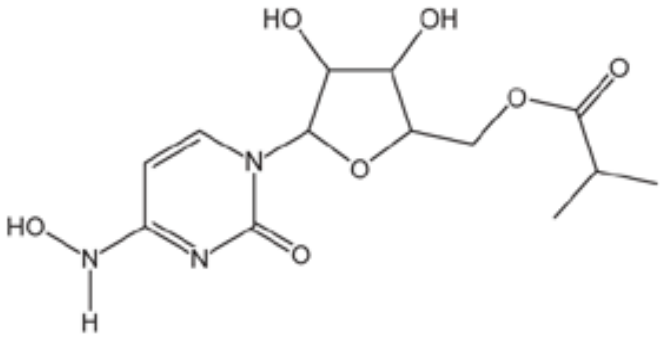
1. Compound **B**, shown below, is an antiviral medicine



compound B

i. What is the molecular formula of compound **B**

---

[1]

ii. How many chiral carbon atoms are there in one molecule of compound **B**?

---

[1]

iii. A research chemist synthesises two related compounds, compound **C** and compound **D**, from compound **B**.

- In compound **C**, the N atoms in compound **B** had been replaced by P atoms.
- In compound **D**, the O atoms in compound **B** had been replaced by S atoms.

What is the difference between the relative molecular masses of compound **C** and compound **D**?

difference = ... **[2]**

2. α-Amino acids have the general formula $RCH(NH_2)COOH$.

The R group in an α-amino acid contains C and H only.

This R group has a molar mass of 91 g mol^{-1}.

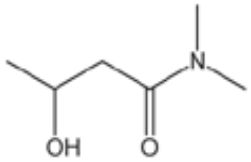
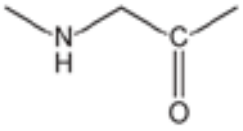
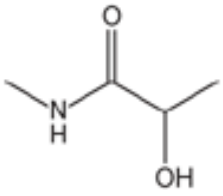
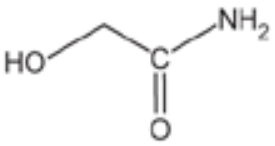
A polymer is formed from 500 molecules of this α-amino acid.

Determine the molar mass of this polymer.

Give your answer to the nearest whole number.

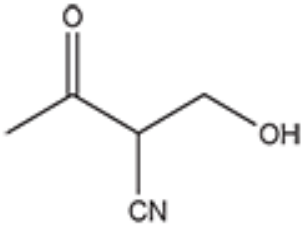
molar mass of polymer = ... g mol^{-1} **[3]**

3. Which compound is a secondary amide?

A	
B	
C	
D	

Your answer ☐ **[1]**

4. A chemist is investigating compound **A**, shown below, as a potential organic intermediate.



Compound A

Describe the type of stereoisomerism shown by compound **A** and suggest three reactions of compound **A**, one for each of the **three** functional groups using reagents of your choice.

In your answer, show stereoisomers of compound **A**, your chosen reactants and conditions, and the structures for the organic products produced.

Mechanisms and equations are **not** required.

[6]

5(a). This question is about α-amino acids.

The general formula of an α-amino acid is $RCH(NH_2)COOH$.

Most α-amino acids show optical isomerism.

Explain the term **optical isomerism**.

---

[1]

(b). The α-amino acid valine has the R group of $–CH(CH_3)_2$.

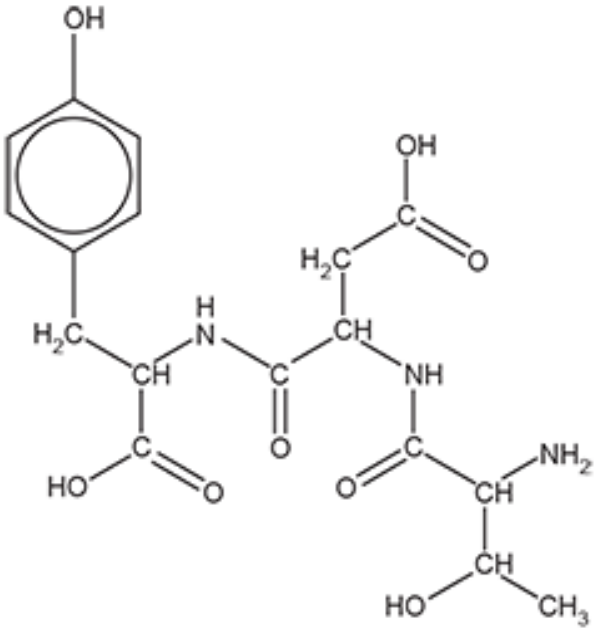
i. What is the systematic name of valine?

[1]

ii. Draw diagrams to show 3D structures of the optical isomers of valine.

[2]

(c). Three α-amino acids can react together to form compound **E**, shown below.



Compound E

i. How many optical isomers are possible for compound **E**?

[1]

ii. A student hydrolyses compound **E** with dilute hydrochloric acid, HCl (aq).

Draw the structures of the organic products formed by this hydrolysis.

[4]

6. This question is about unsaturated hydrocarbons.

Compounds **B** and **C** are **branched** hydrocarbons that are structural isomers of C_6H_{12}.

Compounds **B** and **C** both have stereoisomers.

• Compound **B** has *cis* and *trans* isomers but does **not** have optical isomers.

• Compound **C** has optical isomers but does **not** have *cis* and *trans* isomers.

i. What is meant by the term **structural isomers**?

[1]

ii. What is meant by the term **stereoisomers**?

[1]

iii. Draw structures for the *cis* and *trans* isomers of the branched hydrocarbon **B**.

***cis* isomer**	***trans* isomer**

[2]

iv. Draw 3D structures for the optical isomers of compound **C**.

Optical isomers	

[2]

v. Compounds **D** and **E** are two more structural isomers of C_6H_{12}.

Compounds **D** and **E** do **not** show stereoisomerism.

Table 16.1 shows NMR and infrared (IR) spectral data for **D** and **E**.

	Number of peaks in ^{1}H NMR spectrum	**Number of peaks in ^{13}C NMR spectrum**	**IR peak at 1620–1680 cm^{-1}**
D	1	1	No
E	1	2	Yes

Table 16.1

Draw the structures of **D** and **E** and explain how the spectral data in **Table 16.1** provides evidence for the structures.

D	**E**

[4]

7. This question is about an analysis of an unknown organic **Compound X**.

Some properties of **Compound X** are shown in the table.

Molecular formula	Functional groups	Chirality
$C_xH_yF_6O$	C–F C–O–C	1 chiral carbon

At a pressure of 1.07×10^5Pa at 30 °C, 1.327 g of **Compound X** is a gas with a volume of 186 cm^3.

Determine the molar mass of **Compound X** and its molecular formula.

Draw a possible structure for a molecule of **Compound X**.

molar mass ..... $gmol^{-1}$

molecular formula .....

Structure of Compound X

[6]

8. This question is about compounds that contain the carboxylic acid functional group.

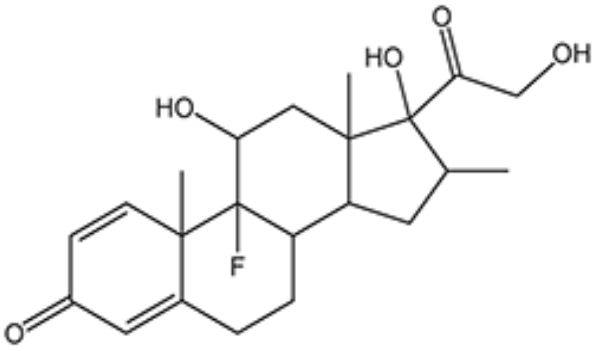
Carboxylic acids react with alkalis, metals and carbonates to form salts.

Write full equations for the following **three** reactions. Show structures for organic compounds.

- the reaction of propanoic acid with aqueous potassium hydroxide:
- the reaction of aqueous methanoic acid with magnesium:
- the reaction of the α−amino acid, aspartic acid ($R=CH_2COOH$), with an excess of aqueous sodium carbonate, Na_2CO_3:

[4]

9. The structure of a drug is shown below:



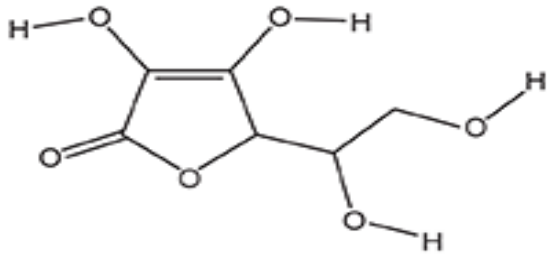
How many chiral carbon atoms are there in a molecule of the drug?

A 5
B 6
C 7
D 8

Your answer ☐ **[1]**

10(a). A student carries out an investigation on vitamin C, $C_6H_8O_6$.

The structure of vitamin C is shown below. Vitamin C is an optical isomer.



Vitamin C

What is the total number of optical isomers with the structure of vitamin C?

total number of optical isomers = ... **[1]**

(b). Vitamin C is extremely soluble in water. This means that vitamin C is removed rapidly from the body. 'Vitamin C ester' is available in tablet form as a less soluble source of vitamin C which stays in the body for longer.

i. Suggest why vitamin C is extremely soluble in water.

[1]

ii. A 'vitamin C ester' tablet contains an ester with the molecular formula $C_{22}H_{38}O_7$.

This ester can be prepared by reacting vitamin C with a long chain carboxylic acid, C_xH_yCOOH, in the presence of an acid catalyst.

Vitamin C and the long chain carboxylic acid react in a 1:1 molar ratio.

Determine *x* and *y* in the formula of this carboxylic acid.

x = ... *y* = ... **[2]**

11. Glycine, H_2NCH_2COOH, is an α-amino acid.

i. Glycine reacts with NaOH to form the salt H_2NCH_2COONa.

Glycine reacts with HC*l* to form the salt $HOOCCH_2NH_3Cl$.

The salts have different H-N-H bond angles.

State the different H-N-H bond angles and explain why they are different.

H_2NCH_2COONa H-N-H bond angle = ... °

$HOOCCH_2NH_3Cl$ H-N-H bond angle = ... °

explanation _____

_____

_____

_____

[3]

ii. Glycine reacts with aqueous copper(II) ethanoate to form copper(II) glycinate, $Cu(H_2NCH_2COO)_2$, and ethanoic acid. Copper(II) glycinate is a complex which exists as two square planar isomers.

Write an equation for this reaction and draw the structures of the two square planar isomers of the complex $Cu(H_2NCH_2COO)_2$.

equation

_____

structures

[3]

END OF QUESTION PAPER