | | | | | *K*a(C3H6O3(aq)) = [C3H5O3¯(aq)] x [H3O+(aq)] / [C3H6O3(aq)]  (*answer to question a) v.*)  ( so pH = p*K*a(C3H6O3(aq)) + log( [C3H5O3¯(aq)] / [C3H6O3(aq)] ) )  At the half equivalence point of the titration curve the pH = 3.9 ± 0.2 and [C3H6O3 (aq)] = [C3H5O3¯(aq)] **[1]**  so pH = p*K*a(C3H6O3(aq)) (*or K*a(C3H6O3(aq)) = [H3O+ (aq)]) **[1]**  () *not required* | 2 marks | | | |  | 1 | | | 1 | |
|  | | | vii. | | | | | | Accurate definition | 1 mark | | | | 1 |  | | |  | |
|  | | | viii. | | | | | | The pH range of colour change of phenolphthalein is on the steepest part of the titration curve **[1]** (***or, accept also:*** … includes the pH at equivalence), so phenolphthalein is the most suitable indicator. **[1]** | 2 marks | | | | 1 | 1 | | |  | |
| c) | | | i. | | | | | | If the concentration of H3O+(aq) increases, the following reaction will take place:  HCO3¯(aq) + H3O+(aq)  H2CO3(aq) + H2O(l)  If the concentration of OH¯(aq) increases, the following reaction will take place:  H2CO3(aq) + OH¯(aq)  HCO3¯(aq) + H2O(l)  ***Equations* [1] + [1], *explanation* [1]** | 2 marks | | | | 1 | 1 | | |  | |
|  | | | ii. | | | | | | pH = p*K*a(H2CO3(aq)) + log( [HCO3¯(aq)] / [H2CO3(aq)] ) **[1]**  so [HCO3¯(aq)] / [H2CO3(aq)] = 10pH- p*K*a(H2CO3 (aq))  = 107.4- 6.1 = 20 **[1]** | 2 marks | | | |  | 2 | | |  | |
| **Question A2** | | | | | | | | | | | | | | **COMPETENCES** | | | | | |
| **Page 1/2** | | | | | | | | | | | **Marks** | | | **KC** | | **AP** | | | **AE** |
| a) | | | i. | | | | 2I­–(aq)  🡪 I2(aq) + 2e– | | | | 1 mark | | | 1 | |  | | |  |
|  | | | ii. | | | | Fe3+(aq)+ e– 🡪 Fe2+(aq) | | | | 1 mark | | | 1 | |  | | |  |
|  | | | iii. | | | | 2I­–(aq) + 2Fe3+(aq) 🡪 I2(aq) + 2Fe2+(aq) | | | | 1 mark | | |  | | 1 | | |  |
|  | | | iv. | | | | E.m.f. = +0.77 – 0.54 = +0.23V | | | | 1 mark | | |  | | 1 | | |  |
|  | | | v. | | | |  | | | | 4 marks | | | 1 | | 3 | | |  |
|  | | |  | | | | **[**Assign **1** mark Knowledge and Comprehension for the blank diagram, **1** mark Application for polarity of electrodes, **1** mark Application for direction of electrons, **1** mark Application for ion flow**]** | | | |  | | |  | |  | | |  |
|  | | | vi. | | | | Concentration solutions of 1 mol dm–3 **[1]**  , pressure of 1 atm (not required here), 25 ºC. **[1]** | | | | 2 marks | | | 2 | |  | | |  |
| b) | | | i. | | | | | **Oxidation:** NO2–(aq) + H2O(l) 🡪 NO3–(aq) + 2H+(aq) + 2e– **[1]**  **Reduction:** Cr2O72–(aq) + 14H+(aq) + 6e– + 🡪 2Cr3+(aq) + 7H2O(l) **[1]** | | | 2 marks | | |  | | 2 | | |  |
|  | | | ii. | | | | | Cr2O72–(aq) + 3NO2–(aq) + 8H+(aq) 🡪 2Cr3+(aq) + 3NO3–(aq) + 4H2O(l) **[2]** | | | 2 marks | | |  | | 2 | | |  |
|  | | | iii. | | | | | Mol Cr2O72– : 0.0108 dm–3 x 3.00 x 10-1 mol dm-3 = 3.24 x 10–3 mol **[1]**  Mol NO2– : 3.24 x 10–3 mol x 3 = 9.72 x 10–3 mol **[1** mark Analysis/Evaluation, **1** mark Application**]** | | | 3 marks | | |  | | 2 | | | 1 |
| **Question A2** | | | | | | | | | | | | | | **COMPETENCES** | | | | | |
| **Page 2/2** | | | | | | | | | | | **Marks** | | | **KC** | | **AP** | | | **AE** |
| c) | | | | i. | | | K+(l) + e– 🡪 K(l) [1 mark AE] | | | | 1 mark | |  | | |  | | | 1 |
|  | | | |  | | | 2Br – (l) 🡪 Br2(l) + 2e– **[1]** | | | | 1 mark | |  | | |  | | | 1 |
|  | | | | ii. | | | At the positive electrode, formation of Bromine.  **[1]**  **[1]**  Mass of Br2: 5.56 x 10–2 x ½ x 159.8 = 4.47 g **[1]** | | | | 3 marks | | 1 | | | 2 | | |  |
|  | | | | iii. | | | You would expect the formation of O2(g) at the anode, and the formation of H2(g) at the cathode. **[1]**  The couple H2O/H2 has a less negative Ered than the K+ /K couple therefore it would be preferred. **[1]**  The oxidation of water to O2(g) would be preferred over the oxidation of bromide ion as the couple Br2/Br – has a more positive Ered than the O2/H2O couple. **[1]** | | | | 3 marks | |  | | |  | | | 3 |
| **Question B1** | | | | | | | | | | | | | **COMPETENCES** | | | | | | |
| **Page 1/2** | | | | | | | | | | | **Marks** | | **KC** | | | **AP** | | | **AE** |
| a) | | | i. | | | | | Due to the hydrophobic hydrocarbon chains, 3-methylbutylbutanoate is not miscible to water (***or*** the ester is non-polar whereas water is polar) **[1]** | | | 1 mark | |  | | |  | | | 1 |
|  | | | ii. | | | | | ***Formula of butanoic acid [1]; Stoichiometry (water) [1]*** | | | 2 marks | |  | | | 2 | | |  |
|  | | | iii. | | | | | If concentrated H2SO4(aq) is replaced with diluted H2SO4(aq) the equilibrium is shifted towards the reactants **[1]**. This is explained by the Le Chatelier principle, related to the addition of H2O (product). **[1]** | | | 2 marks | |  | | | 1 | | | 1 |
|  | | | iv. | | | | | H2SO4 catalyzes the reaction. **[1]** | | | 1 mark | | 1 | | |  | | |  |
|  | | | v. | | | | | 3-methylbutan-1-ol **[1]** | | | 1 mark | | 1 | | |  | | |  |
|  | | | vi. | | | | | By radiolabelling 3-methylbutanol with the 18O radioisotope. **[1].** If after the reaction with butanoic acid the 18O radioisotope is detectable as the bridging oxygen in the ester 3-methylbutylbutanoate, this proves that the linking oxygen atom comes from the alcohol. If it is detectable in the water molecule after the reaction then the linking oxygen atom is derived from the butanoic acid. **[1]**  ***Or comparable reasoning with 18O in the HO- group [1] of the butanoic acid.*** | | | 2 marks | | 1 | | |  | | | 1 |
| b) | | | i. | | | | |  | | | 4 marks | |  | | | 4 | | |  |
|  | | ii. | | | | | Oxidation **[1]** which is possible with the secondary alcohol but not the tertiary alcohol **[1]** | | | | 2 marks | | 2 | | |  | | |  |
|  | | iii. | | | | | Use of KMnO4(aq) (***or*** K2Cr2O7) **[1]** Correct balanced reaction **[1]** | | | | 2 marks | | 1 | | | 1 | | |  |
| **Question B1** | | | | | | | | | | | | | **COMPETENCES** | | | | | | |
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|  | | iv. | | | | |  | | | | 1 mark | |  | | | 1 | | |  |
|  | | v. | | | | | The positive inductive effect of the methyl group in 3-methylbutanoic acid increases the electron density on the carboxyl group thus increasing the attraction of the proton. **[1]** Therefore 3-methylbutanoic acid is a weaker acid compared to butanoic acid. However, the difference is relatively small because the methyl group is not close to the carboxyl group. **[1]** | | | | 2 marks | |  | | |  | | | 2 |
|  | | vi. | | | | | The delocalization of the pi electrons of the phenyl group (mesomeric effect) **[1]** decreases the electron density on the carboxyl group thus decreasing the attraction of the proton. **[1]** | | | | 2 marks | |  | | |  | | | 2 |
| c) | i. | | | |  | | | | | | 1 mark | |  | | | 1 | | |  |
|  | ii. | | | | ***Salicylic acid* [1] *Ethanoic acid* [1]** | | | | | | 2 marks | |  | | | 2 | | |  |
| **Question B2** | | | | | | | | | | | | | **COMPETENCES** | | | | | | |
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| a) | i. | | | | Lysine is the most water soluble as it does not contain a hydrophobic benzene ring **[1]** and it also contains an extra polar amino group **[1]**. | | | | | | 2 marks | |  | | |  | | | 2 |
|  | ii. | | | |  | | | | | | 2 marks | |  | | | 2 | | |  |
|  | iii. | | | | The isoelectric point is the pH of an aqueous solution at which the amino acid has a neutral charge **[1]** | | | | | | 1 mark | | 1 | | |  | | |  |
|  | iv. | | | |  | | | | | | 1 mark | |  | | | 1 | | |  |
|  | v. | | | |  | | | | | | 1 mark | |  | | | 1 | | |  |
|  | vi. | | | | Serine: Strong ionic bonds **(between the zwitterions) [1]**.  Hexan-1-ol: Weaker hydrogen bonds **(and Van der Waal’s forces) [1].**  () *not required* | | | | | | 2 marks | |  | | |  | | | 2 |
|  | vii. | | | | | Ester linkage **[1]** | | | | | 1 mark | | 1 | | |  | | |  |
|  | viii. | | | | | Glutamic acid **[1]** and Serine **[1]** | | | | | 2 marks | |  | | | 2 | | |  |
| **Question B2** | | | | | | | | | | | | | **COMPETENCES** | | | | | | |
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|  | ix. | | | | |  | | | | | 2 marks | |  | | | 2 | | |  |
| b) | i. | | | | | Azo group. **[1]** | | | | | | 1 mark | 1 | | |  | | |  |
|  | ii. | | | | | The molecule contains extensive conjugation or delocalisation of electrons across the double bonds and the two benzene rings, **[1]**, which makes the absorption of light in the visible region possible. **[1]** | | | | | | 2 marks | 1 | | | 1 | | |  |
|  | iii. | | | | | Protein | | | | | | 1 mark | 1 | | |  | | |  |
|  | iv. | | | | | No, the hydrogenated molecule can’t be used as a dye because the delocalisation is not extended enough anymore. **[1] (the double**  **bond between the two nitrogen atoms is now a single bond.)**  () *not required* | | | | | | 1 mark |  | | | 1 | | |  |
|  | v. | | | | | **(The calculation involves the calculation of the amount of dye,**  **which is identical to the amount of A required:)** *M*(dye) = *M*(A) + *M*(B) + *M*(N) – 3 *M*(H)  = 110 +195 +14.0 –3.03 = **316 g mol–1** **[1]**    **(From this amount, the mass of A can be calculated:)**  *m*(A) = *n*(A) x *M*(A) = 0.316 x 110 = **34.8 g [1]**  () *not required* | | | | | | 3 marks |  | | | 3 | | |  |
| c) | i. | | | | | The Poly(p-phenylene terephthalamide)-molecule contains hydrogen bonding between the chains **[1]**. Long chain molecules stiffened due to conjugation through benzene rings and amide links. **[1]**  ***Any correct explanation including the Phenyl group is to be accepted.*** | | | | | 2 marks | |  | | |  | | | 2 |
|  | ii. | | | | | Peptide bond **[1]** | | | | | 1 mark | | 1 | | |  | | |  |