Neap

Diagnostic Topic Test 2024

VCE Chemistry Units 3&4

Question and Answer Booklet

Test time: 45 minutes
Total marks: 35 marks

Test 7: How are organic compounds analysed and used?

- Medicinal chemistry

Student's Name: _____

Teacher's Name: _____

Instructions

Write your **name** and your **teacher's name** in the space provided above on this page.

A data booklet is provided.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Answer **all** questions in the spaces provided.

SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Circle the response that is **correct** or that **best answers** the question.

A correct answer scores 1; an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Question 1

Which one of the following is **not** an important property of the solvent used for the extraction of a potential drug molecule from a plant sample?

A. The solvent extracts the active constituent and leaves the inert material behind.

B. The solvent is non-toxic and non-flammable for safety.

C. The solvent has high viscosity for ease of penetration of the sample.

D. The solvent has a low boiling temperature to prevent degradation of the extract by heat during concentration of the extract.

Question 2

Extraction of potential drug molecules from plants often results in a mixture of compounds that must be separated for further testing of their pharmacological properties.

Fractional distillation can be used for this separation if the compounds

A. have differing solubilities in water.

B. show different reactions to acid–base indicators.

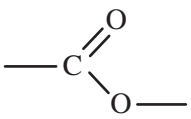
C. have different boiling temperatures.

D. show different viscosities.

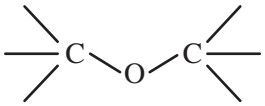
Question 3

Which one of the following options shows the linkage that forms when amino acids polymerise to form an enzyme molecule?

A.



B.



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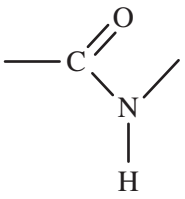
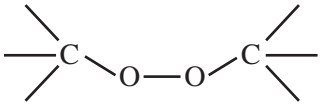


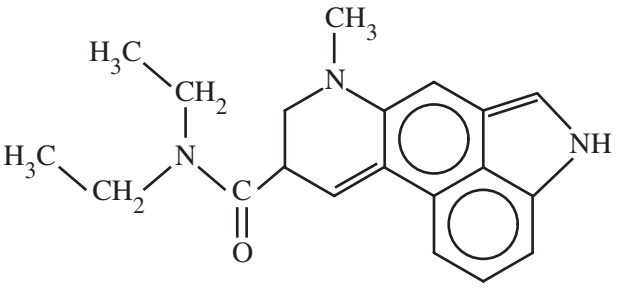
D.



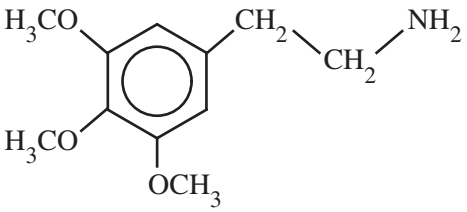
Question 4

The structures of three drug molecules are shown below.

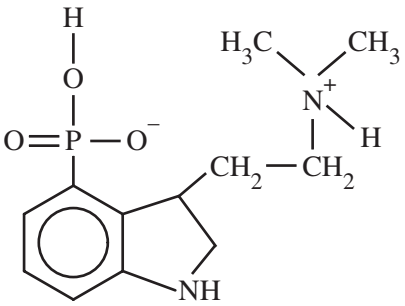
I



II



III



Which one of the following is a correct comparison of the three molecules?

A. All three molecules contain an amide functional group.

B. Each molecule would include at least one unsplit peak on its high resolution ^{1}H NMR spectrum.

C. Based on their structures, the three compounds would be expected to show similar pharmacological effects.

D. All three molecules would be considered unsaturated as they all contain carbon–carbon double bonds.

Question 5

When an enzyme is heated above its optimal temperature for catalytic activity, its secondary and tertiary structures change.

Which one of the following bond types present in the enzyme is **least** likely to be altered as a result of heating slightly above the enzyme's optimal temperature?

A. dispersion forces

B. dipole–dipole bonds

C. hydrogen bonds

D. peptide links

Question 6

Enzymes are proteins that form by the polymerisation of amino acids.

This polymerisation occurs by

A. condensation reactions in which water is a product.

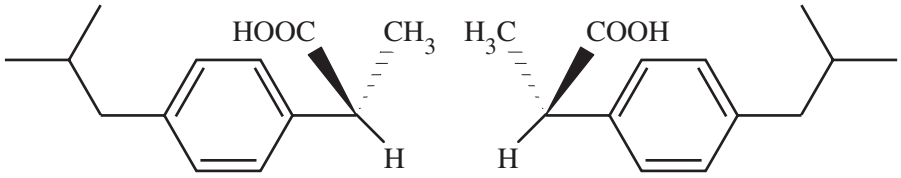
B. condensation reactions in which water is a reactant.

C. addition reactions in which water is a product.

D. addition reactions in which water is a reactant.

Question 7

The drug ibuprofen exists as two enantiomers – one being active as a pain and fever reliever, the other inactive with no biochemical function. The structures of the two isomers are shown below.



Which one of the following tests could distinguish between samples of the two isomers of ibuprofen?

A. observing the direction in which they rotate a beam of plane polarised light

B. determining the wavenumbers for peaks on their infrared spectra beyond 1500 cm^{-1}

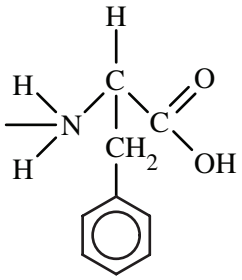
C. reaction with sodium carbonate solution

D. determining the location of peaks on their ^{13}C nuclear magnetic resonance spectra

Question 8

Which one of the following options shows the structure of the amino acid phenylalanine in a solution of pH 3?

A.



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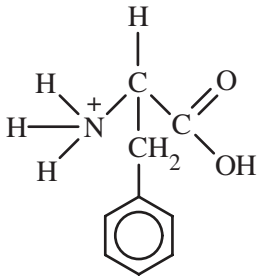
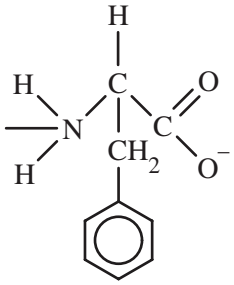
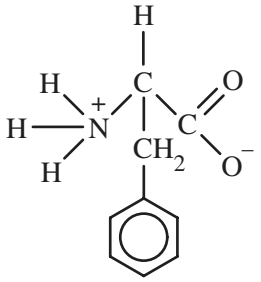


C.



D.



Question 9

Which one of the following statements about enzymes is correct?

A. Enzymes slightly increase the rate of specific biochemical reactions.

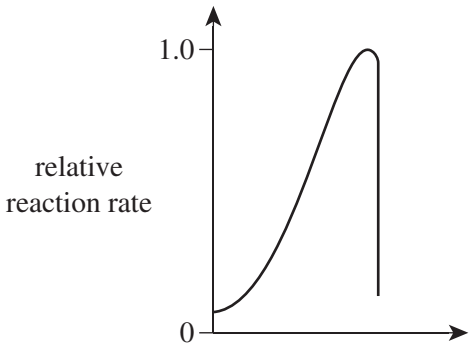
B. Each enzyme catalyses a wide range of different types of biochemical reactions.

C. Enzymes have an active site that binds by strong covalent bonds to the substrate molecules.

D. Enzymes function by lowering the activation energy of the reactions they catalyse.

Question 10

A student conducted an experiment to test the effect of a variable on the rate of a reaction catalysed by an enzyme in the human body. The graph below shows the rate of the reaction, but the label of the horizontal axis has been omitted.



Which one of the following is the most reasonable label and scale for the horizontal axis?

A. concentration of substrate

B. concentration of enzyme

C. pH (from 1 to 14)

D. temperature (from 10°C to 40°C)

END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided.

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, $H_2(g)$, NaCl(s).

Unless otherwise indicated, the diagrams in this booklet are **not** drawn to scale.

Question 1 (13 marks)

An important step in the design and synthesis of a drug is the determination of the three-dimensional structure of the protein being targeted by the drug. One step in this process is establishing the amino acid sequence of the protein.

a. Why is it important for drug design success to know the three-dimensional structure of the target protein? 2 marks

b. Determining the amount of each amino acid in a protein involves acid digestion to break the linkages between the amino acids in the protein chain. This involves heating the protein in 6 M hydrochloric acid for 24 hours at temperatures near 100°C.

i. Name the linkage between the amino acids broken in this acid digestion process. 1 mark

ii. Why are these conditions of concentrated acid, heating and a long reaction time needed for digestion of the protein? 1 mark

c. Acid digestion is more successful if shorter polypeptides are used in place of the whole protein. Producing polypeptides can be achieved with the use of the enzyme trypsin. The use of trypsin will cleave the linkages of a protein chain on the carboxyl side of either lysine or arginine.

i. State **one** similarity in the side groups of lysine and arginine. 1 mark

ii. In terms of the structure of the trypsin enzyme, explain why only the linkage on the carboxyl side of arginine is cleaved, and not the linkage on the amino side of arginine. 2 marks

d. After the protein and polypeptides have been digested, individual amino acids need to be separated.

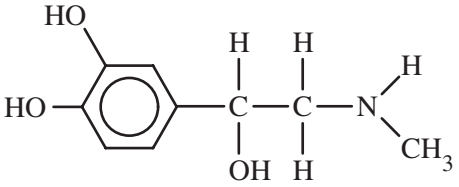
Briefly describe **one** process that could be used to separate and collect the amino acids for further analysis. 3 marks

e. Trypsin only shows catalytic activity when in solutions of pH from 5 to 10. Outside this pH range the enzyme does not function as a catalyst.

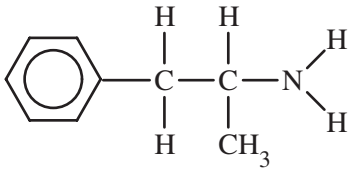
In terms of the structure and bonding in trypsin, explain this limited pH range for enzyme activity. 3 marks

Question 2 (5 marks)

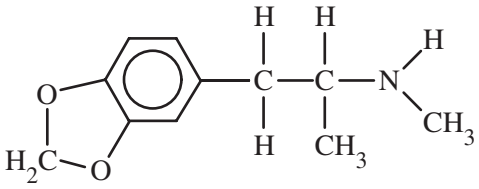
Amphetamine is chemically related to adrenalin, the 'fight or flight' hormone. Amphetamines were used initially as a treatment for sleep disorders. Their short-term effects include increases in heart rate and breathing rate. Long-term effects include emotional instability. A related compound is methylenedioxymethamphetamine, or MDMA (ecstasy). The structures of adrenaline, amphetamine and MDMA are shown below.



adrenaline



amphetamine



MDMA

a. **i.** Name a functional group that is found in all three molecules. 1 mark

_____

ii. Name a functional group that is found in adrenaline but is not found in amphetamine or MDMA. 1 mark

_____

iii. Name a functional group that is found in MDMA but is not found in adrenaline or amphetamine. 1 mark

_____

b. Many drugs consist of optically active molecules whose activity depends on the particular isomer used. Amphetamine is one such optically active molecule.

Draw an asterisk (*) next to the chiral carbon atom in the amphetamine molecule shown above. 1 mark

c. Modification of drugs to improve performance or reduce side effects can involve reaction of groups within the molecule.

Circle a group of atoms in the adrenaline molecule above that could be oxidised to form a ketone. 1 mark

Question 3 (7 marks)

The drug zanamivir was one of the first to be used for the treatment of the disease influenza. The drug was developed following the identification of the three-dimensional structure of a key protein (neuraminidase) in the virus that causes influenza. This protein enables many more virus particles to be released into a person infected with the influenza virus. The drug zanamivir was synthesised so that it inhibited the functioning of neuraminidase.

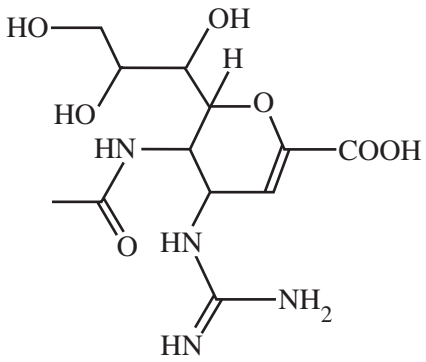
a. Zanamivir was initially taken as a nasal spray so that the drug was directly absorbed into the bloodstream across the nasal membranes.

Suggest why zanamivir could not be administered orally like many other drugs. 1 mark

b. It was necessary to ensure that the drug was water soluble.

i. Explain why high solubility in water may improve a drug's effectiveness. 2 marks

ii. The structure of zanamivir is shown below.



Based on its structure, explain why zanamivir is likely to be water soluble. 2 marks

iii. Solubility of drugs containing basic groups can be increased by reaction with hydrochloric acid to form salts.

Circle **one** functional group in the molecule shown above that could function as a base. 1 mark

c. A later influenza medicine – another neuraminidase inhibitor – was oseltamivir. It was a pro-drug, meaning that it was taken in an inactive form, and became active only after it was hydrolysed in the liver to produce an active drug.

Explain the meaning of the term 'hydrolysed'. 1 mark

END OF TEST