

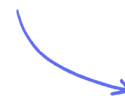
Structured Questions: Paper 2

2.2 Carbohydrates & Lipids

2.2.1 Carbohydrates / 2.2.2 Fatty Acids / 2.2.3 Lipids / 2.2.4 Skills: Visualising Carbohydrates / 2.2.5 Skills: Calculating BMI

Easy (5 questions)	/41
Medium (5 questions)	/49
Hard (5 questions)	/54
Total Marks	/144

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Easy Questions

1 (a) State the type of bond that forms between two sugar molecules in a disaccharide.

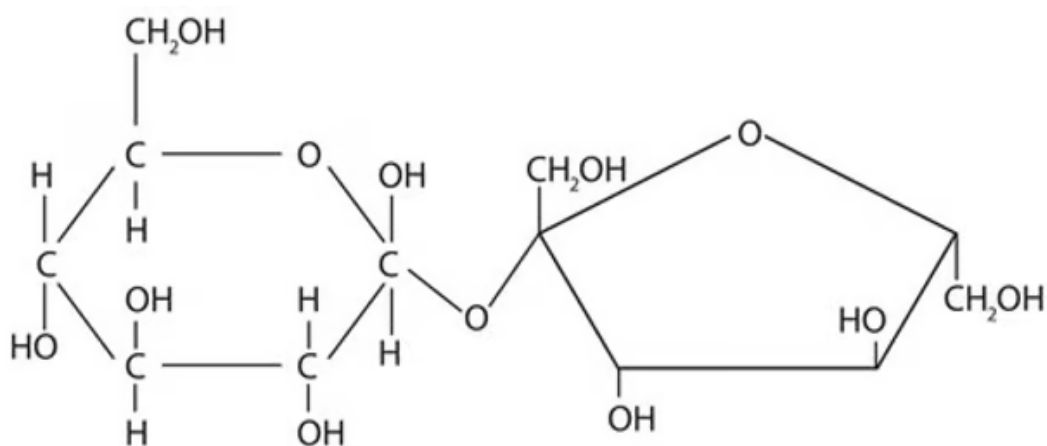
(1 mark)

(b) Place these types of carbohydrate into **decreasing** order of molecular size.

- tetrasaccharides
- monosaccharides
- polysaccharides
- disaccharides

(2 marks)

(c) A disaccharide has the formula $C_{12}H_{22}O_{11}$ and is pictured below.



Draw a ring around the chemical group that bonds two monosaccharides together.

(1 mark)

- (d) Glucose, galactose and fructose all have the same molecular formula but differ in their physical and chemical properties.

State the collective name for compounds like these, that have the same molecular formula but different properties.

(1 mark)

2 (a) List **two** properties of starch that make it an effective storage polysaccharide.

.....
.....
(2 marks)

(b) List **two** properties of cellulose that make it an effective structural polysaccharide.

.....
.....
(2 marks)

(c) State the specific type of bond in amylopectin that gives the molecule its highly branched structure.

.....
(1 mark)

(d) Glycogen has an even more branched structure than amylopectin, which makes it ideal as an energy storage molecule in animal cells.

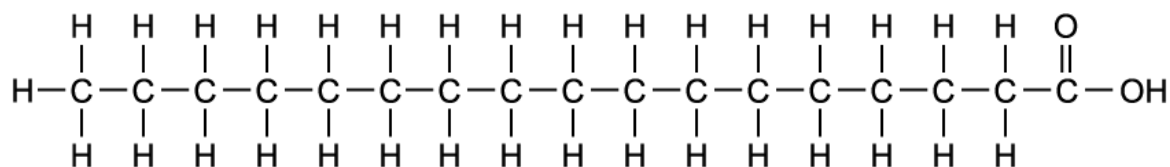
Describe how the branched structure of glycogen helps fulfil its role as a short-term energy storage compound.

.....
.....
(2 marks)

3 (a) Identify the two distinct parts of a typical fatty acid molecule.

(2 marks)

(b) The diagram shows a fatty acid.



(i) Identify the type of fatty acid shown in the diagram.

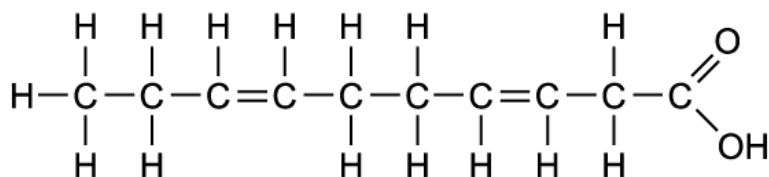
[1]

(ii) State a reason for your answer in part i).

[1]

(2 marks)

(c) The diagram shows a different fatty acid.



Use a tick (✓) in each table to identify words to describe the structure of the fatty acid shown.

Monounsaturated	Polyunsaturated	Saturated

All Cis	All Trans	Mixture of Cis- and Trans-

(2 marks)

(d) The table below gives information on two different unsaturated fatty acids.

Unsaturated Fatty Acid	Number of C=C double bonds	Melting point / °C
A	18	-5
B	18	45

(i) Identify which of these is a cis-fatty acid and which is a trans-fatty acid.

[1]

(ii) State a reason for your answer in part i).

[1]

(2 marks)

- 4 (a)** The low oxygen content of lipids enables them to be more energy-dense forms of energy storage than carbohydrates.

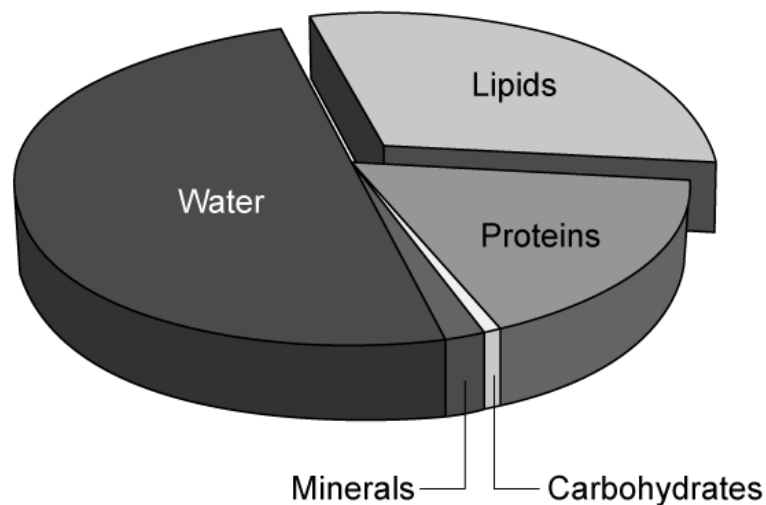
Explain why.

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(1 mark)

- (b)** Define the term 'metabolic water'.

.....
(2 marks)

- (c)** The pie chart gives the proportions of the main food groups in the yolk of a typical hen's egg, which serves as a source of nutrition for the growing embryo. This does not include the 'egg white'.



Suggest why the lipids sector of the chart is so much larger than that of carbohydrates.

.....
(1 mark)

- (d)** State the type of bond, and the number of those bonds, between fatty acids and a glycerol molecule in a typical triglyceride molecule.

(2 marks)

5 (a) One mark is awarded for clarity of communication throughout this question

A woman of height 152cm has a body mass of 55 000g.

Using the formula below, calculate the woman's Body Mass Index (BMI)

$$\text{Body Mass Index} = \frac{\text{Body mass (kg)}}{\text{Height}^2 \text{ (metres)}}$$

.....

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(3 marks)

(b) State, with an example in each case, **four** different ways in which lipids are used in nature.

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(8 marks)

(c) Draw a labelled molecular diagram of a triglyceride which contains **one** monounsaturated fatty acid.

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(4 marks)

Medium Questions

- 1 (a) The table below contains statements that could apply to three polysaccharides. Complete the table with a tick (✓) in each box if the statement applies correctly

Statement	Glycogen	Cellulose	Starch
Contains 1-6 links			
Contains α -glucose			
Contains hydrogen bonds			

.....

.....

.....

(3 marks)

- (b) Explain the name of the type of reaction that forms the carbohydrates in part (a) from their monomers.

.....

.....

(2 marks)

- (c) State **one** feature of starch and explain how this feature allows it to act as a storage substance.

.....

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(2 marks)

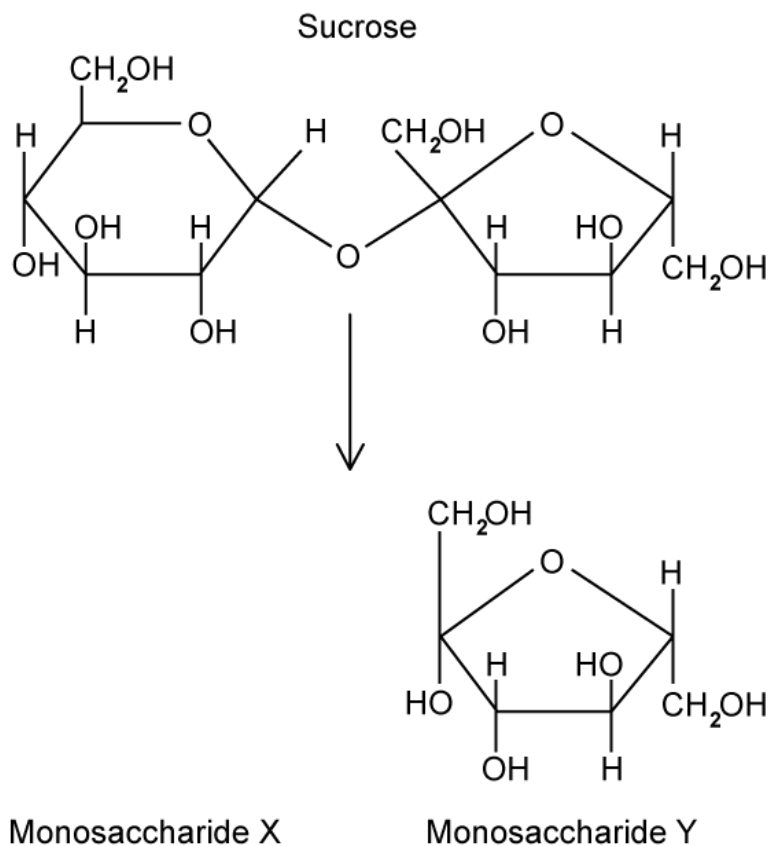
- (d) Two molecules of a disaccharide are condensed together to form a larger sugar molecule. The chemical formula of the disaccharide is $C_{12}H_{22}O_{11}$.

Deduce the formula of the resulting larger sugar molecule.

(1 mark)

2 (a) Sucrose is formed from monosaccharides **X** and **Y**.

The diagram below shows the structure of sucrose and monosaccharide **Y**.



Draw and identify monosaccharide **X**.

(2 marks)

(b) Fructose and glucose have the same molecular formula, $C_6H_{12}O_6$. However, their differing structures give them different properties; for example, fructose tastes sweeter than glucose.

Suggest one advantage to the food industry of this difference.

(1 mark)

- (c) Molecular analysis was carried out using various laboratory techniques to distinguish between samples of three different polysaccharides. Starch was separated into its constituent polysaccharides (amylose and amylopectin) before analysis. The results are shown in the table below.

Sample	Branches per molecule	Speed of hydrolysis / arbitrary units
A	87	35
B	1467	80
C	1780	98

The three samples were **amylopectin**, **glycogen** and **amylose** (not necessarily in that order).

Use your knowledge of polysaccharide structure to assign each sample to one of those three polysaccharides.

Sample	Polysaccharide
A	
B	
C	

.....

.....

.....

(3 marks)

- (d) Within animal cells, fats are used as a long-term energy storage. A carbohydrate, glycogen, is used as a short-term energy storage molecule as well.

Explain the benefits of having this kind of short-term storage system.

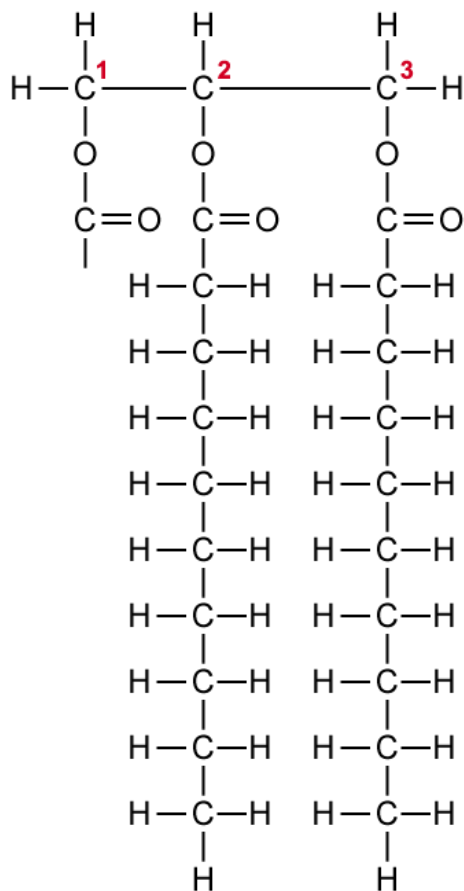
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(2 marks)

3 (a) The diagram below shows an incompletely-drawn triglyceride molecule.

Complete the drawing to show a trans-monounsaturated fatty acid chain at position 1 of the glycerol molecule.



(2 marks)

(b) As part of a 50-year study into health and diet, data was gathered in 1960 and 2000 for the numbers of deaths due to cardiovascular disease in a western European country. This data was compared to the percentage of energy provided by trans-fats in the diets of elderly men (aged 70 and above). Some of the research findings are shown below.

Year	Proportion of dietary energy from trans-fats / %	Deaths from cardiovascular disease in that year
1960	7	20 185
2000	1	15 542

Calculate the percentage decrease in numbers of deaths from cardiovascular disease between 1960 and 2000.

.....

.....

(2 marks)

- (c)** Referring to the study described in (b), post-mortem investigations of some patients who had died from cardiovascular disease revealed that fatty deposits in their diseased arteries contained high concentrations of trans-fats.

Explain why this finding, though positively correlated, does not prove causation.

.....

.....

(2 marks)

- (d)** Trans-fats have been favoured by manufacturers of processed foods.

Outline how one structural property of trans-fatty acids makes trans-fats a more attractive ingredient of choice for processed food manufacturers.

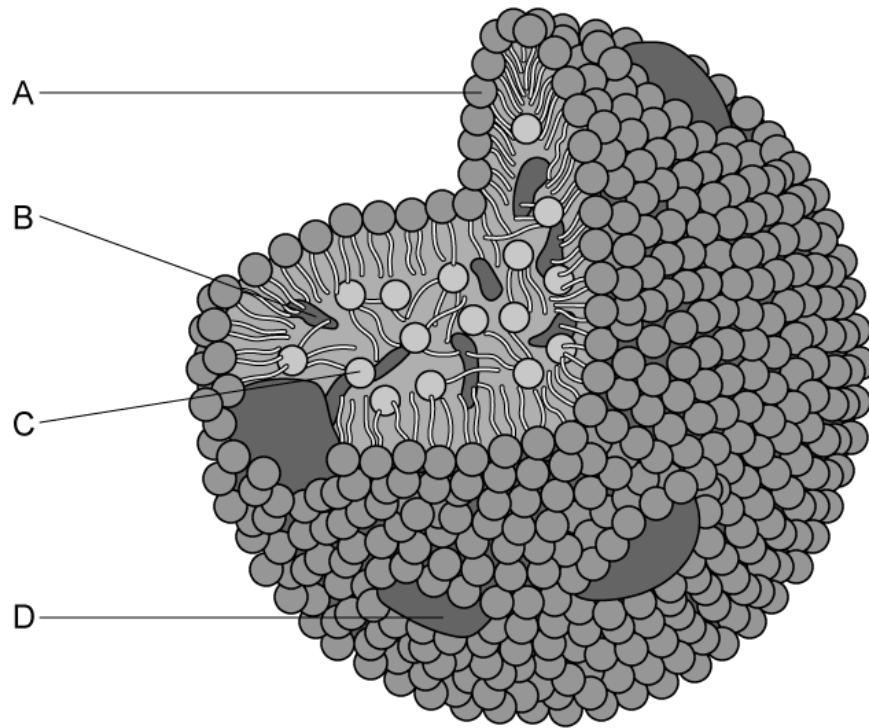
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(3 marks)

4 (a) Label the four components **A-D** of a low-density lipoprotein (LDL) complex shown in the diagram below.



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(4 marks)

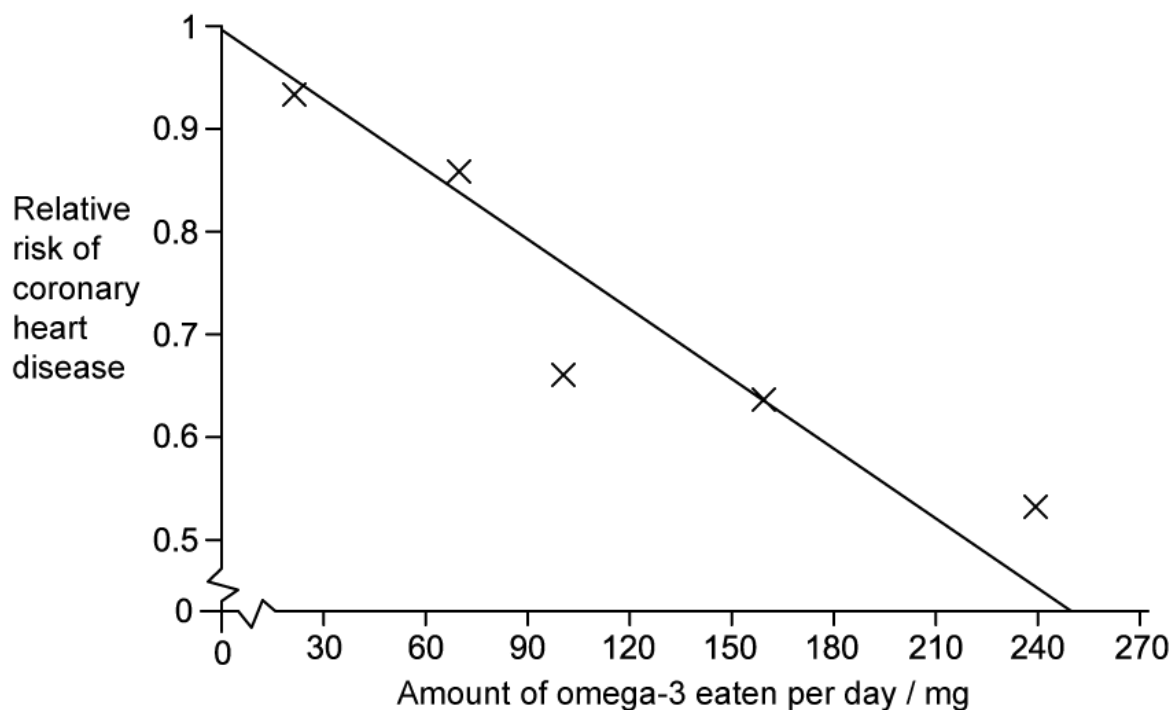
(b) State **one** function of a lipoprotein complex such as that illustrated in question (a).

.....

(1 mark)

(c) The graph below shows the data obtained by scientists investigating the effect of omega-3 fatty acid consumption on the relative risk of coronary heart disease in humans.

Figure 1



Using the data in the graph, evaluate whether coronary heart disease can be prevented by increasing omega-3 intake.

(3 marks)

- (d)** Omega-3 fats are all examples of lipids that contain polyunsaturated cis-fatty acids. In the space below, draw the appearance of one carbon-to-carbon double bond as found in a cis-fatty acid's structure. You should include in your drawing all atoms connected to each carbon atom in that double bond.

(1 mark)

5 (a) *One mark is available for clarity of communication throughout this question.*

Draw a diagram of a section of a molecule of cellulose.

Your drawing should contain no fewer than three monomers joined together.

(4 marks)

(b) Outline why lipids are more suitable for long-term energy storage than carbohydrates in animals.

(3 marks)

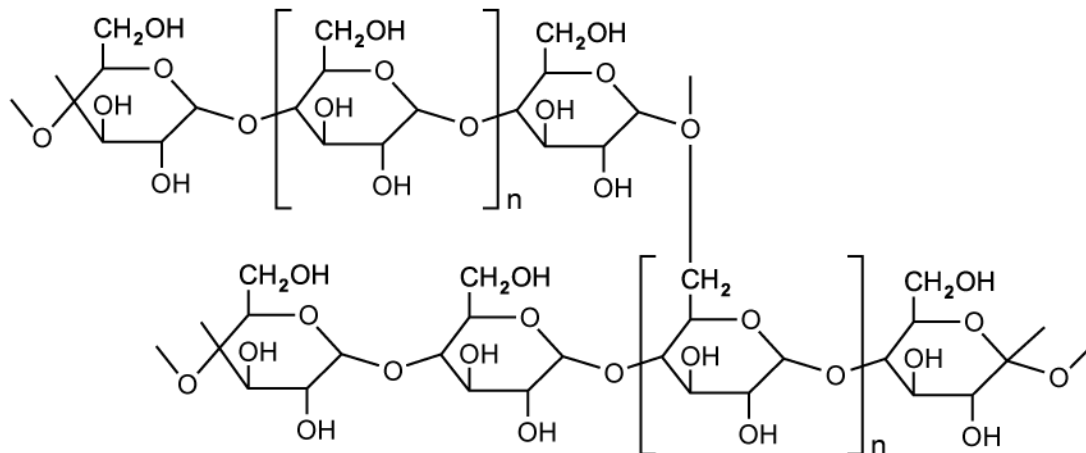
(c) Discuss the advantages and disadvantages of using Body Mass Index (BMI) as a measure of a person's health.

Your answer should include a description of how BMI is calculated, with units, in the absence of a nomogram.

(8 marks)

Hard Questions

1 (a) The following diagram shows the structure of a polysaccharide found in plant cells.



(i) Identify the polysaccharide pictured in the diagram.

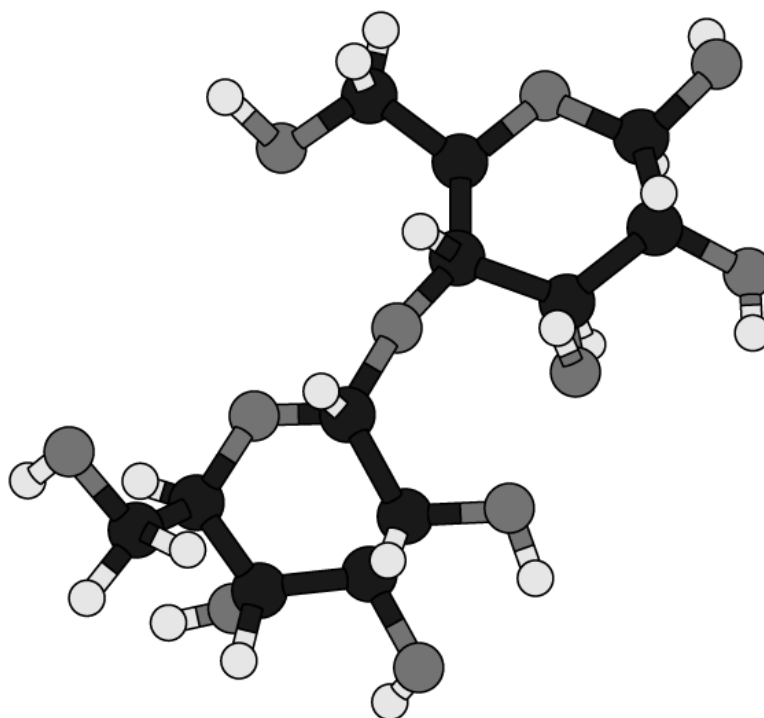
[1]

(ii) Explain your answer at part i).

[1]

(2 marks)

(b) Molecular visualisation software such as Jmol can be used to depict biological molecules.



Identify the molecule in this Jmol visualisation.

(2 marks)

- (c) Three molecules of the same monosaccharide are joined in a line into a trisaccharide.

The molecular formula of the monosaccharide is $C_5H_{10}O_5$.

Deduce the formula of the resulting trisaccharide.

(2 marks)

- (d) The tetrasaccharide stachyose has the molecular formula $C_{24}H_{42}O_{21}$.

Describe **two** aspects of its molecular formula that identifies stachyose as a carbohydrate.

(2 marks)

(e) A disaccharide has the formula $C_{12}H_{22}O_{11}$

It is made up of two identical monosaccharides.

Deduce the formula of the monosaccharides that form the disaccharide.

(2 marks)

2 (a) Draw a molecular diagram of a 10-carbon saturated fatty acid.

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(2 marks)

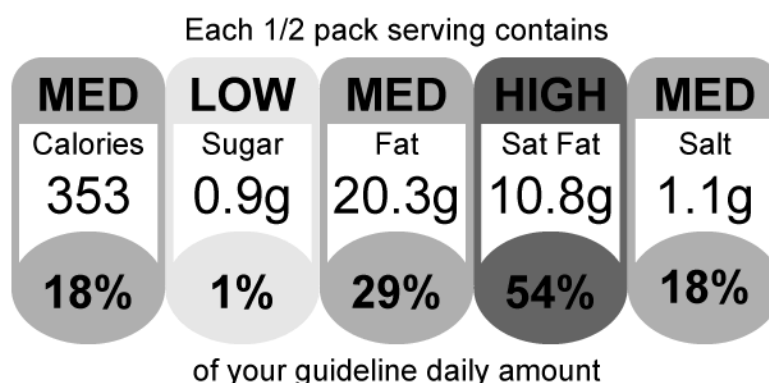
(b) Explain why unsaturated fatty acids form different shaped-triglycerides whereas saturated fatty acids do not.

.....

.....

(2 marks)

(c) Below is a typical label printed on a piece of food packaging.



The product in question is a cookie-style snack food, sold in small packets with see-through plastic packaging.

Suggest and explain **one** aesthetic reason why a food company might wish to market such a food product despite its high saturated fat content.

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.....

(2 marks)

- (d) Doctors recommend that the majority of dietary fat intake should come from monounsaturated and polyunsaturated fats.

Explain why.

(2 marks)

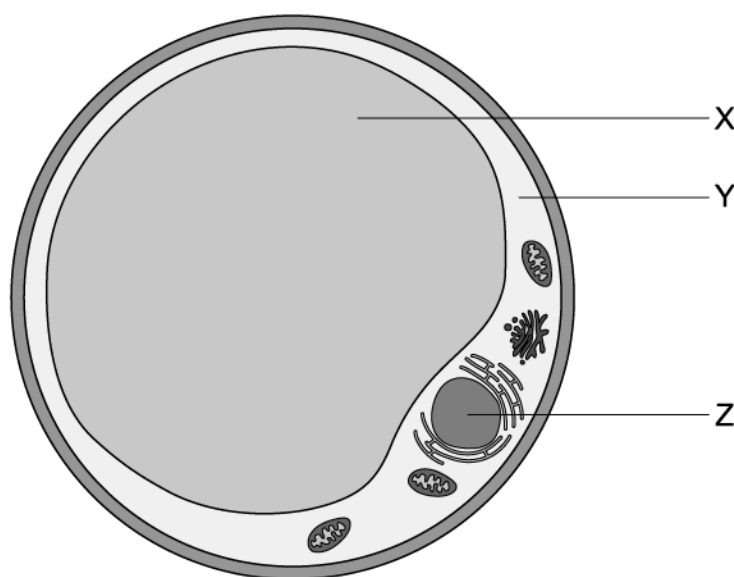
3 (a) Typical energy content values of various food group molecules are given in the table below.

Food Group	Typical energy content / kJg^{-1}
Protein	15
Carbohydrate	17
Fat	38

State the molecular feature of fats that allows them to contain more energy per gram than carbohydrates or proteins.

(2 marks)

(b) The diagram shows a cell with a role in storage.



(i) Identify structures **X**, **Y** and **Z** in this diagram.

[3]

(ii) Suggest which tissue this cell forms part of.

[1]

(4 marks)

(c) A person's body mass index is 26.4 and their mass is 78.3kg.

Calculate the person's height in metres, to 2 decimal places. The formula for BMI is shown below:

$$\text{Body Mass Index} = \frac{\text{Body mass (kg)}}{\text{Height}^2 \text{ (metres)}}$$

(2 marks)

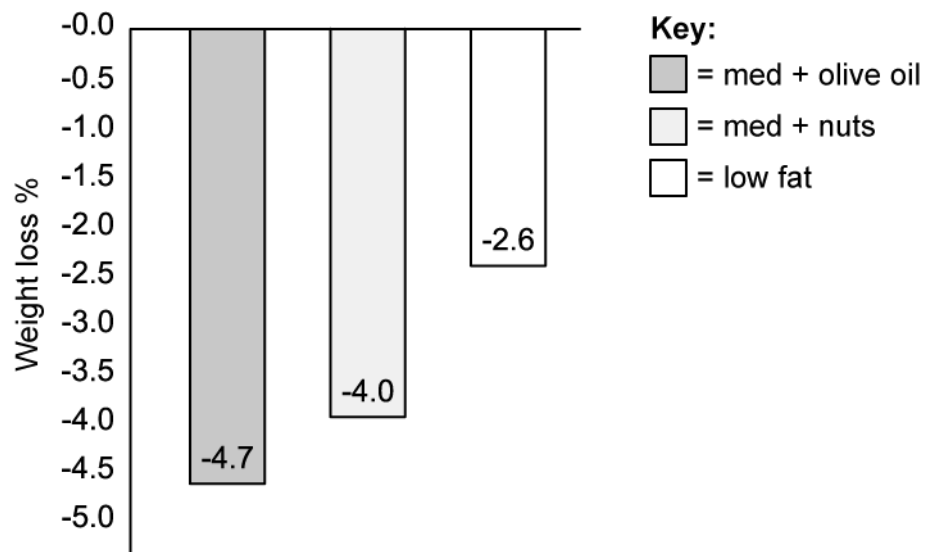
(d) A newspaper heading states that "High fat diets lead to weight loss!" based on the following study and data.

Scientists carried out a study across five years in which 8254 participants followed one of three diets:

- a Mediterranean diet with added extra virgin olive oil
- a Mediterranean diet with added nuts
- a low fat diet

None of the diets involved reducing calories or increasing physical activity.

The graph below shows the results of weight loss in participants after five years.



Use the data and information provided to evaluate the newspaper's claim.

(4 marks)

4 (a) Explain why cholesterol forms associations with proteins called lipoproteins eg. LDL (low density lipoproteins) and HDL (high density lipoproteins).

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(2 marks)

(b) Outline the series of events by which low density lipoproteins (LDLs) raise the risk of a person suffering from coronary heart disease.

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.....

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(4 marks)

(c) Many claims about the health benefits and drawbacks of food are made. One such is the claim that a high consumption of trans- fats causes coronary heart disease.

Evaluate this claim.

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.....

.....

(3 marks)

5 (a) One mark is available for clarity of communication throughout this question.

Compare and contrast the compounds glycogen and starch.

(8 marks)

(b) Sketch a labelled diagram of the part of a trans-fatty acid that identifies its chemical structure as *trans*-.

(3 marks)

(c) A healthy 35 year-old man of height 1.75m has a mass of 95kg.

He calculated correctly that his Body Mass Index was 31, which places him in the 'obese' category. Online sources he read gave him cause for concern about his future health prospects.

Evaluate the claim that a BMI of 31 is detrimental to his health.

(4 marks)