AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

A-level CHEMISTRY

Paper 3

Time allowed: 2 hours

Materials

For this paper you must have:
- the Periodic Table/Data Booklet, provided as an insert (enclosed)
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do **not** write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
Section B	
TOTAL	

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 90.

Advice
- You are advised to spend 70 minutes on **Section A** and 50 minutes on **Section B**.

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Section A

Answer **all** questions in this section.

0 1 This question is about ethanedioic acid (HOOCCOOH) and the ethanedioate ion ($^{-}$OOCCOO^{-}).

0 1 . 1 Ethanedioic acid reacts with propane-1,3-diol ($HOCH_2CH_2CH_2OH$) to form a polyester.

Draw the repeating unit of this polyester.

[2 marks]

0 1 . 2 Explain why polyesters are biodegradable but polyalkenes are not biodegradable.

[2 marks]

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0 1 . 3 Sodium ethanedioate is used to find the concentration of solutions of potassium manganate(VII) by titration. The equation for this reaction is

$$2\,MnO_4^- + 16\,H^+ + 5\,C_2O_4^{2-} \rightarrow 2\,Mn^{2+} + 8\,H_2O + 10\,CO_2$$

A standard solution is made by dissolving 162 mg of $Na_2C_2O_4$ (M_r = 134.0) in water and making up to 250 cm^3 in a volumetric flask.

25.0 cm^3 of this solution and an excess of sulfuric acid are added to a conical flask.
The mixture is warmed and titrated with potassium manganate(VII) solution.
The titration is repeated until concordant results are obtained.
The mean titre is 23.85 cm^3

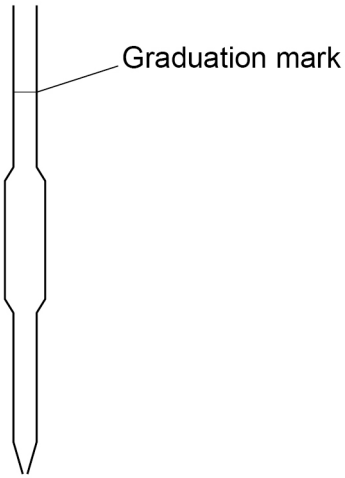
Calculate the concentration, in mol dm^{-3}, of the potassium manganate(VII) solution.

[4 marks]

Concentration _____ mol dm^{-3}

0 1 . 4 **Figure 1** shows the 25.0 cm^3 pipette used to measure the sodium ethanedioate solution.

Figure 1



On **Figure 1**, draw the meniscus of the solution when the pipette is ready to transfer 25.0 cm^3 of the sodium ethanedioate solution.

[1 mark]

0 1 . 5 Potassium manganate(VII) is oxidising and harmful.
Sodium ethanedioate is toxic.

Suggest safety precautions, other than eye protection, that should be taken when:
- filling the burette with potassium manganate(VII) solution
- dissolving the solid sodium ethanedioate in water.

[2 marks]

Filling the burette _____

_____

Dissolving the solid _____

_____

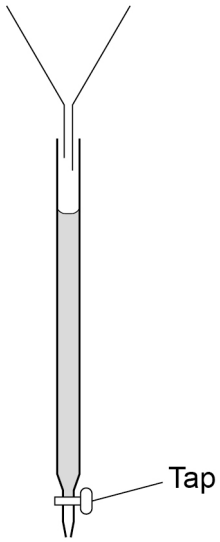
0 1 . 6 State the colour change seen at the end point of each titration.

[1 mark]

_____

0 1 . 7 **Figure 2** shows the burette containing potassium manganate(VII) solution.

Figure 2



Give **two** practical steps needed before recording the initial burette reading.

[2 marks]

1 _____

2 _____

Question 1 continues on the next page

0 1 . 8 When $Na_2C_2O_4(aq)$ is added to a solution containing $[Fe(H_2O)_6]^{3+}$ ions, a reaction occurs in which all six water ligands are replaced by ethanedioate ions.

Explain why the replacement of the water ligands by ethanedioate ions is favourable. In your answer refer to:

- the enthalpy and entropy changes for the reaction
- how the enthalpy and entropy changes influence the free-energy change for the reaction.

[6 marks]

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20

Turn over for the next question

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0 2 The protein fibroin can be broken down into amino acids using an enzyme.

0 2 . 1 A student uses thin-layer chromatography (TLC) to identify these amino acids.

The student identifies two of the amino acids as alanine and serine.

Use **Figure 3** to calculate the R_f value of the unknown amino acid.
Show your working.

Use your R_f value and **Table 1** to identify the unknown amino acid.

[2 marks]

Figure 3

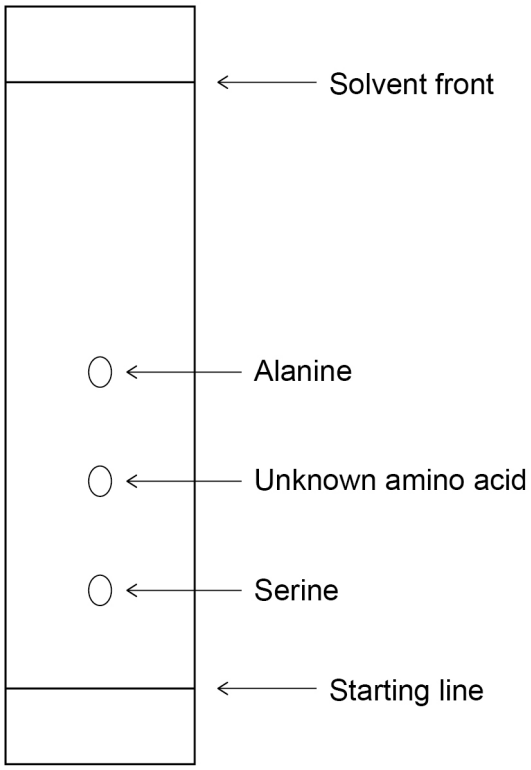

Table 1

Amino acid	**R_f value**
tyrosine	0.25
glycine	0.34
valine	0.64
leucine	0.73

R_f value _____

Identity _____

Do not write outside the box

0 2 . 2 The amino acids cannot be seen as they move during the experiment.

State how the amino acids can be made visible at the end of the experiment.

[1 mark]

0 2 . 3 State why each amino acid has a different R_f value.

[1 mark]

4

Turn over for the next question

Do not write outside the box

0 3 This question is about ketones.

0 3 . 1 Solution **X** reacts with liquid ketones to form a crystalline solid.

This reaction can be used to identify a ketone if the crystalline solid is separated, purified by recrystallisation, and the melting point determined.

Describe how the crystalline solid is separated and purified.

[5 marks]

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0 3 . 2 Propanone (CH_3COCH_3) reacts with the weak acid HCN to form a hydroxynitrile.

This hydroxynitrile is usually made by reaction of propanone with KCN followed by dilute acid, instead of with HCN

State the hazard associated with the use of KCN

Suggest a reason, other than safety, why KCN is used instead of HCN.

[2 marks]

Hazard _____

Why KCN is used _____

_____

0 3 . 3 Outline the mechanism for the reaction of propanone with KCN followed by dilute acid.

[4 marks]

11

Turn over for the next question

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0 4 This question is about Group 7 chemistry.

0 4 . 1 Give an equation for the reaction of solid sodium bromide with concentrated sulfuric acid to form bromine.

State **one** observation made during this reaction.

[2 marks]

Equation

Observation

0 4 . 2 A solution that is thought to contain chloride ions and iodide ions is tested.

1. Dilute nitric acid is added to the solution.
2. Aqueous silver nitrate is added to the solution.
3. A pale yellow precipitate forms.
4. Excess dilute aqueous ammonia is added to the mixture.
5. Some of the precipitate dissolves and a darker yellow precipitate remains.

Give a reason for the use of each reagent.

Explain the observations.

Give ionic equations for any reactions.

[5 marks]

Do not write outside the box

7

Turn over for the next question

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0 5 A mixture of methanoic acid and sodium methanoate in aqueous solution acts as an acidic buffer solution.

The equation shows the dissociation of methanoic acid.

$$HCOOH(aq) \rightleftharpoons HCOO^{-}(aq) + H^{+}(aq)$$

Calculate the mass, in g, of sodium methanoate (HCOONa) that must be added to 25.0 cm^3 of 0.100 mol dm^{-3} methanoic acid to produce a buffer solution with pH = 4.05 at 298 K

For methanoic acid, pK_a = 3.75 at 298 K

Assume that the volume of the solution remains constant.

[5 marks]

Mass _____ g

5

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Turn over for the next question

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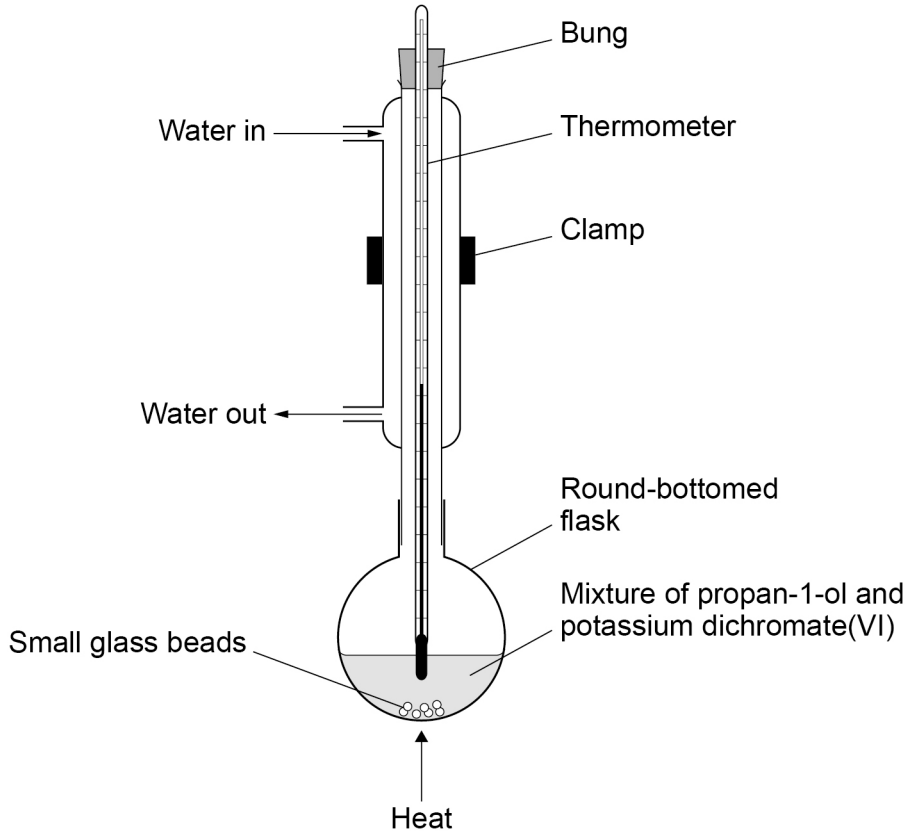
ANSWER IN THE SPACES PROVIDED

0 6 A student plans an experiment to investigate the yield of propanoic acid when a sample of propan-1-ol is oxidised.

Figure 4 shows the apparatus that the student plans to use for the experiment.

The student's teacher says that the apparatus is not safe.

Figure 4



0 6 . 1 Give **two** reasons why the apparatus shown in **Figure 4** is not safe.

[2 marks]

1 _____

_____

2 _____

_____

Do not write outside the box

0 6 . 2 Give **one** additional reagent that is needed to form any propanoic acid.

[1 mark]

0 6 . 3 State **two** more mistakes in the way the apparatus is set up in **Figure 4**.

[2 marks]

1 _____

2 _____

0 6 . 4 State the purpose of the small glass beads in the flask in **Figure 4**.

[1 mark]

Question 6 continues on the next page

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0 6 . 5 After correcting the mistakes, the student heats a reaction mixture containing 6.50 g of propan-1-ol with an excess of the oxidising agent.
The propanoic acid separated from the reaction mixture has a mass of 3.25 g

State the name of the technique used to separate the propanoic acid from the reaction mixture.

Calculate the percentage yield of propanoic acid.

[4 marks]

Technique _____

Percentage yield _____

0 6 . 6 State a simple chemical test that distinguishes the propanoic acid from the propan-1-ol.

Give **one** observation for the test with each substance.

[3 marks]

Test _____

Propanoic acid _____

Propan-1-ol _____

13

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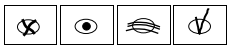
Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.
For each answer completely fill in the circle alongside the appropriate answer.

CORRECT METHOD  WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

You may do your working in the blank space around each question but this will not be marked. Do **not** use additional sheets for this working.

0 7 Which does **not** involve the absorption of ultraviolet radiation or visible light?

[1 mark]

A The blue appearance of copper(II) sulfate solution in daylight. ⬭

B The breakdown of ozone in the upper atmosphere. ⬭

C The ionisation of a molecule in a mass spectrometer. ⬭

D The reaction between chlorine and methane at room temperature. ⬭

0 8 Which statement about chloride ions is **not** correct?

[1 mark]

A They form a white precipitate with silver nitrate solution that is soluble in dilute aqueous ammonia. ⬭

B They form an octahedral cobalt(II) complex when aqueous cobalt(II) ions are reacted with an excess of chloride ions. ⬭

C They form when chlorine reacts with potassium bromide solution. ⬭

D They have the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6$ ⬭

Turn over ►

0 9 What is the mole fraction of 1.0 g of a compound of relative molecular mass 100.0 dissolved in 30.0 g of a solvent of relative molecular mass 50.0?

[1 mark]

A 6.0×10^{-3} ⬭

B 1.6×10^{-2} ⬭

C 1.7×10^{-2} ⬭

D 3.0×10^{-2} ⬭

1 0 Which has the electron configuration of a noble gas?

[1 mark]

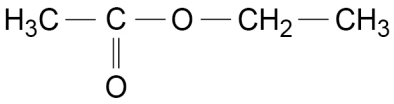
A H^+ ⬭

B O^- ⬭

C Se^{2-} ⬭

D Zn^{2+} ⬭

1 1 Which statement does **not** support the suggestion that an unknown organic compound is



[1 mark]

A Its ^{1}H NMR spectrum has 3 peaks with an integration ratio of 2:3:3 ⬭

B Its ^{13}C NMR spectrum has 3 peaks. ⬭

C Its infrared spectrum has an absorption at 1735 cm^{-1} ⬭

D It has 36.36% by mass of oxygen and 9.09% by mass of hydrogen. ⬭

Do not write outside the box

1 2 Which statement about inorganic ionic compounds is **always** correct?

[1 mark]

A They dissolve in water to give neutral solutions. ⬭

B They release energy when they melt. ⬭

C They contain metal cations. ⬭

D They form giant structures. ⬭

1 3 Which species has a lone pair of electrons on the central atom?

[1 mark]

A CO_2 ⬭

B SO_2 ⬭

C PCl_6^- ⬭

D SO_4^{2-} ⬭

1 4 In which substance do covalent bonds break when it melts?

[1 mark]

A hexane ⬭

B ice ⬭

C iodine ⬭

D silicon dioxide ⬭

1 5 In which molecule are all the atoms in the same plane?

[1 mark]

A CH_3CHO ⬭

B CH_3NH_2 ⬭

C C_6H_5Cl ⬭

D $C_6H_5CH_3$ ⬭

Turn over ►

Do not write outside the box

1 6 Which molecule has a permanent dipole?

[1 mark]

A BF_3 ⬭

B NH_3 ⬭

C $SiCl_4$ ⬭

D SO_3 ⬭

1 7 Which statement about $(CH_3)_2CHCH_2COOH$ is correct?

[1 mark]

A In aqueous solution it reacts with magnesium to form carbon dioxide. ⬭

B It can form hydrogen bonds. ⬭

C It has optical isomers. ⬭

D It has the IUPAC name 2-methylbutanoic acid. ⬭

1 8 A mixture of 2 dm^3 of hydrogen and 1 dm^3 of oxygen is at room temperature.

Which statement is correct?

[1 mark]

A There is no reaction to form water because the molecules do not collide with sufficient energy. ⬭

B There is no reaction to form water because the molecules do not collide with sufficient frequency. ⬭

C The mean velocity of the hydrogen molecules is less than that of the oxygen molecules. ⬭

D The partial pressure of each gas is the same. ⬭

Do not write outside the box

1 9 Which statement about the distribution curve of molecular energies in an ideal gas at a given temperature is correct?

[1 mark]

A There are no molecules with zero energy. ⬭

B The curve is symmetrical about the maximum. ⬭

C Changing the temperature has no effect on the position of the maximum. ⬭

D Most molecules have the mean energy. ⬭

2 0 Which statement about the addition of a catalyst to an equilibrium mixture is correct?

[1 mark]

A The activation energy for the reverse reaction increases. ⬭

B The equilibrium constant for the forward reaction increases. ⬭

C The rate of the reverse reaction increases. ⬭

D The enthalpy change for the forward reaction decreases. ⬭

2 1 Which equation does **not** show the reduction of a transition metal?

[1 mark]

A $TiCl_4 + 2\,Mg \rightarrow Ti + 2\,MgCl_2$ ⬭

B $2\,FeCl_3 + 2\,KI \rightarrow 2\,FeCl_2 + 2\,KCl + I_2$ ⬭

C $MnO_2 + 4\,HCl \rightarrow MnCl_2 + Cl_2 + 2\,H_2O$ ⬭

D $CoO + 4\,HCl \rightarrow [CoCl_4]^{2-} + H_2O + 2\,H^+$ ⬭

Turn over for the next question

Do not write outside the box

2 2 Which substance contains delocalised electrons?

[1 mark]

A cyclohexane ⬭

B graphite ⬭

C iodine ⬭

D sodium chloride ⬭

2 3 Which compound has *E*–*Z* isomers?

[1 mark]

A CH_2=CHBr ⬭

B CH_2=CBr_2 ⬭

C CHBr=CHBr ⬭

D CBr_2=CHBr ⬭

2 4 Which polymer has hydrogen bonding between the polymer chains?

[1 mark]

A Kevlar ⬭

B PVC ⬭

C poly(phenylethene) ⬭

D Terylene ⬭

Do not write outside the box

2 5 Which compound needs the greatest amount of oxygen for the complete combustion of 1 mol of the compound?

[1 mark]

A ethanal ⬭

B ethanol ⬭

C ethane-1,2-diol ⬭

D methanol ⬭

2 6 Which compound is produced when 1-phenylethanol reacts with acidified potassium dichromate(VI)?

[1 mark]

A $C_6H_5CH_2CH_2OH$ ⬭

B $C_6H_5CH_2CHO$ ⬭

C $C_6H_5COCH_3$ ⬭

D $C_6H_5CH(OH)CH_3$ ⬭

2 7 Which is the correct general formula for non-cyclic compounds in the homologous series?

[1 mark]

A alcohols $C_nH_{2n+2}O$ ⬭

B aldehydes $C_nH_{2n+1}O$ ⬭

C esters $C_nH_{2n+1}O_2$ ⬭

D primary amines $C_nH_{2n+2}N$ ⬭

Turn over for the next question

2 8 Which compound forms a white precipitate when added to aqueous silver nitrate?

[1 mark]

A bromoethane ⬭

B ethanal ⬭

C ethanoic anhydride ⬭

D ethanoyl chloride ⬭

2 9 Nitration of 1.70 g of methyl benzoate (M_r = 136.0) produces methyl 3-nitrobenzoate (M_r = 181.0). The percentage yield is 65.0%

What mass, in g, of methyl 3-nitrobenzoate is produced?

[1 mark]

A 0.830 ⬭

B 1.10 ⬭

C 1.47 ⬭

D 2.26 ⬭

3 0 A two-step preparation of propylamine is shown.

bromoethane → **X** → propylamine

What is **X**?

[1 mark]

A $CH_3CH_2CH_2NH_2$ ⬭

B CH_3CH_2CN ⬭

C $CH_3CH_2CH_2Br$ ⬭

D $CH_3CH_2NH_2$ ⬭

Do not write outside the box

3 1 Which compound reacts with warm dilute aqueous sodium hydroxide?

[1 mark]

A C_6H_6 ⬭

B $CH_3CH=CH_2$ ⬭

C $CH_3CH_2CH_2NH_2$ ⬭

D $(CH_3CO)_2O$ ⬭

3 2 Methylamine reacts with bromoethane by nucleophilic substitution to produce a mixture of products.

Which is **not** a possible product of this reaction?

[1 mark]

A $C_2H_5NHCH_3$ ⬭

B $(C_2H_5)_2NCH_3$ ⬭

C $[(C_2H_5)_2N(CH_3)_2]^+ Br^-$ ⬭

D $[(C_2H_5)_3NCH_3]^+ Br^-$ ⬭

Turn over for the next question

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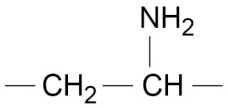
3 3 Which is the repeating unit of a polyamide?

[1 mark]

A



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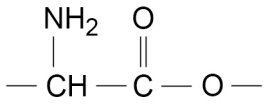

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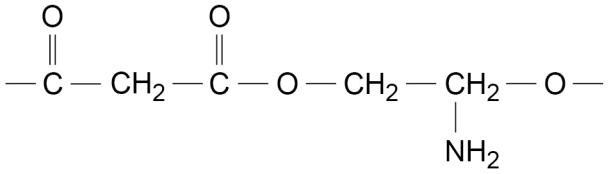

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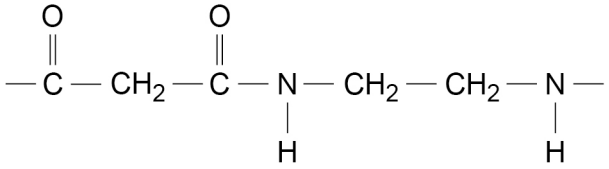

3 4 Which type of polymer is **not** hydrolysed by heating with concentrated aqueous sodium hydroxide?

[1 mark]

A poly(alkene)

B poly(amide)

C poly(ester)

D protein

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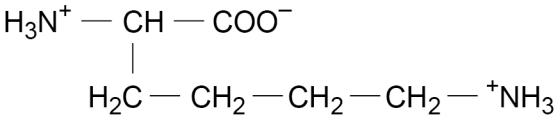
3 5 Which is the structure of a zwitterion of an amino acid?

[1 mark]

A



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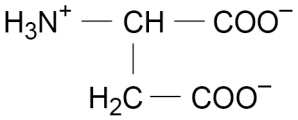

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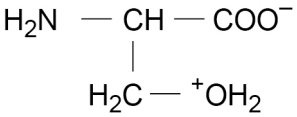

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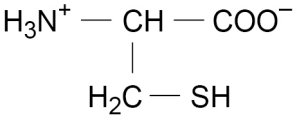

3 6 Which row shows a pair of bases that can link two strands of DNA with three hydrogen bonds?

Use the Data Booklet to help you answer this question.

[1 mark]

	Base 1	Base 2
A	adenine	guanine
B	cytosine	thymine
C	cytosine	guanine
D	adenine	thymine

30

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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