Topics in the June 2014 Exam Paper for CHEM1611

Click on the links for resources on each topic.

2014-J-2:

- Atomic Structure
- The Periodic Table

2014-J-3:

- Chemical Bonding
- The Shapes of Molecules

2014-J-4:

- Chemical Bonding

2014-J-5:

- Alkenes
- Aldehydes and Ketones
- Alcohols, Phenols, Ethers and Thiols
- Carboxylic Acids and Derivatives

2014-J-6:

- Stereochemistry

2014-J-7:

- Aromatic Hydrocarbons
- Aldehydes and Ketones
- Carboxylic Acids and Derivatives
- Alkenes
- Alcohols, Phenols, Ethers and Thiols

2014-J-8:

- Carbohydrates

2014-J-9:

- Amino Acids, Peptides and Proteins

2014-J-10:

- Amino Acids, Peptides and Proteins

2014-J-11:

- DNA and Nucleic Acids

Marks

- Reaction of nitrogen-14 with a neutron forms two products, one of which is carbon-14. Radiocarbon dating involves the carbon-14 isotope which undergoes β-decay (emission of an electron from the nucleus). Write the two nuclear equations that illustrate the formation and decay of carbon-14. **2**

^{14}C formation: $^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{14}_{6}C + {}^{1}_{1}p$

^{14}C decay: $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

- Complete the following table. **3**

Orbital	Principal quantum number, *n*	Angular momentum quantum number, *l*	Number of spherical nodes	Number of planar nodes
4*s*	**4**	**0**	**3**	0
3*p*	**3**	**1**	**1**	1
3*d*	3	**2**	**0**	2

- It requires 151 kJ mol^{-1} to break the bond in I_2. What is the minimum wavelength of light needed to break this bond? Give your answer in nm. **2**

151 kJ mol^{-1} corresponds to:

energy per molecule = $151 \times 10^3 / 6.022 \times 10^{23}$ J = 2.51×10^{-19} J

According to Planck's relationship between the energy and wavelength, λ, of light:

$E = hc / \lambda$

Hence

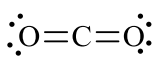
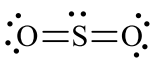
$\lambda = hc / E$
$= (6.626 \times 10^{-34}\ \text{J s}) \times (2.998 \times 10^8\ \text{m s}^{-1}) / (2.51 \times 10^{-19}\ \text{J})$
$= 7.90 \times 10^{-7}\ \text{m} = 790.\ \text{nm}$

Answer: **790. nm**

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

Marks 12

- Complete the following table.

Molecule	CO_2	SO_2
Draw a Lewis structure		
Name the molecular geometry	**linear**	**bent (approx 120°)**
Does the molecule have a dipole moment? Give a reason for your answer.	**No. The molecule is linear so the dipoles in the C=O bonds cancel each other out.**	**Yes. The molecule is bent so the dipoles in the S=O bonds do not cancel each other out.**
Give the hybridisation of the central atom.	***sp***	***sp*^{2}**

Comment on the relative strength of a π-bond in carbon dioxide compared to a π-bond in sulfur dioxide.

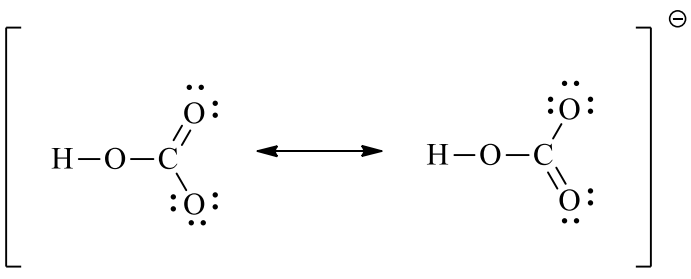
The π-bond is stronger in CO_2 because the overlapping orbitals (2*p* in C and 2*p* in O) are of similar size allowing maximum overlap. In SO_2, the 3*p* orbital in S is bigger than the 2*p* orbital in O so the overlap is not as good.

Both oxides dissolve in water to give a weak acid. Choose one of the oxides and write balanced equations representing the formation of the corresponding weak acid and the dissociation of the acid into ions.

$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq) \rightarrow H^+(aq) + HSO_3^-(aq)$

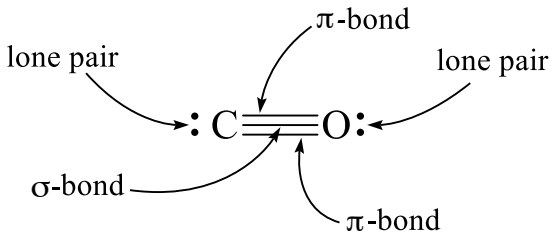
$CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq) \rightarrow H^+(aq) + HCO_3^-(aq)$

Use one of the molecules/ions from the above equations to illustrate the concept of resonance.

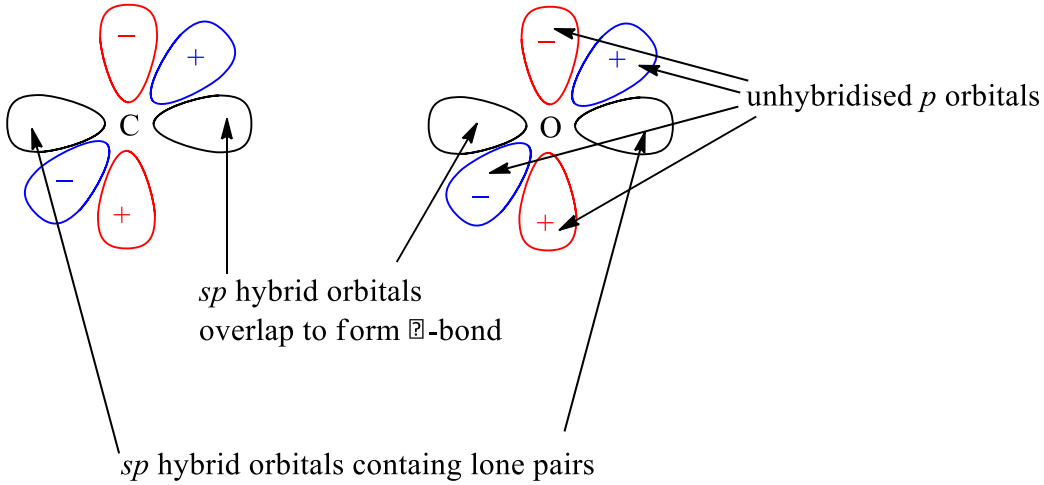


Marks 5

- Carbon monoxide is a poisonous gas that may be obtained from incomplete combustion. Draw the Lewis structure of carbon monoxide and add the labels *lone pair, σ-bond, π-bond* as appropriate.



On the atoms below, draw and label the orbitals (atomic and/or hybridised) that give rise to the bonds and lone pairs on carbon monoxide and clearly show which orbitals overlap with each other and the type of bond that results.



Unhybridised atomic *p* orbitals overlap to form a π-bond. The lobes of the red orbitals are in the plane of the paper whilst those of the blue orbitals are perpendicular to the plane of the paper.

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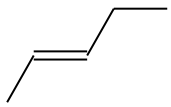
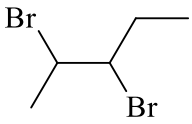
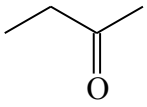
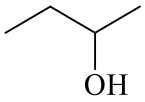
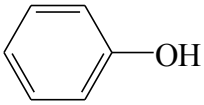
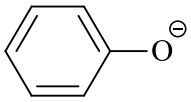
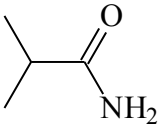
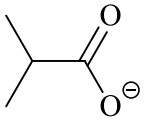
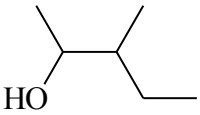
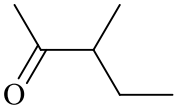
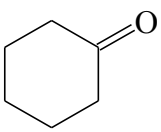
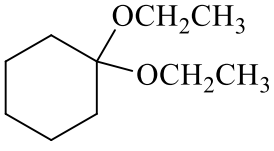
Marks 10

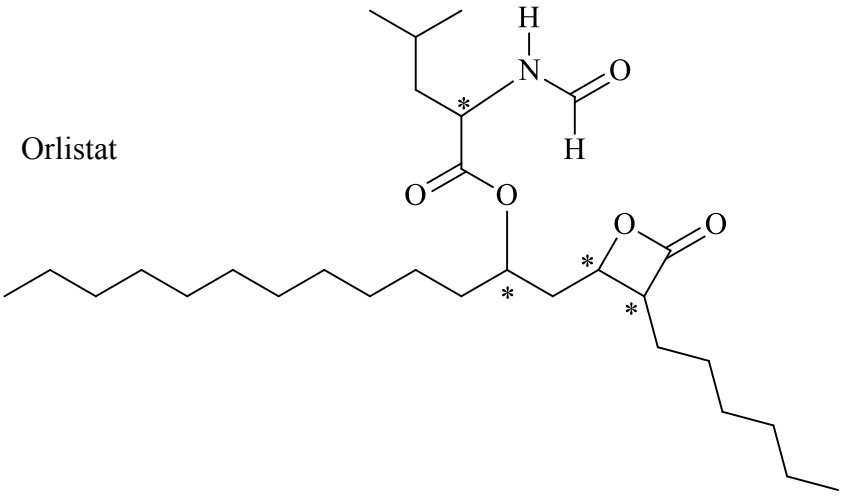
- Complete the following table. Make sure you complete the name of the starting material where indicated.

STARTING MATERIAL	REAGENTS/ CONDITIONS	CONSTITUTIONAL FORMULA(S) OF MAJOR ORGANIC PRODUCT(S)
 Name: **(*E*)-2-pentene**	Br_2 CCl_4 solvent	
 Name: **butanone**	1. $LiAlH_4$ 2. dilute HCl	
 Name: **phenol**	dilute NaOH	
	6 M NaOH heat	
	$Na_2Cr_2O_7$ in dilute sulfuric acid	
 Name: **cyclohexanone**	excess CH_3CH_2OH conc. H_2SO_4 catalyst heat	

Marks 6

- Orlistat (shown below) is a drug for obesity management which acts by inhibiting the absorption of dietary fats. Indicate all stereogenic centres on the structure below.

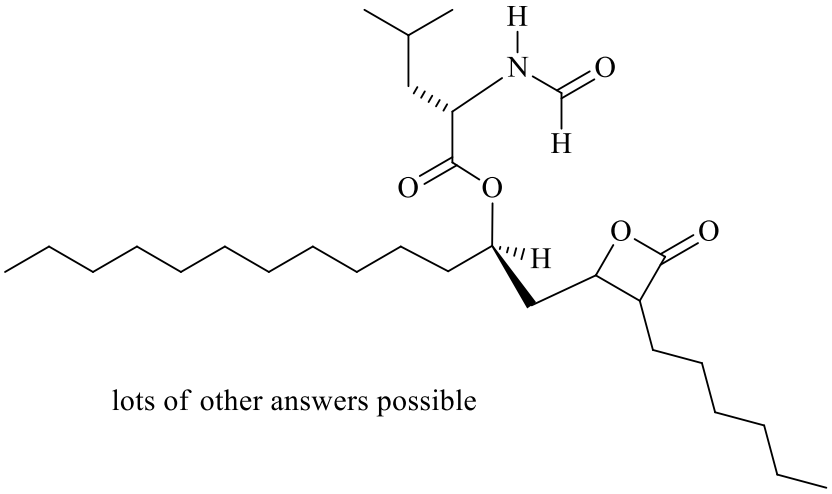
Orlistat



How many different diastereoisomers are possible for Orlistat?

With 4 chiral centres, there are $(4)^2 = 16$ possible diastereomers.

Select one of the stereogenic centres and draw the isomer with the (*R*)-configuration.



lots of other answers possible

List the functional groups present in Orlistat.

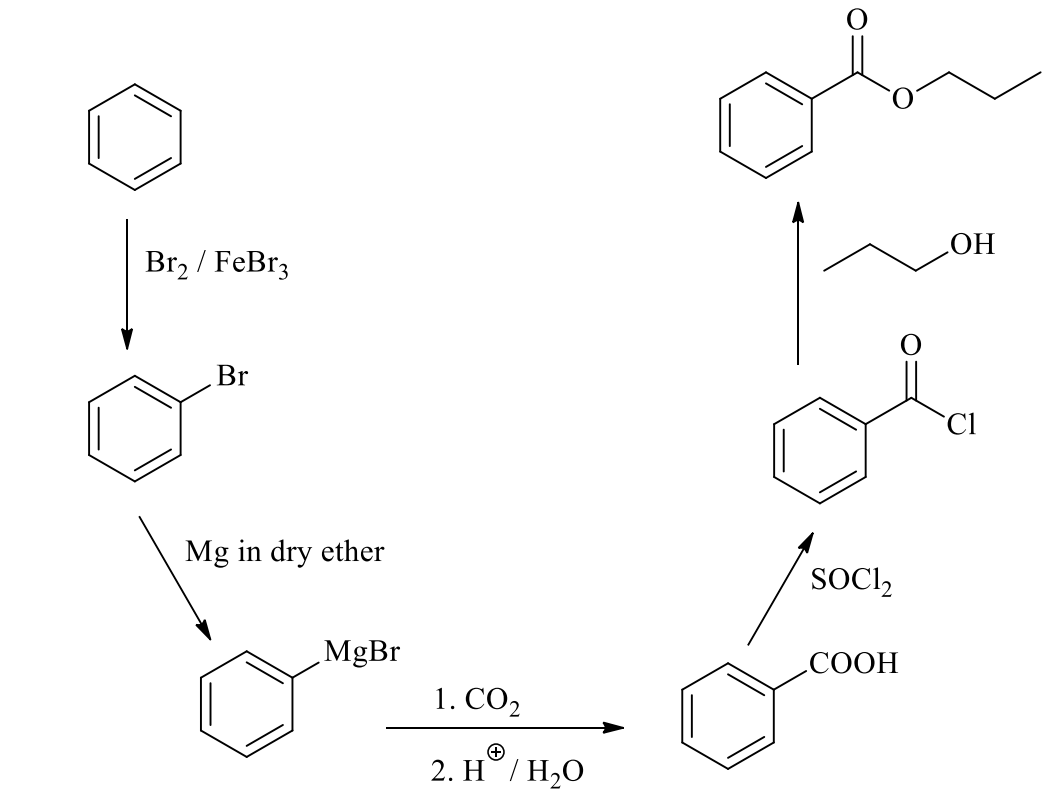
Amide and ester

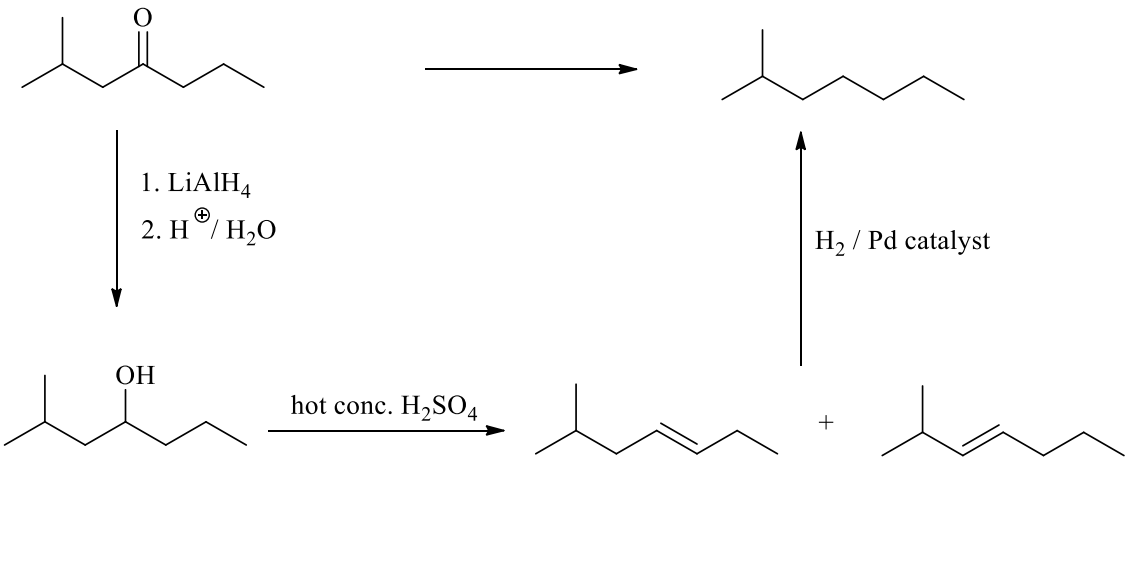
Is Orlistat likely to be soluble in water? Why?

No. Long hydrocarbon chains means that the molecule is hydrophobic and will not dissolve in water, which is a polar solvent.

Marks 8

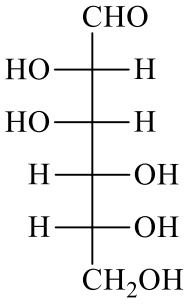
- Show clearly the reagents you would use to carry out the following chemical conversions. Note that more than one step is required and you should indicate all necessary steps and the constitutional formulas of any intermediate compounds.



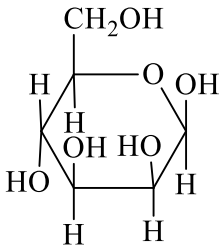


Marks 6

- The open chain form of D-mannose has the structure shown.

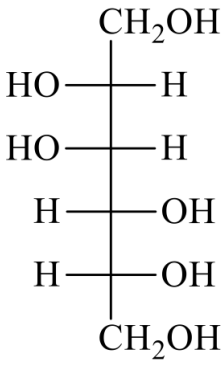


Draw the Haworth projection of β-D-mannopyranose.

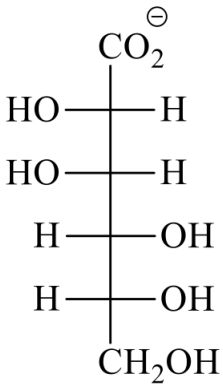


Draw the major organic product of the reaction of D-mannose with the following reagents.

1. $NaBH_4$ 2. $H^{\oplus}$ / H_2O



$[Ag(NH_3)_2]^{\oplus}$ / $OH^{\ominus}$

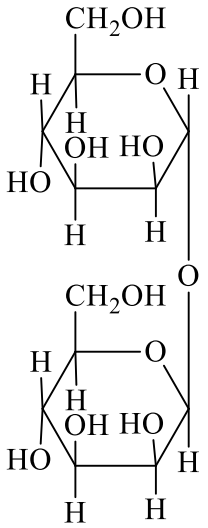


What is a reducing sugar?

A sugar that reduces Tollens' or Fehling's reagent. Sugars containing aldehyde or hemiacetal groups are reducing sugars.

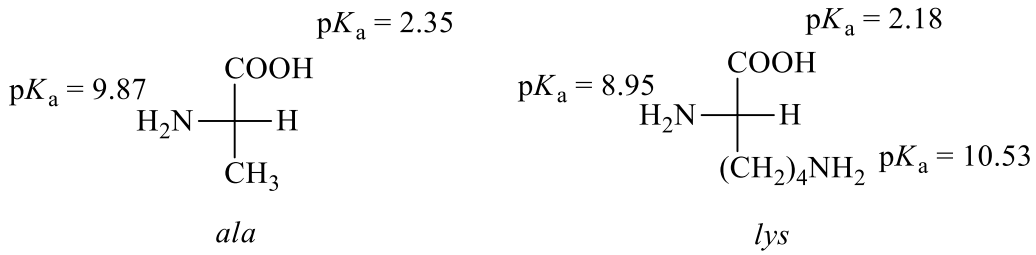
ANSWER CONTINUES ON THE NEXT PAGE

Give the Haworth formula of a non-reducing disaccharide that yields D-mannose as the only product on acid hydrolysis.



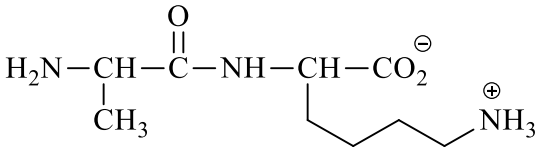
Marks 5

- Alanine (*ala*) and lysine (*lys*) are two amino acids with the structures given below as Fischer projections. The pK_a values of the conjugate acid forms of the different functional groups are indicated.



ala *lys*

Draw the structure of the dipeptide *ala-lys* in its zwitterionic form.



Note that the amine group on the side chain is more basic so it is the one that is protonated.

Would you expect the dipeptide to be acidic, neutral or basic? Give a brief reason for your choice.

Basic. The side chain in lysine is basic whilst that in alanine is neutral.

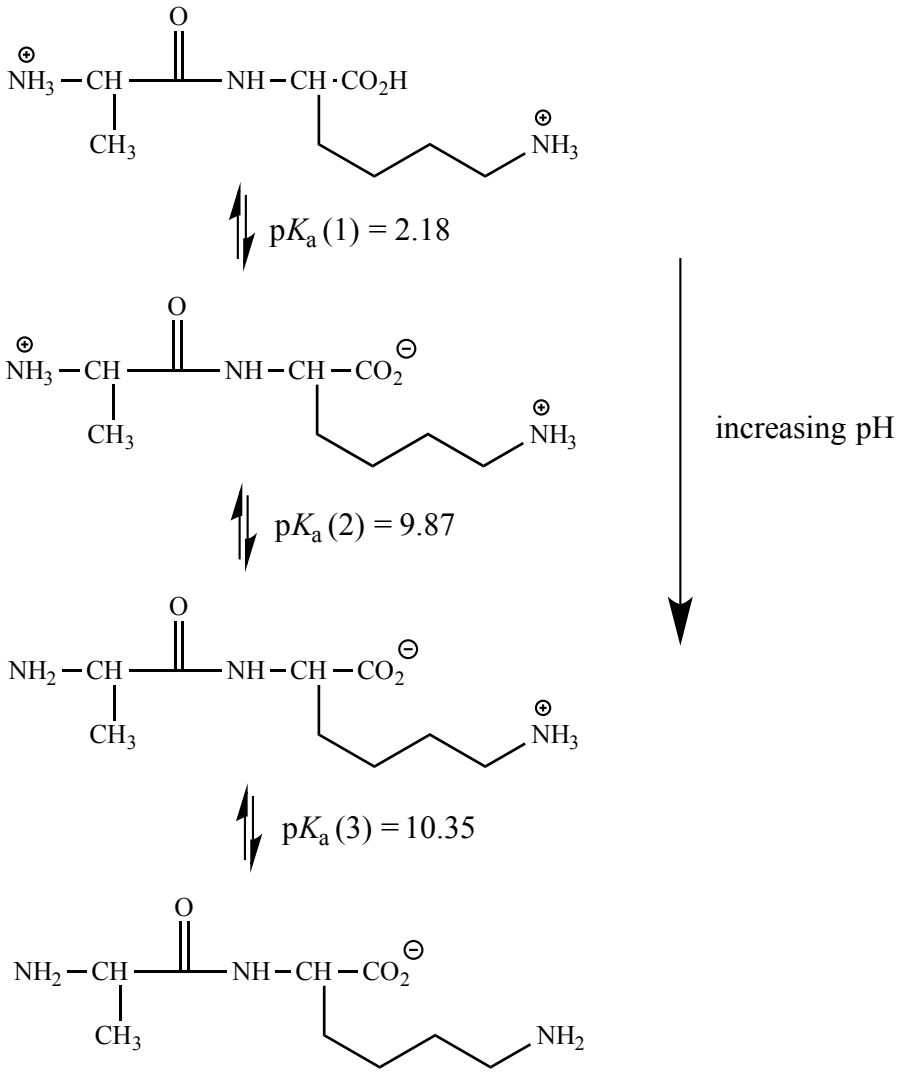
Estimate the isoelectric point of the dipeptide.

The isoelectric point occurs when the peptide has no overall charge. The dipeptide has 2 amine and one carboxylic acid group left after the formation of the amide bonds.

The zwitterionic form is the third form drawn overleaf, occurring between pH = 9.87 and 10.35.

pI is half way between these values: pI = ½ (9.87 + 10.35) = 10.20.

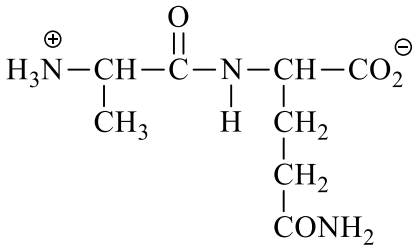
ANSWER CONTINUES ON THE NEXT PAGE

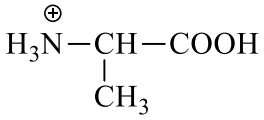


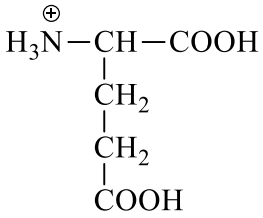
Answer: **10.20**

Marks 3

- Draw all products from the acid hydrolysis of the following dipeptide, indicating the correct charge state under these conditions.







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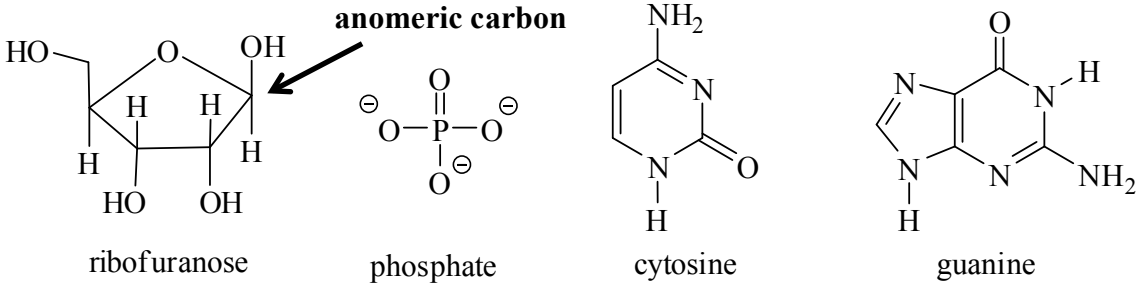
Marks 7

- The following species represent some of the building blocks of RNA.



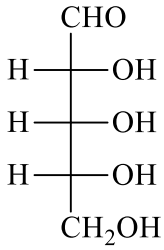
ribofuranose phosphate cytosine guanine

Is the sugar depicted the α or the β form? Circle the correct answer. α **β**

Is the sugar depicted a reducing sugar or a non-reducing sugar? Circle the correct answer. **reducing** non-reducing

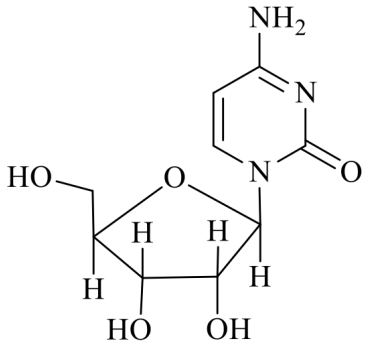
Indicate on the above structure the 'anomeric' carbon atom that gives rise to the α or the β form. **See above**

Draw the Fischer projection of D-ribose.



Using a selection of the species given, draw a nucleoside and a nucleotide.

nucleoside



nucleotide