CHEMISTRY

DATE : 11 June 2015

DURATION OF EXAMINATION :

3 hours (180 minutes)

PERMITTED EQUIPMENT :

Calculator : TI-Nspire in 'Press-to-Test' mode

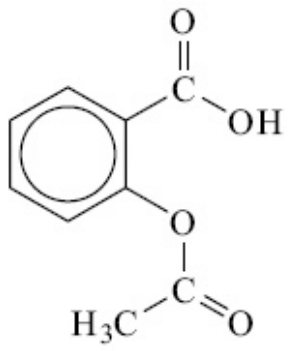
INSTRUCTIONS :

- Answer both A questions and both B questions.
- Use a separate answer sheet for each of the four main questions.

Question A1

Page 1/3 | **Marks**

a) Aspirin, acetylsalicylic acid, is a monoprotic acid with the following structural formula :



Aspirin

i. Give the Brønsted definition of an acid. — 1 mark

ii. Give the structural formula of the acetylsalicylate ion, that is the conjugate base of acetylsalicylic acid. — 1 mark

For simplicity, in the questions that follow and in your answers, acetylsalicylic acid should be designated by just HA.

b) i. Write the equation for the reaction of acetylsalicylic acid, HA(aq), with water. — 2 marks

ii. Give the expression for the acid dissociation constant, K_a, for acetylsalicylic acid, HA(aq). — 1 mark

iii. Calculate the pH of the solution obtained by dissolving 1.80 g of acetylsalicylic acid in distilled water and making the total volume up to 1.00 dm^3. — 4 marks

The pH of the gastric juice in the stomach is around 2.

iv. Explain, using its pK_a value, why acetylsalicylic acid exists mainly in the undissociated form in the stomach. — 2 marks

Given: pK_a of acetylsalicylic acid : 3.5

Molar molecular mass of acetylsalicylic acid (in g mol^{-1}) : 180

Question A1	
Page 2/3	**Marks**
c) When undissociated acetylsalicylic acid stays in the stomach for too long it can cause stomach ulcers. This is why different formulations, such as sodium acetylsalicylate, NaA(s), exist that are less aggressive to the walls of the stomach. Sodium acetylsalicylate is soluble in water. **i.** Explain why.	2 marks
ii. Give the equation for the reaction that occurs when sodium acetylsalicylate comes into contact with the acid in the stomach.	1 mark
d) The label on a box of aspirin tablets states: "Aspirin content: 100 mg per tablet". A student wanted to check the mass of acetylsalicylic acid, HA, in a tablet. A solution was prepared by placing one aspirin tablet in a 500 cm^3 volumetric flask, dissolving it in distilled water and then making it up the 500 cm^3 mark with distilled water. 100 cm^3 of this solution was titrated with 1.00 x 10^{-2} mol dm^{-3} sodium hydroxide solution, NaOH(aq). Phenolphthalein was used as the indicator. The volume of sodium hydroxide solution required to reach the equivalence point, V(NaOH), was 10.7 cm^3. **i.** Give the equation for the reaction occurring during the titration.	1 mark
ii. Using the titration result, calculate the amount (in mol) of acetylsalicylic acid in 100 cm^3 of the solution before it was titrated.	2 marks
iii. From the titration result, determine the mass of acetylsalicylic acid contained in the tablet.	2 marks
iv. Determine the percentage difference based on the value found in **iii.** and the value stated on the label.	1 mark
v. Explain why phenolphthalein is used as the indicator whereas methyl red cannot be used in this titration.	1 mark
Given: pK_a of phenolphthalein : 9.3 ; pK_a of methyl red: 5.1 Molar molecular mass of acetylsalicylic acid (in g mol^{-1}) : 180	

Question A1	
Page 3/3	**Marks**
e) One can also find aspirin tablets that effervesce when dissolved in water. They include sodium hydrogencarbonate, $NaHCO_3(s)$.	
i. Give the equation for the reaction that occurs between acetylsalicylic acid and sodium hydrogencarbonate when the tablet is dissolved in water.	2 marks
ii. Explain, using their respective pK_a values, why acetylsalicylic acid and sodium hydrogencarbonate react together when in aqueous solution.	2 marks
Given: pK_a of acetyl salicylic acid : 3.5 pK_a of carbonic acid $H_2CO_3(aq)$ = 6.4	

Question A2

Page 1/3 | **Marks**

a) i. Using the relevant couples from the table below, give the half-equations for oxidation and reduction and the overall redox equation for the formation of silver(I) oxide, $Ag_2O(s)$, when silver reacts with oxygen in a humid atmosphere. — 3 marks

Given: Standard redox potentials :

Couple	$E^{\ominus}$ / V
$Ag_2O(s)$ /$Ag(s)$	+ 1.17
$O_2(aq)$ /$H_2O(l)$	+ 1.23

Silver, Ag(s), does not react with hydrochloric acid, HCl(aq), but does react with nitric acid, $HNO_3(aq)$.

ii. Explain this difference in behaviour using the table below. — 3 marks

Given: Standard redox potentials :

Couple	$E^{\ominus}$ / V
$H^+(aq)/H_2(aq)$	0,00
$Ag^+(aq)/Ag(s)$	+ 0.80
$NO_3^-(aq)/NO(g)$	+ 0.96
$Cl_2(g)/Cl^-(aq)$	+ 1.36

b) The tarnishing of silver is a complex process that involves hydrogen sulphide, $H_2S(g)$. It can be summarised by the following unbalanced equation :

$$Ag(s) + H_2S(g) + O_2(g) \rightarrow Ag_2S(s) + H_2O(l)$$

i. Determine the oxidation numbers of the four elements that appear on both sides of this equation. — 4 marks

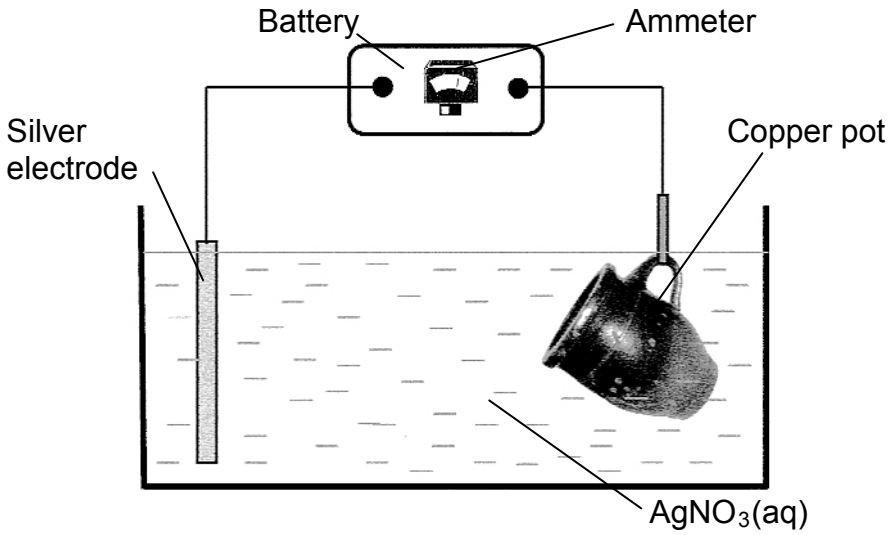
Question A2	
Page 2/3	**Marks**
ii. Identify the species that is oxidised and the species that is reduced.	2 marks
iii. Balance the equation given in **b)** above.	1 mark
c) When silver corrodes, a thin dark-grey layer composed of silver(I) sulphide, $Ag_2S(s)$, is formed. The silver(I) sulphide can be removed by bringing the corroded silver object into contact with a piece of aluminium foil, Al(s), in a bath of warm salty water. The unbalanced equation for the reaction occurring is : $\mathbf{Al(s) + Ag_2S(s) \longrightarrow Al^{3+}(aq) + S^{2-}(aq) + Ag(s)}$	
i. Give the oxidation half-equation.	1 mark
ii. Give the reduction half-equation.	1 mark
iii. Give the balanced overall equation for the reaction.	1 mark
The remainder of this question is on the next page.	

Question A2

Page 3/3	Marks

d) A surface coating on a metal, obtained by electrolysis, can be used as a protection against corrosion or to change the appearance of the metal or for both of these reasons.

The electrolytic cell described below was used to cover the surface of a copper pot with silver by electrolysis .



i. Indicate the polarity of the electrode made from the copper pot which becomes covered in silver. — 1 mark

ii. Give the half-equations of the two main reactions taking place at the electrodes. — 2 marks

iii. Explain why a silver electrode is used rather than an inert electrode, such as graphite. — 1 mark

A copper pot has a total surface area of 600 cm^2 and is to be uniformly covered by a layer of silver 3.00 x 10^{-3} cm thick.

iv. Show by calculation that the mass of silver required to cover the pot is 18.9 g. — 2 marks

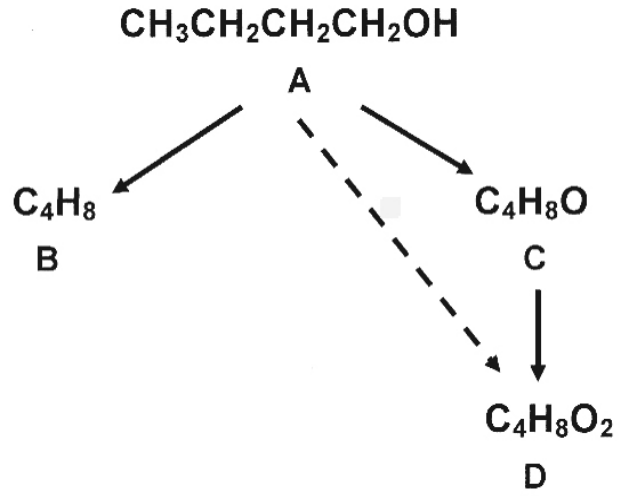
A steady current of 5.00 x 10^{-1} A is used.

v. Calculate the time, <u>in seconds</u>, it will take to cover the pot with a layer of silver 3.00 x 10^{-3} cm thick. — 3 marks

<u>Given :</u> 1 *F* = 9.65 x 10^4 C mol^{-1}
Density (in g cm^{-3}) of Ag : 10.5
Molar atomic mass (in g mol^{-1}) of Ag : 108

Question B1	
Page 1/2	**Marks**

a) **A, B, C** and **D** are four organic compounds.
B, C and **D** can be made from **A**.



i. Give the systematic (IUPAC) name of compound **A.** — 1 mark

ii. Give the structural formula and systematic name (IUPAC) of compound **B**. — 2 marks

iii. Name the type of reaction that occurs when **A** is converted into **B** and suggest an appropriate catalyst. — 2 marks

Compound **C** gives a positive test with Fehling's solution.

iv. Give the structural formula and systematic name (IUPAC) name of compound **C**. — 2 marks

The reactions for the conversion of **A** to **C** and from **C** to **D** involve oxidation in acid solution.

v. Give the half-equation for the reduction of one of the oxidising agents commonly used in these reactions. — 2 marks

vi. Place compounds **A, B** and **C** in increasing order of their boiling points and explain your reasoning. — 3 marks

B1 torsdag lektion 3 vecka 19

Question B1

Marks

b) Linoleic acid, $C_{17}H_{31}COOH$, and linoleneic acid, $C_{17}H_{29}COOH$, both contain eighteen carbon atoms and have very similar molar molecular masses.
The iodine index is expressed as the mass of iodine, $I_2(s)$, in g, which reacts with 100 g of an organic compound.

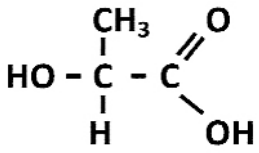
i. What information does the iodine index provide about an organic compound? — 1 mark

ii. Calculate the iodine index for linoleic acid, $C_{17}H_{31}COOH$. — 3 marks

iii. On the basis of their molecular structures, deduce the ratio between the iodine index for linoleneic acid and the iodine index for linoleic acid. — 2 marks

Given: Molar atomic mass (in g mol^{-1}) of I : 127
Molar molecular mass (in g mol^{-1}) of linoleic acid: 280

c) A molecule of lactic acid contains two functional groups. Molecules of lactic acid can react amongst themselves to form a condensation polymer.
The polymer formed from lactic acid is used, among other things, for tissue implants and surgical sutures.



Lactic acid

i. Give the systematic (IUPAC) name for lactic acid. — 1 mark

ii. Represent, using the structural formula, a portion of the polymer made from three molecules of lactic acid. — 2 marks

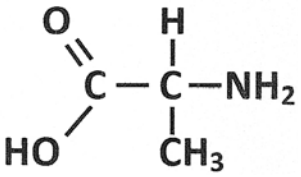
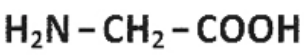
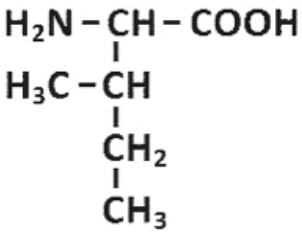
iii. Represent, using the structural formula, the repeating unit of the polymer made from lactic acid. — 1 mark

iv. State the type of condensation polymer formed. — 1 mark

Lactic acid exists in two enantiomeric forms.

v. Draw the three-dimensional representation of the two enantiomers of lactic acid. — 2 marks

Question B2

Page 1/3	Marks
a) Alanine is an amino acid with the following structural formula :  **Alanine**	
i. Give the systematic (IUPAC) name for this amino acid.	1 mark
Amino acids are amphoteric substances.	
ii. Taking alanine as an example and using the simplified structural formulas write two equations that illustrate this property.	2 marks
iii. State the meaning of isoelectric point with regard to amino acids.	1 mark
iv. Explain why alanine has a relatively high melting point.	2 marks
b) Glycine and isoleucine are two other amino acids with the following structural formulas :  **Glycine**  **Isoleucine**	
Unlike glycine, isoleucine can show optical activity.	
i. Explain what is meant by optical activity.	1 mark
ii. Using their structural formulas, explain why isoleucine can show optical activity whereas glycine cannot.	1 mark
iii. Explain why these two amino acids are soluble in water.	2 marks
iv. Explain why isoleucine is less soluble in water than glycine.	1 mark

Question B2

Page 2/3 | **Marks**

In order to prepare a certain dipeptide, the following three successive reactions were performed :

- Reaction **A** : An ester was made by reacting isoleucine, $CH_3CH_2CH(CH_3)CH(NH_2)COOH$, with methanol, CH_3OH.
- Reaction **B** : The ester obtained from reaction **A** was then reacted with glycine, H_2NCH_2COOH.
- Reaction **C** : One of the product from reaction **B** was then hydrolysed to obtain the required dipeptide and methanol.

v. Using the simplified structural formulas, such as those given above, write the equations for the two reactions **A** and **B**. — 4 marks

vi. State two necessary experimental conditions for reaction **A**. — 2 marks

vii. Give the structural formula of the dipeptide obtained from reaction **C**. — 2 marks

The remainder of this question is on the next page.

Question B2

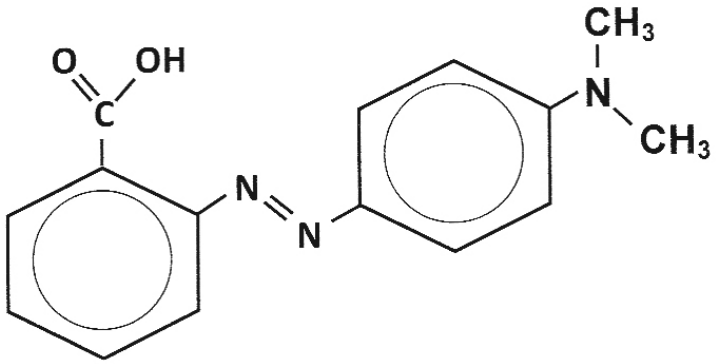
Page 3/3 | **Marks**

c) Methyl red is used as an acid base indicator.

Methyl red is a weak acid with a pK_a value of 5.1.

In aqueous solution its colour is red when the pH is below 4.4, yellow if the pH is above 6.2, and orange if the pH lies between these two pH values.

The structure of methyl red is given below.



Methyl red

i. Name the oxygen-containing functional group and the two nitrogen-containing functional groups present in the molecule. — 3 marks

ii. Give the structural formula of the dominant form of methyl red when the pH is greater than 6.2. — 1 mark

iii. Explain, by referring to its molecular structure, why this compound is coloured. — 2 marks