FATS & OILS – WORKSHEET 1

QUESTION 1
Fats and oils vary in their degree of solubility in aqueous solutions. Give a reason for this observation.

Solution

QUESTION 2
Why are fatty acids such as palmitic acid, insoluble in water, while ethanoic acid (CH_3COOH) is soluble?

Solution

QUESTION 3
Why does the body prefer to store energy as fats as opposed to carbohydrates?

Solution

QUESTION 4
Explain the difference between the following terms: saturated fat, monounsaturated fat and polyunsaturated fat.

Solution

QUESTION 5
Why are polyunsaturated fats more reactive than saturated fats?

Solution

QUESTION 6
A polyunsaturated fat is hydrolysed to produce glycerol and a polyunsaturated acid. Which one of the following is a possible formula of the acid?

A $C_{18}H_{37}COOH$
B $C_{18}H_{37}COOH$
C $C_{18}H_{37}COOH$
D $C_{18}H_{37}COOH$

QUESTION 7
Write the molecular formula for each of the following compounds:

(a) A saturated fatty acid consisting of 18 carbon atoms.

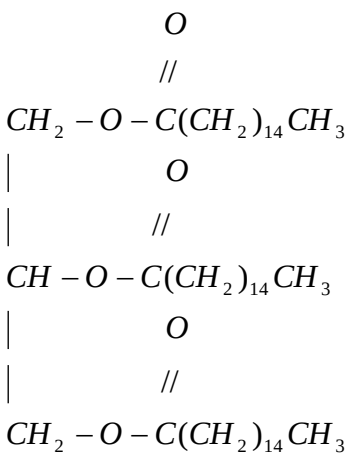
(b) A polyunsaturated fatty acid containing 3 carbon to carbon double bonds, and consisting of 22 carbon atoms.

QUESTION 8
A common triglyceride found in vegetable oils is shown below.

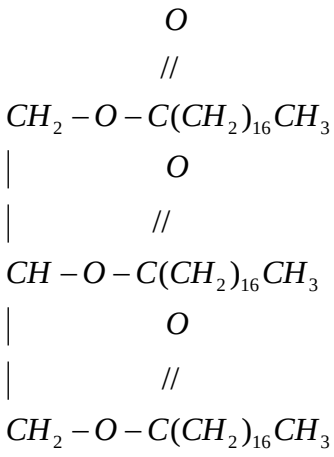
(a) Is this triglyceride saturated or unsaturated?

(b) Circle the ester functional groups in this structure.

(c) Write reactions to show the complete hydrolysis of this triglyceride molecule.



QUESTION 9
The following structural formula represents a fat.



(a) When this fat is treated with the enzyme lipase, two products are formed. Draw the structural formulae of these two products.

(b) Which one of the products in (a) is hydrophobic? Give a reason for your answer.

QUESTION 10

(a) The fat tripalmitin has the formula $(C_{15}H_{31}COO)_3C_3H_5$. Give the formulae of the two compounds from which this fat is made.

(b) Is this fat saturated or unsaturated? Give a reason for your answer.

QUESTION 11

The molecular formula of linoleic acid, a common fatty acid is given below.

$CH_3(CH_2)_4CHCHCH_2CHCH(CH_2)_7COOH$

(a) Is this fatty acid saturated or unsaturated?

(b) Circle the functional group(s) in this molecule.

(c) Is this fat likely to exist as a solid or liquid at room temperature? Give a reason for your answer.

QUESTION 12
Which has a higher melting point – fats or oils? Give a reason for your answer.

Solution

QUESTION 13
Why do polyunsaturated fats have a lower melting temperature than monounsaturated fats?

Solution

QUESTION 14
How do the contents of butter and margarine differ?

Solution

QUESTION 15
Why is margarine so easily spread?

Solution

QUESTION 16
Explain why butter is hard to spread when it's taken straight out of the refrigerator, yet many margarines are easy to spread when they are cold?

Solution

QUESTION 17
Explain why butter is easier to spread when it's been left out at room temperature as opposed to refrigerated butter.

Solution

QUESTION 18
How could you make butter more spreadable?

Solution

QUESTION 19
Margarine is made from vegetable oils which have been converted to a more solid form. This process is known as hardening. What steps are involved in the hardening process?

Solution

QUESTION 20
Candles can be made from fats or waxes.

(a) An edible oil can be converted into fat for a candle by a reaction with reagent **A**, in the presence of substance **B**, as shown in the equation below:

$$\text{oil} + \mathbf{A} \xrightarrow{\mathbf{B}} \text{fat}$$

(i) Identify:

Reagent **A**: _____

Substance **B**: _____

(ii) Certain reaction conditions are essential for this conversion to occur.

State *one* essential reaction condition.

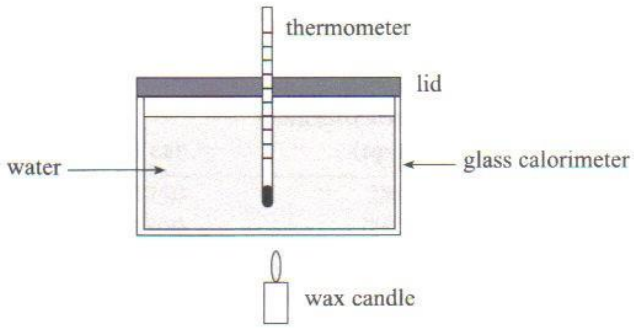
(iii) State the change in the chemical structure of the oil when it's converted into fat.

(iv) Describe the change in *one* physical property of the oil when it's converted into fat.

(b) The molar enthalpy of combustion of a common wax in candles, $C_{25}H_{52(s)}$ is 16800 kJ mol^{-1}.

(i) Write a thermochemical equation for the complete combustion of candle wax, $C_{25}H_{52(s)}$.

(ii) The molar enthalpy of combustion of candle wax, $C_{25}H_{52(s)}$, was determined in an experiment using the apparatus shown in the diagram below:



The following two quantities were measured:

The mass of water in the calorimeter = 200 g
The initial temperature of the water = 25.4°C

State *two* other quantities that would also have been measured in order to determine the molar enthalpy of combustion of the candle wax.

(iii) Suggest *one* improvement that could be made to the experimental apparatus and briefly state how this would help to increase the accuracy of the result.

In another experiment the following hypothesis was tested:

'A different value for the molar enthalpy of combustion of candle wax will be obtained if cooking oil is used instead of water to absorb the heat.'

(iv) Identify the independent variable in this experiment.

(v) State *two* factors that should be held constant throughout this experiment.

QUESTION 21
The table shows fatty acid composition of some common oils and fats.

Fatty acids present (% by weight)

Fat or oil hydrolysed	Lauric	Palmitic	Stearic	Oleic	Linoleic
Butter	2-3	23-26	10-13	30-40	4-5
Lard	< 1	28-30	12-18	41-48	6-7
Tallow	< 1	24-32	14-32	35-38	2-4
Coconut	45-51	4-10	1-5	2-10	0-2

An oily sample was hydrolysed and the fatty acids analysed.

	Lauric	Palmitic	Stearic	Oleic	Linoleic
Oil sample	<1	29	28	36	4

(a) Which fat or oil has been identified?

(b) Explain the solubility in water of fatty acids, in terms of their structure.

SOLUTIONS

QUESTION 1

The longer the hydrocarbon chain, the more soluble the lipid becomes.

QUESTION 2

Short chains soluble (note: CH_3COOH is NOT a fatty acid)
Long chain hydrocarbons mask the charged head, compromising solubility.

QUESTION 3

Fats have a higher energy content per gram ∴ more energy can be stored. B/c Fat is hydrophobic it can be easily compartmentalised/ immobilised in certain regions of the body.

QUESTION 4

sat- no double bonds btw carbon atoms
monounsat - 1 double bond btw 2 carbon atoms
polyunsat - more than 1 double bond btw C atoms

QUESTION 5

B/c they have double bonds btw carbon atoms that can be broken ∴ more reactive

QUESTION 6 **Answer is C**

QUESTION 7

(a)

Sat fatty acids = $C_nH_{2n+1}COOH$ or $C_nH_{2n}O_2$ $C_{18}H_{36}O_2$

(b)

Sat fatty acid with 22 C is $C_{22}H_{44}O_2$

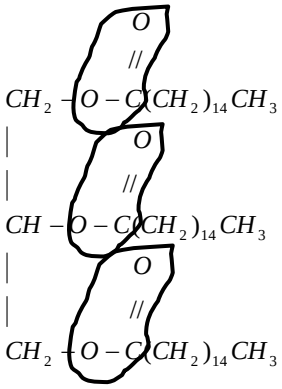
For each C=C bond, the number of H atoms decreases by 2 ∴ For 3 C=C : there are 6 less H

∴ $C_{22}H_{38}O_2$

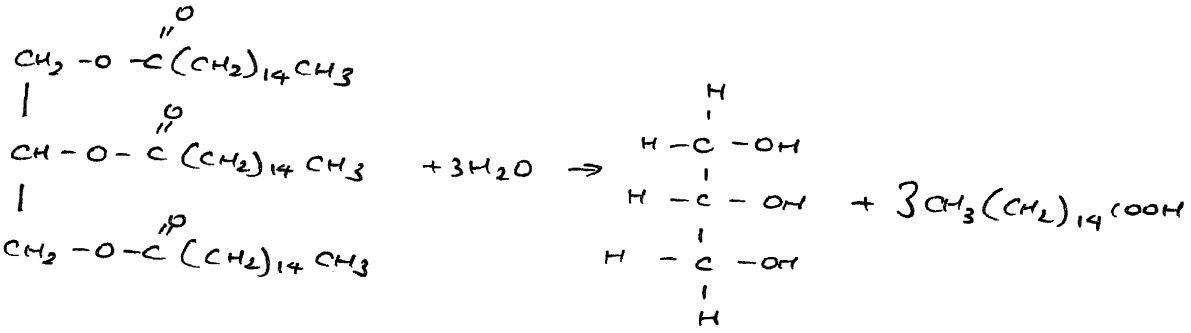
QUESTION 8

(a) Saturated

(b)

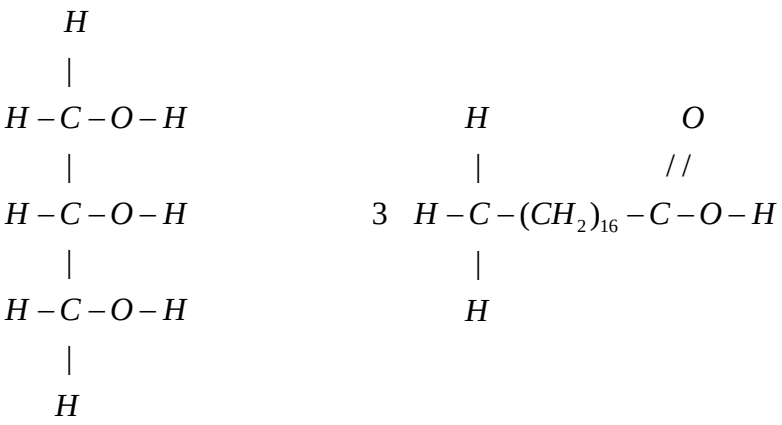


(c)



QUESTION 9

(a)



(b) $CH_3(CH_2)_{16}COOH$ because of the long hydrophobic hydrocarbon chain.

QUESTION 10

(a) $C_{15}H_{31}COOH$ and $C_3H_8O_3$

(b) If saturated, hydrocarbon chain = C_nH_{2n+1}
ie: no double bonds btw carbons.
$C_{15}H_{31} = C_nH_{2n+1}$ ∴ Saturated

QUESTION 11

(a) Unsaturated

(b) Circle the COOH

(c) Liquid due to the unsaturation of the molecule. Chains cannot pack closely to one another ∴ total dispersion forces acting between molecules is low ∴ little energy is required to disrupt these forces and hence lipid is more likely to exist as a liquid at room temperature.

QUESTION 12

Fats ⇒ b/c saturated ∴ molecules pack more closely together ∴ more dispersion forces formed btw chains ∴ need to supply higher temp to break the intermolecular bonds and cause the fat to melt.

QUESTION 13

B/c they have more double bonds btw C atoms ∴ structures occupy more space ∴ don't pack as closely together ∴ fewer dispersion forces ∴ lower temp required

QUESTION 14

Butter - sat fats ∴ more solid at RoomTemp
Margarine - unsat fats ∴ less solid at RT

QUESTION 15

Unsat fats ∴ fewer dispersion forces ∴ more easy to spread.

QUESTION 16

Refer to Question 15

QUESTION 17

RoomTemp supplies heat energy that disrupts some of the intermolecular bonds ∴ becomes easier to spread.

QUESTION 18

Add more unsaturated fats.

QUESTION 19

converting double bonds to single bonds by reacting with H_2 (ie saturate double bonds)

QUESTION 20
Candles can be made from fats or waxes.

(a) (i) A = $H_{2(g)}$
B = Catalyst

(ii) High temperatures
(iii) Molecule becomes more saturated
(iv) Product becomes more solid and less spreadable. Melting point increases.

(b) (i) $C_{25}H_{52(s)} + 38O_{2(g)} \rightarrow 25CO_{2(g)} + 26H_2O_{(l)}$
$\Delta H = -16800\ kJ/mol$

(ii)

Final temp of water.
Mass of candle before and after burning.

(iii) Insulation around system to maximise transfer of heat from candle to glass calorimeter.
Incorporation of stirrer so that an accurate temp change can be recorded.

(iv)

Solution / Liquid in calorimeter.
The ability to absorb heat is a property of a material + is not dependent on any other variable eg. heat etc

(v) The two factors to be held constant should NOT be associated with the calculations.

eg. Distance between source of heat and calorimeter.
Thermometer.
Degree / nature of insulation.
Nature / design of calorimeter.

QUESTION 21

(a) Tallow

(b)

fatty acids are essentially insoluble in polar solvents due to their long hydrophobic hydrocarbon chains.

The longer this hydrocarbon chain, the poorer the solubility of fatty acids in water.