Revision food, calorimetry and volumetric analysis

1. Below is a table with data pertaining to arachidic and arachidonic acids.

Fatty acid	Formula	Melting point (C°)	Boiling point(C°) (at 1 atm)
Arachidic	$C_{19}H_{39}COOH$	76	328
Arachidonic	$C_{19}H_{31}COOH$	-50	407

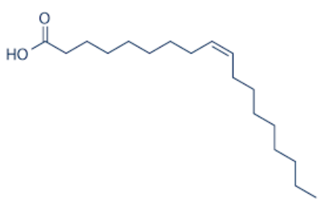
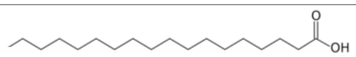
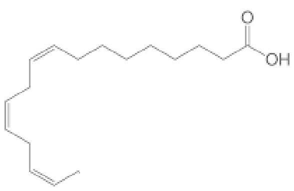
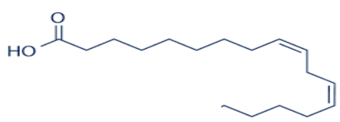
a. Explain the trend in melting temperature between the two molecules.

Melting temperature is reflection of the intermolecular bonds between the molecules and the packing in the solid state. Since there is little to separate the strength of intermolecular bonds between arachidonic and arachidic acid we turn to packing. A higher degree of unsaturation, greater number of double bonds, the more kinked the molecule becomes, hence packing in the solid state is not as ordered as it would be in the saturated molecule.

b. Explain the trend in boiling temperature between the two molecules.

Cis double bonds tend to create dipoles. As the molecules are able to move about, dipoles interact freely increasing the intermolecular force of attraction. Since the unsaturated fatty acid, arachidonic, with four double bonds has intermolecular forces composed of dipole-dipole and van der Waals forces whereas the intermolecular forces of attraction between arachidic molecules are just van der Waals forces.

2. Below are the structural formulae of 4 fatty acids, all of which have a carbon chain length comprising of 18 carbon atoms.

Fatty acid		Boiling temperature (°C)	Melting temperature (°C)
A		*360*	*13*
B		*359*	*69*
C		*443*	*-11*
D		*430*	*-5*

The boiling and melting temperatures, in °C and at 760 mmHg, of the acids are listed in no particular order.

- Boiling temperature - 443, 430, 360, 359.
- Melting temperatures -11, -5, 13, 69.

Allocate the MP and BP to the appropriate molecule. C is done for you.

3. A bottle is labelled " 1.00 M Linoleic fatty acid". A spelling error was suspected and so a titration was conducted to analyse the fatty acid. A 30.00 mL aliquot of this solution was placed into a 100 mL conical flask and titrated against a 2.800 M I_2 solution. A titre of 32.20 mL was required to reach the end point.
   a. Calculate the amount of acid, in mol, present in the 30.00 mL aliquot of the original solution.

      Mol of fatty acid = C X V = 1.00 X 0.0300 = 0.0300 mol

   b. Calculate the mol of I_2 required to completely react with the acid in the conical flask.
      Mol of I_2 = C X V = 2.800 X 0.03220 = 0.0902 mol
   c. Is this fatty acid linolenic or linoleic? Justify your choice.
      The ratio between the mol of acid and the mol of I_2 required to react is exactly the ratio of the double bonds per molecule of acid.
      => mol of acid : mole of I_2
      => 0.0300 : 0.0902
      => 1 : 3
      Three double bonds, hence it is linolenic
   d. This time a 0.300 mL aliquot of the original solution was taken and the solvent was evaporated so that the pure fatty acid remained. This was then burnt in a bomb calorimeter which contained 100g of distilled water. If the temperature of the water was originally at 30.0 °C, calculate the final temperature of the water, to the right number of significant figures assuming all the energy released was absorbed by the water.

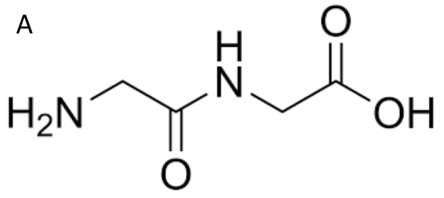
      Energy = 4.18 C X mass X ΔT
      step 1 – find the mass of linolenic acid.
      => 0.000300 X F_{mass} = 0.000300 X 278 = 0.0834 grams
      => Energy given out by 8.34 grams of fat/oil = 0.0834 X 37 kJ/g = 3086.J
      **(37kJ/g is the figure given in the data booklet for the energy content of fats/oils.)*
      Step 2 – Find ΔT
      => ΔT = 3086 J / (4.18 X 100) = 7.4°C

      Step 3 – Final temp = 30.0 + 7.4 = 37°C (2 sig figs)

4. Consider molecule " A" shown on the right.
   a. What are the products when molecule " A" is digested? *Two glycine molecules.*

   b. What is the general name for this type of compound? *Dipeptide*

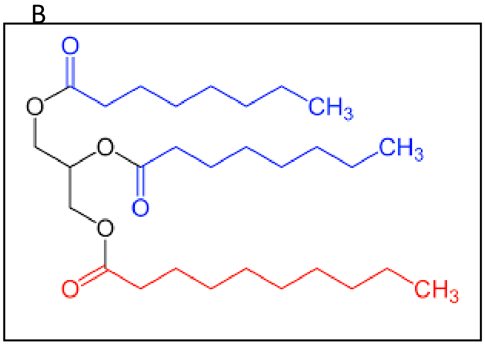
A



c. What type of reaction is involved in the breakdown of molecule " A" ?

Hydrolysis

B



d. Using chemical formulae write a balanced chemical equation, states not required, for the formation of compound " B" .

$C_3H_8O_3 + 2C_8H_{16}O_2 + C_{10}H_{20}O_2 \rightarrow C_{29}H_{54}O_6 + 3H_2O$

e. What category of food contains molecule " B"?

Fats/oils

f. Name the functional group present in this compound.

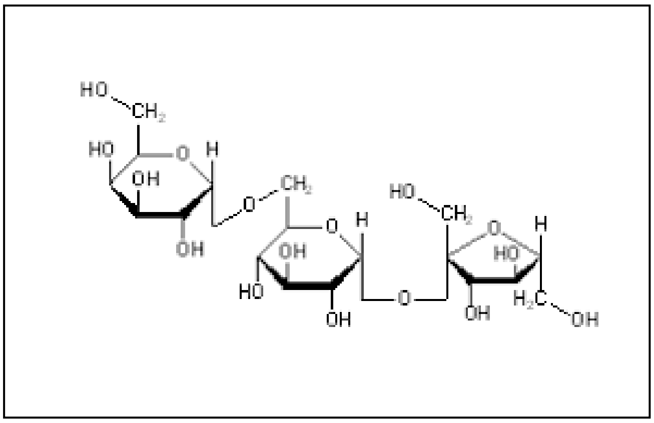
Ester

5. Carbohydrates are the primary energy source for animals.

a. Give an example of a high GI food and explain why it is Labelled as "High GI"

Any disaccharide as these are relatively small molecules that can be quickly broken down into monosaccharides and quickly absorbed through the intestinal wall and into the blood stream. Any food containing monosaccharides such as glucose and/or disaccharides such as sucrose are high GI foods.

b. Consider the trisaccharide, raffinose, shown on the right.



i. What type of reaction formed raffinose?

Condensation

ii. Complete digestion of raffinose yields three monosaccharides, one of which is galactose. Name the other two monosaccharides.

From the data booklet **β**-*fructose,* **α**-*glucose*

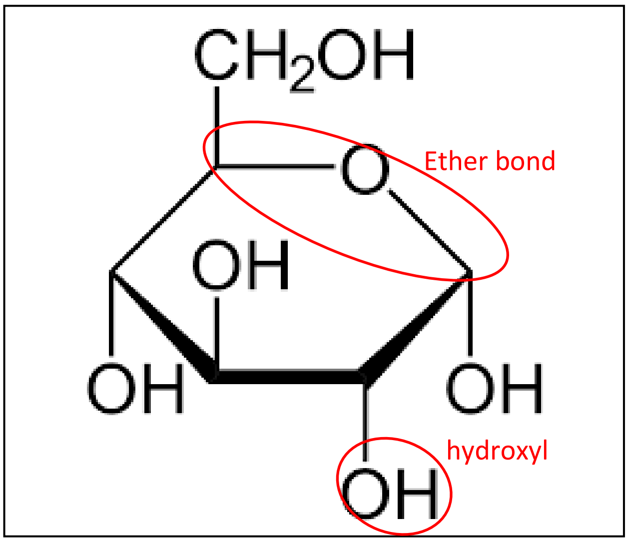
iii. What type of bonds link the saccharide monomers of raffinose?

Ether (glycosidic)

iv. Name the saccharide shown on the right.

α-glucose

v. Circle and name two different functional groups present.



c. Two snack foods are sold commercially.
"Superbo Energy", contains starch, 10% of which is amylose and 90% is amylopectin. "Fit-n-healthy Energy" on the other hand, contains starch made up of 80% amylose and 20% amylopectin. Which snack food can be given to a diabetic suffering from hypoglycaemia (low blood sugar) to speed their recovery? Explain.

Since the linear polysaccharide, amylose is less soluble than the branched polysaccharide, amylopectin, it is considered to be a low GI carbohydrate. A greater percentage of amylopectin in the food makes if a a high GI food. The branching of amylopectin causes it to hydrolyse, via enzyme action, faster than the linear, less soluble polysaccharide, amylose.

A person suffering from hypoglycaemia needs to have their blood sugar elevated quickly. This means ingesting high GI food. Superbo-Energy is the high GI food out of the two foods and will be digested quicker than the other food snack.

6. A bomb calorimeter was calibrated by passing a current of 1.50 amps for 5.00 minutes at 2.50 V through the heating element. A mass 50.00 grams of water was heated and recorded a temperature change 5.00 °C.

a. Calculate the calibration factor of the calorimeter.

Step 1 Calculate the energy input.
=> Energy(J) = VIt = 2.50 X 1.50 X 5.00 X 60 = 1.125kJ
Step 2 Find the calibration factor
=> 1.125 kJ / 5.00 °C = 225J/°C

b. A mass of 0.50 grams of sucrose (formula mass 342 g/mol) was burnt in the same calorimeter and the temperature change of the water measured at 39.72 °C. Calculate the ΔH of the reaction below, in kJ per mol, to the right number of significant figures.
$C_{12}H_{22}O_{11}(s) + 12O_2(g) \rightarrow 12CO_2(g) + 11H_2O(l)$ ΔH =
Step 1 – Find the mol of sucrose
=> 0.50 / 342 = 1.46 X 10^{-3} mol
Step 2 – Find the energy released from the mol of sucrose burnt in the bomb using the calibration factor (C_f)
=> Energy (J) = C_f X 39.72 = 225 j/°C X 39.72 = 8.94 kJ
Step 3 – Find the molar heat of combustion of sucrose.
=> 8.94 kJ/1.46 X 10^{-3} = 6.1 X 10^3 kJ/mol
$C_{12}H_{22}O_{11}(s) + 12O_2(g) \rightarrow 12CO_2(g) + 11H_2O(l)$ ΔH = *-6.1 X 10^3 kJ/mol*

c. Suggest a reason as to why a calibration factor is used rather than the heat capacity of water (4.18 J/g/°C).
Using the heat capacity of water to calculate the energy released from the combustion of sucrose assumes that all the energy released has been absorbed by the water. In actual fact the heat has been absorbed not only by the water but by the metal casing of the reaction vessel, the thermometer and the casing of the calorimeter. Calibration factors account for all the ways that energy is absorbed by the calorimeter and hence gives a more accurate representation of the relationship between energy released and temperature change of the water.

d. Fat (palmitate fatty acid), when burnt in a bomb calorimeter, produces approximately 37 kJ of heat energy per gram. During cellular respiration fat yields its energy via the formation of high energy chemical bonds in the form of ATP. Both cellular respiration and combustion reactions are shown below.
cellular respiration – $C_{16}H_{32}O_2 + 6O_2 + 129ADP + 129P \rightarrow 6CO_2 + 6H_2O + 129ATP$
combustion – $C_{16}H_{32}O_2 + 23O_2 \rightarrow 16CO_2 + 16H_2O$
How does the heat energy produced by a known mass of palmitate compare with the energy produced, by the exact same mass of palmitate, during cellular respiration?
If we compare the amount of energy produced in the form of ATP by cellular respiration with the amount of energy produced in the form of heat by combustion, cellular respiration produces less heat energy. The reason is that not all energy is released as heat during cellular respiration as some of it is preserved in the form of bonds in the ATP molecule.