VICTORIAN CERTIFICATE OF EDUCATION

CHEMISTRY Unit 4 - SAC 4 - 2026

Area of Study 1 – Analysis of Media communication

Reading time: 5 minutes

Writing time: 60 minutes

Student's Name: _____Solutions_____

Student number: _____

Teacher: _____

Structure of booklet

Section	Number of Questions	Marks
Short Answer	5	47
		/ 47

Directions to students

Materials

- Students **are permitted** to bring into the examination room: pens/pencils, highlighters, erasers, sharpeners, rulers, and an approved scientific calculator.
- Students are **NOT permitted** to bring into the examination room: white out liquid/tape, phones or electronic devices, including smart watches.
- Students are provided with the following: Blank Media Article, Question and answer book of **12** pages, and a VCAA Data booklet (can be written on).

The task

- There are a total of **47** marks available.
- Be sure to include states with all chemical equations.
- All numerical answers must show working and answers quoted to the correct number of significant figures.

Question 1

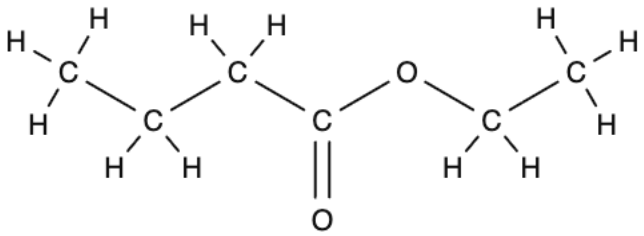
The article explores the misconception of sun tanning being worse for your skin than using the peptide supplement melanotan II (MT-II). Based on the information in the article and your understanding of peptides answer the following questions:

a) Suggest a reason why some people think there is no danger in taking this MT-II synthetic peptide chemical hormone.

This peptide is a chemical hormone that is already naturally occurring in your body.

(1 mark)

b) The article suggested these peptides are generally unreactive unless in the presence of an acid. There was also concern with side effects with worsening health concerns for those who are dual MT-II and fruit flavoured vape users. For example, the pineapple flavouring seen below:



i) Name the functional group vape flavouring molecules have.

(1 mark)

Ester (-COO-)

ii) If the chemical flavouring ingredient in vapes are not acid molecules, explain how the presence of fruit vape flavouring on its own increases the bodies blood acidity.

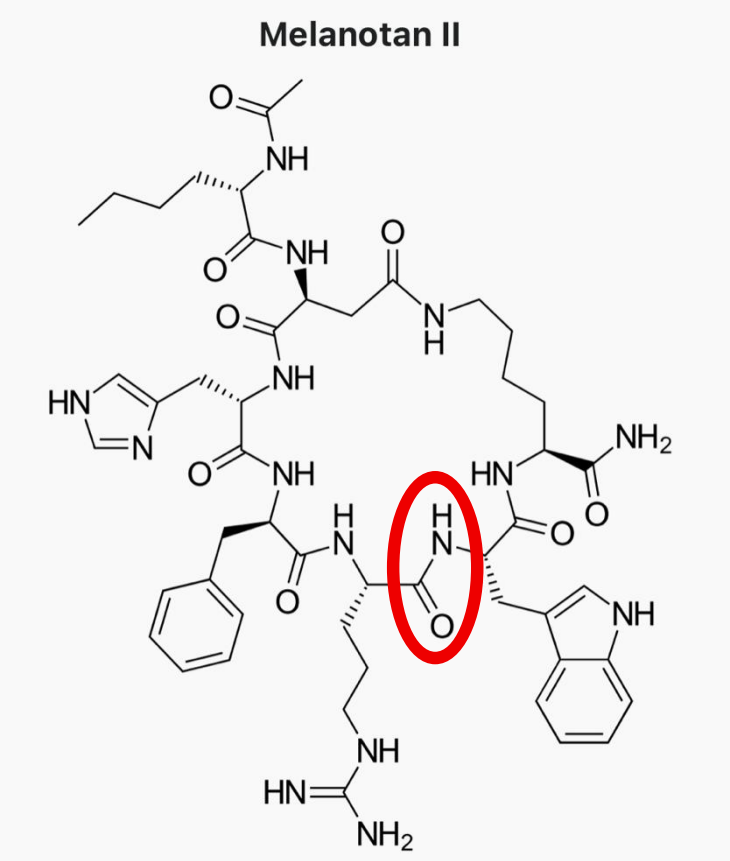
1- Esters hydrolyse into carboxylic acids and alcohols

1- Carboxylic acids deprotonate, producing H+ so have a low pH→ contribute to a higher blood/ body acidity

(2 marks)

Question 2

MT-II is a synthetic peptide hormone designed to trigger a knock-on effect when it reaches target cells in the body, for example skin cells to create more pigment to help protect against UV rays. There are many other peptide hormones that are constantly circulating throughout your bloodstream.



The molecular structure of MT-II peptide is synthesised through the linking of smaller components.

a) Name the type of molecule used to create this peptide

Amino Acid

(1 mark)

b) The ends of these smaller components have to chemically change and react to link the different pieces together.

i) <u>On the diagram above</u> of MT-II, circle one of these new linkages where two original ends of different components joined together.

Example above on diagram but accept any amide link (1 mark)

ii) Write the semi structural formula of this linkage functional group. (1 mark)

-CONH- also accept HNCO

iii) Name the other product(s) formed because of this linkage. (1 mark)

Water

c) MT-II comes as an injectable aqueous so is therefore water soluble. Explain how MT-II is soluble in water. In your response identify and explain one structural feature that increases its solubility and one structural feature that limits its solubility in water.

1- Very polar. Many dipoles and sites that can form dipole/dipole such as C=O dipole or N-H hydrogen bonding that interact with waters dipoles
2- Very large molecule, much larger than water. Makes it harder to be soluble or takes longer to dissolve as requires a higher ratio of water molecules to fully dissolve.

(2 marks)

d) MT-II has many nitrogen based function groups within this structure. Identify whether the majority of nitrogen groups in MT-II are considered primary, secondary or tertiary. Justify your response.

1- Secondary.
1- There is a nitrogen bonded to 2 carbons, making it a secondary nitrogen group

or most groups are NH, NH2 would be primary and N is tertiary.

(2 marks)

e) While MT-II is quite large, other hormones can be much smaller. For example, Thyrotropin- Releasing hormone (TRH) which signals your pituitary gland. This has only 3 components and can be written in a chain format of : Glu-His-Pro

i) Name the link that connects glutamic acid (Glu) to the Histidine (His).

Amide link * also accept peptide link/ bond (1 mark)

ii) Describe in detail what happens to the specific **atoms** and bonds of Glu and His for this linkage to occur successfully, include what is required to perform this reaction and start the TRH chain.

Students must include 3 of the 4 below to get 3 marks

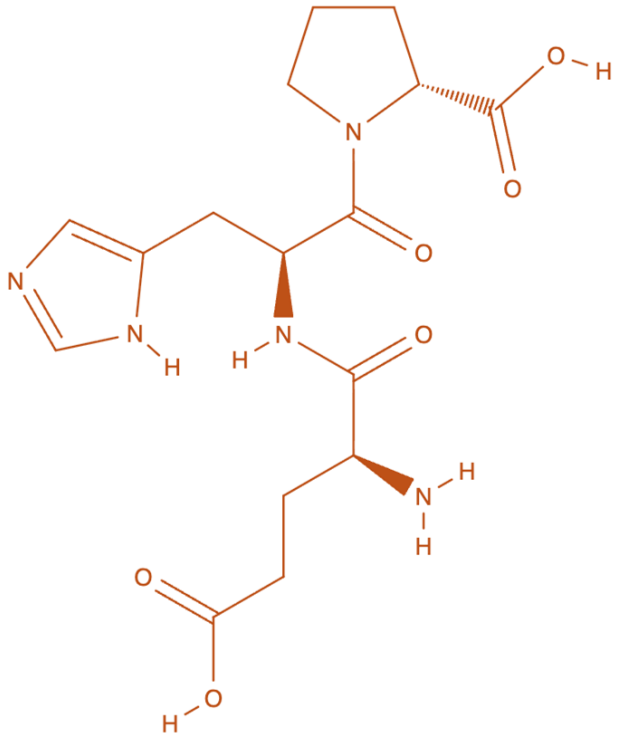
1- Sufficient activation energy/ successful collisions required for the reaction to start
2- The carbon from the carboxyl group from the Glu amino acid loses the OH to form a C=O and an unpaired electron that forms a bond to the Nitrogen on the next amino acid
3- The amino group on the His loses one hydrogen off of the Nitrogen, leaving an unpaired electron that forms a bond to the carbon on the next amino acid
4- The OH from the carboxyl group and H from the amino group form water

(3 marks)

iii) Draw the structure of the resulting TRH peptide formed from the components Glu-His-Pro.

*Don't need to show every bond (e.g as in Databook) for R groups as wording is not structural formula.

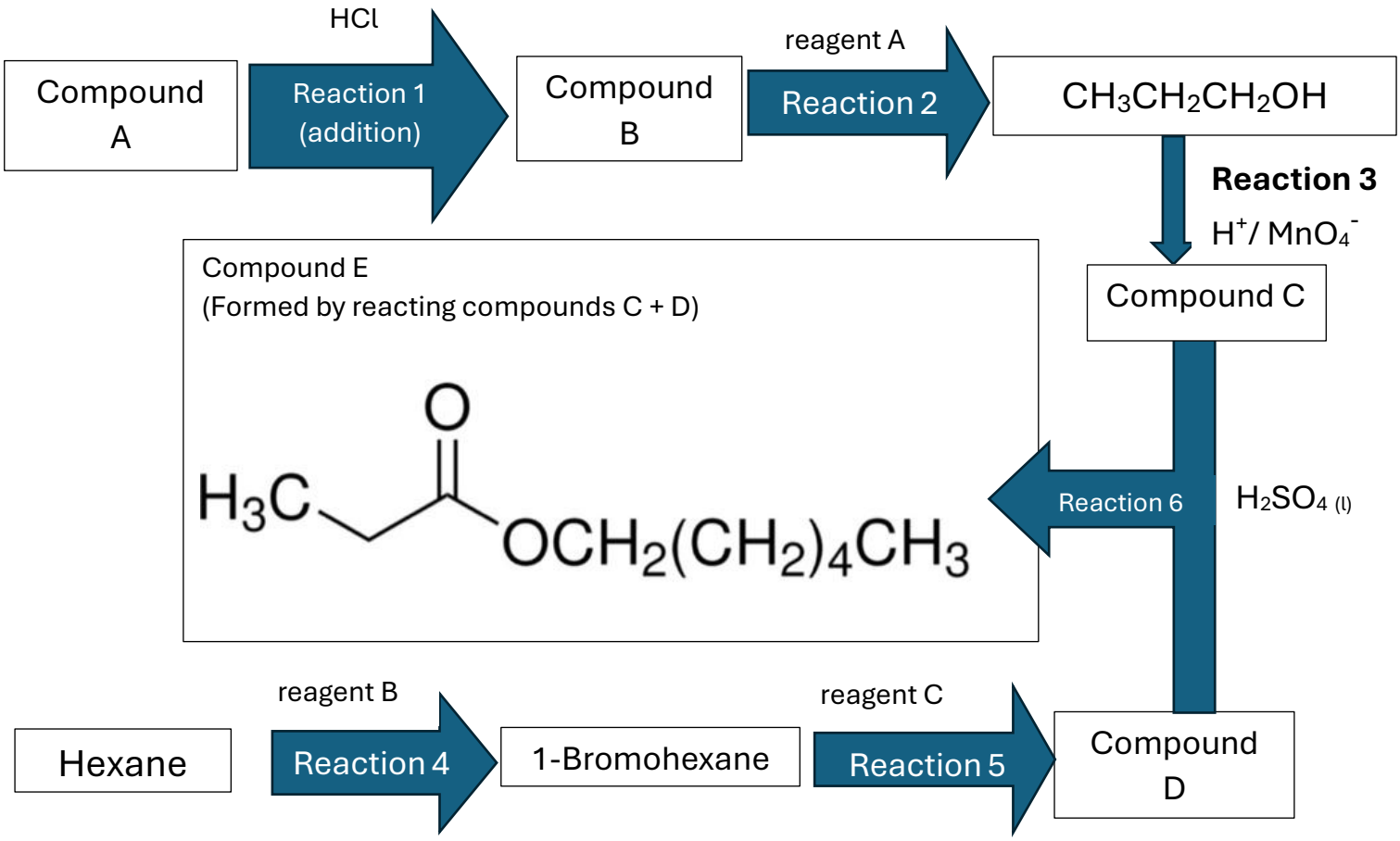
*R groups must alternate which side they are on



(2 marks)

Question 3

The article expressed concern around dual Vape and MT-II users. The stages to chemically synthesis a tropical scented, compound E are laid out below in the reaction flow diagram.



a) Write the IUPAC name for compounds A and E

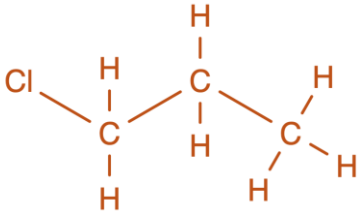
A: Propene accept prop-1-ene.

E: hexyl propanoate

b) Write the semi structural formula for compound C

CH_3CH_2COOH

c) Draw the structural formula for compound B



Cl must be on end (2 + 1 + 1 = 4 marks)

d) Draw the skeletal formula for compound D (1 mark)



OH must be on end

e) State the chemical reagents used for reaction 2 and reaction 4

Reagent A (reaction 2): NaOH

Reagent B (reaction 4): Br2 Br2/ UV also ok but not needed (2 marks)

f) Name the other byproduct(s) not shown above that are formed in reaction 5.

NaBr , also accept KBr (1 mark)

g) Design an alternative synthesis pathway from compound A to propan-1-ol that better aligns with the principles of green chemistry, ensure you include all reagents and/or conditions required.

(To help, you may like to draw a chemical reaction sequence or equation)

Alternate pathway:

Propene to propan-1-ol in one step. Reagent $H_2O_{(g)}$ + 300^{O} C + $H_3PO_{4\,(l)}$ catalyst

1- Reactants drawn out/ written out
2- Products and all steps are shorter & drawn out clearly
3- All reagents/ conditions/ catalysts

(3 marks)

h) Referring to the green chemistry principles, justify why your pathway is greener.

1- Higher atom economy

2- By going straight from alkene to alcohol decreases the 'wasted' atoms that are not part of the end product. There are less steps so less energy required/ wasted. Doesn't use halogens- reduce toxicity.

Accept other reasonable or based on their pathway.

(2 marks)

i) Many organic compounds can be hard to make in large quantities effectively. Using the following information calculate the respective percentage yields.

Yield of compound C formation (reactions 1, 2 & 3 combined) = 79.90%

Yield of compound D formation (reactions 4 & 5 combined) = 45.50%

Yield of only reaction 6 = 65.00%

ii) Calculate the percentage yield of reactions 1-5 combined.

% yield reactions 1-5 = 36.35% (*also accept 45.5% as the limiting yield if 1:1 ration??)

(1 mark)

iii) Calculate the percentage yield of the entire pathway sequence to form compound E.

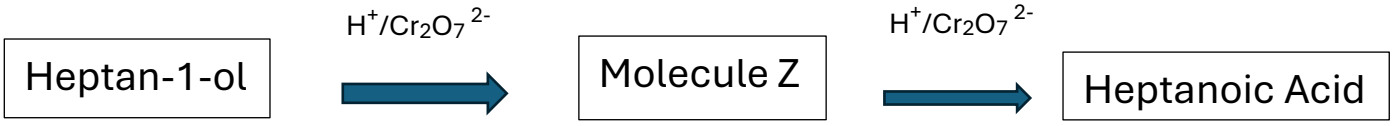
% yield whole synthesis = 0.3635 x 0.65 x 100 = 23.63%

(*also accept 0.455 x 0.65 x 100 = 29.575% as parallel conditional chance from the 'limiting' yield sequence pathway, then reaction 6 has 65%- but doubt students will work it out this way)

(1 mark)

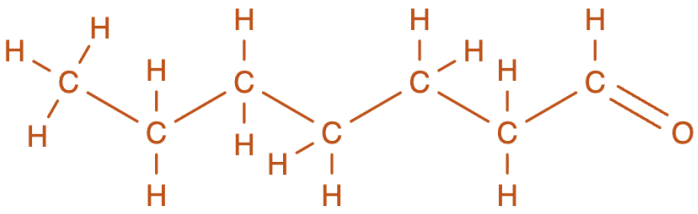
Question 4

Other vape flavours such as berry use the reactant heptan-1-ol. Differing from the reaction pathway steps seen in question 3, an alternative format showing the formation of heptanoic acid is seen below:



a) Provide the IUPAC <u>name **and** draw</u> the structural formula of molecule Z.

(2 marks)



Heptanal

b) Explain why heptan-3-ol cannot be used to form heptanoic acid using this reaction progression sequence even with the correct reagents and conditions.

The carbon that forms a secondary alcohol can only be oxidised to form a ketone. You can't further oxidise this to a carboxylic acid as requires too many bonds.

(1 mark)

Question 5

Neither synthetic MT-II or retatrutide are officially legal or regulated by the therapeutics goods administration (TGA) who are in charge of making sure medicines are safe for consumption. These synthetic medications have issues with both purity and quality.

Retatrutide peptide can be used for hunger blockers and has the molecular formula:

$$C_{221}H_{342}N_{46}O_{68}.$$

The vial of retatrutide had 19mg, almost double the 10mg dose it claimed to have. The synthesis of retatrutide is hard to do well and has many steps, the simplified chemical equation for the formation of retatrutide is seen below:

$$3C_{15}H_{24}N_2O_4 + 2C_{74}H_{141}N_{16}O_{37} + C_{13}H_{29}N_3O_5 + 5C_3H_7NO_3 \rightarrow C_{221}H_{342}N_{46}O_{68} + 38H_2O$$

Reactant 1	Reactant 2	Reactant 3	Reactant 4 →	Retatrutide	+ Water
M= 296gmol^{-1}	M= 1845gmol^{-1}	M= 307gmol^{-1}	M= 105gmol^{-1}		

a) Calculate the number of moles of retatrutide present in the 19mg vial.

M(retatrutide) = 4726g/mol

n(retatrutide) = m/M = $\frac{0.019\ g}{4726}$ (1 mark for unit conversion)

n(retatrutide) = 0.00000402mol or 4.02×10^{-6} mol

(2 marks)

b) The purity of the sample was recorded at 16.6% for the entire 3.00mL vial that actually contained 19.0mg of the peptide. Calculate the total mass of all compounds, both retatrutide and impurities dissolved in the vial.
(ensure your response is to the correct number of significant figures)
1- Answer w. units
1- 3 Sig figs

m(total) = 19 / 0.166 = 114.4578mg = 114mg or m(total)= 0.114g

(2 marks)

c) Calculate the percentage atom economy for the formation of retatrutide, assuming the manufacture had completed their synthesis accurately.

Atom economy = $\frac{M \text{ (desired product)}}{M \text{ (all reactants)}}$ = M(retatrutide) = $\frac{4726}{5410}$ X 100

= 87.36%

As 1 mark can also do M(retatrutide)/ 1 x M(retatrutide) + 38 x M(H_2O)

(1 mark)

d) Presuming the manufacture was supposed to fill the vial with 19mg of retatrutide using 2.91g of all reactants, the chemists used;
Reactant 1 =0.6g, reactant 2= 1.45g, the last 0.86g of was from reactants 3 and 4 (assume reactants 3 and 4 were both in excess).

i. Calculate which reactant was the limiting reagent. Show clear evidence to support your answer.

n(reactant 1) = 0.6/ 296 = 0.002027mol

n(reactant 2) = 1.45/1845 = 0.0007859mol

Mole ratio reactant 1: reactant 2

3:2

reactant 1. 0.002027/ 3 = 0.000676
reactant 2 0.0007859/ 2= 0.000393
After ratio reactant 1 > reactant 2, therefore reactant 2 is limiting

- Or other clear evidence to show limiting

(2 marks)

ii. In another synthesis trial, the amount in mole of **reactant 1** used was 0.00021mol (assume this was the limiting reagent), use item 3 in the databook to calculate the percentage yield of this synthesis reaction to produce 19mg of retatrutide.

n(retatrutide)= n(reactant 1 /3) n(retatrutide) = 0.00021/3= 0.00007mol produce

m(theoretical retatr. produced)= n x M = 0.00007 x 4726 = 0.33082g produced

m(actual) = 0.019g

$$\% \text{ yield} = \frac{\text{actual mass}}{\text{theoretical mass}} \times 100 \qquad \frac{0.019}{0.33082} \times 100 = 5.74\% \text{ yield}$$

*can calculate as moles percentage

1- Theoretical mass and or moles
1- answer

(2 marks)

e) It is difficult to use an effective catalyst to synthesis retatrutide without degrading the sample. Explain the impacts of using a catalyst on the atom economy for this reaction to produce retatrutide.

1- No impact on atom economy
1- Catalysts increase the ROR. They do not change the reaction/ type of products etc.

(2 marks)

** End of SAC**