

Victorian Certificate of Education

CHEMISTRY 2026 Unit 4

SAC 3 AOS 1 Outcome 1

Reading time: 5 minutes

Writing time: 70 minutes

Directions to students

Student's Name: _____

Teacher: _____

Structure of booklet

Section	Question to be answered	Total marks
Short answer	6	58
Total		58

Materials

Students are permitted to bring into the examination room: 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:

- Question and answer book of 10 pages and the VCAA Data booklet.
- Media reference article

The task

- Please ensure that you write your name and teacher's name on this booklet. This paper consists of short answer questions.
- There are a total of **58** marks available.
- Be sure to include states with all chemical equations.
- All numerical answers need to be quoted to the correct number of significant figures.
- All working out must be shown in the space provided.

1. Consider the structural formula of DMC shown in fig. 2 in the information booklet provided. (13 marks)

a. Does DMC contain a typical ester functional group? Justify your answer.

2 marks

b. What other functional group is clearly present in the DMC structural formula?

1 mark

c. Consider reaction “B” in fig 2 in the information booklet provided.

i. Write the word equation for the reaction.

1 mark

ii. Write the balanced chemical equation, for the word equation given in part i. above. States not required

1 mark

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- d. With reference to Fig. 3, the synthesis of dimethyl carbonate (DMC) can proceed via two reactions, the phosgene reaction and the direct synthesis from CO₂ reaction.
- i. Calculate the **atom economy** for both the phosgene and the CO₂ reactions, showing your working clearly in the space below. 2 marks

- ii. Select any three green chemistry principles. For each principle, compare how the phosgene reaction and the direct CO₂ synthesis reaction of dimethyl carbonate align with or violate that principle. Use specific examples from each synthesis reaction to support your explanation.

2. A student wrote the following statement about the direct synthesis of dimethyl carbonate (DMC) from carbon dioxide.

“Use of a catalyst improves yield and eliminates the reliance on high temperature and pressures which makes the production more economically viable”

Using your knowledge of the CO₂ synthesis reaction and the role of catalysts, answer the following. (6 marks)

- a) Identify and explain the correct aspects of the student’s statement.

3 marks

- b) Identify and explain any inaccuracies or misconceptions in the statement.

3 marks

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3. Under certain conditions, reaction 3 has a % yield of 75%. Calculate the expected mass of DMC (90.1 g/mol) formed if an amount of 3.200 grams of methanol is placed in the reaction vessel.

(3 marks)

4. The following questions refer to fig. 2 shown above. (4 marks)

a. Consider the molecule labelled “B” in fig. 2 above.

i. Give the systematic name of the molecule.

_____ 1 mark

ii. Give the semi-structural formula of molecule “B”?

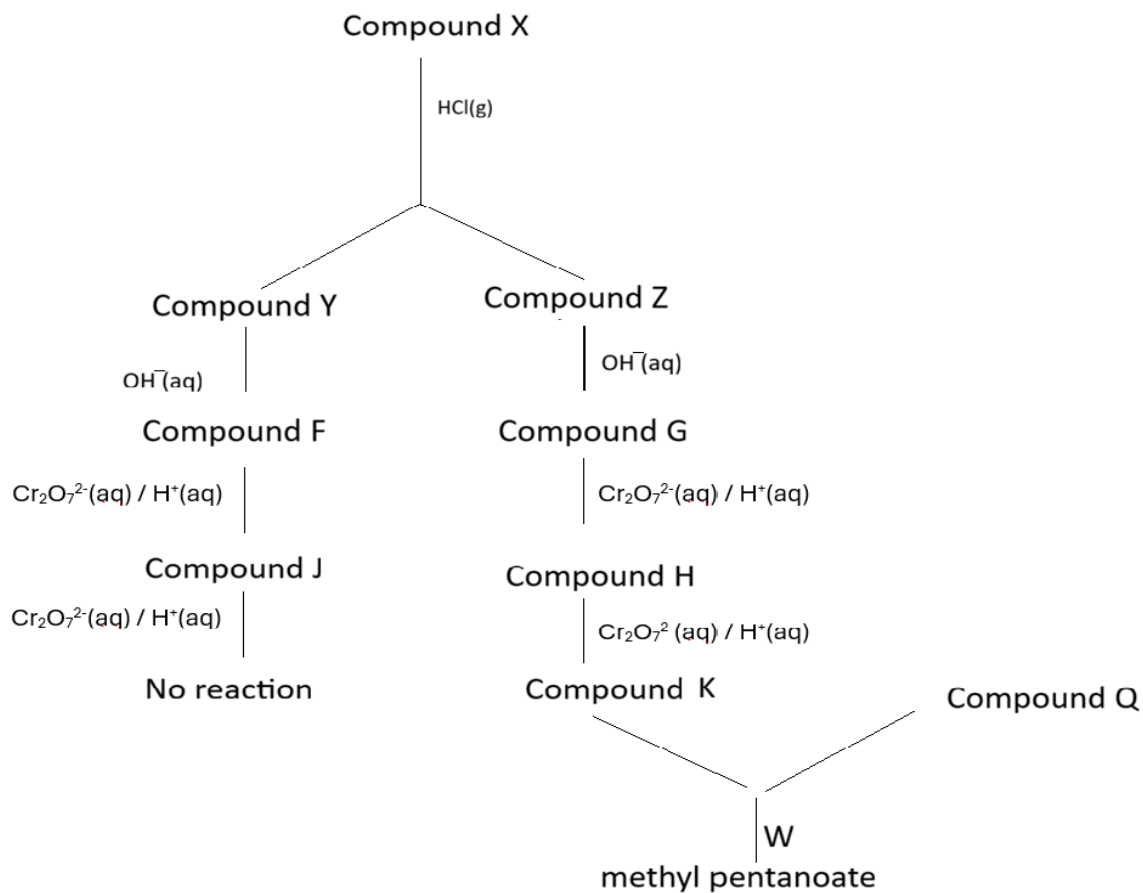
_____ 1 mark

b. Give the degree of unsaturation of ethylene carbonate, shown in fig. 2 and explain how you derived this number.

_____ 2 marks

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5. Many pharmaceuticals are produced from esterification reactions. Below is a reaction pathway to form methyl pentanoate. (17 marks)



- a. Identify the following .

10 marks

X _____
 Y _____
 F _____
 J _____
 Z _____
 H _____
 K _____
 W _____
 Q _____
 G _____

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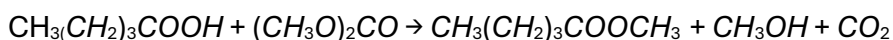
b. What general class of reaction forms compound Y?

1 mark

c. What term would you use to best describe compounds Y and Z?

1 mark

d. An alternative synthesis reaction is shown below using DMC ((CH₃O)₂CO).



This reaction takes place in the presence of a metal catalyst and is regarded as being more green than the traditional method of producing esters which uses corrosive H₂SO₄(l).

During this alternative reaction methanol (CH₃OH, BP 65 °C) and CO₂ are produced.

i. Given that esters are unstable at high temperatures, explain why it is easier to purify the ester, methyl pentanoate (BP 145 °C), using this method than the traditional method that produces water as a byproduct.

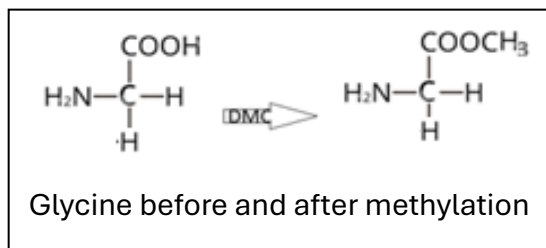
3 marks

ii. With reference to fig. 3 (reaction 3 -direct synthesis of DMC) suggest why the production of CO₂ gas during the synthesis of methyl pentanoate is not considered an environmental hazard.

2 marks

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6. DMC is used as a green chemical in the methylation of amino acids such as glycine.
(15 marks)



- a. With reference to acidity and reactivity, explain how methylation of the –COOH group on glycine using dimethyl carbonate (DMC) affects the chemical properties of the amino acid.

2 marks

- b. Describe how methylation of the carboxyl group influences the solubility of the amino acid in water.

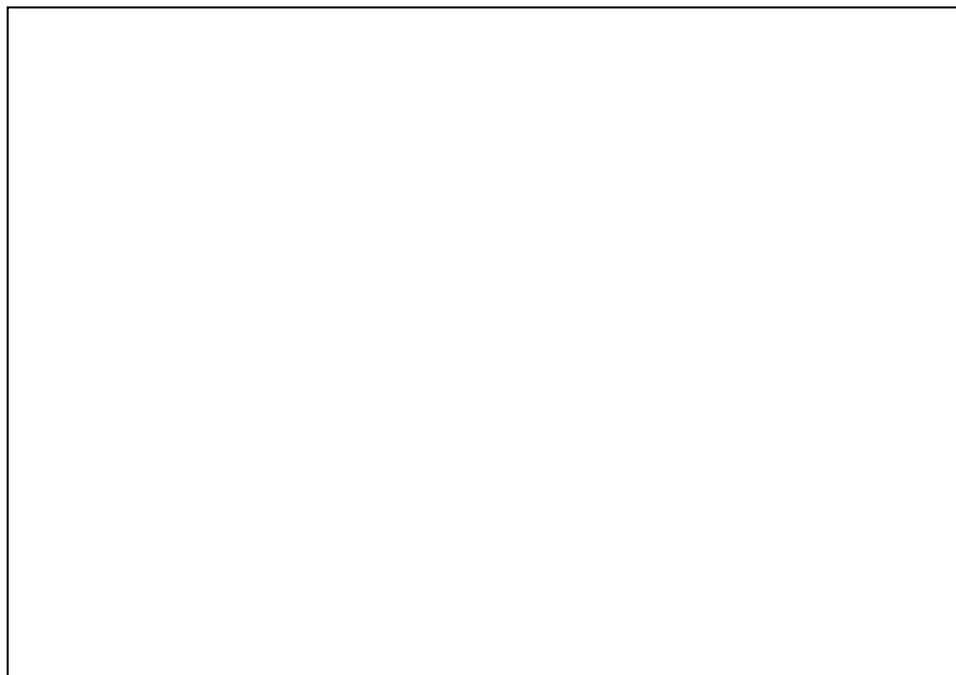
2 marks

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- c. How does the boiling temperature of a methylated amino acid ester compare with its pure unmethylated form? Justify your answer.

2 marks

- d. Draw the structural formula and clearly show the charges of the zwitterion form of glutamic acid in the box below. 2 marks

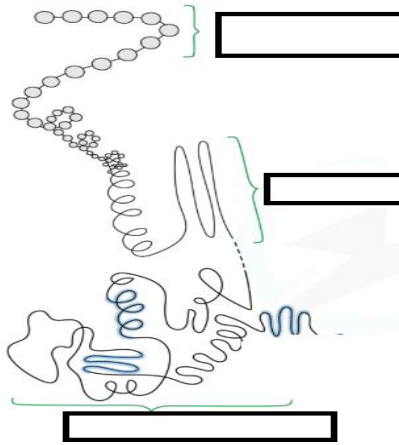


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e. Consider three different structures of a protein, shown below.

i. Label each structure on the diagram below.

1 mark



ii. Explain how methylation of the carboxyl group on the R group of glutamic acid impacts each of the three structures. Justify your answer in each case.

- Primary

2 marks

- Secondary

2 marks

- Tertiary

2 marks

End of assessment