

## Unit exam with answers

# Unit 4 Organic chemistry and chemical synthesis

Time permitted: 70 minutes

	Section	Number of questions	Marks available
<b>A</b>	Multiple choice	30	30
<b>B</b>	Short answer	10	40
	<b>Total</b>		<b>70</b>

Scale:

<b>A+</b>	66–70	<b>A</b>	60–65	<b>B</b>	50–59	<b>C</b>	40–49	<b>D</b>	35–39	<b>E</b>	21–34	<b>UG</b>	0–20
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## Section A Multiple choice (30 marks)

Section A consists of 30 questions, each worth one mark. Each question has only one correct answer. Circle the correct answer. Attempt all questions. Marks will not be deducted for incorrect answers. You are advised to spend no more than 30 minutes on this section.

- In which of the following mixtures would the only intermolecular forces be dispersion forces?
  - Hydrochloric acid and benzene
  - Pentane and methanol
  - Ethanol and water
  - Carbon tetraiodide and pentane*
- What is the correct IUPAC name for  $(\text{CH}_3)_2\text{C}=\text{C}(\text{CH}_3)_2$ ?
  - 1,1,2,2-tetramethylethene
  - 2,3-dimethylbut-2-ene*
  - 1,2-dimethylbut-2-ene
  - cis-2,3-dimethylbut-1-ene
- Which of the following would form methyl ethanoate when warmed with sulfuric acid?
  - Ethanol and ethanoic acid
  - Ethanoate and methanoic acid
  - Ethanoic acid and methanol*

- D Ethanol and propanoic acid
- 4 By what type of polymerisation is polythene made?
- A *Addition*
- B Condensation
- C Multiplication
- D Neutralisation
- 5 What monomer is used to make PVC?
- A Ethyne
- B *Chloroethene*
- C Ethane
- D Chloroethane
- 6 Which of the following substances will *not* act as a surfactant?
- A  $\text{CH}_3(\text{CH}_2)_{16}\text{COOK}$
- B  *$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$*
- C  $\text{CH}_3(\text{CH}_2)_{14}\text{COONa}$
- D  $\text{CH}_3(\text{CH}_2)_{12}\text{C}_6\text{H}_4\text{SO}_3\text{Na}$
- 7 Green chemistry is an initiative designed to:
- A *prevent pollution, treat chemicals to make them safe and dispose of them safely.*
- B reduce pollution, neutralise chemicals and dispose of them.
- C treat pollution, reduce chemical waste, and produce disposal methods.
- D prevent pollution, use safe solvents and dispose of them quickly.
- 8 By which formula can atom economy be determined?
- A 
$$\frac{\text{mass of atoms in the products}}{\text{mass of atoms in the reactants}} \times 100$$
- B *$$\frac{\text{mass of atoms in the desired product}}{\text{mass of atoms in the reactants}} \times 100$$*
- C 
$$\frac{\text{mass of atoms in the reactants}}{\text{mass of atoms in the desired product}} \times 100$$
- D 
$$\frac{\text{mass of atoms in the reactants}}{\text{mass of atoms in the products}} \times 100$$
- 9 Which reaction cannot have an atom economy of 100%?
- A  $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$
- B  $\text{CH}_2\text{CH}_2 + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{OH}$
- C  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
- D  *$\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$*
- 10 Condensation polymers:
- A produce water.

- B** *do not require double bonds to form polymers.*
- C** are limited to polyester plastics.
- D** require water to catalyse the reaction.
- 11** A copolymer:
- A** *uses two different monomers.*
- B** has only one type of monomer molecule.
- C** releases water molecules during the reaction.
- D** uses multiple bonding to link monomers.
- 12** An ester link in a copolymer is made using:
- A** a triester and sodium hydroxide.
- B** *a dicarboxylic acid and a diol.*
- C** an alcohol and a carboxylic acid.
- D** a monoester and acid.
- 13** Which molecule exhibits *cis* and *trans* isomerism?
- A** *Pent-2-ene*
- B** Propene
- C** Cyclopentane
- D** But-1-ene
- 14** In a mass spectrometer a sample is:
- A** ionised and then detected for analysis.
- B** vaporised, deflected and detected.
- C** *injected, ionised, deflected and detected.*
- D** sprayed, deflected and detected.
- 15** What are the advantages of using instruments in analyses?
- i** There is less human error.
- ii** Fewer harmful chemicals and apparatus are involved.
- iii** Smaller samples are used.
- A** i and iii
- B** i and ii
- C** ii and iii
- D** *i, ii and iii*
- 16** What information cannot be found using mass spectrometry?
- A** Molecular mass of the compound
- B** Structure of the compound
- C** *Concentration of the compound*
- D** Empirical formula of the compound

- 17 In mass spectrometry, the ions path through the machine depends on:
- A the ion's charge.
  - B the ion's mass.
  - C only the speed of the ion.
  - D *both the charge and mass of the ion.*
- 18 NMR is useful for determining the structure of organic compounds because:
- A they contain carbon atoms.
  - B their bonding is only covalent in nature.
  - C they are volatile.
  - D *they contain hydrogen atoms.*
- 19 What added information does infrared spectroscopy give over mass spectrometry?
- A Size of alkyl groups
  - B The number of functional groups that are present
  - C *Presence or absence of functional groups*
  - D Purity of substance
- 20 The arrangement of side groups on a polymer enhances or weakens intermolecular bonds. From strongest to weakest, what is the arrangement of methyl groups?
- A Atactic, syndiotactic and isotactic
  - B *Isotactic, syndiotactic and atactic*
  - C Syndiotactic, atactic and isotactic
  - D Isotactic, atactic and syndiotactic
- 21 Define the term 'reflux'.
- A *A technique of heating liquids without losing any ingredients*
  - B A process of breaking down reactants into products
  - C A process of breaking down a product into reactants
  - D A process used to produce one product
- 22 Which of the following is a biofuel made in Australia?
- A *Ethanol*
  - B LPG
  - C Premium petrol
  - D Diesel
- 23 Infrared spectroscopy of a diatomic molecule produces absorbance of infrared radiation by:
- A *bonds stretching in a compound.*
  - B atoms in compound.
  - C bonds bending in a compound.

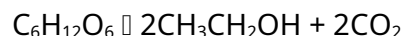
- D bonds bending and stretching in a compound.
- 24 What is another name for the world's most common polymer, polythene?
- A *Polyethylene*
- B Teflon
- C PVC
- D Vinyl
- 25 Amino acids all contain:
- A *amine and carboxylic acid groups.*
- B a carbonyl and amine group.
- C an alcohol group.
- D a ketone.
- 26 Green chemistry is an initiative designed to:
- A prevent pollution, use safe solvents and dispose of them quickly.
- B reduce pollution, neutralise chemicals and dispose of them.
- C treat pollution, reduce chemical waste and produce disposal methods.
- D *prevent pollution, treat chemicals to make them safe and dispose of them safely.*
- 27 In mass spectrometry, the heaviest peak in the spectrum:
- A reveals the free radicals present.
- B *determines size of the parent molecule.*
- C is the most stable fragment of the molecule.
- D shows the most deflected fragment.
- 28 Protective groups in molecular manufacture:
- A *prevent non desired products being formed.*
- B are large functional groups.
- C are reactive sites on a molecule.
- D are esters and amides.
- 29 What does carbon-13 NMR spectroscopy focus on?
- A Hydrogen nuclei
- B Carbon nuclei
- C Electronegativity of C
- D *Electrons held by C atoms*
- 30 UV visible spectroscopy uses standard solutions to produce a calibration curve to:
- A show what type of absorption occurs.
- B determine where absorption occurs.
- C *to determine unknown concentrations.*
- D calculate what the unknown compound is.

### Section B Short answer (40 marks)

Section B consists of 10 questions. Write your answers in the space provided. You are advised to spend 40 minutes on this section.

- 1 Alcoholic fermentation converts one mole of glucose ( $C_6H_{12}O_6$ ) into two moles of ethanol and two moles of carbon dioxide. Calculate the atom economy of producing alcohol this way.

*Answer:* Glucose → ethanol + carbon dioxide



Atomic masses: C = 12.01, H = 1.008 and O = 16.00

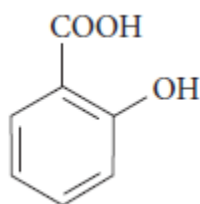
Molar mass of  $C_6H_{12}O_6$  = 180.156

Molar mass of ethanol = 46.068

$$\text{Atom economy} = \frac{2 \times 46.068}{180.156} = 51.1\%$$

(= 4 marks total)

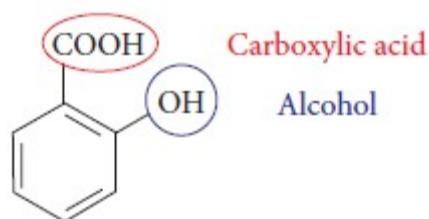
- 2 Salicylic acid is a reactant in the production of a common pain killer. Circle and name the two functional groups on its benzene ring.



It can react to produce the compound, methyl salicylate.

What other ingredient and catalyst are needed to produce the product? Write out the reaction.

*Answer:* Methanol is needed to react with the carboxylic acid group to form the ester group. The catalyst needed is sulfuric acid.



(= 4 marks total)

- 3 Polymers are widely used around us, in clothing and in our food.  
a Nylon 6,6 has the following repeating unit,  $[-CO-(CH_2)_4-CO-NH-(CH_2)_6-NH-]$

Name the following Nylon polymers.

- i  $[-CO-(CH_2)_4-CO-NH-(CH_2)_{10}-NH-]$

Answer: Nylon 6,10

(1 mark)

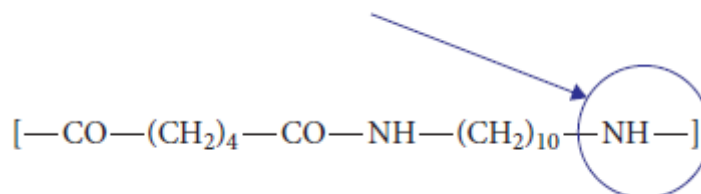


Answer: Nylon 4,6

(1 mark)

- b Circle the amide link in one of the polymers named.

Answer:



(1 mark)

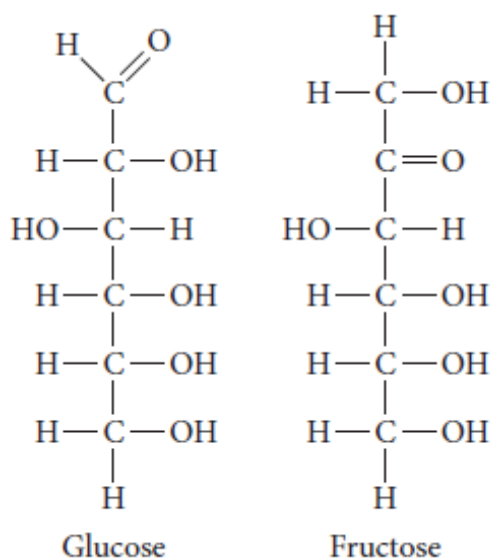
- c Starch, when digested, is broken into its soluble monomers. Name that monomer.

Answer: Glucose

(1 mark)

(= 4 marks total)

- 4 Glucose and fructose are both monosaccharides.



- a Write the molecular formula of each sugar.

Answer: The molecular formula of both sugars is  $\text{C}_6\text{H}_{12}\text{O}_6$

(1 mark)

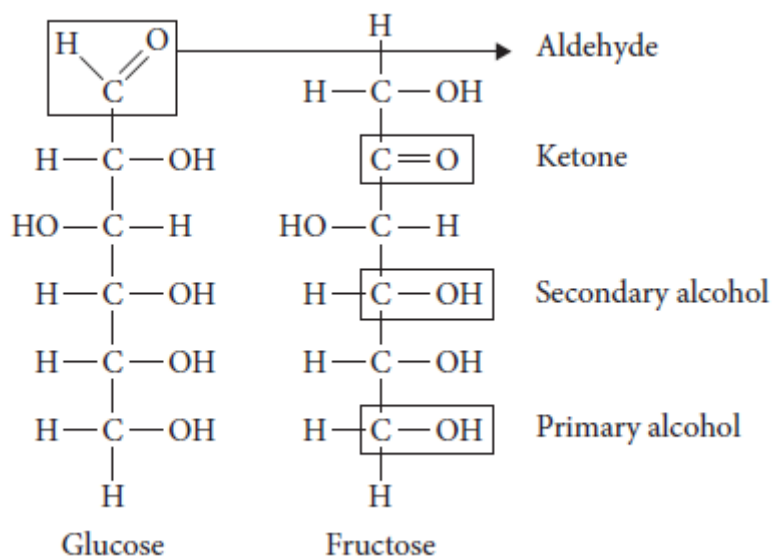
- b Why are they called structural isomers?

Answer: They are called structural isomers because they have the same atoms but in different arrangements.

(1 mark)

- c Identify four different types of functional groups on the molecules above.

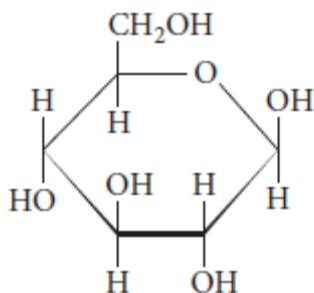
Answer:



(1 mark)

- d Glucose is in equilibrium with a cyclical form. Draw it.

*Answer:* The cyclical form of glucose is in equilibrium with its linear form.

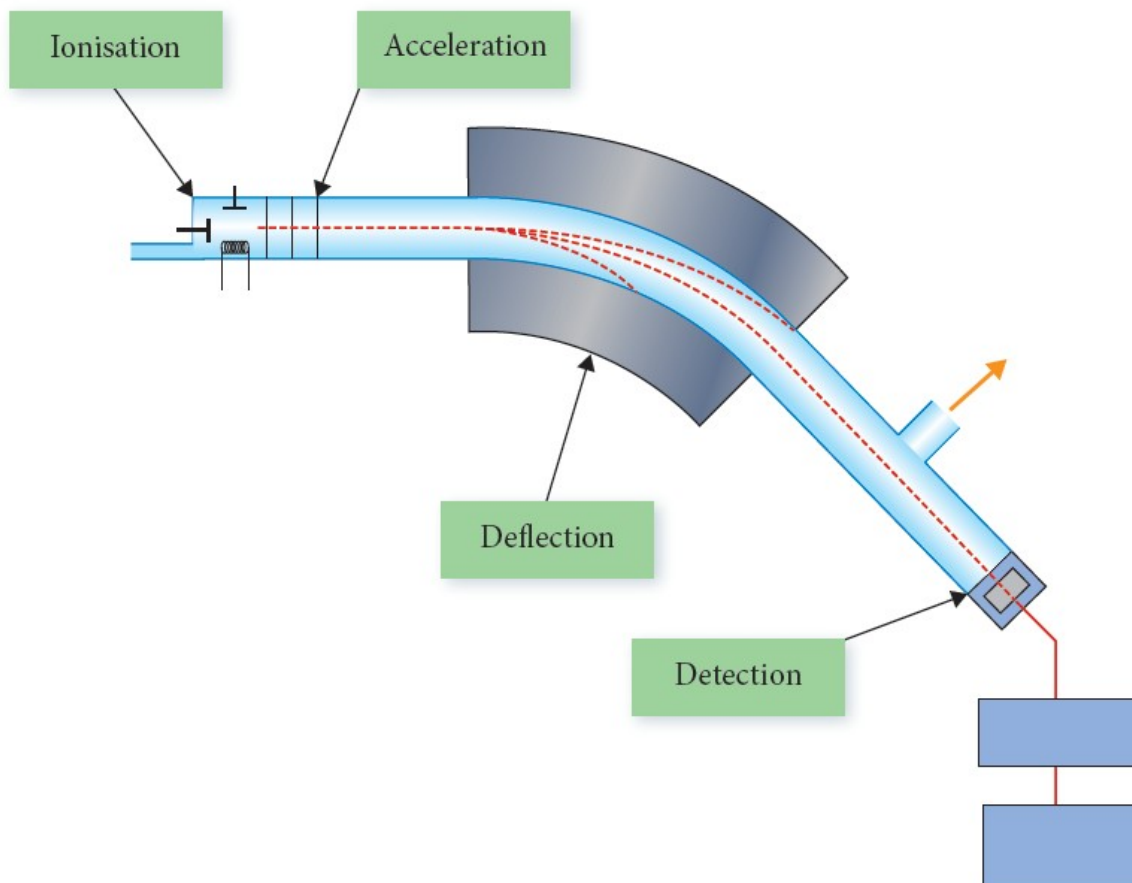


(1 mark)

(= 4 marks total)

- 5 A mass spectrometer analyses samples.





- a** What does the electron gun do to the injected samples?

*Answer:* The electron gun ionises the vaporised sample by removing electrons from the species, and can split the species into smaller ions.

(1 mark)

- b** Explain how the samples are deflected in the machine.

*Answer:* Samples are deflected by a magnetic field. The amount of deflection depends on both mass and charge of the particle.

(1 mark)

- c** Explain how the detector works.

*Answer:* When the ion arrives at the detector, electrons neutralise its charge. The greater the charge, the more electrons flow to neutralise them, the more ions the more electrons as well. This current flow is graphed as a peak for that particular ion. Other ions are detected by varying the magnetic field, so they too arrive at the detector and are detected.

(1 mark)

- d** Why is a vacuum in the machine necessary?

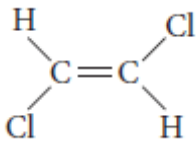
*Answer:* A vacuum is needed so that the ions are not impeded (slowed down or deflected) by any air particles, so they fly through the machine unhindered.

(1 mark)

(= 4 marks total)

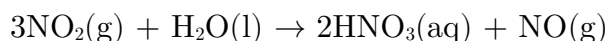
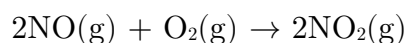
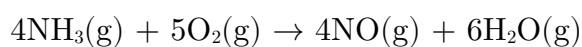
**6** Complete the following table of compounds using IUPAC nomenclature.

Answer:

Structure	Name
 <p>(1 mark)</p>	Trans-1,2-dichloropropene
CH <sub>3</sub> CH <sub>2</sub> CHO	Propanal (1 mark)
CH <sub>3</sub> COCH <sub>3</sub>	Propanone or acetone (1 mark)
CH <sub>3</sub> CH <sub>2</sub> COOCH <sub>2</sub> CH <sub>3</sub> (1 mark)	Ethylpropanoate

(= 4 marks total)

- 7 Nitric acid is made industrially by the Ostwald process.



How much nitric acid, in kg, would you expect to make if you started with 150 L of ammonia with an 85% yield?

Answer: From equations molar ratio gives 4 moles of NH<sub>3</sub> giving 2 moles HNO<sub>3</sub>, molar volumes stay the same for gas volumes.

So 150 L of ammonia will produce 75 L at 100% yield.

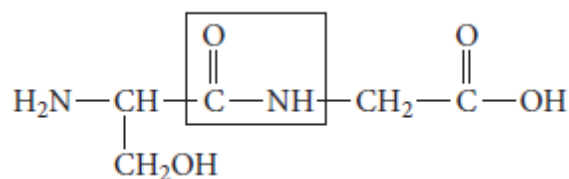
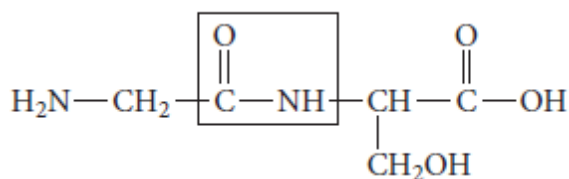
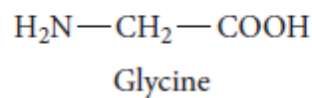
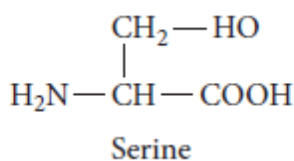
At 85% yield 63.75 L of nitric acid will be expected.

(= 4 marks total)

- 8 Glycine and serine are two amino acids, which can combine to form dipeptides.

Draw the structures of two dipeptides formed from glycine and serine. (See data book for structures of amino acids.) Explain how the two structures can form.

Answer:



(2 marks)

Dipeptides contain the  $\text{O}=\text{C}-\text{NH}$  peptide link. Two can be formed when the amine groups and carboxylic acid groups react. Two dipeptides are possible each end of each molecule can react with one end of the other. (2 marks)

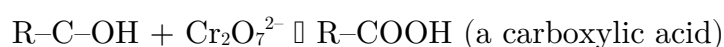
(= 4 marks total)

- 9 a How would you determine the difference between a primary and a secondary alcohol in the laboratory?

*Answer:* React them with either potassium dichromate or potassium permanganate; these will oxidise the primary alcohol, but not the secondary alcohol. (2 marks)

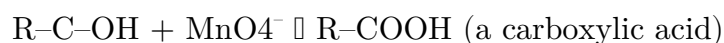
- b Describe two reactions you could use to distinguish between the two alcohols.

*Answer:*



Colour change from orange to green (dichromate ion (orange) to chromic ion,  $\text{Cr}^{3+}$  (green))

Or:



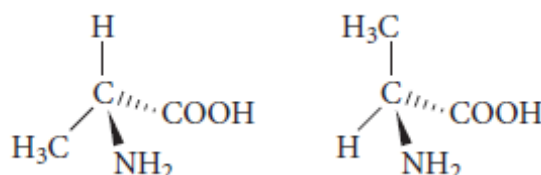
Colour change from purple ( $\text{MnO}_4^-$ ) to colourless ( $\text{Mn}^{2+}$ )

Secondary alcohols will not react; that is, will not be oxidised. (2 marks)

(= 4 marks total)

- 10 a Amino acids can come in mirror image forms. What is necessary for this to occur? Draw diagrams of an amino acid showing this nature.

*Answer:*



They are two non-superimposable mirror images of each other. All amino acids (except simple glycine) contain a chiral, carbon atom, a carbon atom with four different groups attached. (3 marks)

- b What is the general name for these isomers?

*Answer:* Enantiomers

(1 mark)

(= 4 marks total)