Lisachem Materials

Chemistry Physics Biology
Psychology

VCE CHEMISTRY 2007
FOOD CHEMISTRY
UNIT 4

Time allowed: 50 minutes
Total marks: 40

SECTION A
Contains 12 multiple choice questions

SECTION B
4 Extended response questions

A data sheet and multiple choice answer sheet are provided. Answer extended response questions in the space provided. Use the marks and time allowed as a guide to how much time you should spend answering each question.

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relative atomic number
symbol
name
relative atomic mass

1 H Hydrogen 1.0																	2 He Helium 4.0
3 Li Lithium 6.9	4 Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminium 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulfur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 44.9	22 Ti Titanium 47.9	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.9	27 Co Cobalt 58.9	28 Ni Nickel 58.7	29 Cu Copper 63.6	30 Zn Zinc 65.4	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
37 Rb Rubidium 85.5	38 Sr Strontium 87.6	39 Y Yittrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium 98.1	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Caesium 132.9	56 Ba Barium 137.3	57 La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Ha Hahnium (262)	106 Sg Seaborgium (266)	107 Ns Neilsbohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (272)	111 Rg Roentgenium (272)	112 Uub Ununbium (277)		114 Uuq Ununquadium (289)				

	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.3	63 Eu Europium 152.0	64 Gd Gadolinium 157.2	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
Lanthanide series														
Actinide series	90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium 237.1	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (255)	103 Lr Lawrencium (256)

Data Sheet VCE Chemistry 2007 Food Chemistry Unit 4

Physical Constants

F = 96 500 C mol^{-1}

R = 8.31 JK^{-1} mol^{-1}

V_m (STP) = 22.4 L mol^{-1}

V_m (SLC) = 24.5 L mol^{-1}

Specific heat of water = 4.18 J g^{-1} $^oC^{-1}$

Ideal gas equation

$pV = nRT$

The Electrochemical Series

		$E°$ in volt
$F_2(g) + 2e^-$	$\rightarrow 2F^-(aq)$	+ 2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^-$	$\rightarrow 2H_2O(l)$	+ 1.77
$Au^+(aq) + e^-$	$\rightarrow Au(s)$	+ 1.68
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+ 1.50
$Cl_2(g) + 2e^-$	$\rightarrow 2Cl^-(aq)$	+ 1.36
$O_2(g) + 4H^+(aq) + 4e^-$	$\rightarrow 2H_2O(l)$	+ 1.23
$Br_2(l) + 2e^-$	$\rightarrow 2Br^-(aq)$	+ 1.09
$Ag^+(aq) + e^-$	$\rightarrow Ag(s)$	+ 0.80
$Fe^{3+}(aq) + e^-$	$\rightarrow Fe^{2+}(aq)$	+ 0.77
$I_2(s) + 2e^-$	$\rightarrow 2I^-(aq)$	+ 0.54
$O_2(g) + 2H_2O(l) + 4e^-$	$\rightarrow 4OH^-(aq)$	+ 0.40
$Cu^{2+}(aq) + 2e^-$	$\rightarrow Cu(s)$	+ 0.34
$CO_2(g) + 8H^+(aq) + 8e^-$	$\rightarrow CH_4(g) + 2H_2O(l)$	+ 0.17
$S(s) + 2H^+(aq) + 2e^-$	$\rightarrow H_2S(g)$	+ 0.14
$2H^+(aq) + 2e^-$	$\rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^-$	$\rightarrow Pb(s)$	- 0.13
$Sn^{2+}(aq) + 2e^-$	$\rightarrow Sn(s)$	- 0.14
$Ni^{2+}(aq) + 2e^-$	$\rightarrow Ni(s)$	- 0.23
$Co^{2+}(aq) + 2e^-$	$\rightarrow Co(s)$	- 0.28
$Fe^{2+}(aq) + 2e^-$	$\rightarrow Fe(s)$	- 0.44
$Zn^{2+}(aq) + 2e^-$	$\rightarrow Zn(s)$	- 0.76
$2H_2O(l) + 2e^-$	$\rightarrow H_2(g) + 2OH^-(aq)$	- 0.83
$Mn^{2+}(aq) + 2e^-$	$\rightarrow Mn(s)$	- 1.03
$Al^{3+}(aq) + 3e^-$	$\rightarrow Al(s)$	- 1.67
$Mg^{2+}(aq) + 2e^-$	$\rightarrow Mg(s)$	- 2.34
$Na^+(aq) + e^-$	$\rightarrow Na(s)$	- 2.71
$Ca^{2+}(aq) + 2e^-$	$\rightarrow Ca(s)$	- 2.87
$K^+(aq) + e^-$	$\rightarrow K(s)$	- 2.93
$Li^+(aq) + e$	$\rightarrow Li(s)$	- 3.02

Student name.....

VCE Chemistry 2007 Food Chemistry Unit 4

SECTION A
MULTIPLE CHOICE ANSWER SHEET

Instructions:

For each question choose the response that is correct or best answers the question.
Circle the chosen response on this answer sheet.
Only circle **one** response for each question.

Question 1.	A	B	C	D
Question 2.	A	B	C	D
Question 3.	A	B	C	D
Question 4.	A	B	C	D
Question 5.	A	B	C	D
Question 6.	A	B	C	D
Question 7.	A	B	C	D
Question 8.	A	B	C	D
Question 9.	A	B	C	D
Question 10.	A	B	C	D
Question 11.	A	B	C	D
Question 12.	A	B	C	D

VCE Chemistry 2007 Food Chemistry Unit 4

SECTION A - [12 marks, 15 minutes]

This section contains 12 multiple choice questions.
For each question choose the response that is correct or best answers the question.
Indicate your answer on the answer sheet provided.
*(Choose only **one** answer for each question.)*

Question 1
In a polysaccharide molecule the saccharide units are joined by

A. an ester functional group.
B. a hydroxy functional group.
C. a carboxy functional group.
D. a ether functional group.

Question 2
The main material that a plant uses to store its energy is in the form of

A. starch.
B. glucose.
C. glycogen.
D. cellulose.

Question 3
The chemical process most likely to occur during the denaturing of a protein is

A. the formation of disulfide linkages.
B. an hydrolysis reaction.
C. a condensation reaction.
D. a reduction reaction.

Question 4
Which one of the following would provide the **least** amount of available energy to humans?

A. 10.0 g of fat.
B. 20.0 g of glucose.
C. 20.0 g of cellulose.
D. 10.0 g of sucrose.

Question 5
A fat containing only one type of fatty acid had the molecular formula $C_{57}H_{98}O_6$. When this fat is hydrolysed the molecular formula for the fatty acid would be

A. $C_{18}H_{32}O_2$.
B. $C_{19}H_{32}O_2$.
C. $C_{17}H_{32}O_2$.
D. $C_{18}H_{31}O_2$.

Question 6
The structure of an α-amino acid has

A. the carboxy and amino functional groups attached to two different carbon atoms.
B. the amino and carboxy functional groups attached to the same carbon atom.
C. the carboxy and amino functional groups attached to two adjacent carbon atoms.
D. the amino functional group protonated and the carboxy functional group deprotonated.

Question 7
Which one of the following processes will result in a decrease in the amount of carbon dioxide in the atmosphere?

A. Respiration.
B. Warming of the oceans.
C. The deposition of limestone on the ocean floors.
D. Volcanic activity.

Question 8
Which one of the following nitrogen containing species does not play a significant role in the nitrogen cycle?

A. NH_4^+
B. NO_3^-
C. H_2NCONH_2
D. CH_3NH_2

Question 9
When a protein is hydrolysed the total mass of the amino acids produced will be

A. the same as the mass of the original protein.
B. less than the original mass of the protein.
C. greater than the original mass of protein.
D. will depend on the protein being hydrolysed.

Question 10
Which one of the following statements is **not** correct in relation to enzymes?

A. The function of an enzyme can be significantly reduced by changing the pH of the reaction medium.
B. An enzyme can catalyse reactions at much lower temperatures compared with inorganic catalysts.
C. An enzyme can catalyse a variety of reactions.
D. Heating an enzyme can cause it to denature.

Question 11
Proteins are one of the three main food groups and are

A. not produced by plants.
B. mainly used in animal diets for growth and repair functions.
C. used as a significant source of energy for animals in their diets.
D. polymers of amino acids joined by ester functional groups.

Question 12
The food additive that would be used to prevent a monounsaturated fat from becoming rancid, would be

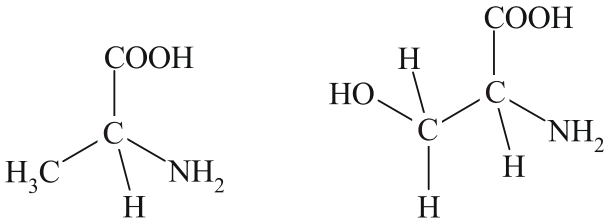
A. a thickener.
B. an emulsifier.
C. a preservative.
D. an antioxidant.

End of Section A

SECTION B - [28 marks, 35 minutes]

This section contains four questions, numbered 1 to 4.
All questions should be answered in the spaces provided.
The mark allocation and approximate time that should be spent on each question are given.

Question 1 - [9 marks, 10 minutes]
The structures for the two amino acids alanine and serine are shown below.



Alanine Serine

a. The small changes to structures of amino acids in solution can be achieved by changing the pH of the solution.

i. Explain why the structures of amino acids in solution are effected by the pH of the solution?

1 mark

ii. Draw the structure for alanine in solution at low pH.

1 mark

iii. Draw the zwitterion structure for serine

1 mark

b. What type of chemical reaction occurs when amino acids react to form proteins?

1 mark

c. Draw the structures for the two possible dipeptides that would form when alanine reacts with serine.

2 marks

d. The shape and function of proteins is determined by the combination of their primary, secondary and tertiary structures.

i. What is the primary structure of a protein?

1 mark

ii. What is the main type of chemical bonding involved in the primary structures of proteins?

1 mark

iii. The formation of disulfide linkages influences which of the three component structures of a protein? (Circle the correct response.)

Primary Secondary Tertiary

1 mark

Question 2 - [8 marks, 10 minutes]

a. A 3.762 g sample of a food was burnt in a bomb calorimeter with a calibration factor of 6920 J $°C^{-1}$ and produced a 16.3 °C increase in temperature of the calorimeter and its contents.

i. Calculate the amount of energy released by this food and express it in kJ g^{-1}.

2 marks

ii. Which of the three main food groups would make up most of this food?

1 mark

iii. Give a reason to support your answer to ii. above.

1 mark

b. Chemical analysis of a fatty acid revealed that it had the molecular formula $C_{19}H_{32}O_2$.

i. What type of fatty acid is this?

1 mark

ii. Write an appropriate chemical equation for the complete oxidation of this fatty acid.

1 mark

c. When a fat is hydrolysed fatty acids and another compound are formed.

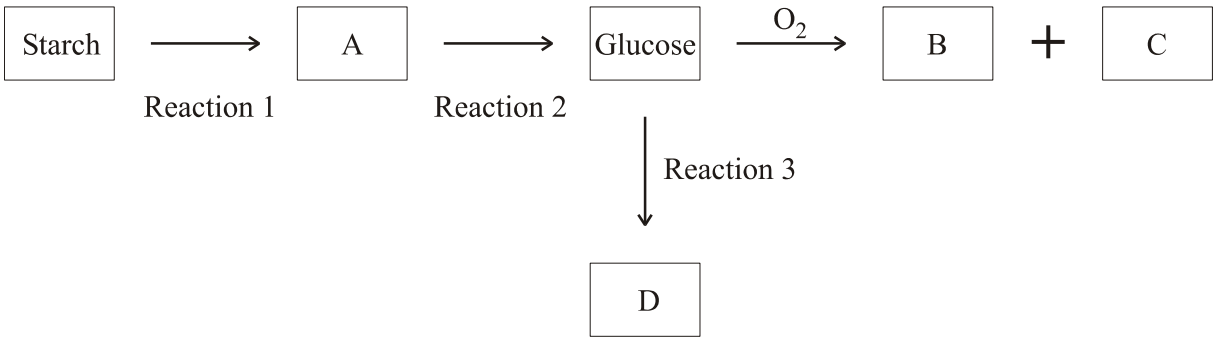
i. Draw the structure for this compound.

1 mark

ii. What is the name of this compound?

1 mark

Question 3 - [7 marks, 10 minutes]
The diagram below shows a reaction scheme that shows some of the reactions and products produced when a human consumes starch.



a. What are the compounds labelled A to D in the above reaction scheme?

A.

B.

C.

D.

4 marks

b. What processes occur during the following reactions?

Reaction 1

Reaction 2

Reaction 3

3 marks

Question 4 - [4 marks, 5 minutes]
Emulsifying agents are added to many processed foods.

a. What is an emulsion?

1 mark

b. What are the two common types of emulsions found in processed foods and give a food example of each type.

2 marks

c, What are the chemical structural features that a substance must have for it to be able to act as an emulsifying agent?

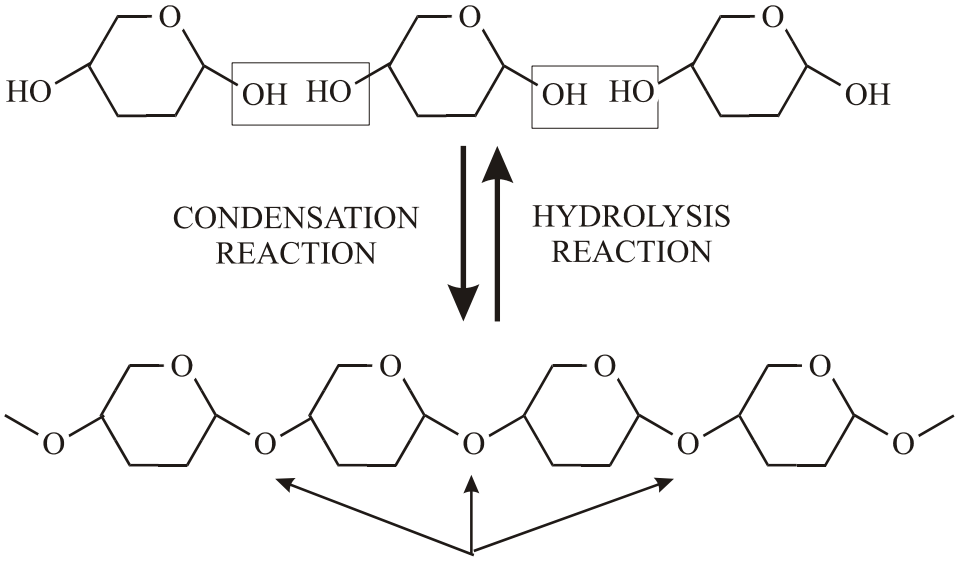
1 mark

END OF TASK

Suggested Answers VCE Chemistry 2007 Food Chemistry Unit 4

SECTION A [1 mark per question.]

Q1 D The functional group that joins the saccharide units in a polysaccharide is the **ether functional group**. Polysaccharides are formed by condensation reactions between two hydroxy groups from the saccharide units to form the ether functional group and water. This can be represented diagrammatically as shown below.

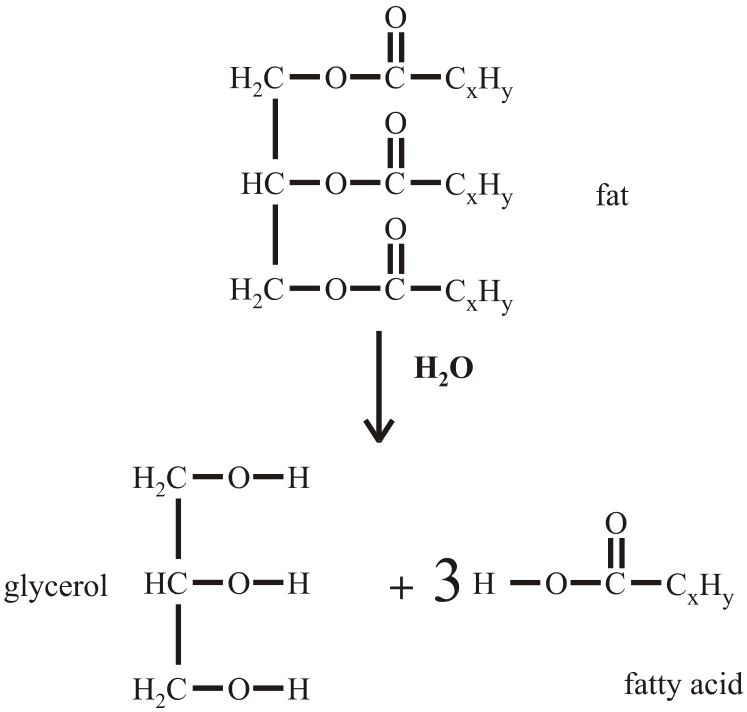


Q2 A Plants produce glucose during photosynthesis then either use this to produce energy or cellulose for structural growth. **Excess glucose** is polymerised and **stored in the form of starch** which the plant can use or provide as a source of energy for its seeds while they are germinating.

Q3 A When proteins are denatured it is their secondary and tertiary structures that are mainly affected. Of the responses only response A would satisfy this criterion, since the formation of disulfide linkages, –S–S–, will alter the tertiary structure of many proteins. Hydrolysis and condensation reactions would change the size of the protein molecules thereby altering the protein and its primary structure. A reduction reaction would change the nature of the protein, most likely changing the functional groups attached to carbon atoms on the side chains (R or Z groups).

Q4 C Since the human body only digests a small portion of the cellulose, commonly referred to as dietary fibre, that is consumed, as a result of microbial action in the digestive system, this would provide the least amount of **available energy**.

Q5 A Fats are triglycerides and the hydrolysis reaction can be represented by the structure shown in the diagram below.
In this structure the glycerol residue contributes C_3H_5 to the molecular formula, therefore the fatty acid contribution to formula would be
C: 57 – 3 = 54 H: 98 – 5 = 93
Since there are three fatty acid molecules, C_xH_yCOOH, then each would contribute C: 54/3 = 18 and H: 93/3 = 31
An additional hydrogen atom, the acidic proton of the carboxy group has to be added, therefore **$C_{18}H_{32}O_2$.**



Alternative approach: Allowing the fatty acid to be represented as C_xH_yCOOH and glycerol $C_3H_8O_3$
From this it can be seen that the number of carbon atoms in the fat will be
3x + 3 from the fatty acid and 3 from the glycerol = 3x + 6
3x + 6 = 57 therefore 3x = 51 therefore **x = 17**
The number of hydrogen atoms will be 3y from the fatty acid and 5 from the glycerol = 3y + 5
3y + 5 = 98 therefore 3y = 93 therefore **y = 31**
The fatty acid is $C_{17}H_{31}COOH$ = **$C_{18}H_{32}O_2$**

Q6 B The structure of α-amino acids have **both the amino and carboxy functional groups attached to the same carbon atom**.

While the amino acid can be in its zwitterion form at neutral pH's, response D could refer to any type of amino acid and is not specific for α-amino acids.

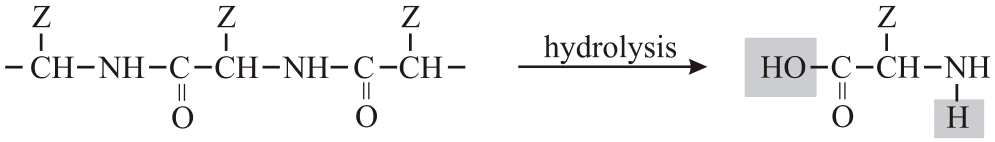
Q7 C The **deposition of limestone, $CaCO_3$, from the oceans** will allow more carbon dioxide to dissolve in the water as a result of the shifts to the right in the following equilibria reactions,

$CO_2(g) \rightleftharpoons CO_2(aq)$
$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$
$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$
$HCO_3^-(aq) + H_2O(l) \rightleftharpoons CO_3^{2-}(aq) + H_3O^+(aq)$
$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightleftharpoons CaCO_3(s)$

Respiration and volcanic activity both result in CO_2 entering the atmosphere. Warming of the Earth's oceans will result in an increase in atmospheric CO_2 because CO_2 is less soluble at higher temperatures.

Q8 D Methylamine, CH_3NH_2, plays the least important role in the nitrogen cycle. Both the ammonium, NH_4^+, and nitrate, NO_3^-, ions play a significant role in the nitrogen cycle in soils and plants, while urea, H_2NCONH_2, is the molecule that animals use to excrete waste nitrogen from their bodies.

Q9 C An hydrolysis reaction will break the protein into its component amino acids. In this process **water molecules are added as the peptide (amido) link is broken**. Therefore the total mass of the amino acids produced will be greater than the protein they were produced from.



Q10 C **Enzymes catalyse specific reactions** because of their structure that requires the binding of specific substrate structures to their active sites in what is referred to as a *lock and key mechanism*. Like a lock only a the correct key shape will fit, thereby allowing enzymes to catalyse only specific reactions. A good example of this is the enzyme amylase which will only catalyse the hydrolysis of starch to maltose. Amylase will not catalyse the hydrolysis of cellulose which is also a polymer of glucose (polysaccharide), but with a slightly different structure.
The other responses are correct, as changing the pH and heating can lead to denaturing the protein and a loss in catalytic activity. Enzymes catalyse reactions at lower temperatures whereas inorganic catalysts require higher temperatures, such as V_2O_5 in the contact process at 450 °C.

Q11 B The main role of proteins in animal diets is **growth and repair of the organism's cells**. When proteins are digested they are broken down into their amino acids which can then be reassembled back into *new* proteins by the organism's cells. Proteins can be used to provide energy if there is insufficient fat and carbohydrate available, but this is not their role in a normal diet.

Q12 D **Monounsaturated fats contain fatty acids that have a single carbon-carbon double bond**. The carbon-carbon double bonds are **liable to oxidation** and this will result in the fat turning rancid. To prevent this, **an antioxidant** is added. Preservatives are designed to prevent the food being attacked by bacteria or moulds.

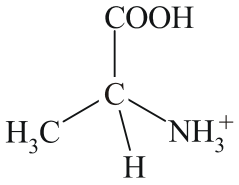
SECTION B

Question 1 - [9 marks, 10 minutes]

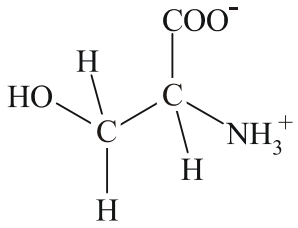
a. i. Amino acid contain both **an acidic carboxy**, -COOH, functional group which can be deprotonated at high pHs to give the carboxylate ion, $-COO^-$, and **a basic amino**, $-NH_2$, functional group that can be protonated at low pHs to form the $-NH_3^+$ ion. **[1 mark]**

ii. At low pH both the amino and carboxy functional groups will be protonated, as shown in the diagram below. **[1 mark].** At low pH, concentration of H^+ (aq) is high so the basic amino group accepts a H^+ ion to form the $–NH_3^+$ ion (protonation). Also the weak acid carboxy group does not donate its proton because the position of equilibrium for the weak acid is shifted to the left.
$X–CO0H\ (aq) + H_2O\ (aq) \rightleftharpoons \times–CO0^-\ (aq) + H_3O^+\ (aq)$.

iii. A zwitterion is the doubly ionised form of the amino acid where the acidic proton from the carboxy functional group has be removed and added to the basic amino group, as shown in the diagram below. This is one of the possible structures for amino acids at near neutral pHs. **[1 mark]**



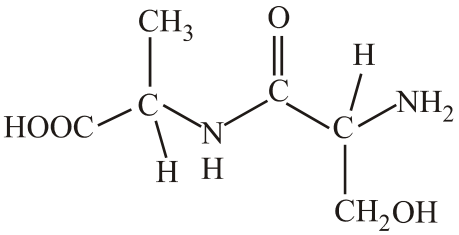
ii.

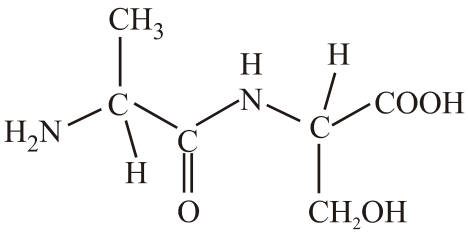


iii.

b. The chemical reaction that occurs when amino acids react to for proteins is a **condensation reaction** between the carboxy and amino functional groups to form a peptide linkage, -CONH-. **[1 mark]**

c. The are two possible structures for the dipeptide formed between alanine and serine depending on which functional groups of the amino acids reacts to form the peptide linkage. These are shown in the diagram below. **[1 mark for each correct structure]**





d. i. The primary structure of a protein is **the order or sequence of amino acid units** in the protein. **[1 mark]**

ii. The main type of chemical bonding involved in the primary structure is **covalent bonding** between the carbon and nitrogen atoms since the amino acid units are joined by peptide linkages. **[1 mark]**

iii. Disulfide linkages, -S-S-, are a major influence in the **tertiary** structure of a protein. This type of linkages can occur between side chains on the amino acid units and can lead to a folding of the main protein chain. **[1 mark]**

Question 2 - [8 marks, 10 minutes]

a. i. For the calorimeter
$E = CF \times \Delta T = 6920 \times 16.3 = 1.13 \times 10^5$ J = 113 kJ **[1 mark]**
Energy per gram = E / m = 113 / 3.762 = **30.0 kJ g^{-1} [1 mark]**

ii. **Fat or Oil [1 mark]**

iii. The energies released by each of the three main food groups when they undergo combustion are:
Carbohydrates 17 kJ g^{-1}
Fats & Oils 39 kJ g^{-1}
Protein 24 kJ g^{-1}
Fats and oils release significantly more energy than either of the other two food groups.
The **energy released from this food is 30 kJ g^{-1}, since this is significantly greater than the energy released by either carbohydrates or proteins**, therefore it must have a **high fat content**. **[1 mark]**

b. i. A fatty acid is made up of a hydrocarbon chain attached to a carboxy functional group, therefore it can be represented by the general formula, C_xH_yCOOH.
Therefore $C_{19}H_{32}O_2$ can be rewritten as $C_{18}H_{31}COOH$.
The absence or presence of carbon-carbon double bonds in the hydrocarbon chain determines if a fatty acid is saturated, monounsaturated or polyunsaturated.
Saturated hydrocarbons have the general formula C_nH_{2n+2}.
Therefore saturated C_{18} hydrocarbon chain attached to a carboxy group would have the formula $C_{18}H_{37}$ (One less H atom than the hydrocarbon itself.)
Each double carbon-carbon bond in the structure would **reduce the number of hydrogen atoms by 2**. Therefore this fatty acid has **three carbon-carbon double bonds**, thus it is a **polyunsaturated fatty acid. [1 mark]**

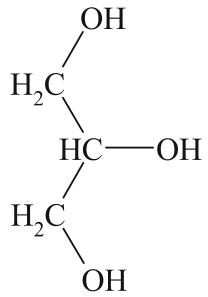
ii. The products of complete oxidation are carbon dioxide and water. The equation can be best balanced by using the following steps.

1. Write the reactants and products.
   $C_{19}H_{32}O_2 + O_2 \rightarrow CO_2 + H_2O$
2. Balance the number of carbon atoms as CO_2.
   $C_{19}H_{32}O_2 + O_2 \rightarrow \mathbf{19}CO_2 + H_2O$
3. Balance the hydrogen atoms as water
   $C_{19}H_{32}O_2 + O_2 \rightarrow 19CO_2 + \mathbf{16}H_2O$
4. Balance the number of oxygen atoms.
   On product side: $19\times2 + 16 = 54$
   On reactant side: From fatty acid 2O atoms therefore require 52 from O_2
   $C_{19}H_{32}O_2 + \mathbf{26}O_2 \rightarrow 19CO_2 + 16H_2O$
5. Add appropriate states.
   $\mathbf{C_{19}H_{32}O_2(s) + 26O_2(g) \rightarrow 19CO_2(g) + 16H_2O(l)}$ **[1 mark]**

c. Fats are triglycerides and when they are hydrolysed 3 fatty acid molecules and 1 molecule of glycerol (glycerine) are formed.
See Section A Question 5 answers for hydrolysis equation.

i. Structure shown in diagram. **[1 mark]**

ii. **Glycerol or glycerine. [1 mark]**



Question 3 - [7 marks, 10 minutes]

a. A. **Maltose [1 mark]** – the initial stage in the digestion of starch involves the hydrolysis of the polysaccharide to the disaccharide maltose.
B. **Carbon dioxide [1 mark]**
C. **Water [1 mark]** - the oxidation products of glucose in the respiration process.
D. **Glycogen [1 mark]** - excess glucose is stored in the body in the form of the polysaccharide glycogen.

b. Reaction 1. **Hydrolysis [1 mark]**
Reaction 2. **Hydrolysis [1 mark]**
Reaction 3. **Condensation [1 mark]**

Question 4 - [4 marks, 5 minutes]

a. An emulsion is a stabilised **colloidal distribution of tiny droplets of one liquid in another liquid** in which it is not soluble. **[1 mark]**

b. **Oil-in-water (O/W)** – where the tiny **oil droplets are distributed throughout the water**, examples include; **milk, ice cream, mayonnaise**. **[1 mark]**

Water-in-oil (W/O) – where the tiny **water droplets are distributed throughout the oil** phase, examples include; **margarine, butter**. **[1 mark]**

c. The chemical characteristics required for a compound to be able to act as an emulsifying agent are that it must have a **hydrophilic, water soluble, polar head** and a **hydrophobic, oil soluble, non-polar tail. [1 mark]**