	Marks
• Complete the following table, giving either the systematic name or the molecular formula as required.	**2**

Formula	Systematic name
$NaHSO_4$	**sodium hydrogensulfate**
$AsCl_3$	arsenic(III) chloride
$CrCl_3 \cdot 6H_2O$	**chromium(III) chloride-6-water**
$Ag_2Cr_2O_7$	silver dichromate

• Complete the following table, providing the ground state electron configuration for each of the following species.	**3**

Species	Ground state electron configuration
chlorine atom	**$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$**
magnesium ion	**$1s^2\ 2s^2\ 2p^6$**
arsenic(V) ion	**$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^0\ 3d^{10}$**

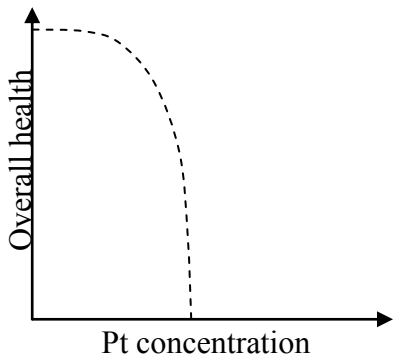
• Like most medicines, the platinum complex, cisplatin, *cis*-$[PtCl_2(NH_3)_2]$, is both effective and toxic. What is cisplatin used to treat?	**4**

Cisplatin is used to treat a number of cancers, including testicular and ovarian cancer.

What does the cisplatin react with in the body to cause most of the toxicity?

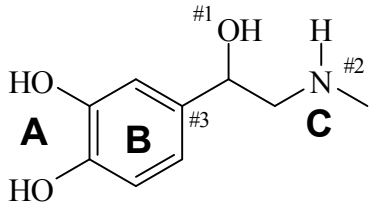
Sulfur containing enzymes in the kidneys

Draw a graph showing the relationship between overall health and the level of platinum in the body of a healthy person.



Marks 8

- The molecular structure of adrenaline (epinephrine), a hormone involved in the "fight or flight" response, is shown below.



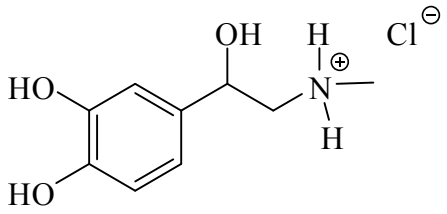
List the types of intermolecular interactions that each of the following sites on adrenaline would be involved in if dissolved in water.

A H-bonding, dipole-dipole, dispersion forces

B dispersion forces

C H-bonding, dipole-dipole, dispersion forces

Pharmaceuticals with amine groups are frequently supplied as their "hydrochloride salts". Draw the structure that would result if adrenaline were reacted with one equivalent of HCl. What **additional** intermolecular forces would be present if this form of adrenaline were dissolved in water?



With this form present, ion-dipole interactions would be introduced.

Provide the requested information for each of the indicated sites on adrenaline.

Atom	Geometric arrangement of the electron pairs around the atom	Hybridisation of the atom	Geometry around the atom	Approximate angles around the atom
$^{\#1}$O	**tetrahedral**	***sp*^{3}**	**bent**	**109°**
$^{\#2}$N	**tetrahedral**	***sp*^{3}**	**trigonal pyramidal**	**109°**
$^{\#3}$C	**trigonal planar**	***sp*^{2}**	**trigonal planar**	**120°**

• Cadmium chloride and cadmium sulfate are both soluble in water. Describe, using equations where appropriate, how to convert cadmium chloride into cadmium sulfate.	**Marks 4**

Dissolve the cadmium chloride in water.

- **$CdCl_2(s) \rightarrow Cd^{2+}(aq) + 2Cl^-(aq)$**

Add a solution of sodium carbonate. Cadmium carbonate will precipitate.

- **$Cd^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CdCO_3(s)$**

Filter off and wash the precipitate and then dissolve it in dilute sulfuric acid.

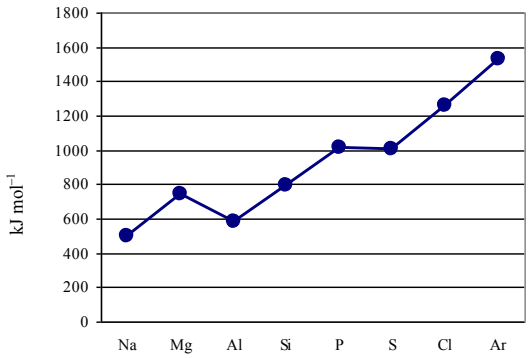
- **$CdCO_3(s) + 2H^+(aq) \rightarrow Cd^{2+}(aq) + H_2O(l) + CO_2(g)$**

Evaporate the solution to give cadmium sulfate.

- **$Cd^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CdSO_4(s)$**

Marks 3

- The diagram below shows the general trend for the first ionisation energy for some *s* and *p* block elements.



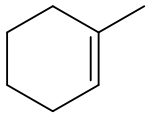
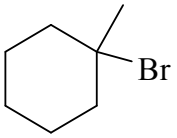
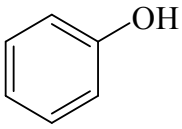
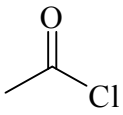
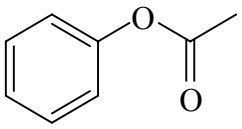
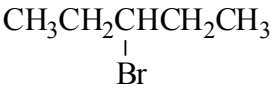
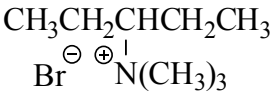
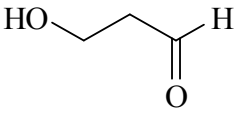
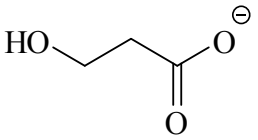
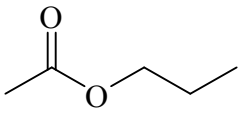
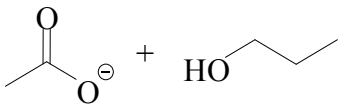
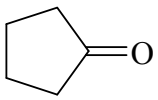
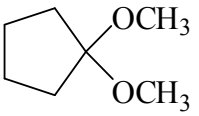
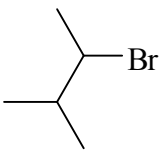
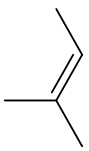
How will the general trend differ for the second ionisation energy of these elements (*i.e.* $X^+(g) \rightarrow X^{2+}(g) + e^-$)? Explain.

The second ionisation of Na will be off the scale as a core electron is ionised. (Actual value > 4500 kJ mol^{-1})

Mg^+ is isoelectronic with Na, Al^+ is isoelectronic with Mg, *etc*., so the second ionisations of the other elements follow the same trends as the first ionisations (for exactly the same reasons), but displaced one atomic number to the right and at a slightly higher energy (as Z_{eff} is greater).

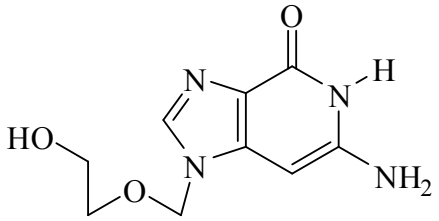
Marks 11

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

STARTING MATERIAL	REAGENTS/ CONDITIONS	CONSTITUTIONAL FORMULA(S) OF MAJOR ORGANIC PRODUCT(S)
	HBr / CCl_4 (solvent)	
		 **Name: phenyl acetate**
 **Name: 3-bromopentane**	**$(CH_3)_3N$**	
	$[Ag(NH_3)_2]^{\oplus}$ / $OH^{\ominus}$	
	3 M NaOH / heat	
 **Name: cyclopentanone**	excess CH_3OH / $H^{\oplus}$ cat. heat	
	hot conc. KOH in ethanol solvent	

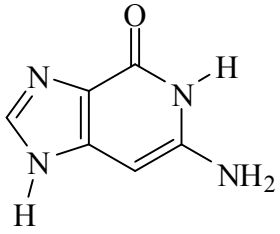
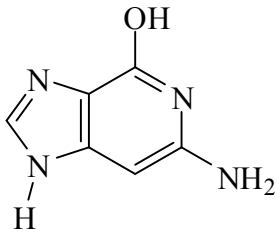
Marks 4

- Acyclovir is an analogue of the nucleoside guanosine, and is used clinically as an antiviral agent.



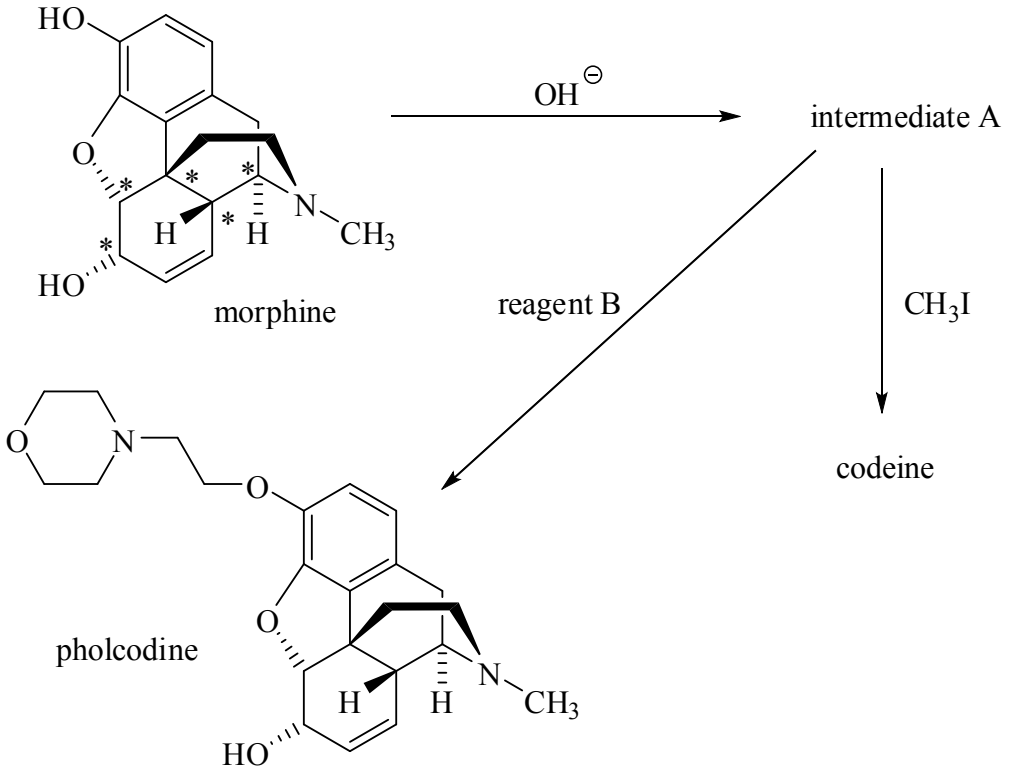
acyclovir

Hydrolysis of acyclovir gives the nucleic base guanine, a diol and a carbonyl compound. Give the structures of guanine, a tautomer of guanine, and the diol and carbonyl compounds formed.

guanine	tautomer of guanine
	
the diol **$HOCH_2CH_2OH$**	the carbonyl compound **CH_2O**

Marks 7

- Morphine is the principal active agent in opium and is a highly potent analgesic drug. Its structure and conversion into codeine (a moderate analgesic) and pholcodine (a cough suppressant) are shown below.



Give the molecular formula of morphine. **$C_{17}H_{19}O_3N$**

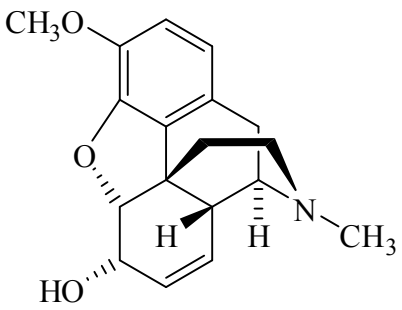
How many stereogenic (chiral) centres are there in morphine? **5 (* on picture)**

Identify the functional groups present in morphine.

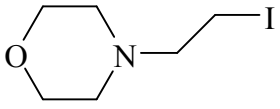
phenol, amine, alcohol, ether, alkene

Draw the structures of codeine and reagent B.

codeine

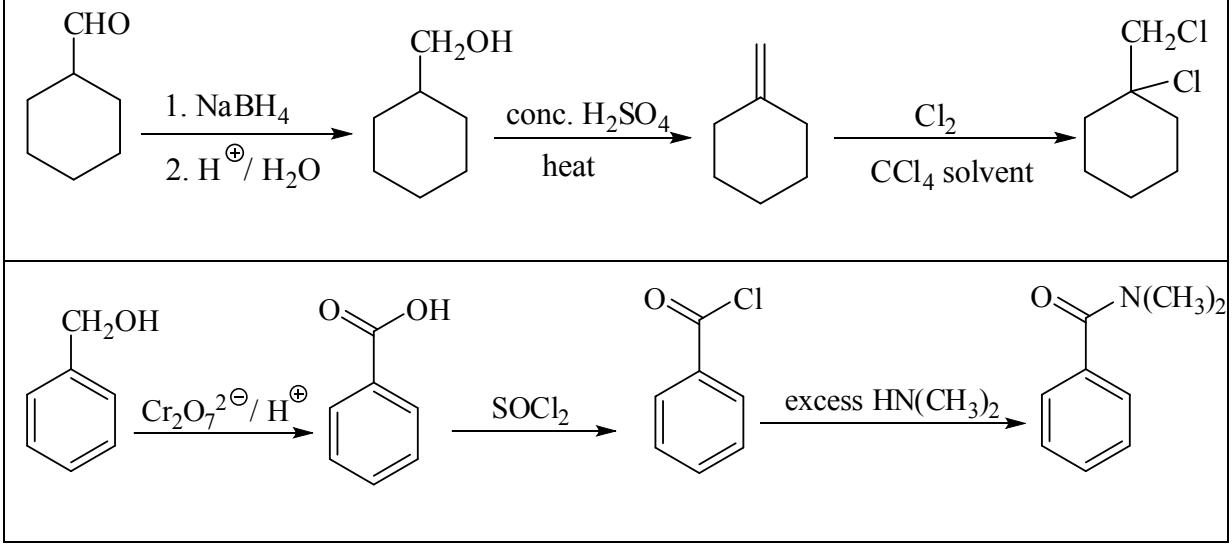


reagent B



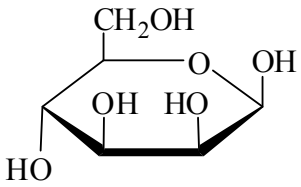
- Show clearly the reagents you would use to carry out the following chemical conversions. Note that more than one step is required and you should indicate all necessary steps and the constitutional formulas of any intermediate compounds.

Marks 6

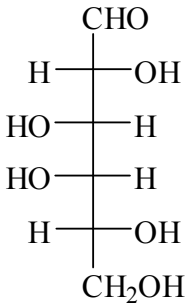


Marks 8

- Shown below are the Haworth structure of β-D-mannopyranose and the Fischer projection of D-galactose.



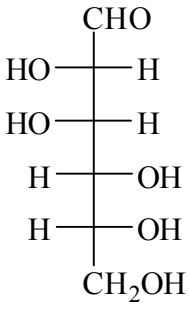
β-D-mannopyranose



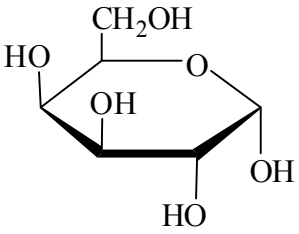
D-galactose

Draw structures for the following sugars.

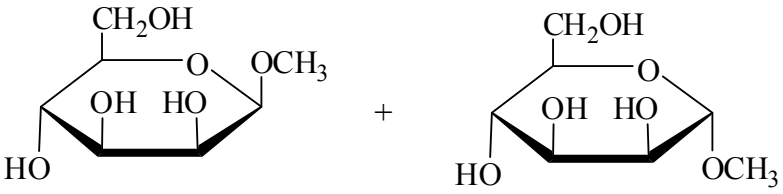
Fischer projection of D-mannose



Haworth structure of α-D-galactopyranose



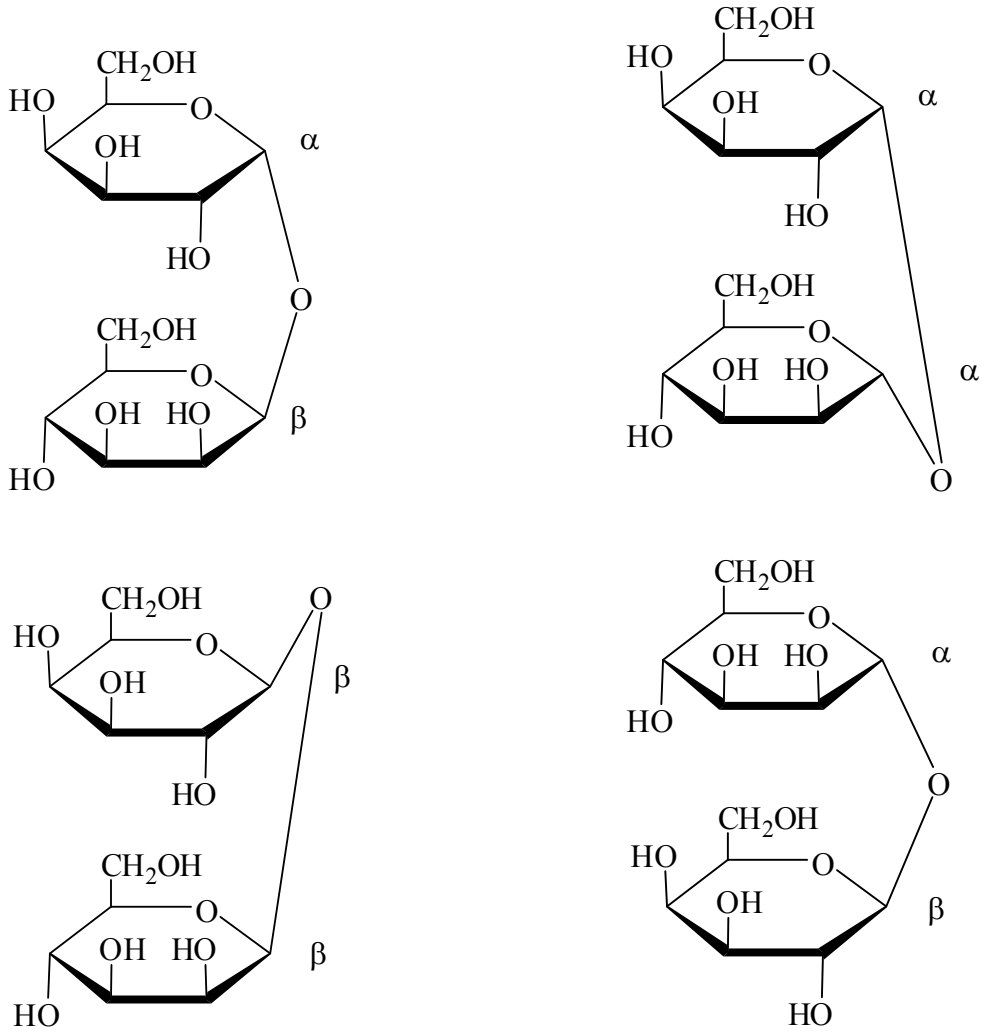
Give the product(s) obtained when D-mannose is treated with acidified methanol.



ANSWER CONTINUES ON THE NEXT PAGE

Draw the structure of any non-reducing disaccharide formed from D-mannose and D-galactose, indicating the configurations at the anomeric carbon atoms.

Any one of the following 4 structures.

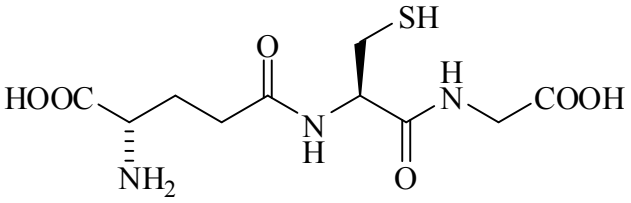


How many different non-reducing disaccharides can be formed from D-mannose and D-galactose? What is the relationship between any two of these compounds?

4 diastereomers

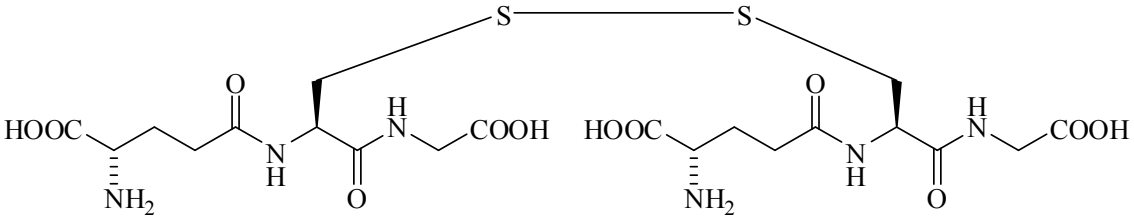
Marks 10

- Glutathione is an important tripeptide (Glu-Cys-Gly) which acts as an antioxidant, protecting cells from toxins such as free radicals. It is an unusual peptide in that the peptidic linkage with glutamic acid (Glu) involves the carboxylic acid group in the side chain.

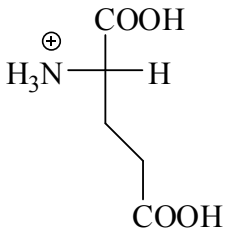


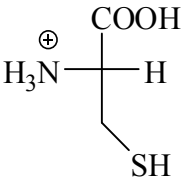
glutathione

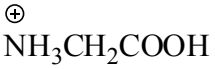
Give the product when glutathione undergoes oxidation.



Draw the Fischer projections of the three amino acids (in their natural absolute configurations, where applicable) that result from the vigorous acid hydrolysis (with 6 M HCl) of glutathione.

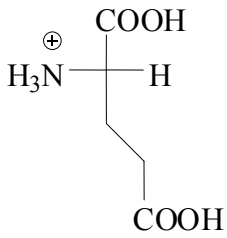




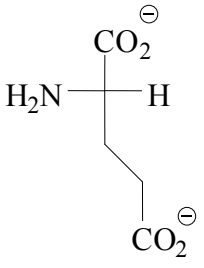


Draw the major species present when glutamic acid (Glu) is dissolved in water at pH 1 and pH 12. The pK_a values of glutamic acid are 2.1 (α-COOH), 9.5 (α-$NH_3^{\oplus}$) and 4.0 (side chain).

pH 1



pH 12



ANSWER CONTINUES ON THE NEXT PAGE

Give the constitutional formula for the dipeptide Cys-Gly in its zwitterionic state.