Trinity College

ATAR Chemistry 3+4
Chemical Synthesis Chemistry Test

TOTAL MARKS = 55

Multiple choice 12 marks

1. The equation below shows the key step involved in the Contact process.

$$2\ SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g) \qquad \Delta H = -198\ kJ\ mol^{-1}$$

Which of the following sets of conditions would increase both the rate and yield of $SO_3(g)$?

	Increased rate	**Increased yield**
(a)	High temperature	Low pressure
(b)	High pressure	Low temperature
(c)	Low temperature	High pressure
(d)	Low pressure	High temperature

2. Considering only the information given below, which reaction is **most likely** to proceed quickly in the reverse direction?

	ΔH(forward) (kJ mol^{-1})	**E_a(forward) (kJ mol L^{-1})**
(a)	+850	875
(b)	+120	645
(c)	-95	730
(d)	-545	90

Questions 3 and 4 refer to the following information.

There are two main methods for the industrial production of ethanol; fermentation of glucose and hydrolysis of ethene. The chemical equations for each process are shown below.

Hydrolysis: $CH_2CH_2(g) + H_2O(g) \overset{H_3PO_4}{\rightleftharpoons} CH_3CH_2OH(g) \qquad \Delta H = -45\ kJ\ mol^{-1}$

Fermentation: $C_6H_{12}O_6(aq) \overset{zymase}{\rightarrow} 2\ CH_3CH_2OH(aq) + 2\ CO_2(g)$

3. Which of the following statements is **not** correct, regarding the hydrolysis of ethene to produce ethanol?

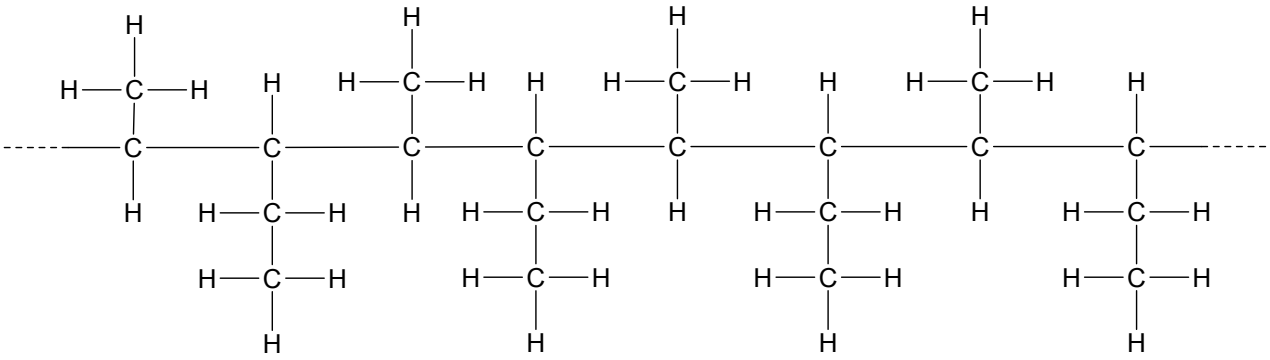
(a) An increased pressure increases the forward reaction rate.
(b) An increased pressure increases the ethanol yield.
(c) An increased temperature increases the forward reaction rate.

(d) The H_3PO_4 catalyst increases the ethanol yield.

4. Which of the following statements is **not** correct, regarding the fermentation method of ethanol production?

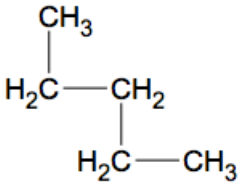
(a) It is performed at a lower temperature than the hydrolysis method.
(b) It is performed at a lower pressure than the hydrolysis method.
(c) It is a less sustainable method than the hydrolysis method.
(d) The *zymase* enzyme provides an alternative reaction pathway with a lower activation energy.

5. Consider the section of polymer shown below.

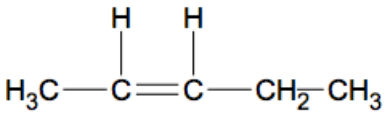


Which of the following monomers could be used to produce this polymer? B

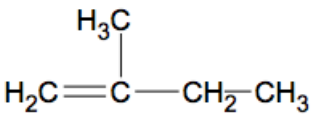
(a)



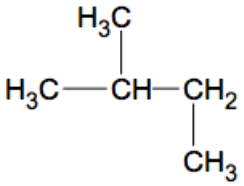
(b)



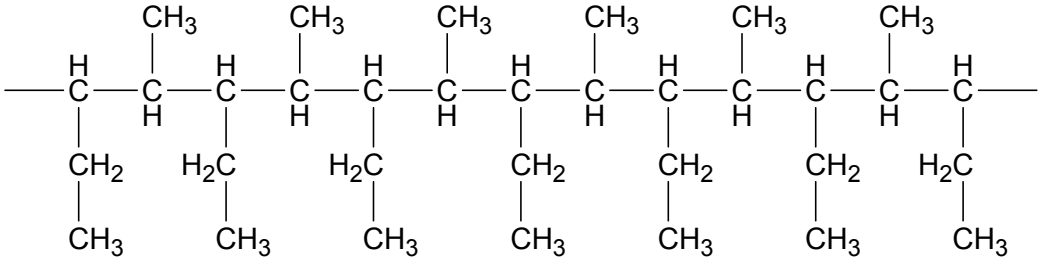
(c)



(d)

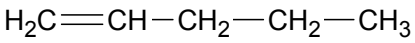


6. Consider the fragment of polymer strand shown below.

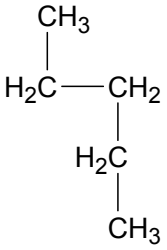


Which of the monomers below was used to make this polymer?

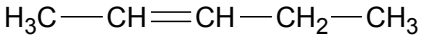
(a)



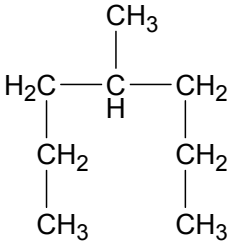
(b)



(c)



(d)



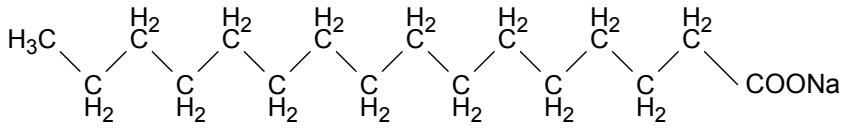
7. Which of the following statements regarding tyrosine are **correct**?

(i) Tyrosine is an amino acid
(ii) Tyrosine is an α-amino acid
(iii) The molecular formula of tyrosine is $C_9H_7NO_3$

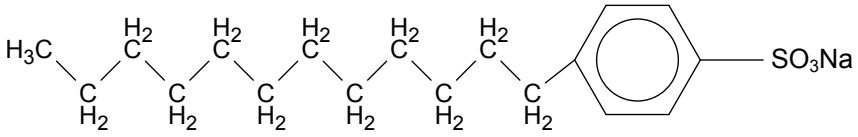
(a) (i) and (ii) only
(b) (i) and (iii) only
(c) (ii) and (iii) only
(d) (i), (ii) and (iii)

8. A sample of soap and a sample of detergent were both added to a beaker of hard water, containing a **low** concentration of $Ca^{2+}(aq)$. The soap and detergent are shown below;

Soap



Detergent



Which of the following species is **not likely** to be present in the beaker after mixing?

(a) $CH_3(CH_2)_{14}COO^-(aq)$
(b) $CH_3(CH_2)_{11}C_6H_4SO_3^-(aq)$
(c) $Ca(CH_3(CH_2)_{14}COO)_2(s)$
(d) $Ca(CH_3(CH_2)_{11}C_6H_4SO_3)_2(s)$

9. An enzyme is a biological catalyst. An esterase enzyme can be used in the hydrolysis of an ester as shown below.

$$\text{ester} + \text{water} \overset{\text{esterase}}{\rightleftharpoons} \text{carboxylic acid} + \text{alcohol}$$

Upon the addition of esterase, which of the following statement is **correct** for this process?

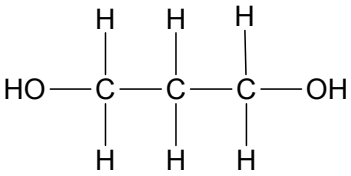
(a) The position of equilibrium for this reaction is shifted to the right.
(b) The rates of the forward and reverse reactions both increase equally.
(c) The rate of the forward reaction increases more than the rate of the reverse reaction.
(d) The rate of the forward reaction increases while the rate of the reverse reaction decreases.

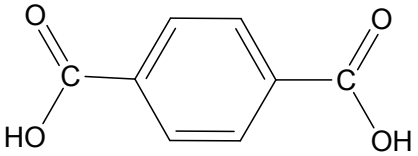
10. Starch is a condensation polymer of glucose. A starch molecule contains 500 glucose units. If the molar mass of glucose is 180 g mol^{-1}, then the molar mass of the starch molecule is

(a) 98982 g mol^{-1}

(b) 90000 g mol^{-1}
(c) 81018 g mol^{-1}
(d) 8982 g mol^{-1}

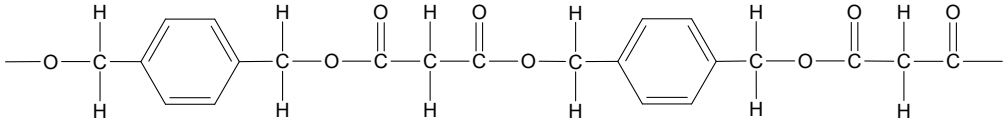
11. The polymer PTT (polytrimethylene terephthalate) was patented in 1941 and is used in the manufacture of carpet fibres. It is produced from the polymerisation of the monomers propane-1,3,-diol and terephthalic acid.



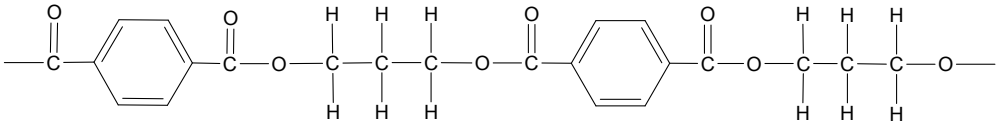


Which of these structural diagrams represents PTT? B

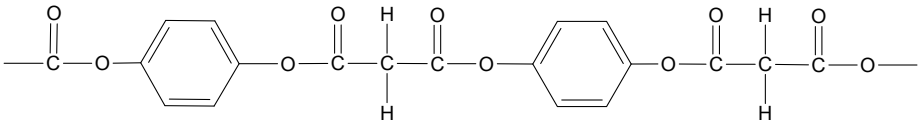
(a)



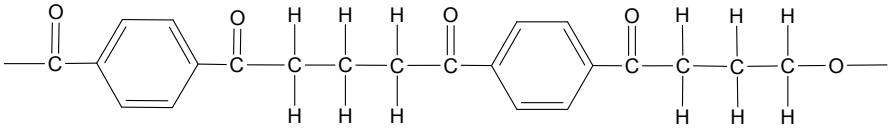
(b)



(c)

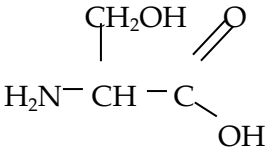


(d)

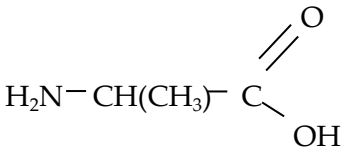


12. Consider the two α-amino acids, **X** and **Y**, shown below.

X



Y



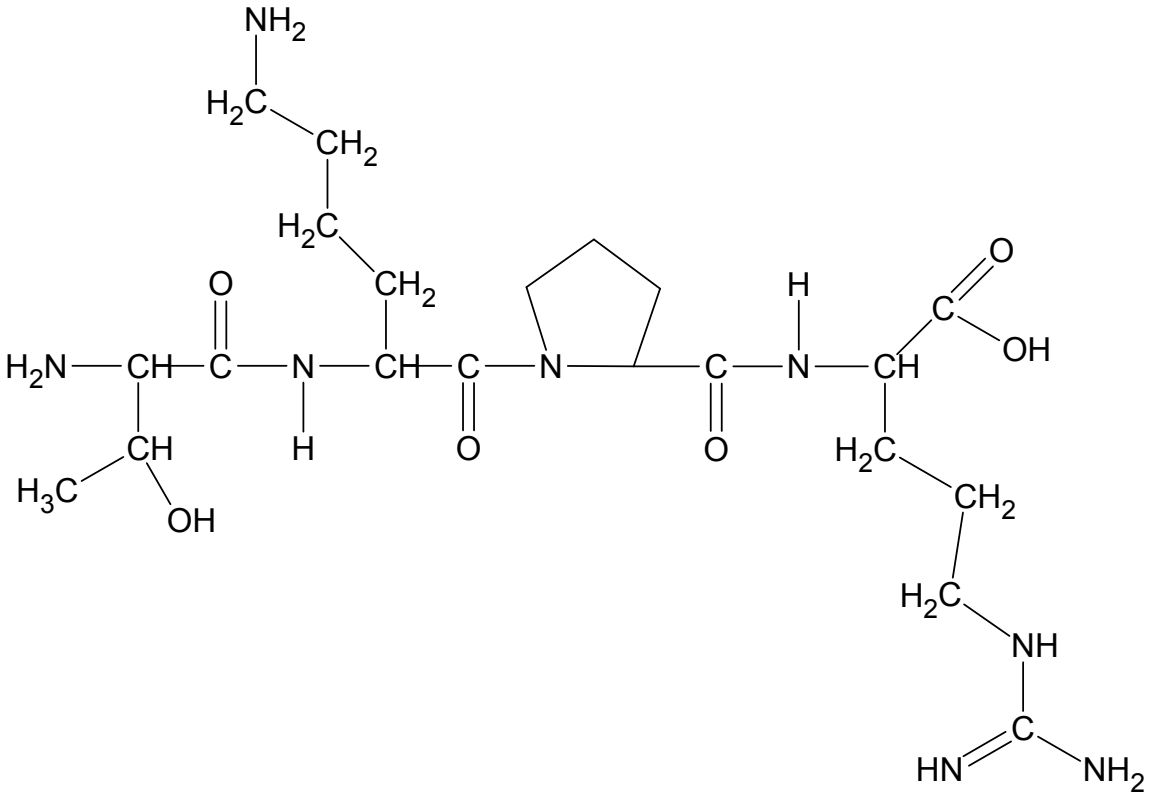
The correct names for these two α-amino acids are:

(a) alanine and valine respectively.
(b) valine and threonine respectively.
(c) serine and alanine respectively.
(d) serine and lysine respectively.

Short Answers 43 marks

Question 13 **(5 marks)**

Tuftsin is a tetrapeptide (a molecule consisting of four amino acid residues) which is produced by the spleen. It has been found that people with low levels of tuftsin in their bodies are susceptible to repeated frequent infections of the skin, lymph nodes and lungs. Low tuftsin levels can be inherited genetically or can be the result of a spleen operation. The tuftsin tetrapeptide molecule is shown below.



(a) Copy and then complete the primary sequence of tuftsin below using the standard three letter abbreviations.

(2 marks)

thr – lys – – –

One medical study has shown that some people have a genetic mutation which causes the lysine residue in tuftsin to be replaced with a glutamic acid residue instead.

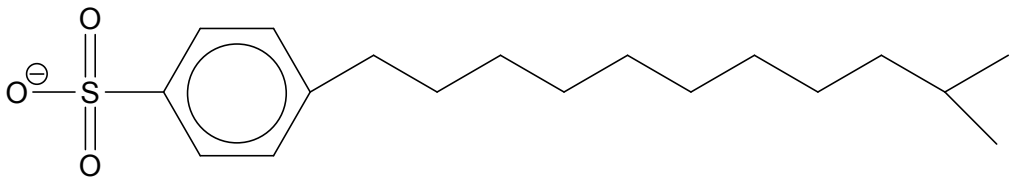
In the mutated form of tuftsin, the primary sequence of the tetrapeptide has been changed, altering its function.

(b) In general terms, explain how alteration of the primary sequence of a protein can affect its secondary and tertiary structures.

(3 marks)

Question 14 **(7 marks)**

The structure of a detergent molecule called 'branched dodecylbenzene sulfonate' is shown below.



(a) Note one similarity and one difference between the structure of this detergent molecule and a soap molecule.

(2 marks)

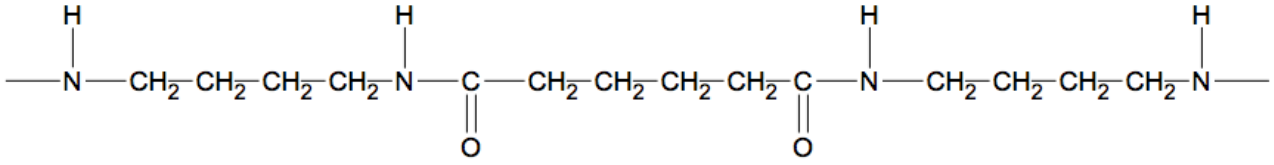
(b) Describe the cleaning action of detergents. Include in your answer a discussion of the advantage detergents have over soaps when used in hard water.

(5 marks)

Question 15 **(6 marks)**

'Nylon 4/6' is a polymer which can be obtained as a fibre, film, rod or sheet. It has wide ranging applications owing to its high heat and chemical resistance in comparison with other nylons. It is most often used for electrical and electronic components, in particular those that must withstand high temperatures for a long period of time.

A segment of nylon 4/6 is shown in the diagram below.



(a) Nylons have the ability to form hydrogen bonds between polymer strands. How does this bonding affect the physical properties of nylon polymers?

(2 marks)

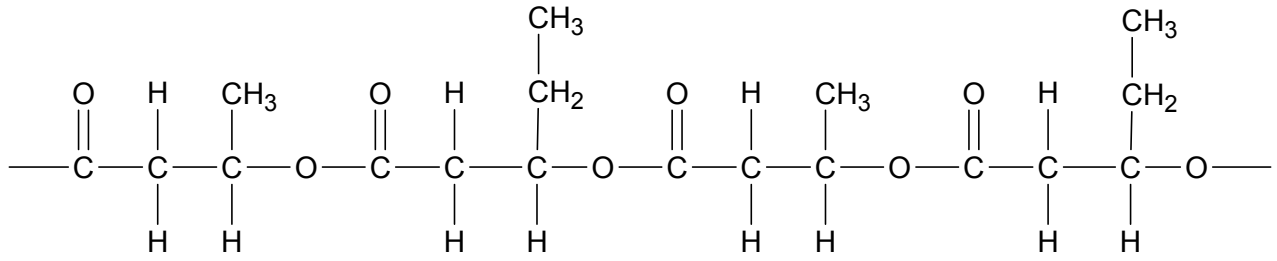
(b) Draw the two (2) monomers from which nylon 4/6 is composed. (2 marks)

(c) Name and briefly describe the process by which these monomers are able to form this nylon polymer.

(2 marks)

Question 16 **(8 marks)**

PHBV is a biodegradable, non-toxic plastic that is produced naturally by some types of bacteria. A fragment of the PHBV polymer is shown below.



(a) Draw the two (2) monomers from which this copolymer is formed and give the IUPAC name for each.

(4 marks)

(b) Is this polymer a 'polyester' or a 'polyamide'? State your answer below, then circle the ester or amide links in the polymer fragment above.

(2 marks)

Polyester

PHBV is a thermoplastic, which means it melts easily when heat is applied, and lacks the strength of a polymer such as nylon.

(c) Briefly account for the different physical properties of PHBV and nylon.

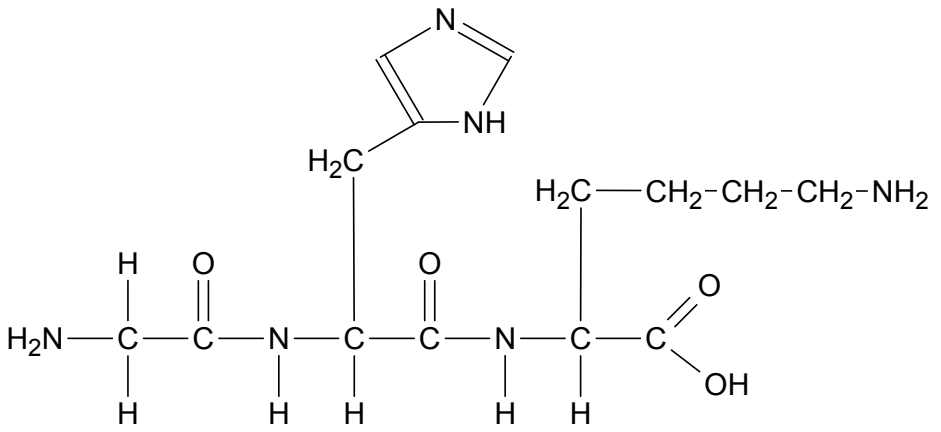
(2 marks)

Question 17 **(7 marks)**

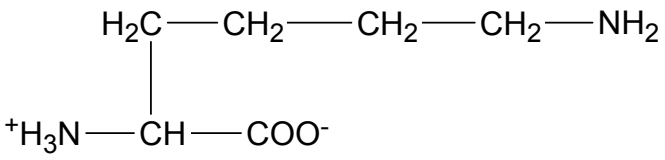
'Copper peptide GHK' (also written GHK-Cu) is a tripeptide composed of the amino acids glycine, histidine and lysine (gly-his-lys). GHK-Cu is found in blood plasma, urine and saliva. Studies have shown that GHK-Cu plays an important role in healing wounds. In one animal study, it was observed that the presence of GHK-Cu increased the rate of healing threefold.

(a) Draw a structural diagram of the GHK-Cu tripeptide.

(3 marks)



The GHK-Cu tripeptide functions due to the ability of the amino acid lysine to interact with copper(II) ions. A diagram of lysine, at physiological pH, is shown below.



(b) Define a 'zwitterion'. Copy and label the acidic and basic groups on the diagram of lysine shown above.

(3 marks)

In the GHK-Cu tripeptide, the lysine residue is only able to interact with copper(II) ions at an alkaline pH.

(c) Draw the structure of lysine at pH 14 (i.e. strongly alkaline). (1 mark)

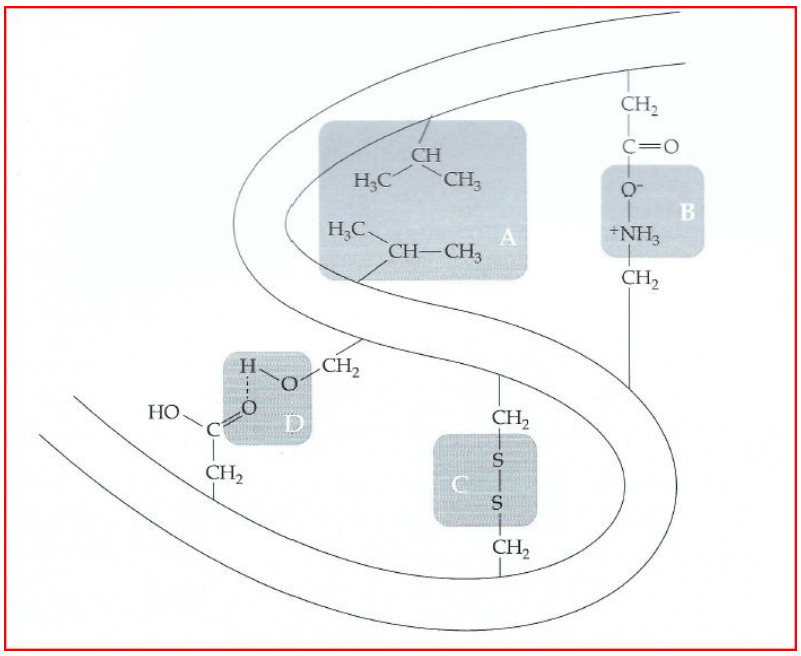
Question 18. Match the following polymers (i → vi) with their uses (a → f)

(6 marks)

i. polyvinylchloride (PVC)	a. moulded plastics - containers, toys, bags, bottles, wrapping materials.
ii. polyethene	b. pipes, rigid panels, floor tiles, electrical insulation, records, window frames.
iii. Teflon	c. greaseless bearings, chemically resistant liners, non-stick liners.
iv. polymethylmethacrylate	d. windows, lenses, panels.
v. nylon	e. surfboards, cups, insulating and packing material.
vi. polystyrene	f. bearings, fibres, and clothing.

Question 19

The diagram below represents a segment of protein, showing the types of interactions that can occur between amino acid side chains to form the tertiary structure.



Identify the type of interactions labelled A, B, C, and D. **(4 marks)**

End of Test