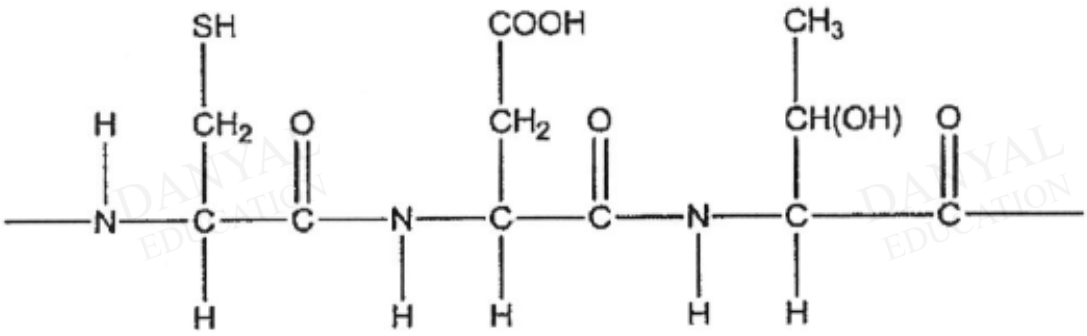
O Level Pure Chemistry Structured

Organic Chemistry Test 6.0

Q1

The diagram below shows the repeat unit (M_r = 349) of polypeptide **X** formed by three different amino acids monomers.



(a) Name a synthetic polymer that has the same linkage as polypeptide **X**.

.....[1]

(b) Draw the structures of any **two** monomers that can react to form polypeptide **X**.

[2]

(c) The amino acid monomers of polypeptide **X** are amphoteric.
Explain why this statement is true.

.....

.....

.....[2]

(d) Manufacturing polypeptide **X** is challenging. One challenge is in controlling the chain length of the polypeptide so that the polypeptide molecules have an average relative molecular mass in the range 37 143 to 42 678.

(i) Use your answer in (b) to suggest another challenge in manufacturing polypeptide **X**.

.....[1]

(ii) Estimate the range of amino acid residues that are present in the polypeptide molecules.

[2]

Q2

Ethanol can be obtained by the hydration of ethene from crude oil in industries or by fermentation of glucose from corn in a batch process.

Hydration: $C_2H_4 + H_2O \rightarrow C_2H_5OH$

Fermentation: $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

The table below compares the making of ethanol by hydration and by fermentation.

	hydration	fermentation
raw materials	ethene from crude oil	glucose from corn
type of process	continuous	batch
conditions used		
purity of product	pure	impure
atom economy	100%	51%

**atom economy is defined as the ratio of the theoretical mass of the desired product to the total mass of all reactants.*

(a) Complete the table above with the conditions used for both methods of obtaining ethanol. [2]

(b) Describe two advantages and two disadvantages of obtaining ethanol by hydration instead of fermentation.

.....

.....

.....

.....

.....

..... [4]

(c) (i) Suggest how pure ethanol can be obtained from the batch process.

..... [1]

(ii) In reality, the yield of ethanol obtained by fermentation is less than 51%. Suggest a reason why.

[1]

(d) 'Carbon-neutral' fuels are fuels that do not result in a change in carbon dioxide in the atmosphere.

Unlike obtaining ethanol by hydration, only obtaining ethanol by fermentation is considered as 'carbon-neutral'.

Explain why obtaining ethanol by fermentation is considered as 'carbon-neutral'.

.....

.....

.....[2]

Q3

An organic compound, **X**, contains carbon, oxygen and hydrogen only. The percentage of carbon and hydrogen are 47.4% and 10.5% respectively. The relative molecular mass of **X** is 76.

(a) Find the empirical and molecular formula of **X**.

[3]

(b) **X** is a sharp smelling liquid at room temperature. It is soluble in water and can be oxidised to form **Y** whose structure is shown in Fig. 7.1.

Fig. 7.1

(i) Draw the full structural formula of **X**.

[1]

(ii) State the reagent(s) needed to oxidise **X** to form **Y**.

.....[1]

(c) Y reacts with methanol, under suitable conditions, to produce Z. Draw the full structural formula of Z.

[1]

(d) 1,4-butyl diamine has the structure shown in Fig. 7.2.

Fig. 7.2

Y undergoes polymerisation with 1,4-butyl diamine to form a polymer W.

(i) State the type of polymerisation which Y undergoes.

.....[1]

(ii) Write the structural formula of a repeating unit of polymer W.

[1]

(iii) Name a synthetic polymer that has the same linkage as polymer W.

.....[1]

Q4

Calcium ethanoate is a white crystalline solid which is soluble in water.
A student wanted to investigate the thermal decomposition of calcium ethanoate. Table 11.1 shows the tests that he conducted and his observations.

Test number	Test	Observation
1	Heat the solid gently. Test the gas produced with a lighted splint. Leave the residue in the test tube to cool and use it in Test 2.	When tested with lighted splint, a flame was seen at the mouth of the test tube. A white solid was left behind.
2	Add dilute hydrochloric acid to the solid from Test 1.	Effervescence was seen.

Table 11.1

(a) The student concluded that the gas produced in Test 1 was oxygen. His friend thought that hydrogen gas was produced. Explain why they were both wrong.

.....

.....

.....

.....

.....[2]

(b) The gas produced was actually propanone, C_3H_6O. Propanone is an organic solvent that is volatile and catches fire easily.

(i) Draw two isomers of propanone.

[2]

(ii) Draw a diagram of a **simple** experimental set-up to condense the gas and collect it as a liquid during heating.

[1]

(c) The student suspected that the effervescence seen in Test 2 was due to the formation of carbon dioxide. Describe a test that he could conduct to confirm this.

.....

.....

.....

.....[2]

(d) Construct a balanced chemical equation to show the decomposition of calcium ethanoate based on the students' investigation and the information provided.

.....[1]

(e) Using the equation constructed in part (d), deduce why the student had failed to decompose calcium ethanoate completely.

.....

.....

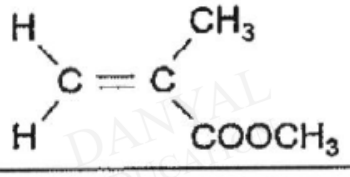
.....

.....[2]

Q5

Perspex is a polymer also known as acrylic or acrylic glass.

The table below shows some information about *Perspex*. The term *softening temperature* is used for materials with no fixed melting point.

average molecular mass	softening temperature	structural formula of monomer
10, 000	160 °C	

(a) (i) Which two homologous series would the monomer of *Perspex* belong to?

.....[2]

(ii) Draw the structural formula of *Perspex*.

[1]

(iii) Name the type of polymerisation that occurs when *Perspex* is formed from its monomers.

.....[1]

(iv) Describe and explain a simple test to show that all the monomers have reacted to form Perspex.

.....

.....[2]

(b) Two types of *Perspex* are available. The *Perspex* shown in the table has high molecular mass. Low molecular mass *Perspex* has different properties.

(i) Calculate the number of monomers in each molecule of high molecular mass *Perspex.*

.....

.....[1]

(ii) Predict how the softening temperatures of both *Perspex* would be different and explain your answer.

.....

.....[2]

Answers

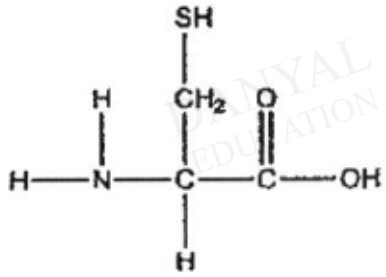
Organic Chemistry Test 6.0

Q1

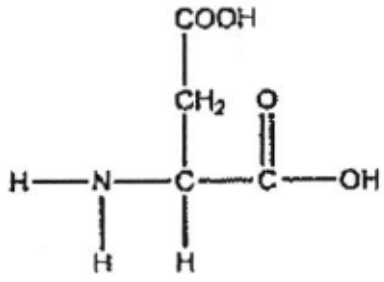
a) Nylon;

b)

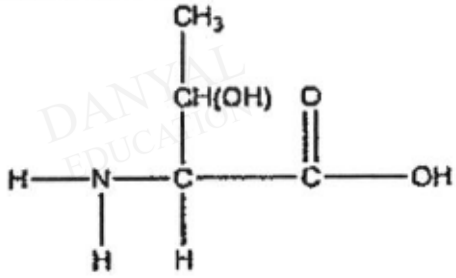
Monomer 1:



Monomer 2:



Monomer 3:



c)
Each monomer consists of an amine ($-NH_2$) that reacts with acid to form a salt; and carboxyl (-COOH) functional group that reacts with bases to form a salt;
Reject: -NH group

d(i) Mixture of monomers can be linked up in a random order hence unlikely to contain the same repeating pattern;
OR
The hydroxyl group in the third amino acid may participate in the condensation reaction instead of the amino group.

d(ii)
Range of average number of repeating units
= 37143/349 to 42678/349
= 106.43 to 122.29;

Range of amino acid residue
= 106.43x3 to 122.29x3
= 319.29 to 366.87
= 319 to 367;

Q2

a)
hydration: 300 °C, H_3PO_4 catalyst and 60 atm
fermentation: 37 °C, yeast catalyst, absence of oxygen

b)
Advantage (any two of the following)
- Ethanol obtained by hydration is more time efficient than by fermentation / No further separation technique is required to obtain pure ethanol by hydration. Fractional distillation is required to obtain pure ethanol by fermentation. / Obtaining pure ethanol by a batch process involves more steps as compared to hydration which involves a single-step.
- H_3PO_4 catalyst used in hydration lasts longer than enzyme in yeast in fermentation. Unlike H_3PO_4 catalyst used in hydration, enzyme in yeast denatures when the temperature of the reaction exceeds 37 °C or when the concentration of ethanol is above 15%.
- Ethanol obtained by hydration is more cost-effective than by fermentation. For every 1 kg of ethene and water used, 1 kg of ethanol is produced by hydration but only 0.51 g of ethanol is produced by fermentation / Product obtained by hydration is pure. Product obtained by fermentation is not pure as further separation is require / 100% yield for hydration but at most 15% yield for fermentation
  [Reject: Fermentation can only be used to produce ethanol unlike hydration which can be used to produce alcohols in general (question is scoped to focused on ethanol)]

Disadvantage (any two of the following)
- Ethanol obtained by hydration is less environmentally friendly than by fermentation. Using high temperature and pressure requires the burning of more fossil fuels which releases harmful gases to the atmosphere.
- Crude oil is a non-renewable resource. Corn is a renewable resource though weather dependent on supply of crop growth.
- Hydration process is more expensive due to high temperature and pressure required.

c(i) Fractional distillation;
c(ii) Enzyme in yeast dies when ethanol concentration is high;

d)
The sugar used during fermentation was formed by absorption of carbon dioxide (during photosynthesis);
Burning of ethanol and fermentation of glucose to form ethanol release the carbon dioxide that was previously absorbed;

Q3

(a)

element	carbon	hydrogen	oxygen
% by mass	47.4	10.5	42.1
A_r	12	1	16
no. of mol	$\frac{47.4}{12} = 3.95$	$\frac{10.5}{1} = 10.5$	$\frac{42.1}{16} = 2.63$
mole ratio	$\frac{3.95}{2.63} = 1.50$	$\frac{10.5}{2.63} = 3.99$	$\frac{2.63}{2.63} = 1.00$
	1.5	4	1
	3	8	2

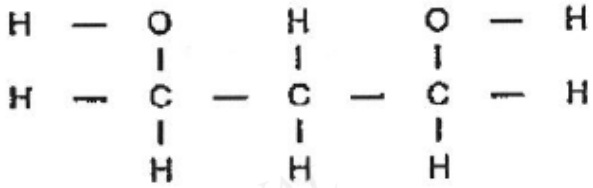
[1]

[1]

Empirical formula of X is $C_3H_8O_2$.

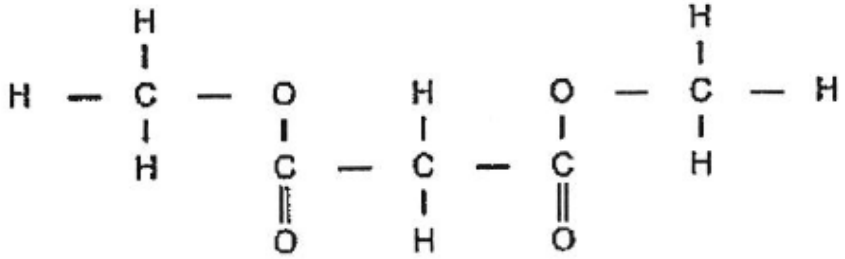
M_r of $C_3H_8O_2$ = 3(12) + 8(1) + 2(16) = 76
Molecular formula of X is $C_3H_8O_2$. [1]

(b) (i)



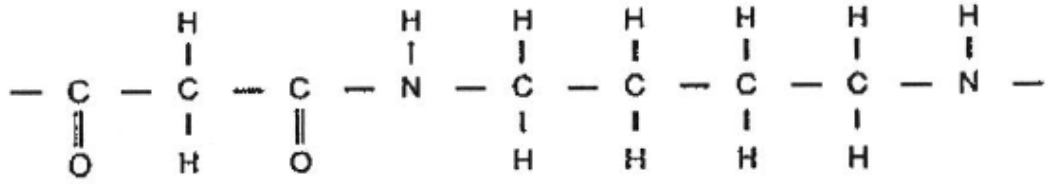
(ii) acidified potassium manganate(VII)

(c)



(d) (i) condensation polymerisation

(ii)



(iii) nylon

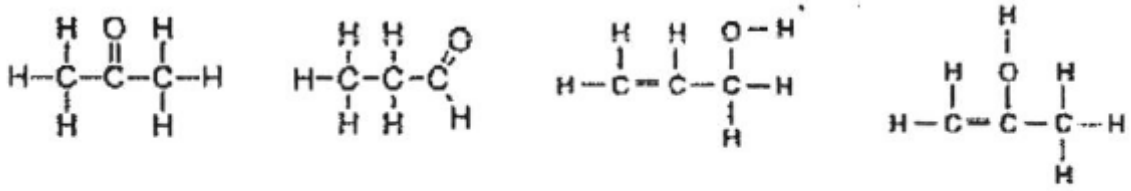
Q4

(a) The gas cannot be oxygen because a lighted splint was used instead of a glowing splint. [1 mk pt] The student did not observe a glowing splint relighting. [1 mk pt]
The gas cannot be hydrogen as there was no 'pop' sound heard [1 mk pt] and instead of the flame being extinguished, a flame was observed [1 mk pt] at the mouth of the test tube.

4 mk pts – [2]
2-3 mk pts – [1]
1 mk pt – [0]

Do not accept if students merely described the tests for oxygen and hydrogen. Students must explain why the conclusions are wrong.

(b) **(i)**



Any 2 answers, [1] each

(ii)

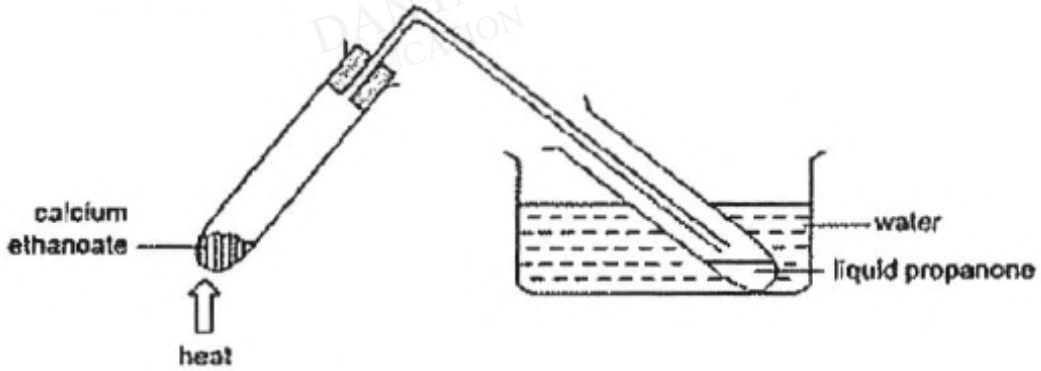


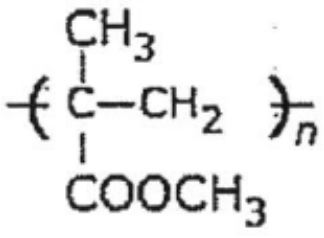
Diagram must be labelled correctly.
Simple distillation set-up with a Liebig condenser is not acceptable because question asked for a simple set-up.

(c) He could bubble the gas into a test tube of limewater. [1]
If carbon dioxide gas is present, a white precipitate forms in limewater. [1]

(d) $(CH_3COO)_2Ca \rightarrow CaCO_3 + C_3H_6O$

(e) Calcium carbonate was left as a residue. [1]
If the student had decomposed calcium ethanoate completely, calcium carbonate would not be left behind. Calcium carbonate could be decomposed further to calcium oxide and carbon dioxide. [1]

Q5

(a)	(i)	alkene [1] and ester [1]
	(ii)	 [1] Reject: - No brackets or n - Incorrect no of bonds around C atoms
	(iii)	Addition [1] Reject: additional
	(iv)	Add aqueous bromine // bromine solution // bromine water. If aqueous bromine decolourises / turns from brown to colourless [1], not all monomers have reacted due to their C=C bonds [1] Accept reverse answer. Reject: change colour
(b)	(i)	n = molecular mass of Perspex / Mr of repeating unit = 10000 / 100 = 100 [1]
	(ii)	High molecular mass Perspex will have a higher softening temperature than low molecular Perspex. [1] Larger molecule // higher number of carbon atoms in a molecule means that there is more extensive intermolecular forces to overcome. [1] Accept reverse answer.