Revision - food chemistry and chromatography

1. A bomb calorimeter, diagram 1, containing 100 mL of water was calibrated by passing a current of 2.86 amps at 12.50 volts for 25.0 seconds through the heating coil. The temperature of the water was taken every 25 seconds after the power was turned on.

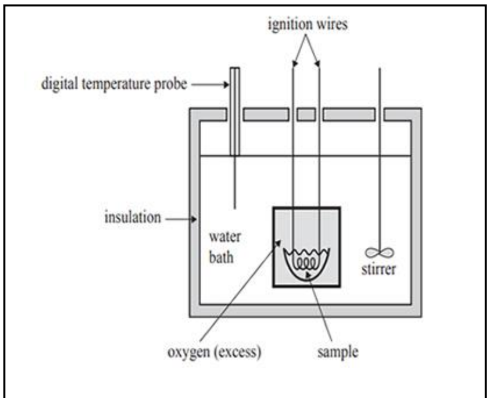
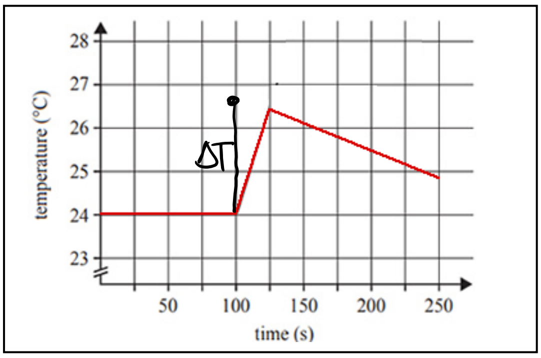


Diagram 1

Results were plotted on the graph shown on the right.



a. Calculate the calibration factor(C_f)

$$CF = \frac{VIt}{\Delta T} = \frac{12.5 \times 2.86 \times 25}{2.6}$$

$$= 343.75 J\ °C^{-1}$$

b. A mass of 0.05801 grams of butane gas was burnt in the calorimeter, in excess oxygen, to change the temperature of the water by 9.03 °C.

i. Write a balanced chemical equation, states included, for the complete combustion of butane gas.

$$2C_4H_{10}(g) + 13O_2(g) \rightarrow 10H_2O_{(l)} + 8CO_2(g)$$

ii. Calculate the ΔH of the combustion reaction.

$$\Delta H = \frac{q}{n} \qquad q = CF \times \Delta T = 343.75 \times 9.03$$

$$= 3104 J$$

$$= 3.104 kJ$$

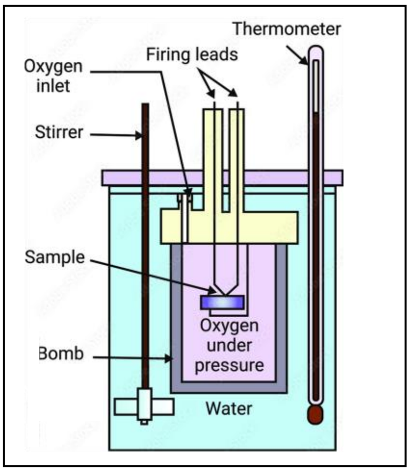
$$= 3.104 / \left(\frac{0.05801}{12 \times 4 + 10}\right)$$

$$= 3104 kJ/mol \Rightarrow \Delta H = -6207 kJ/mol$$ for above reaction

c. Is the calorimeter well insulated? Explain

No, as when the heater was turned off the temperature of the calorimeter decreased quickly, indicating quick heat loss

d. Another bomb calorimeter, containing 200 mL of water at 25 ^{o}C was calibrated. A sample of 0.0640 grams of liquid methanol was burnt in excess oxygen to raise the temperature of the water by 10.00 °C.



i. Calculate the C_f of this calorimeter.

$q = \Delta H \times m$

$= 22.7 \times 0.0640$

$= 1.4528$ kJ

$CF = \frac{1.4528}{10} = 0.145$ kJ/°C

ii. A pure, 0.04600 gram sample of ethanol was burnt in this calorimeter with excess oxygen to raise the temperature of the water by 9.40 °C.
Calculate the molar heat of combustion in kJ/mol of ethanol. Give the answer to the right number of significant figures and show all working out in the space below.

$q = CF \times \Delta T$

$= 0.145 \times 9.40$

$= 1.366$ kJ

$\Delta H = \frac{q}{n} = \frac{1.366}{\left(\frac{0.04600}{2\times12+6+16}\right)}$

$= -1366$ kJ/mol

iii. On the same day another group also calibrated the same calorimeter, following the same procedure, but filled the calorimeter with 100 mL of water instead of 200 mL. Are the results that this group obtained for the molar heat of combustion of ethanol valid? Explain.

Yes - changing the volume of water will not change the CF.

2. Diagram 2 shows the chromatogram of a mixture of six compounds, given below, when run through a HPLC column.
The mixture consists of propane, propan-1-ol, propan-2-ol, propanone, propanoic acid, pentane.

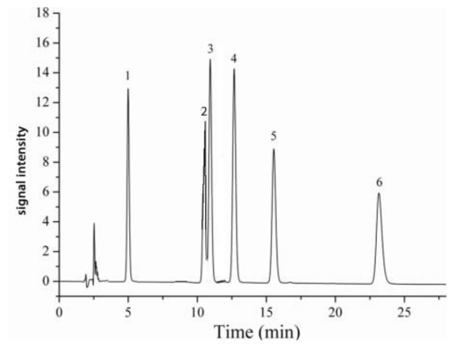


Diagram 2

a. Peak 6 in the chromatogram is identified as pentane. Is this reverse-phase chromatography? Explain using the terms ***adsorption and desorption.***

- pentane is non-polar and has the highest retention time. ⇒ strongest adsorption + weakest desorption
⇒ stationary phase is non-polar.
⇒ this is reverse phase HPLC.

b. Identify each peak.

Peak	Compound
1	propanoic acid
2	propan-1-ol
3	propan-2-ol
4	propanone
5	propane

c. Peaks 2 and 3 overlap. Which of the following will increase the resolution of the chromatogram and separate the peaks? Explain why or why not for each.

i. Increase the temperature that the column runs at.

NO - will cause all R_t to decrease

ii. Increase the concentration of the mixture

NO - will ↑ peak sizes

iii. Decrease the pressure at which the column runs at.

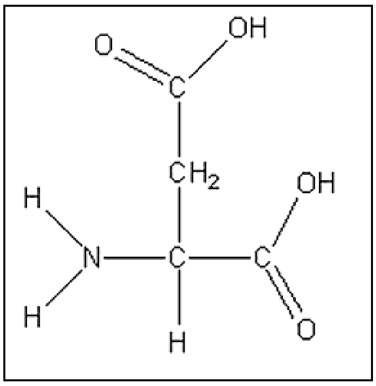
Yes - will ↑ R_t and separation

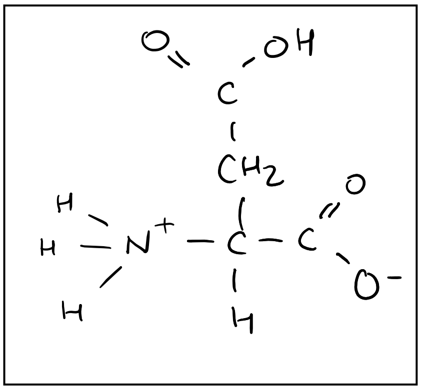
iv. Increase the length of the column.

Yes → will increase R_t and increase separation

3. Consider the structural formula of aspartic acid (M=133 g/mol) shown below.

a. Draw the zwitterion of aspartic acid in the box provided.

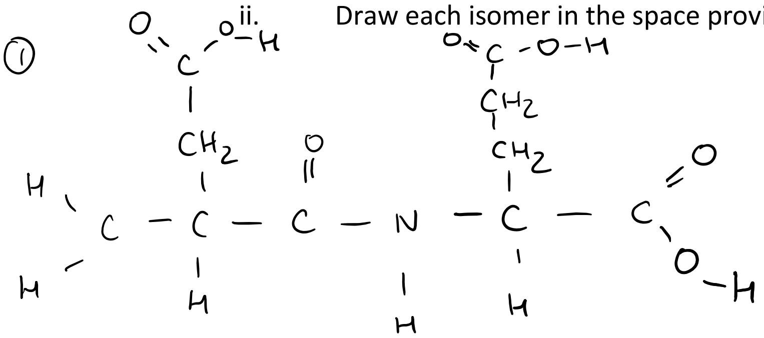


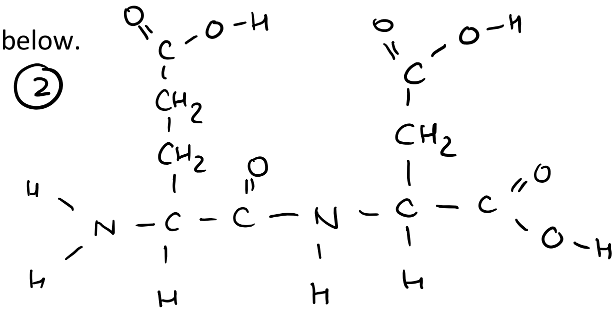


b. A dipeptide is formed from aspartic acid (M=133g/mol) and glutamic acid (M=147g/mol) is called aspartylglutamic acid.

i. How many possible isomers exist of aspartylglutamic acid? 2

ii. Draw each isomer in the space provided below.





iii. Give the molar mass of aspartylglutamic acid? 262 g/mol

iv. Give structural formula of the zwitterionic state of the dipeptide at the pH specified in the boxes below.

At the isoelectric point	At pH 12.5
= NH_3^+ and COO^-	- acts as an acid COOH groups become COO^- + no change to NH_2

4. The number of carbon-to-carbon double bonds (C=C) in a molecule can be identified by reacting the molecule with bromine (Br_2) solution. Four unknown acids are to be identified. A 10.0 g sample of one of the fatty acids listed below was dissolved in an appropriate solvent and titrated with 3.100 M Br_2. An average titre of 42.50 mL was obtained. Identify the acid. Show all calculations.

$n(Br_2) = 3.1 \times 0.0425$
$= 0.1318$ mol

0.035mol = ~~i.~~ ✗ oleic acid (M = 282 g mol^{-1}). 1x C=C

0.036 mol = ii. x3 = 0.1 => ✗ linolenic acid (M = 278 g mol^{-1}). 3x C=C

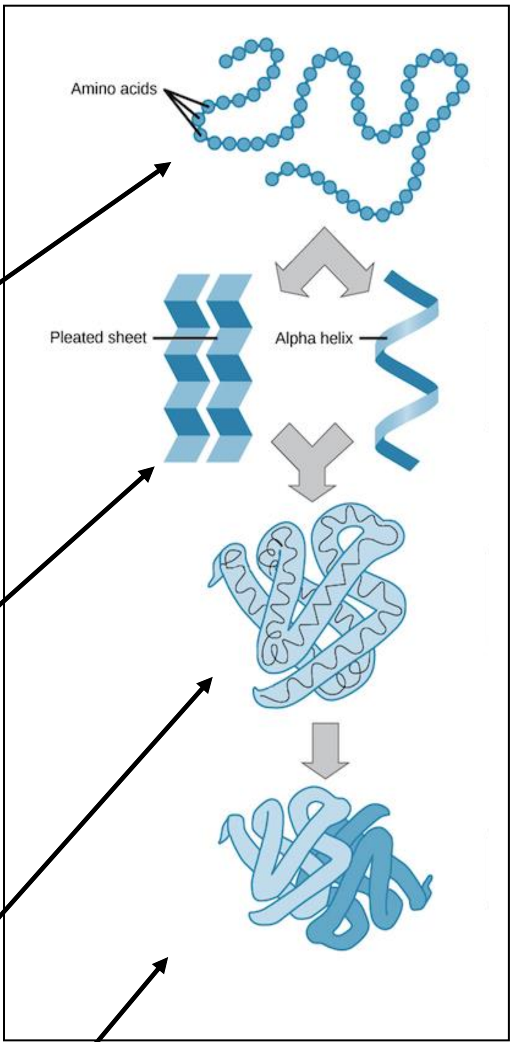
~~iii.~~ ✗ arachidic acid (M = 312 g mol^{-1}) 0x C=C

(iv.) arachidonic acid (M = 304 g mol^{-1}). 4x C=C

$n = \frac{10}{304} = 0.033 \times \frac{4}{1}$

$= 0.131$ mol

5. Consider the following structures shown on the right.
   a. To what group of foods do these structures belong to? protein
   b. Complete the box relating to each structure.



Type of structure primary

Type of bonding forming this structure and functional groups involved.

COOH and NH_2 groups react to form covalent amide links

Type of structure secondary

Type of bonding forming this structure and functional groups involved.

hydrogen bonding between C=O and N–H groups on different amide links

Type of structure tertiary

Type of bonding forming this structure and functional groups involved.

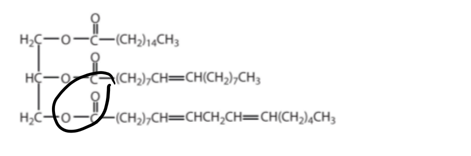
involves R – groups. can be dispersion, dipole-dipole, hydrogen, ionic or disulfide.

Type of structure quanternary

Type of bonding forming this structure and functional groups involved.

mainly dispersion, can be any from tertiary.

6. Consider the molecule shown on the right.



   a. To what class of organic compounds does this molecule belong to.

   triglyceride

   b. Excluding the C=C, circle and name another functional group shown in the structural formula. ester

   c. Name the products expected from the complete hydrolysis of this molecule.

   glycerol + 3 fatty acids < palmitic acid, oleic acid, linoleic acid

   d. Name the essential fatty acid that is formed from the hydrolysis of organic molecule.

   linoleic

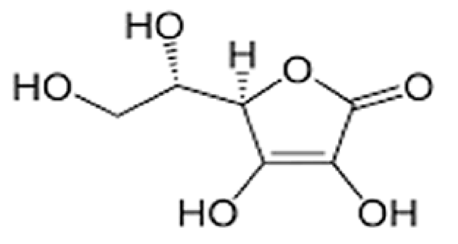
   e. To what class of fatty acid does the essential fatty acid given in question d. belong to?

   diunsaturated

   f. Which one of the products given in c. is most likely to undergo rancidity? Explain.

   linoleic acid - has the most C=C bonds

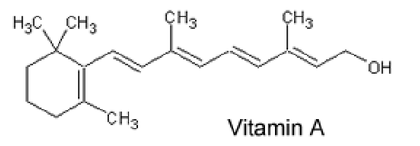
   g. Vitamin C is said to be an anti-oxidant, capable of slowing down the process of rancidity. Explain how vitamin c slows down the process of rancidity.



Vitamin C

   · vitamin C donates a H atom to free radicals ⇒ stoping propagation and preventing oxidative rancidity.

   h. Consider the structure of vitamins A and C.



Vitamin A

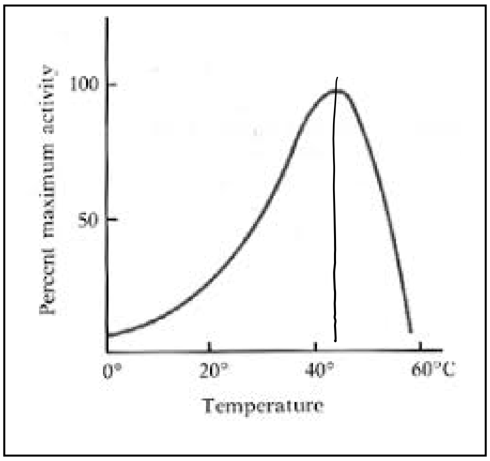
      i. Which vitamin is most likely to be stored in the lipid tissue of animals? Explain

      - vitamin A ⇒ largely non-polar vitamin ⇒ lipid soluble

      ii. Which vitamin is most likely required to be ingested daily? Explain.

      vitamin C - water soluble ⇒ will not be stored

7. The activity of an enzyme is shown by the graph on the right.



a. What is the optimum temperature at which this enzyme functions. 42°C approx.

b. Explain why the activity of the enzyme is very low at temperatures around 20°C.

- low rate of reaction as low kinetic energy and number of successful collisions.

c. When asked why the activity of the enzyme falls away at temperatures above 40°C a student wrote " The enzyme denatures though hydrolysis at temperatures above 40°C"

i. Is the student correct? NO.

ii. Explain the difference between "***hydrolysis***" and ***"denaturing"***

Hydrolysis = breaking of primary structure.

Denaturing = permanent change to tertiary structure resulting in a change to the shape of the active site

d. With reference to the "***active site***" explain how enzymes act as organic catalysts for specific chemical reactions.

- enzymes are biological catalysts
- each have a unique 3D protein shape with a specific active site
- due to the shape of the active site, enzymes can only catalyse reactions where the substrate fits into the shape of the active site

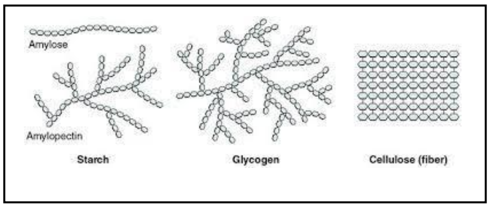
e. Explain with reference to the "***secondary***" and "***tertiary***" structures of a protein, why enzymes have a very narrow pH range in which they perform at an optimum level. Refer to the type of bonds involved and how they are impacted by pH.

- outside the optimal pH range, the tertiary structure of an enzyme can be impacted as the ionic interactions will change at different pH levels.
- These changes may cause a permanent change to the shape of the active site ⇒ denaturing the enzyme.

f. State three differences between an enzyme and a co-enzyme.

- co-enzymes can be altered in a reaction whereas enzymes cannot.
- co-enzymes are required by enzymes to become active whereas enzymes actually catalyse reactions
- enzymes are specific, co-enzymes are not
- enzymes are proteins, co-enzymes are not.

8. Consider the four polysaccharides shown on the right.



   a. How are glycogen and amylose similar?

   both branched α- glucose polymers.

   b. Name one similarity between cellulose and amylose.

   no branching (both straight chains of glucose monomers)

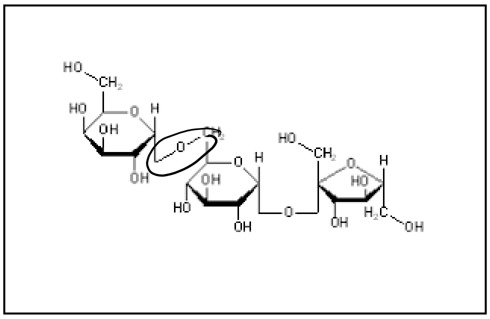
   c. Name one difference between amylose and cellulose.

   cellulose = β - glucose
   amylose = α - glucose

   d. Explain, with reference to the chemical structure of the polymer, why a plant food high in amylopectin is considered to be "high GI".

   · branched amylopectin is easier to break down ⇒ hydrolysed quicker ⇒ causing a spike in blood glucose within the 2 hour period.

   e. Raffinose is an oligosaccharide formed from three monosaccharides.



      i. If one of the monosaccharides is galactose, name the other two.

      glucose + fructose

      ii. Circle and name the functional group linking each monosaccharide to the molecule.

      ether / glycosidic

      iii. Explain the difference between the hydrolysis of raffinose and the metabolism of raffinose with reference to the:
      - products formed
      - type of bonds involved.

   • hydrolysis = breaking down into 3 monosaccharides by breaking ether links.

   • metabolism = using the monosaccharides to undergo respiration to produce energy.