



A-Level Chemistry

DNA

Question Paper

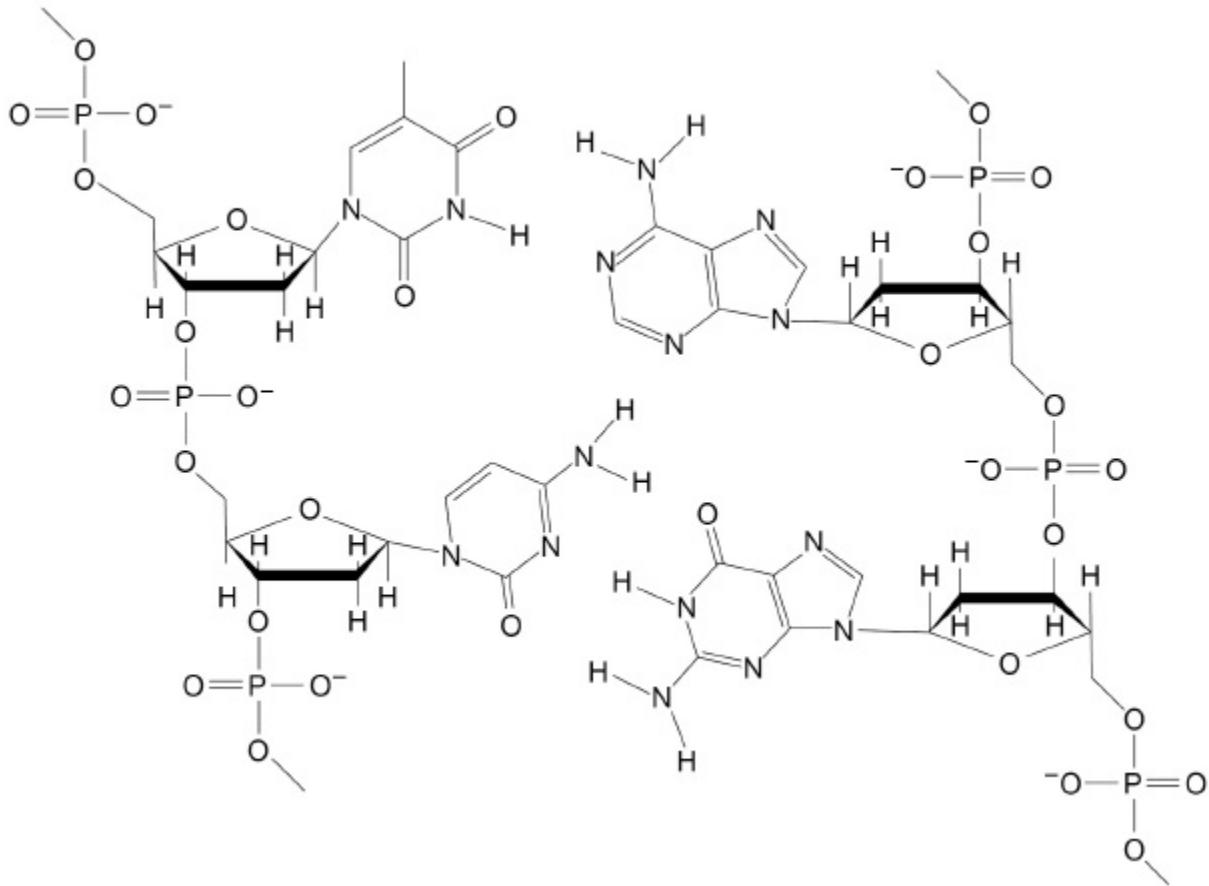
Time available: 60 minutes

Marks available: 51 marks

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1.

The diagram shows two complementary strands in part of a DNA double helix structure.



(a) Draw all the hydrogen bonds between the complementary strands shown in the diagram.

Use dashed lines to show the hydrogen bonds.

You do **not** need to show lone pairs of electrons or partial charges.

(2)

(b) Draw a ring around each of the component parts that make up the cytosine nucleotide in the section of DNA shown in the diagram above.

(2)

(c) State the meaning of the term complementary when it is used to refer to DNA strands.

(1)

(Total 5 marks)

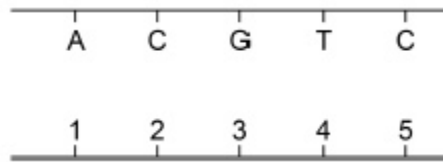
2.

Use the Data Booklet to help you answer this question about DNA.

The figure below shows a fragment of a DNA double helix.

The letters A, C, G and T represent the four bases in one strand.

The numbers 1, 2, 3, 4 and 5 represent the bases in the complementary strand.



- (a) Complete Table 4 to show the correct sequence of bases in the complementary strand represented by the numbers 1 to 5

1	2	3	4	5

(1)

- (b) Deduce the total number of hydrogen bonds formed between the five bases in each strand.

Tick (✓) **one** box.

10	12	13	15

(1)

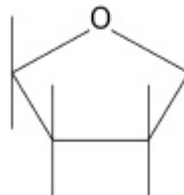
- (c) Base A is part of a nucleotide in the DNA strand shown in the figure above.

A nucleotide contains a 2-deoxyribose molecule.

An incomplete 2-deoxyribose molecule is shown.

Complete the structure to show the nucleotide that contains base A.

You should represent base A by the letter A.



(2)

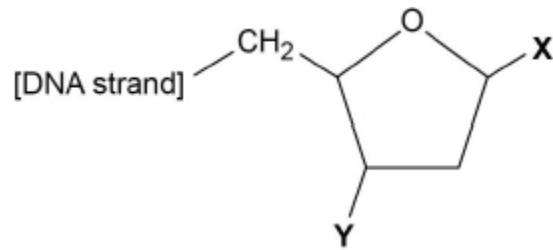
(Total 4 marks)

3.

Use the Data Booklet to help you answer these questions.

DNA exists as two strands of nucleotides in the form of a double helix with hydrogen bonding between the two strands.

(a) A deoxyribose molecule in a strand of DNA is shown.



Name the types of group attached to 2-deoxyribose at positions X and Y.

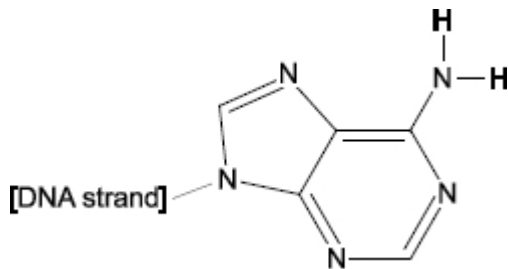
X _____

Y _____

(2)

(b) In the DNA double helix, adenine is linked by hydrogen bonds to a molecule in the other strand of DNA.

Complete the diagram below to show the other molecule and the hydrogen bonds between it and adenine.



(2)

(Total 4 marks)

4.

Use the information in the Data Booklet to help you answer these questions.

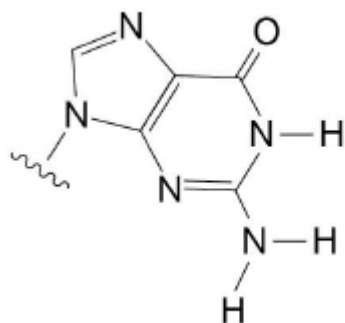
A single strand of DNA is made from many nucleotides linked together.

- (a) Draw the structure of the nucleotide that contains guanine, showing clearly the bonding between the components.

(3)

- (b) Two complementary strands of DNA form a double helix in which one strand is attracted to another by interactions between pairs of bases.

Complete the base pair diagram showing the interactions.

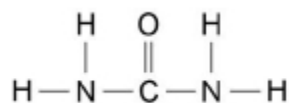


(2)

- (c) State how the interactions in the adenine-thymine base pair differ from those you identified in part (b).

(1)

(d) Urea has the displayed formula



Suggest why urea is effective at separating the complementary strands in DNA.

(2)

(Total 8 marks)

5.

Cisplatin, $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$, is used as an anti-cancer drug.

(a) Cisplatin works by causing the death of rapidly dividing cells.

Name the process that is prevented by cisplatin during cell division.

(1)

After cisplatin enters a cell, one of the chloride ligands is replaced by a water molecule to form a complex ion, **B**.

(b) Give the equation for this reaction.

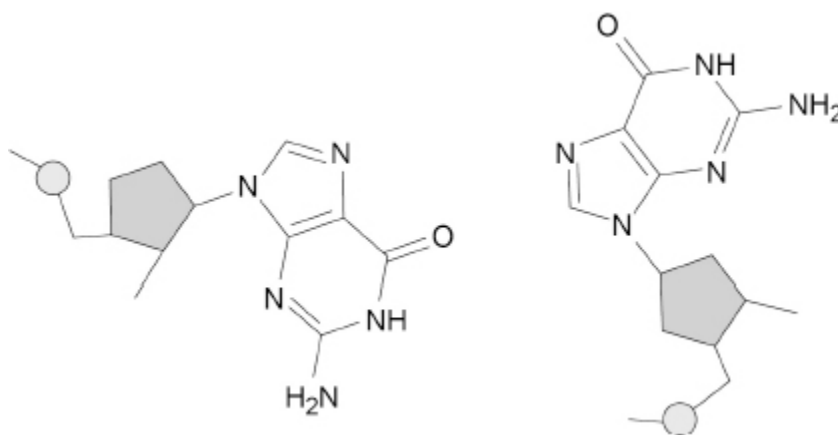
(2)

- (c) When the complex ion **B** reacts with DNA, the water molecule is replaced as a bond forms between platinum and a nitrogen atom in a guanine nucleotide. The remaining chloride ligand is also replaced as a bond forms between platinum and a nitrogen atom in another guanine nucleotide.

Figure 1 represents two adjacent guanine nucleotides in DNA.

Complete **figure 1** to show how the platinum complex forms a cross-link between the guanine nucleotides.

Figure 1



(2)

An experiment is done to investigate the rate of reaction in part (b).

- (d) During the experiment the concentration of cisplatin is measured at one-minute intervals.

Explain how graphical methods can be used to process the measured results, to confirm that the reaction is first order.

(3)

In another experiment, the effect of temperature on the rate of the reaction in part (b) is investigated.

The table shows the results.

Temperature T / K	$\frac{1}{T} / \text{K}^{-1}$	Rate constant k / s^{-1}	$\ln k$
293	0.00341	1.97×10^{-8}	-17.7
303	0.00330	8.61×10^{-8}	-16.3
313	0.00319	3.43×10^{-7}	-14.9
318		6.63×10^{-7}	
323	0.00310	1.26×10^{-6}	-13.6

(e) Complete the table above.

(2)

(f) The Arrhenius equation can be written in the form

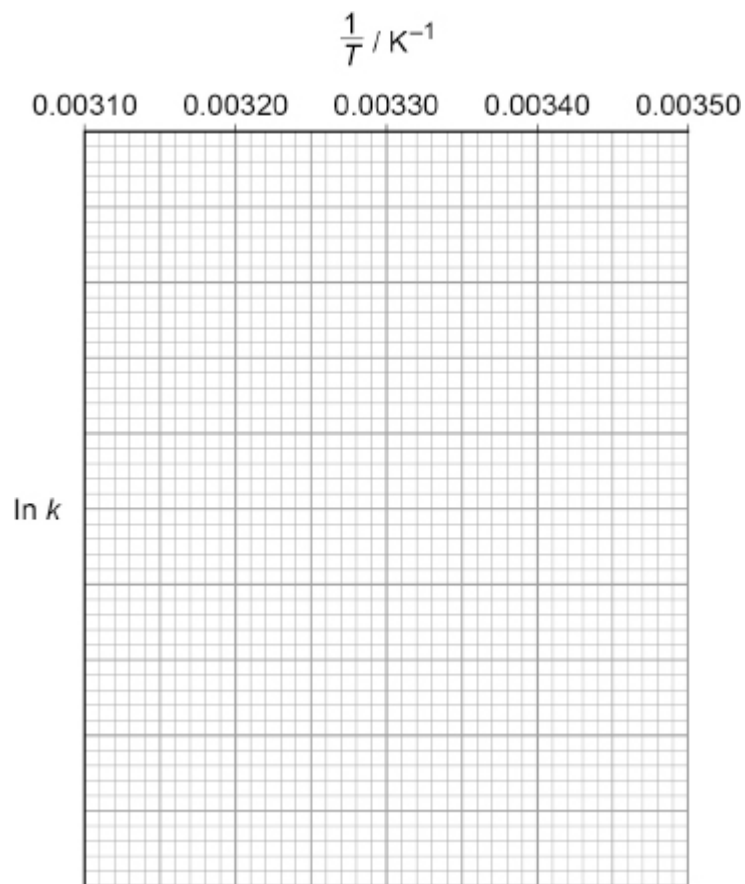
$$\ln k = \frac{-E_a}{RT} + \ln A$$

Use the data in the table above to plot a graph of $\ln k$ against $\frac{1}{T}$ on the grid in **Figure 2**.

Calculate the activation energy, E_a , in kJ mol^{-1}

The gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Figure 2



E_a _____ kJ mol^{-1}

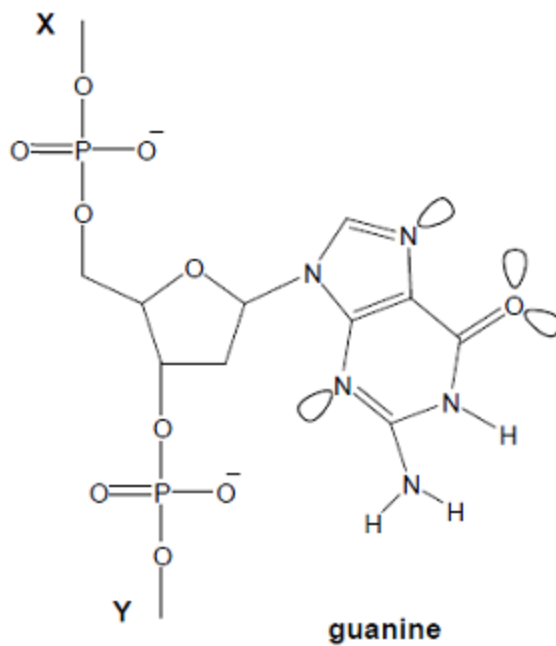
(5)

6.

The anticancer drug cisplatin operates by reacting with the guanine in DNA.

Figure 1 shows a small part of a single strand of DNA. Some lone pairs are shown.

Figure 1



- (a) The DNA chain continues with bonds at X and Y.

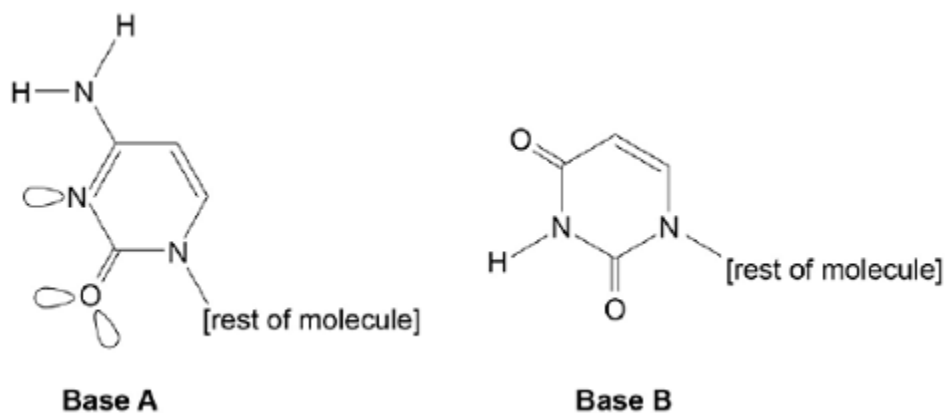
State the name of the sugar molecule that is attached to the bond at X.

(1)

- (b) Messenger RNA is synthesised in cells in order to transfer information from DNA. The bases in one strand of DNA pair up with the bases used to synthesise RNA.

Figure 2 shows two bases used in RNA.

Figure 2



Suggest which of the bases **A** and **B** forms a pair with guanine in **Figure 1** when messenger RNA is synthesised.

Explain how the base that you have chosen forms a base pair with guanine.

(4)

- (c) Cisplatin works because one of the atoms on guanine can form a co-ordinate bond with platinum, replacing one of the ammonia or chloride ligands. Another atom on another guanine can also form a co-ordinate bond with the same platinum by replacing another ligand.

On **Figure 1**, draw a ring round an atom in guanine that is likely to bond to platinum.

(1)

- (d) An adverse effect of cisplatin is that it also prevents normal healthy cells from replicating.

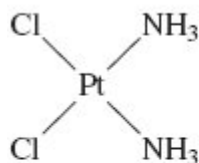
Suggest **one** way in which cisplatin can be administered so that this side effect is minimised.

(1)

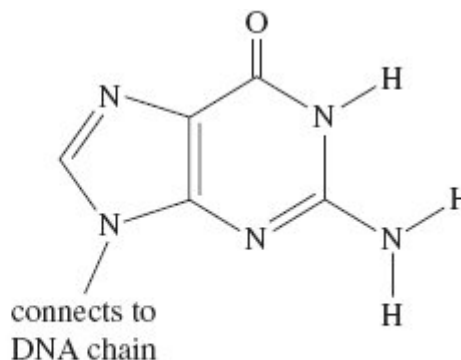
(Total 7 marks)

7.

The complex cisplatin acts as an anticancer drug by changing the properties of DNA when it reacts with guanine, a component of DNA.



cisplatin



guanine

When cisplatin is absorbed into the human body, it undergoes a ligand substitution reaction and one chloride ligand is replaced by a water molecule forming a complex ion **Q**.

- (a) Write an equation for this substitution reaction to form the complex ion **Q**.

(2)

- (b) The complex ion **Q** can bond to guanine in two different ways.

- (i) The first way involves a hydrogen atom, from one of the ammonia ligands on **Q**, bonding to an atom in a guanine molecule. State the type of bond formed to guanine and identify an atom in guanine that could form a bond to this hydrogen atom.

Type of bond _____

Atom in guanine _____

(2)

- (ii) The second way involves a ligand substitution reaction in which an atom in a guanine molecule bonds to platinum by displacing the water molecule from **Q**.
State the type of bond formed between guanine and platinum when a water molecule is displaced and identify an atom in guanine that could bond to platinum in this way.

Type of bond _____

Atom in guanine _____

(2)

- (c) State and explain **one** risk associated with the use of cisplatin as an anticancer drug.

Risk _____

Explanation _____

(2)

(Total 8 marks)