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

Friday 20 June 2025 Morning 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 A value for enthalpy of solution can be determined from the results of a calorimetry experiment or by the application of Hess's law.

0 1 . 1 Give the equation, including state symbols, for the process that occurs when the enthalpy of solution of potassium hydroxide is determined.

[1 mark]

Do not write outside the box

0 1 . 2 A student does an experiment to determine a value for the enthalpy of solution of potassium hydroxide.

The student uses this method.

- Add some distilled water to a measuring cylinder and record the volume.
- Pour the water into a polystyrene cup.
- Record the temperature of the water in the cup.
- Add 3.00 g of solid KOH to the water in the cup.
- Stir the solution and record the maximum temperature reached.

Table 1 shows the student's results.

Table 1

Initial temperature / °C	18.1
Final temperature / °C	30.4

The student calculated the enthalpy of solution of potassium hydroxide to be –51.3 kJ mol^{-1}

The specific heat capacity of the solution, c = 4.18 J K^{-1} g^{-1}

Assume the density of the solution = 1.00 g cm^{-3}

Calculate the volume of water that the student added to the cup.

[5 marks]

Volume of water _____ Units _____

Turn over ►

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0 1 . 3 **Table 2** shows some enthalpy change data.

Table 2

	Enthalpy change / kJ mol^{-1}
Enthalpy of lattice formation of potassium hydroxide	–789
Enthalpy of hydration of potassium ions	–322
Enthalpy of hydration of hydroxide ions	–528

Use the data in **Table 2** to calculate the enthalpy of solution for potassium hydroxide.

[2 marks]

Enthalpy of solution _____ kJ mol^{-1}

0 1 . 4 Suggest why the value calculated in Question **01.3** is different from the experimental value given in Question **01.2**.

[1 mark]

_____

_____

_____

9

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 2 The effect of reactant concentrations on the rate of a reaction is investigated.

The equation for the reaction is shown.

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

The experiment is done five times in the presence of thiosulfate ions and starch.
The reactant concentrations are varied by changing the volume of each reactant in the mixture.
The thiosulfate ions react with the iodine as it is produced, until all the thiosulfate has reacted.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

After all the thiosulfate has reacted, the iodine produced in the mixture then reacts with the starch and the solution turns blue-black.
The time taken for the solution to turn blue-black is recorded.
If the amount of thiosulfate is the same in each experiment, the time recorded represents the time to produce the same amount of iodine in each experiment.

Table 3 shows the results of the investigation.

Table 3

Experiment	$[H_2O_2]$ / mol dm^{-3}	$[I^-]$ / mol dm^{-3}	$[H^+]$ / mol dm^{-3}	Time for reaction mixture to turn blue-black / s
1	0.010	0.010	0.10	60
2	0.020	0.010	0.10	30
3	0.030	0.010	0.10	20
4	0.030	0.020	0.10	10
5	0.030	0.020	0.20	10

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0 2 . 1 The amount of thiosulfate is the same in each experiment. To allow the order of reaction with respect to each reactant to be calculated, several other variables need to be controlled.

Identify **three** other control variables.

[3 marks]

Control variable 1 _____

Control variable 2 _____

Control variable 3 _____

0 2 . 2 Deduce the order of reaction with respect to each reactant.

Explain how you deduced the order of reaction with respect to iodide ions.

[3 marks]

Order with respect to H_2O_2 _____

Order with respect to I^- _____

Order with respect to H^+ _____

Explanation _____

_____

_____

0 2 . 3 Give the rate equation for the reaction.

Determine the units of the rate constant.

[2 marks]

Rate equation

_____

Units of rate constant _____

Question 2 continues on the next page

Do not write outside the box

0 2 . 4 In each experiment, 1.00 cm^3 of 1.00 × 10^{-3} mol dm^{-3} sodium thiosulfate solution is used to react with the iodine initially produced.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

The total volume of the reaction mixture in experiment **3** is 40.0 cm^3

Calculate the initial rate of production of iodine, in mol dm^{-3} s^{-1}, for experiment **3**.

[3 marks]

Initial rate _____ mol dm^{-3} s^{-1}

0 2 . 5 The total uncertainty in the times recorded for each experiment is ±0.5 s but the stopwatch used has a measurement uncertainty of ±0.01 s

Suggest why, in each experiment, the uncertainty in the times recorded is greater than the measurement uncertainty of the stopwatch.

[1 mark]

_____

_____

0 2 . 6 Calculate the percentage uncertainty in the time recorded in experiment **3**.

[1 mark]

Percentage uncertainty _____

Do not write outside the box

0 2 . 7 The five experiments are repeated with the same stopwatch and the same concentrations and volumes of H_2O_2, I^- and H^+

Suggest and explain how the method can be changed to decrease the percentage uncertainty in the times recorded.

[2 marks]

15

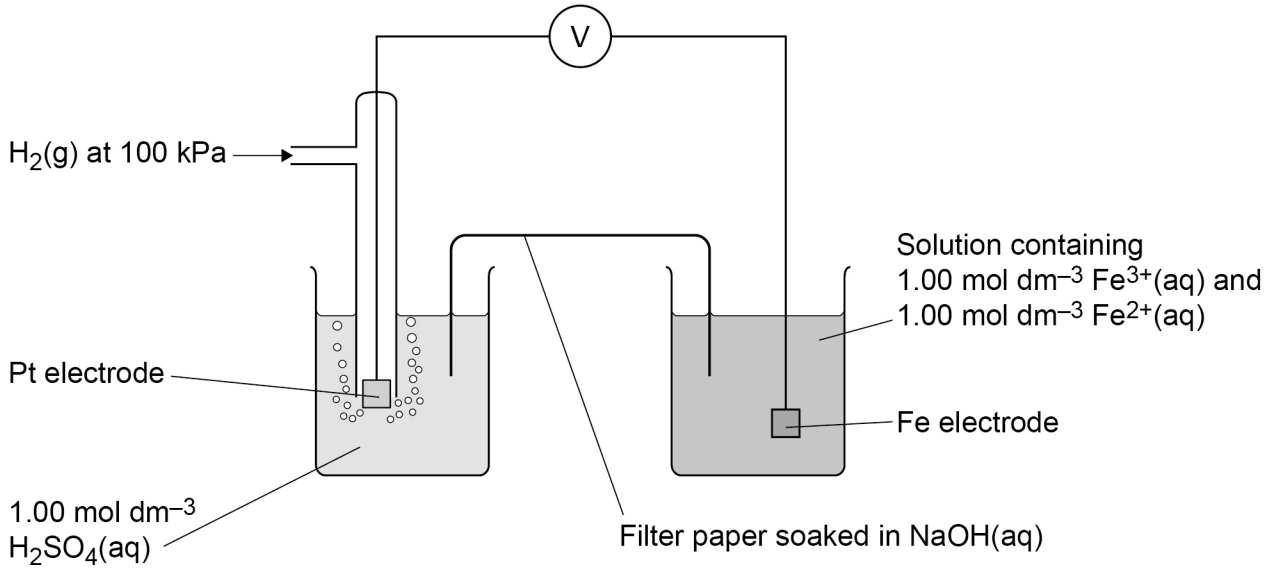
Turn over for the next question

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0 3 A student does an experiment to measure the standard electrode potential of an Fe^{3+}/Fe^{2+} electrode at 298 K

Figure 1 shows the apparatus the student uses.

Figure 1



0 3 . 1 **Figure 1** shows **three** mistakes made by the student.

Identify each mistake and the change needed to correct it.

[3 marks]

Mistake 1 _____

Change 1 _____

Mistake 2 _____

Change 2 _____

Mistake 3 _____

Change 3 _____

Do not write outside the box

0 3 . 2 What feature of the voltmeter ensures that the voltmeter measures the cell EMF?

[1 mark]

Tick (✓) **one** box.

Low resistance ☐

Variable resistance ☐

High resistance ☐

0 3 . 3 The Fe^{3+}/Fe^{2+} electrode is the positive electrode when the cell is set up correctly at 298 K

Give the redox equation for the overall reaction that occurs in the cell when the voltmeter is replaced with a lamp.

[1 mark]

Question 3 continues on the next page

Do not write outside the box

0 3 . 4 **Table 4** shows some standard electrode potentials.

Table 4

Half-equation	$E^{\ominus}$ / V
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$	+0.15
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$Cu^+(aq) + e^- \rightarrow Cu(s)$	+0.52
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77

Finely powdered iron filings are added to a solution of copper(II) sulfate and the mixture is stirred.

The solution gradually changes from blue to pale green and a brown solid forms.

Use the data in **Table 4** to explain these observations.

Give an ionic equation for the reaction that occurs.

Give the conventional representation of the cell that has the same overall reaction as in your equation.

Calculate the EMF, in volts, of this cell.

[6 marks]

Explanation _____

_____

_____

_____

_____

_____

Equation

_____

Do not write outside the box

Conventional representation _____

EMF _____ V

11

Turn over for the next question

Do not write outside the box

0 4 50.0 cm^3 of 0.015 mol dm^{-3} $Fe_2(SO_4)_3(aq)$ are mixed with 50.0 cm^3 of 0.015 mol dm^{-3} $KI(aq)$ at a temperature of 40 °C
The mixture is left for several hours until equilibrium is reached.

$$2Fe^{3+}(aq) + 2I^-(aq) \rightleftharpoons 2Fe^{2+}(aq) + I_2(aq)$$

A sample of the equilibrium mixture is titrated to determine the amount of $I^-(aq)$ in the equilibrium mixture.

0 4 . 1 Give the expression for the equilibrium constant, K_c, for the equilibrium.

[1 mark]

K_c

0 4 . 2 Before the titration, the sample is 'quenched' by adding 50 cm^3 of ice-cold water.

Suggest why the sample is 'quenched' in this way before the titration.
Explain your answer.

[2 marks]

Do not write outside the box

0 4 . 3 The amount of $I^-(aq)$ in the equilibrium mixture is found to be 3.00×10^{-4} mol

Calculate the value of K_c at 40 °C for the equilibrium.

$$2Fe^{3+}(aq) + 2I^-(aq) \rightleftharpoons 2Fe^{2+}(aq) + I_2(aq)$$

Give the units of K_c

Assume that the total volume of the mixture remains constant at 100 cm^3

[6 marks]

K_c _____

Units of K_c _____

9

Turn over ►

Do not write outside the box

0 5 This question is about oxidation.

0 5 . 1 A student has separate unlabelled samples of propan-1-ol and propan-2-ol but does not know which sample is which alcohol.

The student plans a series of steps to identify the alcohols.

Step 1 Oxidise each sample, distilling off the organic product as it is formed.

Step 2 Identify the organic products using a simple chemical test.

Step 3 Confirm the identities using the infrared spectrum of each original sample.

Give further details of each step in the plan. In your answer include

- an appropriate oxidising agent used in Step 1
- equations, using [O] to represent the oxidising agent, for each reaction in Step 1
- a suitable test and expected observations in Step 2
- how the infrared spectra can be used to confirm the identities.

[6 marks]

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Question 5 continues on the next page

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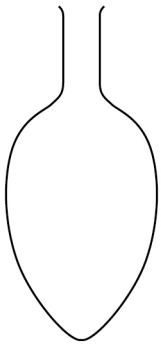
0 5 . 2 A primary alcohol can be oxidised to form a carboxylic acid using an excess of the oxidising agent in Question **05.1**.

Give the condition needed for this reaction.

Complete the diagram, adding labels, to show how the apparatus would be set up.

[3 marks]

Condition _____



Do not write outside the box

0 5 . 3 During oxidation reactions, anti-bumping granules are often added to the pear-shaped flask containing the reactants.

State why anti-bumping granules are used.

[1 mark]

10

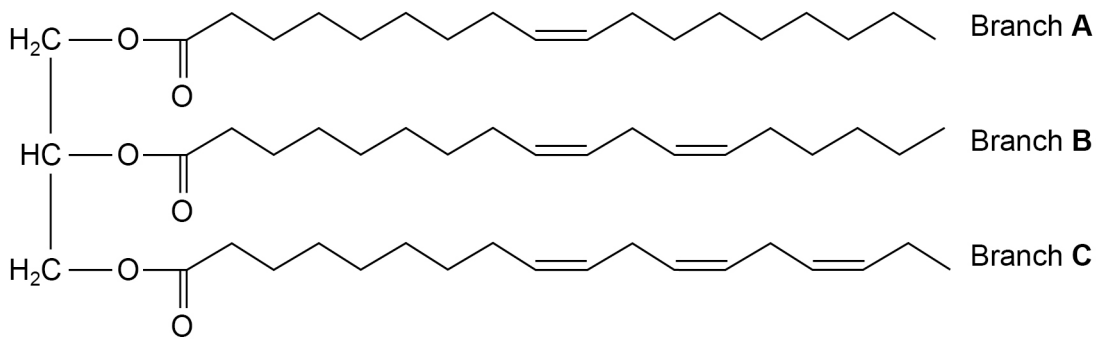
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0 6 This question is about rapeseed oil.

Figure 2 shows the structure of compound **Q** found in rapeseed oil. Each branch in the molecule is formed from a different long-chain carboxylic acid.

Figure 2



0 6 . 1 State the type of stereoisomerism shown in Branch **A**.

[1 mark]

0 6 . 2 **Q** can be reacted with methanol to form three different esters.

State the number used to identify the position of the C=C bond in the name of the ester formed from Branch **A**.

State the number of different stereoisomers of the ester formed from Branch **B**.

Give a use for these esters.

[3 marks]

Number used in the name of the ester _____

Number of stereoisomers _____

Use for esters _____

Do not write outside the box

0 6 . 3 **Q** also reacts with NaOH

State the formula of the product, formed by Branch **B** in **Figure 2**, in this reaction.

State a use for this product.

[2 marks]

Formula _____

Use for product _____

6

Turn over for Section B

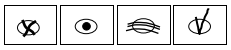
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Section B

Answer **all** questions in this section.

Only **one** answer per question is allowed.
For each question 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 The reaction between methylamine (CH_3NH_2) and excess bromoethane (C_2H_5Br) produces a quaternary ammonium salt.

What is the formula for the cation in this salt?

[1 mark]

A $(C_2H_5)_4N^+$ ⬭

B $(C_2H_5)_3N^+CH_3$ ⬭

C $(C_2H_5)_2N^+(CH_3)_2$ ⬭

D $C_2H_5N^+(CH_3)_3$ ⬭

0 8 Each of the conversions shown uses KOH as a reactant.

In which conversion does KOH **not** act as a base?

[1 mark]

A $(CH_3)_2NH_2^+Br^-$ to $(CH_3)_2NH$ ⬭

B CH_3COOH to $CH_3COO^-K^+$ ⬭

C CH_3CH_2Br to $H_2C=CH_2$ ⬭

D CH_3Br to CH_3OH ⬭

Do not write outside the box

0 9 Which statement about the use of a catalyst in a reaction is correct?

[1 mark]

A The activation energy of the reverse reaction increases. ⬭

B The equilibrium constant increases. ⬭

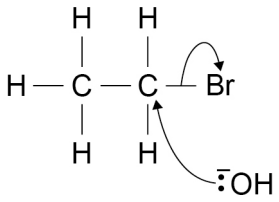
C The rate of the reverse reaction increases. ⬭

D The enthalpy change for the reaction decreases. ⬭

1 0 Which diagram shows a correct step in the mechanism for an elimination reaction of bromoethane?

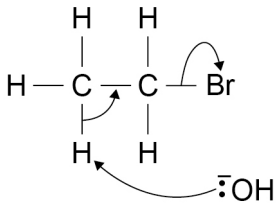
[1 mark]

A



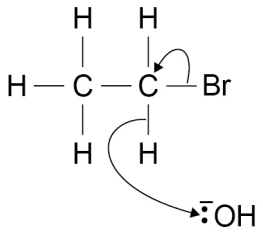
⬭

B



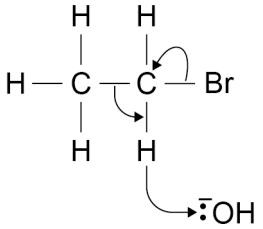
⬭

C



⬭

D



⬭

Turn over ►

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1 1 The melting points of some Period 3 oxides are shown.

Oxide	Na_2O	MgO	Al_2O_3	SiO_2	P_4O_{10}	SO_3
Melting point / °C	920	2900	2040	1610	580	17

Which row is correct?

[1 mark]

	Giant ionic	**Giant covalent**	**Simple molecular**	
A	Na_2O MgO Al_2O_3	SiO_2	P_4O_{10} SO_3	⬭
B	Na_2O MgO Al_2O_3	SiO_2 P_4O_{10}	SO_3	⬭
C	Na_2O MgO	Al_2O_3 SiO_2	P_4O_{10} SO_3	⬭
D	Na_2O	MgO Al_2O_3 SiO_3	P_4O_{10} SO_3	⬭

1 2 A sample of UF_6 consists of molecules containing ^{19}F and either ^{235}U or ^{238}U atoms.

The relative molecular mass of the sample is 351.43

What is the percentage abundance of $^{235}UF_6$ in the sample?

[1 mark]

A 19 ⬭

B 33 ⬭

C 50 ⬭

D 81 ⬭

Do not write outside the box

1 3 Compound **X** reacts with concentrated sulfuric acid to produce compound **Y**.

Compound **Y** reacts with an excess of water to produce an alcohol.

Which compound could be **X**?

[1 mark]

A Ethanoyl chloride ⬭

B Methylbenzene ⬭

C Propanone ⬭

D Propene ⬭

1 4 A piece of strontium is added to an excess of water.

Which observation is correct and complete?

[1 mark]

A Colourless solution ⬭

B Colourless solution and effervescence ⬭

C Dense white precipitate ⬭

D Dense white precipitate and effervescence ⬭

1 5 Which statement about trends from left to right across Period 3 is correct?

[1 mark]

A Atomic radius increases from Na to Si and then decreases ⬭

B Atomic radius decreases ⬭

C First ionisation energy decreases ⬭

D Electronegativity decreases ⬭

Do not write outside the box

1 6 Which statement about ionisation energies in Period 3 is **not** correct?

[1 mark]

A The first ionisation energy of Mg is greater than that of Na ⬭

B The first ionisation energy of Al is less than that of Mg ⬭

C The first ionisation energy of P is less than that of S ⬭

D Ar has the highest first ionisation energy in the period. ⬭

1 7 Which type(s) of stereoisomerism is/are shown by the complex ion $[Cr(H_2NCH_2CH_2NH_2)_3]^{3+}$?

[1 mark]

A none ⬭

B *cis-trans* only ⬭

C optical only ⬭

D *cis-trans* and optical ⬭

1 8 What is the correct structural formula for 4-chloro-2-methylpent-2-enoic acid?

[1 mark]

A $CH_3CCl{=}CHCH(CH_3)COOH$ ⬭

B $(CH_3)_2C{=}CHCHClCOOH$ ⬭

C $CH_3CHClCH{=}C(CH_3)COOH$ ⬭

D $(CH_3)_2CHCH{=}CClCOOH$ ⬭

Do not write outside the box

1 9 0.100 mol of each of the oxides listed is added to separate 1.00 dm^3 samples of water.

Which oxide produces the solution with the lowest pH?

[1 mark]

A MgO ⬭

B Al_2O_3 ⬭

C SO_2 ⬭

D SO_3 ⬭

2 0 Which property of the Group 2 elements increases with increasing atomic number?

[1 mark]

A Atomic radius ⬭

B Electronegativity ⬭

C First ionisation energy ⬭

D Melting point ⬭

2 1 Which electron configuration represents an element that can have a maximum oxidation state of +5 in its compounds?

[1 mark]

A $1s^2\ 2s^2\ 2p^1$ ⬭

B $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$ ⬭

C $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$ ⬭

D $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^5$ ⬭

Do not write outside the box

2 2 Which statement is correct?

[1 mark]

A Tollens' reagent contains linear $[Ag(NH_3)_2]^+$ ions. ⬭

B Tollens' reagent contains octahedral $[Ag(NH_3)_6]^+$ ions. ⬭

C Fehling's solution contains linear $[Ag(NH_3)_2]^+$ ions. ⬭

D Fehling's solution contains octahedral $[Ag(NH_3)_6]^+$ ions. ⬭

2 3 Which reaction produces an octahedral complex **ion**?

[1 mark]

A The addition of excess aqueous ammonia to a solution containing $[Co(H_2O)_6]^{2+}$ ions. ⬭

B The addition of excess aqueous sodium carbonate to a solution containing $[Fe(H_2O)_6]^{2+}$ ions. ⬭

C The addition of excess concentrated hydrochloric acid to a solution containing $[Cu(H_2O)_6]^{2+}$ ions. ⬭

D The addition of excess aqueous sodium carbonate to a solution containing $[Fe(H_2O)_6]^{3+}$ ions. ⬭

2 4 Ethanol biofuel can be produced by fermentation.

Which statement about this process is correct?

[1 mark]

A It is aerobic and the ethanol is separated by filtration. ⬭

B It is aerobic and the ethanol is separated by fractional distillation. ⬭

C It is anaerobic and the ethanol is separated by filtration. ⬭

D It is anaerobic and the ethanol is separated by fractional distillation. ⬭

Do not write outside the box

2 5 Which element is in the p block in the Periodic Table?

[1 mark]

A Radium ⬭

B Radon ⬭

C Rhenium ⬭

D Roentgenium ⬭

2 6 Which statement is correct?

[1 mark]

A A minimum of 0.5 mol of water is needed to react completely with 1 mol of Na_2O ⬭

B A solution of hydrochloric acid containing 1 mol of HCl reacts with 1 mol of MgO to form a solution with pH 7 ⬭

C A solution of hydrochloric acid containing 6 mol of HCl reacts completely with 1 mol of Al_2O_3 ⬭

D A minimum of 4 mol of water is needed to react completely with 1 mol of P_4O_{10} ⬭

2 7 Which species has a tetrahedral shape?

[1 mark]

A SF_4 ⬭

B $FeCl_4^-$ ⬭

C XeF_4 ⬭

D ICl_4^- ⬭

Do not write outside the box

2 8 Alkanes are obtained from crude oil by fractional distillation.

Which statement is correct?

[1 mark]

A Alkanes obtained are converted to alkenes by thermal cracking. ⬭

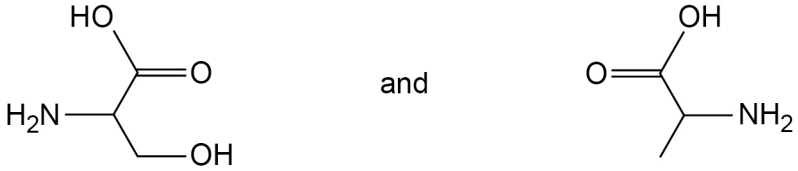
B Alkanes with longer chains rise to the top of the fractionating column. ⬭

C The diesel fraction contains sulfur compounds that react to form SO_3 in car exhausts. ⬭

D The boiling points of alkane isomers increase as the carbon chains become more branched. ⬭

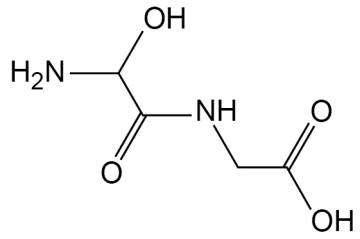
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2 9 What is the structure of a dipeptide formed from the two amino acids shown?

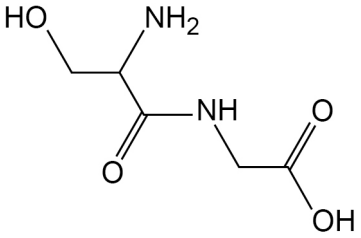


[1 mark]

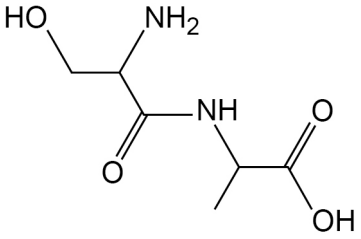
A



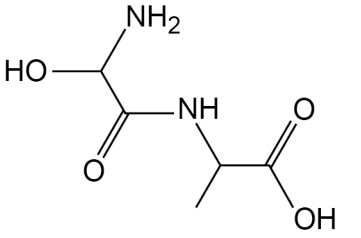
B



C



D



Turn over for the next question

Do not write outside the box

3 0 Equal amounts of three Period 3 elements are added to separate 100 cm^3 samples of water.

Which list is correct when the solutions formed from these elements are arranged in order of decreasing pH?

[1 mark]

A	chlorine	magnesium	sodium	⬭
B	chlorine	sodium	magnesium	⬭
C	magnesium	sodium	chlorine	⬭
D	sodium	magnesium	chlorine	⬭

3 1 The oxides P_4O_{10} and SO_2 both react with water to form acid molecules.

Which row gives the correct shape around the central atom for each acid molecule that is formed?

[1 mark]

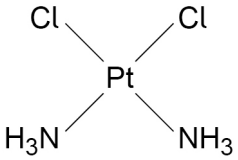
	Molecule formed from P_4O_{10}	**Molecule formed from SO_2**	
A	pyramidal	pyramidal	⬭
B	pyramidal	tetrahedral	⬭
C	tetrahedral	pyramidal	⬭
D	tetrahedral	tetrahedral	⬭

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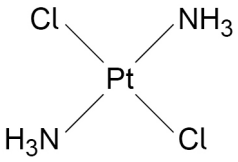
3 2 Which structure is correct for transplatin?

[1 mark]

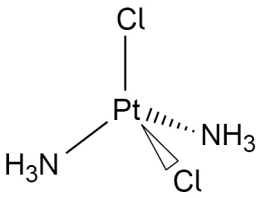
A



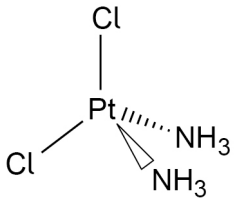
B



C



D



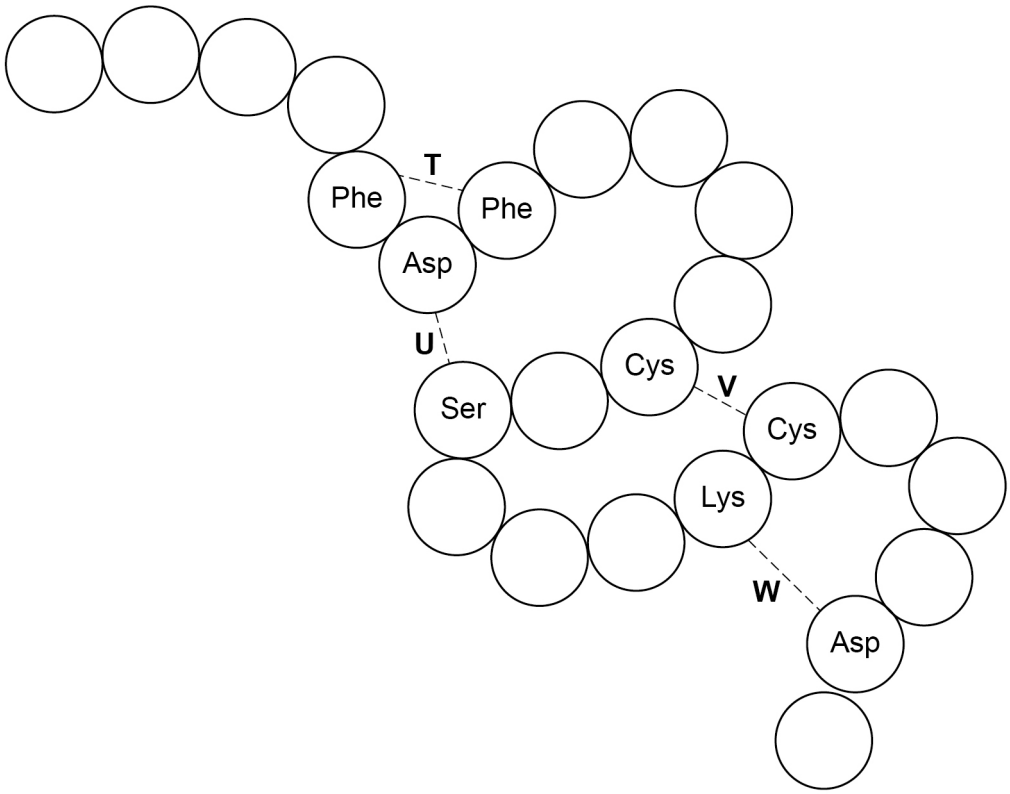
Turn over for the next question

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3 3 The diagram shows part of the tertiary structure for a protein.
Some of the amino acids in this structure are shown using the first three letters of their names.

The general formula of an amino acid is $RCH(NH_2)COOH$

Interactions between amino acid R groups are shown at positions **T**, **U**, **V** and **W**.



Which two R group interactions are a type of intermolecular force and a covalent bond?

Use the Data Booklet to help you answer this question.

[1 mark]

A **T** and **U** ⬭

B **V** and **W** ⬭

C **U** and **V** ⬭

D **U** and **W** ⬭

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3 4 Which statement about enzymes is correct?

[1 mark]

A Enzymes are a type of nucleotide. ⬭

B Enzymes are polymers. ⬭

C Enzymes are **not** affected by changes of pH. ⬭

D Enzymes act as catalysts by increasing activation energy. ⬭

3 5 Which compound can be used as a cationic surfactant?

[1 mark]

A $[C_{16}H_{33}N(CH_3)_3]Br$ ⬭

B $C_{16}H_{33}N(CH_3)_2$ ⬭

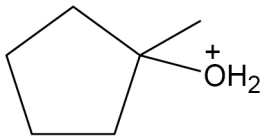
C $C_{17}H_{35}COONa$ ⬭

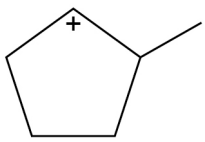
D $C_{17}H_{35}COOH$ ⬭

3 6 The hydration of 1-methylcyclopent-1-ene uses a catalyst of sulfuric acid and produces a mixture of products.

Which ion is formed during the mechanism for this reaction to give the **major** product?

[1 mark]

A  ⬭

B  ⬭

C $^{-}SO_2OH$ ⬭

D ^{-}OH ⬭

30

END OF QUESTIONS

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