CONTENT

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
			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
			25
Question B2 organic chemistry	Knowledge and Comprehension	24	6
	Application	52	13
	Analysis and Evaluation	24	6
		Total B2	**25**
		Total exam	100

CHEMISTRY

DATE: 2 June 2020

DURATION OF EXAMINATION:
3 hours (180 minutes)

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

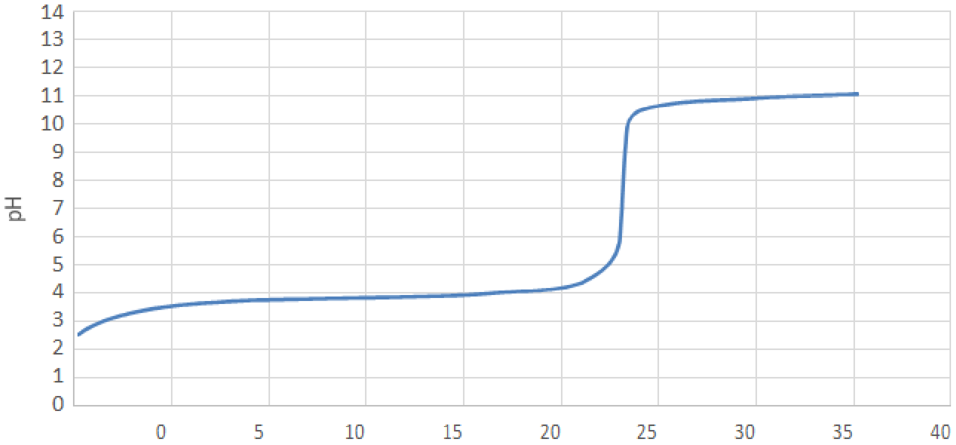
INSTRUCTIONS:

- 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, $C_3H_6O_3$, 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: $K_a(C_3H_6O_3(aq))$ = 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 cm^3 (mL) was determined using titration with a 5.00×10^{-2} mol dm^{-3} (mol L^{-1}) aqueous solution of sodium hydroxide, NaOH(aq).



volume of NaOH(aq) added in cm^3(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 5.6×10^{-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 pK_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. — 2 marks

Indicator	pH range of colour
Crystal violet	0.0 – 1.8
Methyl orange	3.1 – 4.4
Phenolphthalein	8.2 – 10.0

Question A1	
Page 3/3	**Marks**
c) Human blood normally has a pH value of 7.4 at 37 °C. This value is kept constant by a buffer solution which contains, amongst other species, carbonic acid, H_2CO_3(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: $\frac{[HCO^-_3(aq)]}{[H_2CO_3(aq)]}$ at pH = 7.4 at 37 °C.	2 marks
<u>Given</u>: $pK_a(H_2CO_3(aq)) = 6.1$ at 37 °C	

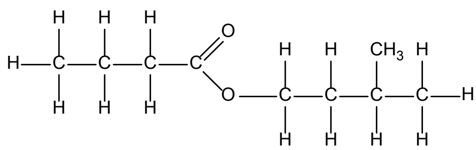
Question A2	
Page 1/2	**Marks**
a) An electrochemical cell was constructed using the couples: $I_{2\ (aq)}$, / $I^-_{(aq)}$ $E^o = + 0.54$ V $Fe^{3+}_{(aq)}$, / $Fe^{2+}_{(aq)}$ $E^o = + 0.77$ V	
i. Write the oxidation half equation.	1 mark
ii. Write the reduction half equation.	1 mark
iii. Write the 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, $NaNO_2$, and sodium nitrate, $NaNO_3$, 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 3.00×10^{-1} mol dm^{-3} solution of acidified potassium dichromate, $K_2Cr_2O_7$. During the reaction, the $Cr_2O_7^{2-}$(aq) ions are converted into Cr^{3+}(aq) ions while the NO_{2^-}(aq) ions are converted into NO_{3^-}(aq) ions. 10.8 cm^3 of the $K_2Cr_2O_7$ 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

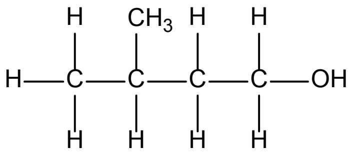
Question A2	
Page 2/2	Marks
c) Given the following standard electrode potentials at 25°C: K^+ (aq) / K(s) E° = - 2.92 V H_2O(aq) / H_2(g), E° = - 0.41 V O_2 (g), / H_2O(aq) E° = + 0.81 V Br_2(aq) / Br^- (aq) E° = + 1.07 V	
i. Write the chemical equations for the reactions occurring at the positive and 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 10^4 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

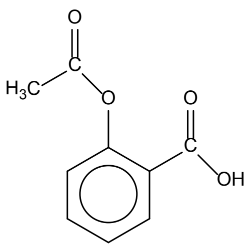
Page 1/2	Marks

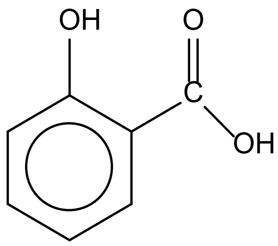
Eucalyptus oil and aspirin are often used to treat the symptoms of the common cold.
Eucalyptus oil has anti-bacterial properties and contains a number of esters, one of which is 3-methylbutyl butanoate. This ester is formed from 3-methylbutan-1-ol and butanoic acid.
Aspirin has anti-inflammatory properties 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:





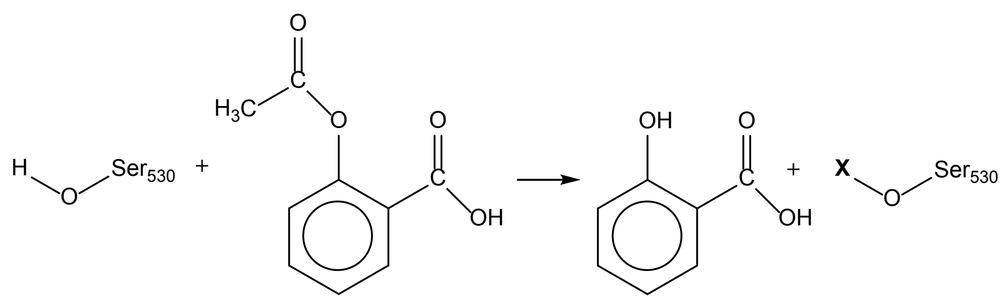
3-methylbutyl butanoate 3-methylbutan-1-ol





acetylsalicylic acid **salicylic acid**

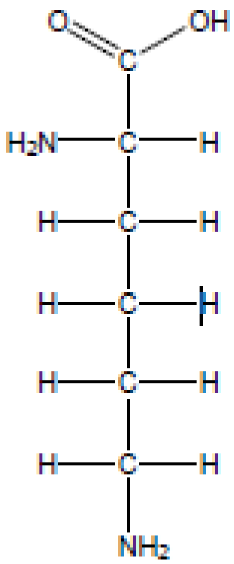
Question	Marks
a) A student mixes 3-methylbutyl butanoate with water in the laboratory and observes the formation of two layers.	
i. Explain the observation.	1 mark
ii. Write the equation for the formation of 3-methylbutyl butanoate using structural formulas.	2 marks
iii. State and explain the effect 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 pK_a value of butanoic acid is 4.82 and that of 3-methylbutanoic acid is 5.01.	
v. Explain the difference in these pK_a values and why this difference is relatively small.	2 marks
Salicylic acid has a pK_a value of 2.97.	
vi. With reference to the structure of salicylic acid, explain, why the pK_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-Ser_{530}, 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—Ser_{530}.	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

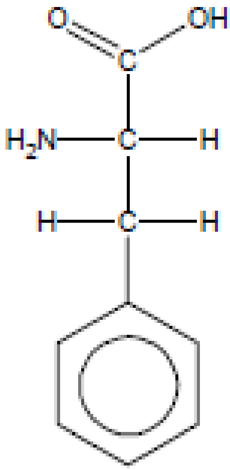
Question B2

Page 1/4	Marks

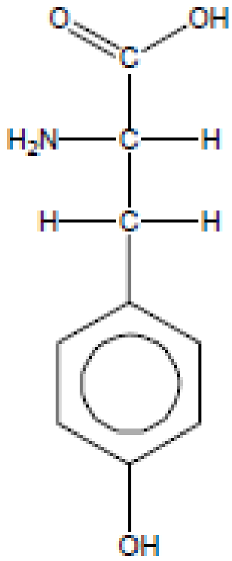
a) Lysine and phenylalanine are essential amino acids for humans. Glutamic acid and serine can be formed by human cell metabolism. Tyrosine can be enzymatically formed from phenylalanine. Glycine can be formed from serine. The structural formulas of the six amino acids are given below:



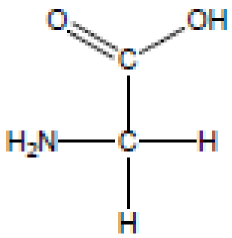
lysine



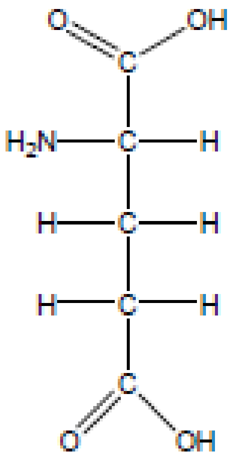
phenylalanine



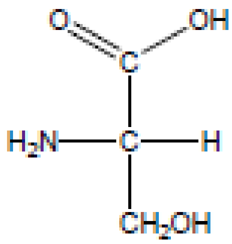
tyrosine



glycine



glutamic acid



serine

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

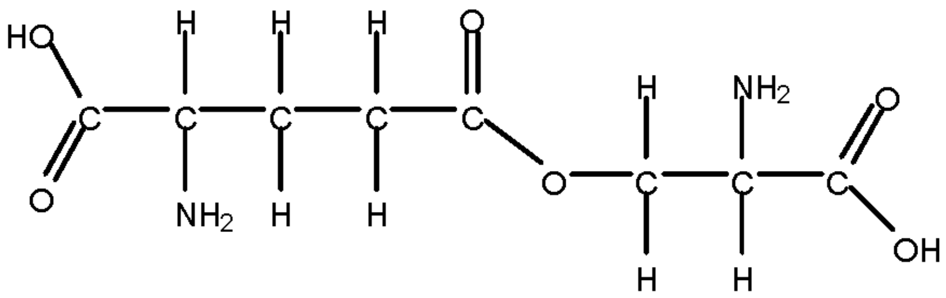
Page 2/4	**Marks**
iv. Give the structural formula of the predominant species of glycine at the isoelectric point.	1 mark
The isoelectric point for serine is 5.68 at 25 °C.	
v. Give the structural formula of the predominant species of serine in an aqueous solution with a pH = 3.0.	1 mark

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

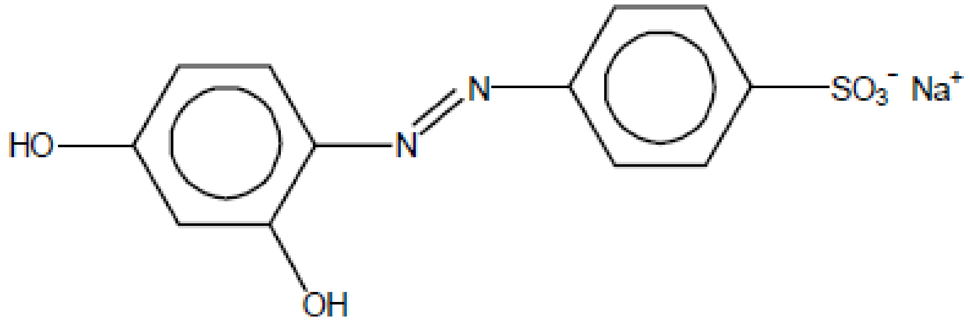
Glycine and phenylalanine can react with one another to form two different dipeptides.

ix. Give the structural formulas of both dipeptides. — 2 marks

Question B2

Page 3/4 | **Marks**

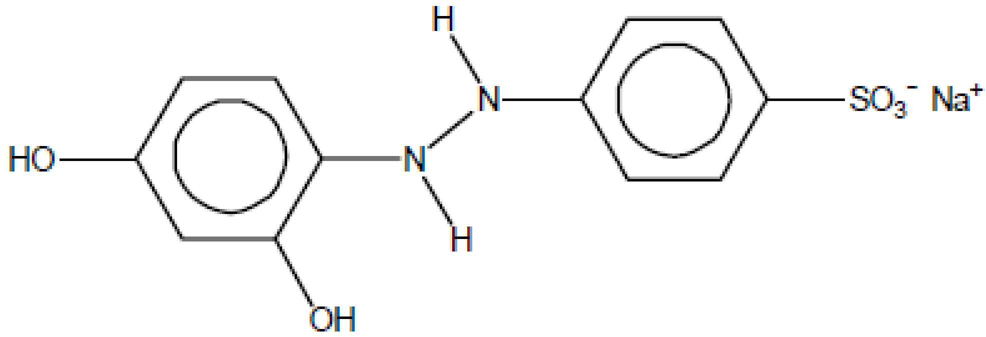
b) During the last decades, several substances used as food dyes have been banned in Europe. The structural formula of one formerly used as a yellow dye is shown below:



i. Name the functional group linking the two aromatic rings. — 1 mark

ii. Explain why this compound is coloured. — 2 marks

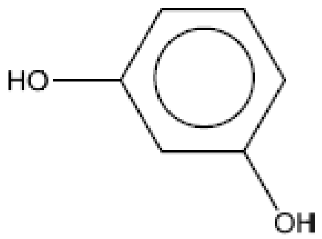
The dye above is hydrogenated under appropriate conditions. The structural formula of the product obtained is shown below:



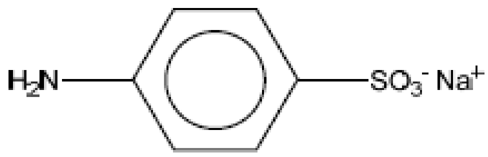
iii. Give the common name of a long chain composed of amino acids. — 1 mark

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:



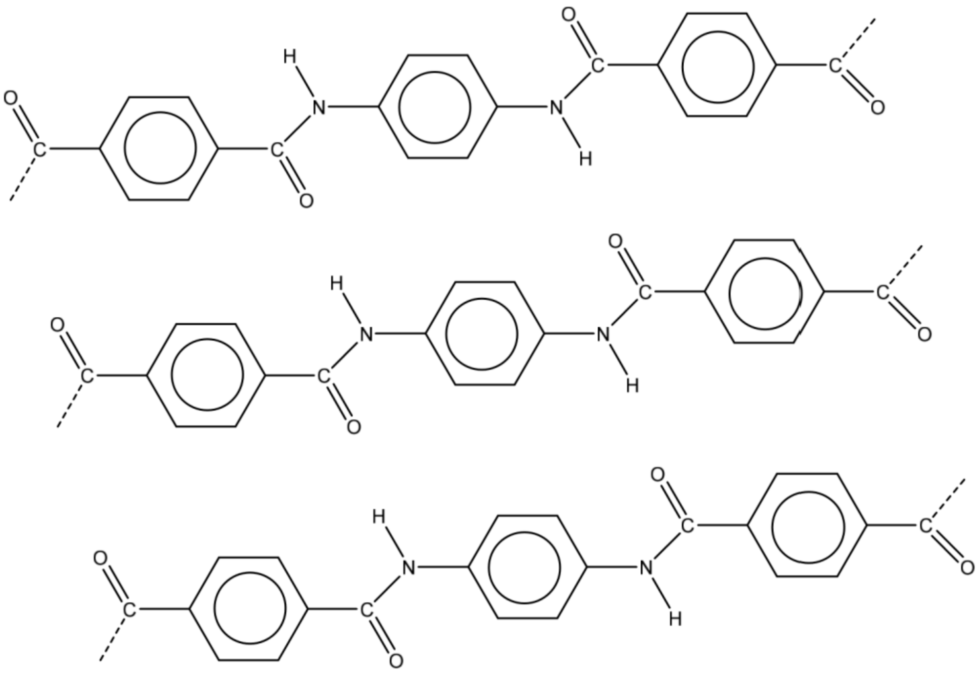
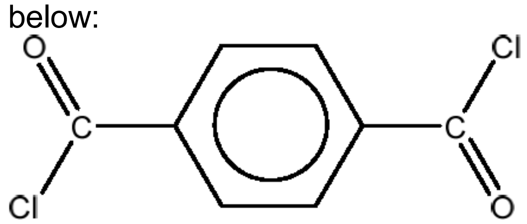
Compound A



Compound B

v. Calculate the minimum mass of **Compound A** required to produce 1.00 x 10^2 g of the dye. — 3 marks

<u>**Given**</u>: 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

CHEMISTRY

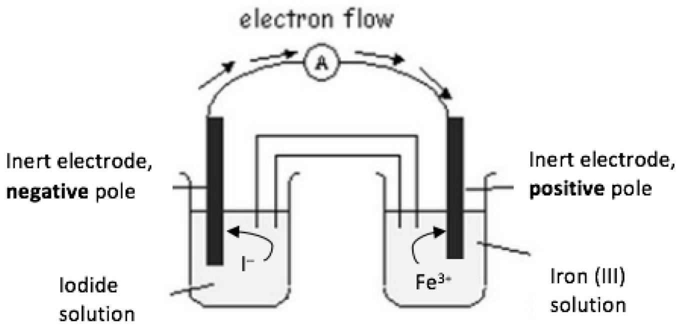
DATE: 2 June 2020

ANSWERS AND MARK SCHEME

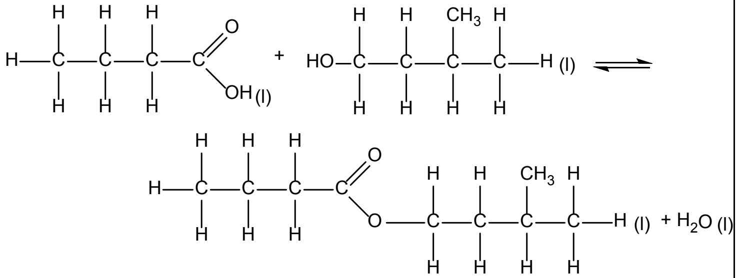
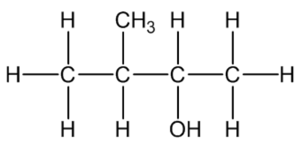
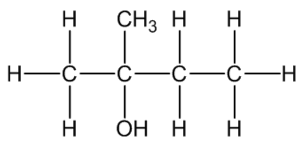
The following are the suggested answers together with the mark scheme for the correction of the papers. The answers are not necessarily 'model' answers. Where a candidate has given a correct alternative answer or used a different correct method to arrive at an answer full credit should be given.
The use of state symbols (i.e. (aq), (s), (l) and (g)) in the answers is optional.
Accept either H^+ or H_3O^+ 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.

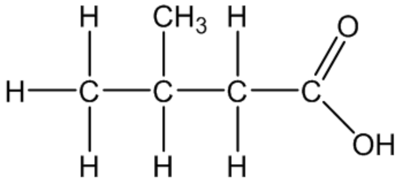
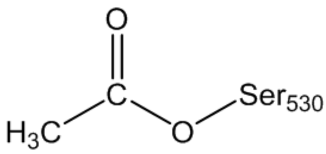
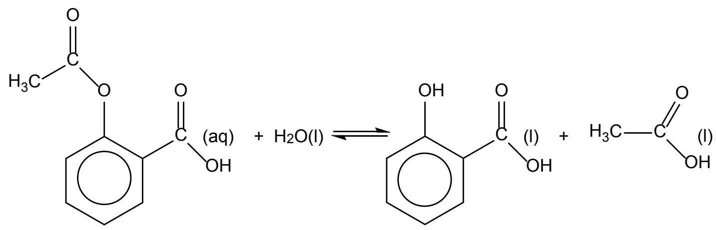
Question A1				COMPETENCES		
		Page 1/2	Marks	KC	AP	AE
a)	i.	Proton donor **[1]**	1 mark	1		
	ii.	$C_3H_5O_3^-$(aq) **[1]**	1 mark		1	
	iii.	$C_3H_6O_3$(aq) + H_2O(l) $\rightleftharpoons$ $C_3H_5O_3^-$(aq) + H_3O^+(aq) **[1]**	1 mark		1	
	iv.	K_a(HX(aq)) = [X^-(aq)] x [H_3O^+(aq)] / [HX(aq)] [1]	1 mark	1		
	v.	M($C_3H_6O_3$) = 90.1 g mol^{-1} **[1]** [$C_3H_6O_3$(aq)] = 1.85 x 10^{-1} / 90.1 = 2.05 x 10^{-3} mol dm^{-3} (mol L^{-1}) **[1]** ([$C_3H_6O_3$(aq)] < 3.00 x 10^{-3} mol dm^{-3} (mol L^{-1}) so the athlete drank enough water.) () *not required*	2 marks			2
	vi.	**[H_3O^+(aq)] = $(C_aK_a)^{1/2}$**	1 mark	1		
	vii.	([$C_3H_5O_3$ (aq)] = [H_3O^+(aq)] weak acid: [$C_3H_6O_3$(aq)] = 1.00 x 10^{-1} mol dm^{-3} (mol L^{-1})) [H_3O^+(aq)]^2 = K_a($C_3H_6O_3$(aq)) x [$C_3H_6O_3$(aq)] [H_3O^+(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.	$C_3H_6O_3$(aq) + OH (aq) → $C_3H_5O_3$ (aq) + H_2O(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($C_3H_6O_3$(aq)) **[1]** [C3H6O3(aq)] = (n($C_3H_6O_3$(aq)) / ($C_3H_6O_3$(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 $C_3H_6O_3$(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

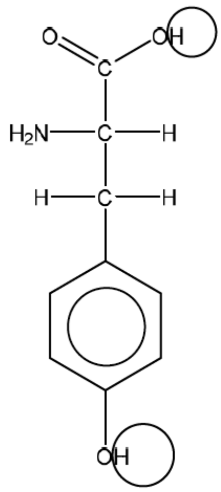
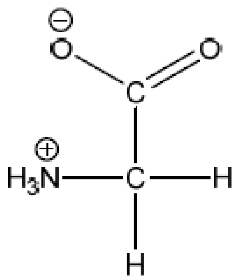
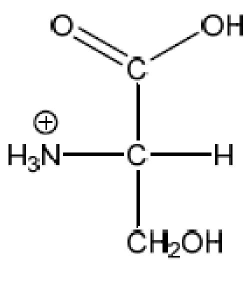
Question A1			COMPETENCES		
Page 2/2		Marks	KC	AP	AE
vi.	$K_a(C_3H_6O_3(aq)) = [C_3H_5O_3^-(aq)] \times [H_3O^+(aq)] / [C_3H_6O_3(aq)]$ (*answer to question a) v.*) (so $pH = pKa(C_3H_6O_3(aq)) + \log([C_3H_5O_3^-(aq)] / [C_3H_6O_3(aq)])$) At the half equivalence point of the titration curve the pH = 3.9 ± 0.2 and $[C_3H_6O_3(aq)] = [C_3H_5O_3^-(aq)]$ **[1]** so $pH = pK_a(C_3H_6O_3(aq))$ (*or* $K_a(C_3H_6O_3(aq)) = [H_3O^+(aq)]$) **[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: $HCO_3^-(aq) + H_3O^+(aq) \rightarrow H_2CO_3(aq) + H_2O(l)$ If the concentration of $OH^-(aq)$ increases, the following reaction will take place: $H_2CO_3(aq) + OH^-(aq) \rightarrow HCO_3^-(aq) + H_2O(l)$ ***Equations*** **[1] + [1],** ***explanation*** **[1]**	2 marks	1	1	
ii.	$pH = pK_a(H_2CO_3(aq)) + \log([HCO_3^-(aq)] / [H_2CO_3(aq)])$ **[1]** so $[HCO_3^-(aq)] / [H_2CO_3(aq)] = 10^{pH - pKa(H_2CO_3(aq))}$ $= 10^{7.4-6.1} = 20$ **[1]**	2 marks		2	

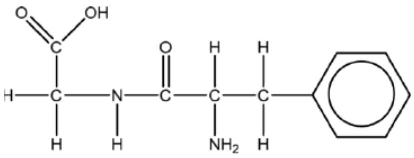
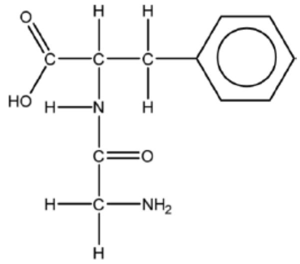
Question A2				COMPETENCES		
		Page 1/2	Marks	KC	AP	AE
a)	i.	$2I^-(aq) \rightarrow I_2(aq) + 2e^-$	1 mark	1		
	ii.	$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	1 mark	1		
	iii.	$2I^-(aq) + 2Fe^{3+}(aq) \rightarrow I_2(aq) + 2Fe^{2+}(aq)$	1 mark		1	
	iv.	E.m.f. = +0.77 – 0.54 = +0.23V	1 mark		1	
	v.	 **[**Assign **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**]**	4 marks	1	3	
	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:** $NO_2^-(aq) + H_2O(l) \rightarrow NO_3^-(aq) + 2H^+(aq) + 2e^-$ **[1]** **Reduction:** $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^{-\,+} \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$ **[1]**	2 marks		2	
	ii.	$Cr_2O_7^{2-}(aq) + 3NO_2^-(aq) + 8H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3NO_3^-(aq) + 4H_2O(l)$ **[2]**	2 marks		2	
	iii.	Mol $Cr_2O_7^{2-}$: 0.0108 dm^{-3} x 3.00 x 10^{-1} mol dm^{-3} = 3.24 x 10^{-3} mol **[1]** Mol NO_2^- : 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. $K^+(l) + e^- \rightarrow K(l)$ [1 mark AE]	1 mark			1
	$2Br^-(l) \rightarrow Br_2(l) + 2e^-$ **[1]**	1 mark			1
	ii. At the positive electrode, formation of Bromine. $n_e = \frac{I \times t}{F}$ **[1]** $n_e = \frac{3.00A \times 1800\ s}{9.65 \times 10^4\ mol^{-1}} = 5.56 \times 10^{-2} mol\ e^-$ **[1]** Mass of Br_2: $5.56 \times 10^{-2} \times ½ \times 159.8 = 4.47$ g **[1]**	3 marks	1	2	
	iii. You would expect the formation of $O_2(g)$ at the anode, and the formation of $H_2(g)$ at the cathode. **[1]** The couple H_2O/H_2 has a less negative E_{red} than the K^+/K couple therefore it would be preferred. **[1]** The oxidation of water to $O_2(g)$ would be preferred over the oxidation of bromide ion as the couple Br_2/Br^- has a more positive E_{red} than the O_2/H_2O 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 $H_2SO_{4(aq)}$ is replaced with diluted $H_2SO_{4(aq)}$ the equilibrium is shifted towards the reactants **[1]**. This is explained by the Le Chatelier principle, related to the addition of H_2O (product). **[1]**	2 marks		1	1
	iv.	H_2SO_4 catalyzes the reaction. **[1]**	1 mark	1		
	v.	3-methylbutan-1-ol **[1]**	1 mark	1		
	vi.	By radiolabelling 3-methylbutanol with the ^{18}O radioisotope. **[1].** If after the reaction with butanoic acid the ^{18}O 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 ^{18}O in the HO-group [1] of the butanoic acid.***	2 marks	1		1
b)	i.	 secondary alcohol 3-methylbutan-2-ol **[1]**  tertiary alcohol 2-Methylbutan-2-ol **[1]** **[1]+[1]**	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 $KMnO_4$(aq) (***or*** $K_2Cr_2O_7$) **[1]** Correct balanced reaction **[1]**	2 marks	1	1	

Question B1				
		COMPETENCES		
Page 2/2	**Marks**	**KC**	**AP**	**AE**
iv.  **[1]**	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]**	1 mark		1	
ii.  ***Salicylic acid*** [1] ***Ethanoic acid*** [1]	2 marks		2	

Question B2				COMPETENCES		
		Page 1/2	**Marks**	**KC**	**AP**	**AE**
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.	 **[1] + [1]**	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]**	1 mark		1	
	v.	 **[1]**	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		
	Page 2/2	**Marks**	**KC**	**AP**	**AE**
	ix.  **[1]**  **[1]**	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]** $n(\text{dye}) = n(\text{A}) = \frac{m(\text{dye})}{M(\text{dye})} = \frac{100}{316}$ = 0.316 mol = 3.16 x 10^{-1}mol **[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		