AQA

SPECIMEN MATERIAL v1.0

Please write clearly, in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

A-level CHEMISTRY

Paper 3

Specimen materials (set 2)

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.

For examiner's use	
Question	Mark
1	
2	
3	
4	
Section B	
TOTAL	

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of the 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.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

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

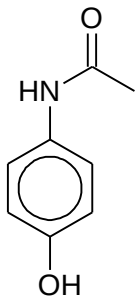
Advice

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

Section A

Answer **all** questions in the spaces provided.

0 1 Paracetamol is a common analgesic used for the relief of pain. It has the structure shown.



The melting point of paracetamol is 170 °C.
Paracetamol can be prepared from the reaction between 4-aminophenol ($HOC_6H_4NH_2$) and ethanoyl chloride.

0 1 . 1 Write an equation for this reaction.

[1 mark]

0 1 . 2 Name and outline the mechanism for this reaction. Use RNH_2 to represent 4-aminophenol.

[5 marks]

Name of mechanism _____

Mechanism

Question 1 continues on the next page

0 1 . 3 The paracetamol formed in this reaction is impure. It contains both soluble and insoluble impurities that must be removed by recrystallisation.

The properties of a suitable solvent for recrystallisation are shown.

- The paracetamol should dissolve when the solvent is hot but be almost insoluble when the solvent is cold.
- The impurities should either be insoluble in the solvent at all temperatures or soluble even in cold solvent.
- When a hot saturated solution of the paracetamol is cooled, as much product as possible should crystallise out, leaving soluble impurities in the solution.

A solvent has been suggested for this recrystallisation. It is a flammable liquid with a boiling point of 80 °C.

Outline how you would carry out an investigation to show that this solvent is suitable for the recrystallisation of the impure paracetamol. You should include brief practical details of how you would carry out your investigation.

You are **not** required to describe the full recrystallisation procedure.

Explain how you would check that a recrystallisation process had been effective at producing a pure sample of paracetamol.

[6 marks]

Question 1 continues on the next page

0 1 . 4 When paracetamol is prepared by reacting an excess of 4-aminophenol with ethanoyl chloride, the expected percentage yield of impure paracetamol is 65%.

An expert practical chemist might expect to lose, at most, a further 20% of the impure product during recrystallisation.

A student started with 3.87 g of ethanoyl chloride.

After preparation of impure paracetamol followed by recrystallisation, the student actually obtained 4.07 g of pure paracetamol.

Calculate the mass of impure paracetamol expected from this experiment, based on a 65% yield.

Use your answer and the actual mass of pure paracetamol obtained, to comment on the statement that "the student has demonstrated expert practical skills".

[4 marks]

0 1 . 5 Suggest why the student should **not** use this sample of paracetamol for the purposes of pain relief.

[1 mark]

0 1 . 6 Suggest **two** reasons why, in an industrial situation, ethanoic anhydride would be preferred to ethanoyl chloride in the production of paracetamol.

[2 marks]

1

2

19

Turn over for the next question

0 2 A student carried out an experiment to determine the value of the equilibrium constant (K_c) for the esterification reaction between ethanoic acid and ethanol.

ethanoic acid + ethanol $\rightleftharpoons$ ethyl ethanoate + water

0 2 . 1 Write an equation for this reaction.

[1 mark]

0 2 . 2 Draw the skeletal formula of ethyl ethanoate.

[1 mark]

0 2 . 3 The student used a small amount of concentrated sulfuric acid as a catalyst to increase the rate of the reaction.

State, in general terms, how a catalyst works.

[2 marks]

0 2 . 4 The student mixed 0.0435 mol of ethanol and 0.0435 mol of ethanoic acid.
The student added 5.00×10^{-4} mol of sulfuric acid to the mixture.
This mixture was left for one week to reach equilibrium.
The equilibrium reaction was stopped by adding the mixture to water.

For this reaction, $K_c = 4.07$ at the temperature of the experiment.

Calculate the volume of 0.400 mol dm^{-3} sodium hydroxide solution required to react completely with the acids in the equilibrium mixture.

[6 marks]

Volume = _____ cm^3

Question 2 continues on the next page

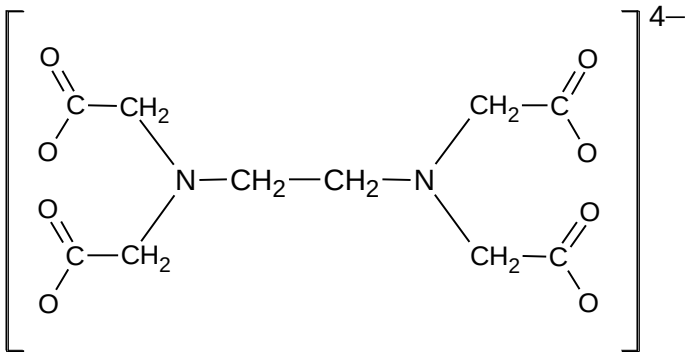
0 2 . 5 Suggest how the student could check that the mixture had reached equilibrium after one week.

[2 marks]

12

0 3 EDTA is a useful laboratory chemical and is found in a wide variety of commercial products including detergents. It is very soluble in water and is often used in its ionic form $EDTA^{4-}$ as shown in **Figure 1**.

Figure 1



0 3 . 1 $EDTA^{4-}$ can act as a multidentate ligand.

Explain the meanings of the terms **multidentate** and **ligand** with reference to the reaction of $EDTA^{4-}$ with $[Cu(H_2O)_6^{2+}](aq)$ ions to form a complex ion.

Draw on **Figure 1** a separate circle around each atom that bonds to the Cu^{2+} ion in this complex ion.

[3 marks]

Multidentate _____

_____

Ligand _____

_____

Question 3 continues on the next page

0 3 . 2 Copper(II) compounds may be used as fungicides in vineyards. When used in this way, copper(II) ions can enter the water supply and cause problems because they are toxic in high concentrations.

The water supply near a vineyard can be tested for copper(II) ions by forming a blue aqueous complex with $EDTA^{4-}$ ions. The concentration of this complex can be determined using a colorimeter.

Outline the practical steps that you would follow, using colorimetry, to determine the concentration of this complex in a sample of water.

[4 marks]

0 3 . 3 The concentration of copper(II) ions, in the sample of water, determined by colorimetry was 7.56×10^{-5} mol dm^{-3}.

This result was checked by titrating a sample of the water with a solution containing $EDTA^{4-}(aq)$ ions.

The $EDTA^{4-}(aq)$ used in the titration had a concentration of 1.00×10^{-3} mol dm^{-3}.

Write an equation for the reaction between $[Cu(H_2O)_6]^{2+}$ and $EDTA^{4-}$ ions.

Calculate the volume of the $EDTA^{4-}$ solution needed to react with a 25.0 cm^3 sample of the water.

Justify whether this titration will give an accurate value for the concentration of copper(II) ions. If necessary, suggest a practical step that would improve the accuracy.

[5 marks]

12

0 4 Iodine reacts slowly with propanone in the presence of an acid catalyst according to the equation

$$CH_3COCH_3 + I_2 \longrightarrow CH_3COCH_2I + HI$$

The rate of this reaction can be followed by preparing mixtures in which only the initial concentration of propanone is varied. At suitable time intervals, a small sample of the mixture is removed and titrated with sodium thiosulfate solution. This allows determination of the concentration of iodine remaining at that time.

Five mixtures, **A**, **B**, **C**, **D** and **E**, are prepared as shown in **Table 1**.

Table 1

Mixture	**A**	**B**	**C**	**D**	**E**
Volume of 0.0200 mol dm^{-3} $I_2(aq)$/cm^3	40.0	40.0	40.0	40.0	40.0
Volume of 0.100 mol dm^{-3} $H_2SO_4(aq)$/cm^3	25.0	25.0	25.0	25.0	25.0
Volume of 1.00 mol dm^{-3} $CH_3COCH_3(aq)$/cm^3	25.0	20.0	15.0	10.0	6.5
Volume of distilled water/cm^3	0.0	5.0	10.0	15.0	18.5

0 4 . 1 Calculate the initial concentration, in mol dm^{-3}, of the propanone in mixture **A**.

[2 marks]

Concentration = _____ mol dm^{-3}

0 4 . 2 State and explain why different volumes of water are added to mixtures **B**, **C**, **D** and **E**.

[2 marks]

_____

_____

_____

_____

0 4 . 3 Calculate the volume of 0.0100 mol dm^{-3} sodium thiosulfate solution required to react with all of the iodine in a 10.0 cm^3 sample of mixture **E**, before the iodine reacts with propanone.

The equation for the reaction in the titration is

$$2Na_2S_2O_3(aq) + I_2(aq) \longrightarrow Na_2S_4O_6(aq) + 2NaI(aq)$$

[4 marks]

Volume = _____ cm^3

Question 4 continues on the next page

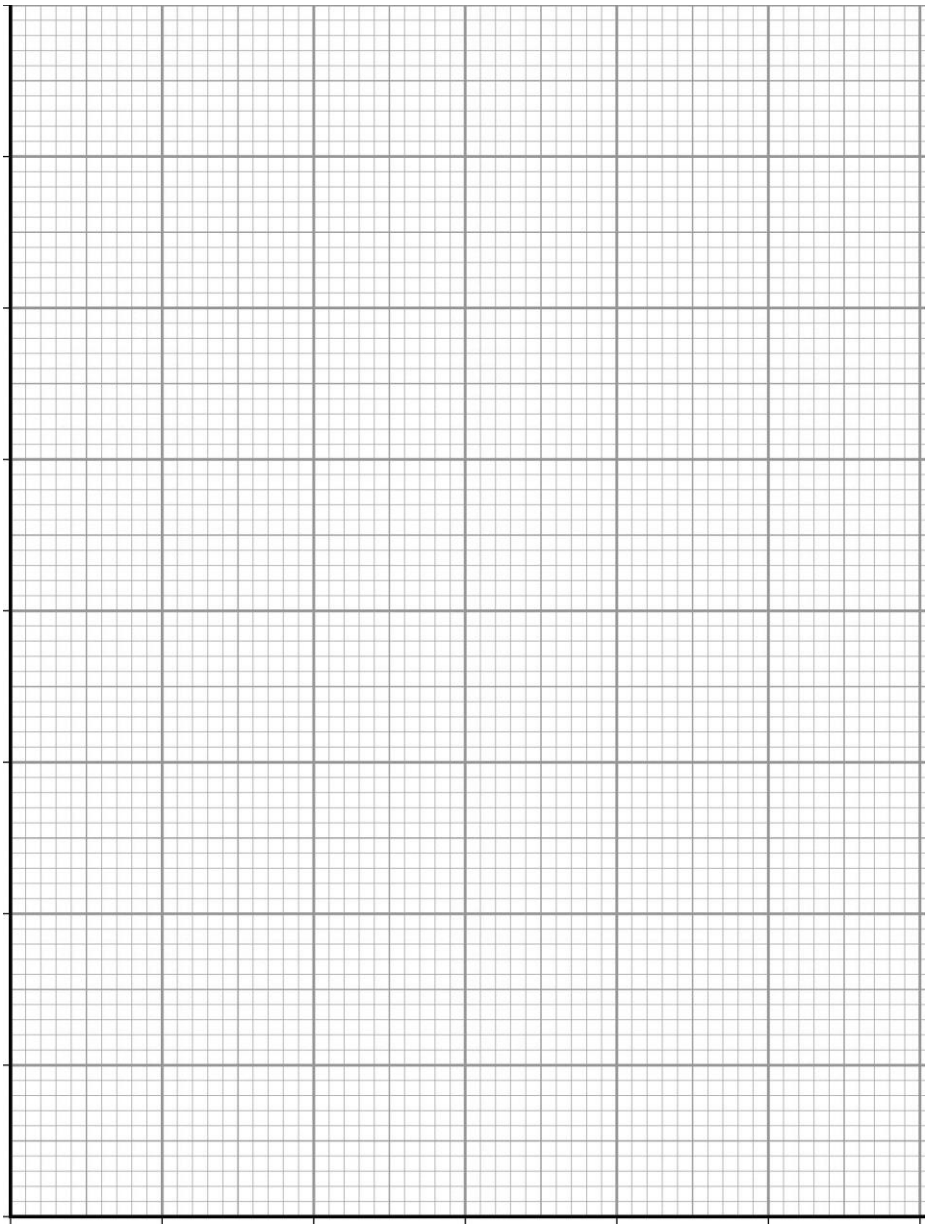
0 4 . 4 The results for mixture **E** are shown in **Table 2**.
V is the volume of 0.0100 mol dm^{-3} sodium thiosulfate solution needed, at different times, **t**, to react with the iodine in a 10.0 cm^3 sample of **E**.

Table 2

t/min	5	10	20	30
V/cm^3	17.5	17.2	16.6	16.0

Use these data and your answer to Question **04.3** to plot a graph of **V** (*y*-axis) against **t** (*x*-axis) for mixture **E**.
Draw a best-fit straight line through your points and calculate the gradient of this line.

[5 marks]



gradient = _____ $cm^3\ min^{-1}$

0 4 . 5 The gradients for similar graphs produced by mixtures **A**, **B**, **C** and **D** are shown in **Table 3**.
Each gradient is a measure of the rate of the reaction between iodine and propanone.

Table 3

Mixture	**A**	**B**	**C**	**D**
Gradient / cm^3 min^{-1}	–0.24	–0.20	–0.15	–0.10

Use information from **Table 1** and **Table 3** to deduce the order with respect to propanone. Explain your answer.

[2 marks]

0 4 . 6 Each sample taken from the reaction mixtures is immediately added to an excess of sodium hydrogencarbonate solution before being titrated with sodium thiosulfate solution.

Suggest the purpose of this addition.
Explain your answer.

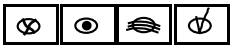
[2 marks]

17

Section B

Answer **all** questions in the spaces provided.

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 5 What are the numbers of neutrons and electrons in the $^{57}Fe^{2+}$ ion?

[1 mark]

	Neutrons	Electrons	
A	31	24	⬭
B	57	24	⬭
C	31	26	⬭
D	57	28	⬭

0 6 Which of these contains the most molecules?

[1 mark]

A 0.0311 kg of carbon dioxide, CO_2 ⬭

B 29.6 g of carbon monoxide, CO ⬭

C 2.22×10^4 mg of oxygen, O_2 ⬭

D 13.3 g of ozone, O_3 ⬭

0 7 Which of these statements best describes a dative covalent bond?

[1 mark]

A A pair of electrons shared between two atoms where each atom has donated one electron. ⬭

B A pair of electrons shared between two atoms where one atom has donated two electrons. ⬭

C Two pairs of electrons shared between two atoms where each atom has donated one electron. ⬭

D Two pairs of electrons shared between two atoms where each atom has donated two electrons. ⬭

0 8 Which molecule is the least polar?

[1 mark]

A Bromomethane ⬭

B Dibromomethane ⬭

C Tribromomethane ⬭

D Tetrabromomethane ⬭

0 9 Which statement about intermolecular forces is **not** correct?

[1 mark]

A Intermolecular forces exist between all simple molecules. ⬭

B Hydrogen bonding occurs between HBr molecules. ⬭

C Hydrogen bonding is the strongest intermolecular force in liquid ethanol. ⬭

D Hydrogen bonds occur between C=O and H–N in proteins. ⬭

1 0 The table shows the standard enthalpy of formation, $\Delta_f H^{\ominus}$, for some of the substances in the reaction

$$C_2H_6(g) + 6F_2(g) \longrightarrow C_2F_6(g) + 6HF(g) \qquad \Delta H^{\ominus} = -2898 \text{ kJ mol}^{-1}$$

	$C_2H_6(g)$	$C_2F_6(g)$
$\Delta_f H^{\ominus}$/kJ mol^{-1}	–84	–1344

What is the standard enthalpy of formation, in kJ mol^{-1}, for HF(g)?

[1 mark]

A –1638 ⬭

B –273 ⬭

C +273 ⬭

D +1638 ⬭

1 1 What is the temperature rise, in K, when 504 J of heat energy are absorbed by 0.110 kg of solid iron?
Specific heat capacity of iron = 0.448 J K^{-1} g^{-1}

[1 mark]

A 9.78×10^{-2} ⬭

B 1.02×10^{1} ⬭

C 2.83×10^{2} ⬭

D 1.02×10^{4} ⬭

1 2 Calculate the enthalpy change, in kJ, for this dissociation of mole of propan-1-ol.

$$C_3H_7OH(g) \longrightarrow 3C(g) + 8H(g) + O(g)$$

	C—H	C—C	C—O	O—H
Mean bond dissociation enthalpy / kJ mol^{-1}	412	348	360	463

[1 mark]

A –4751 ⬭

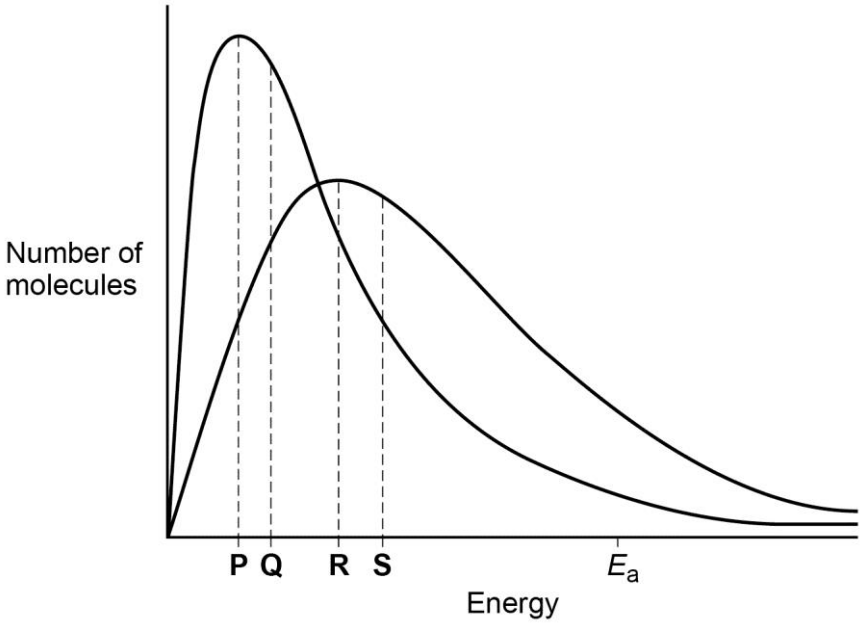
B –4403 ⬭

C +4403 ⬭

D +4751 ⬭

Turn over for the next question

Questions **13** and **14** are about the Maxwell–Boltzmann distribution shown for a sample of a gas, X, at two different temperatures.



1 3 Which letter shows the mean energy of the molecules at the higher temperature?

[1 mark]

A P ⬭

B Q ⬭

C R ⬭

D S ⬭

1 4 Which statement is correct for the higher temperature?

[1 mark]

A The area under the curve to the left of E_a decreases. ⬭

B The total area under the curve increases. ⬭

C The activation energy decreases. ⬭

D More molecules have the mean energy. ⬭

1 5 A rate investigation was carried out on a reaction involving three reactants, **X**, **Y** and **Z**. The concentrations of the reactants were varied and the relative rate for each mixture determined.

Experiment	[**X**]/mol dm^{-3}	[**Y**]/mol dm^{-3}	[**Z**]/mol dm^{-3}	Relative rate
1	1×10^{-3}	1×10^{-3}	2×10^{-3}	1
2	2×10^{-3}	2×10^{-3}	2×10^{-3}	4
3	5×10^{-4}	2×10^{-3}	4×10^{-3}	0.5

The reaction is zero order with respect to **Y**.

What is the overall order of reaction?

[1 mark]

A 0 ⬭

B 1 ⬭

C 2 ⬭

D 3 ⬭

1 6 Which statement about K_p is correct for this reaction in the gas phase?

$$W + X + Y_2 \rightleftharpoons WXY + Y \qquad \Delta H = -46 \text{ kJ mol}^{-1}$$

[1 mark]

A The value of K_p is independent of pressure. ⬭

B The value of K_p increases as pressure increases. ⬭

C The value of K_p increases as temperature increases. ⬭

D The value of K_p is independent of temperature. ⬭

1 7 The table shows the pK_a values for two acids.

Name of acid	**pK_a**
Propanoic acid	4.87
Butanoic acid	4.82

Which statement is correct?

[1 mark]

A Propanoic acid is a stronger acid than butanoic acid. ⬭

B The value of K_a for propanoic acid is greater than that for butanoic acid. ⬭

C The value of K_a for propanoic acid is 1.35×10^{-5} mol dm^{-3} ⬭

D The value of K_a for butanoic acid is 6.61×10^{4} mol dm^{-3} ⬭

1 8 Which element is in the f-block of the Periodic Table?

[1 mark]

A Palladium ⬭

B Phosphorus ⬭

C Platinum ⬭

D Plutonium ⬭

1 9 Which elements are shown in increasing order of the stated property?

[1 mark]

A Atomic radius: phosphorus, sulfur, chlorine. ⬭

B First ionisation energy: sodium, magnesium, aluminium. ⬭

C Electronegativity: sulfur, phosphorus, silicon. ⬭

D Melting point: argon, chlorine, sulfur. ⬭

2 0 Which statement is **not** correct about the addition of chlorine to water?

[1 mark]

A Chlorine can react with water to form an alkaline solution. ⬭

B Chlorine can react with water to produce chloride ions and oxygen. ⬭

C Chlorine can be added to drinking water to kill bacteria. ⬭

D Chlorine can react with water to produce chloride ions and chlorate(I) ions. ⬭

2 1 Which is the formula of the main aluminium-containing species present when aluminium oxide is added to an excess of water?

[1 mark]

A $[Al(H_2O)_6]^{3+}(aq)$ ⬭

B $Al(H_2O)_3(OH)_3(s)$ ⬭

C $[Al(H_2O)_2(OH)_4]^-(aq)$ ⬭

D $Al_2O_3(s)$ ⬭

2 2 What is the electron configuration of Cu^{2+}?

[1 mark]

A $[Ar]3d^9 4s^2$ ⬭

B $[Ar]3d^{10} 4s^1$ ⬭

C $[Ar]3d^9$ ⬭

D $[Ar]3d^{10}$ ⬭

2 3 Electrons in copper(II) ions can be excited by the absorption of light with a wavelength of 600 nm.

What is the increase in energy, in J, for each electron excited?

Speed of light, $c = 3.00 \times 10^8$ m s^{-1}
Planck's constant, $h = 6.63 \times 10^{-34}$ J s

[1 mark]

A 3.98×10^{-40} ⬭

B 1.33×10^{-39} ⬭

C 3.32×10^{-28} ⬭

D 3.32×10^{-19} ⬭

2 4 An oxide of vanadium catalyses the following reaction:

$$SO_2\,(g) + \tfrac{1}{2}O_2\,(g) \rightleftharpoons SO_3\,(g)$$

What is the formula of the vanadium-containing intermediate formed in this reaction?

[1 mark]

A V_2O ⬭

B VO ⬭

C V_2O_3 ⬭

D V_2O_4 ⬭

2 5 Which catalyst is used in the catalytic cracking of alkanes?

[1 mark]

A Concentrated phosphoric acid ⬭

B Iron ⬭

C Nickel ⬭

D Zeolite ⬭

2 6 Which correctly represents an incomplete combustion of pentane?

[1 mark]

A $C_5H_{12} + 8O_2 \longrightarrow 5CO_2 + 6H_2O$ ⬭

B $C_5H_{12} + 8O_2 \longrightarrow 4CO + CO_2 + 6H_2O$ ⬭

C $C_5H_{12} + 6O_2 \longrightarrow 4CO + CO_2 + 6H_2O$ ⬭

D $C_5H_{12} + 5O_2 \longrightarrow 4CO + CO_2 + 4H_2O + 2H_2$ ⬭

2 7 Which species is produced in a propagation step during the reaction of propane with an excess of chlorine in the presence of UV light?

[1 mark]

A H•

B C_3H_5Cl

C $C_3H_6Cl_2$

D C_6H_{14}

2 8 Which compound forms a racemic mixture when reacted with KCN followed by dilute acid?

[1 mark]

A HCHO

B CH_3CHO

C CH_3COCH_3

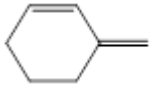
D $(CH_3CH_2)_2CO$

2 9 Use your understanding of the bonding in benzene to identify the compound that has the most exothermic enthalpy of hydrogenation.

[1 mark]

A  ⬭

B  ⬭

C  ⬭

D  ⬭

3 0 Which compound is the strongest base?

[1 mark]

A Ammonia ⬭

B Ammonium chloride ⬭

C Methylamine ⬭

D Phenylamine ⬭

3 1 What type of reaction is used to convert $(CH_3)_3N$ into the cationic surfactant $[(CH_3)_3N(CH_2)_{15}CH_3]Cl$?

[1 mark]

A Bronsted–Lowry acid-base reaction ⬭

B Nucleophilic addition ⬭

C Nucleophilic addition-elimination ⬭

D Nucleophilic substitution ⬭

3 2 Which polymer is least likely to be biodegraded after several years in a landfill site?

[1 mark]

A Kevlar ⬭

B Nylon ⬭

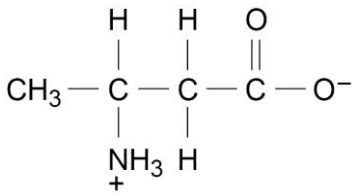
C Polythene ⬭

D Terylene ⬭

3 3 Which structure shows 2-aminobutanoic acid as a zwitterion?

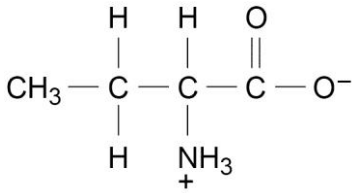
[1 mark]

A



⬭

B



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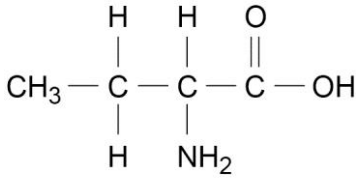
C



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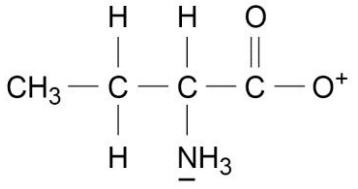
D



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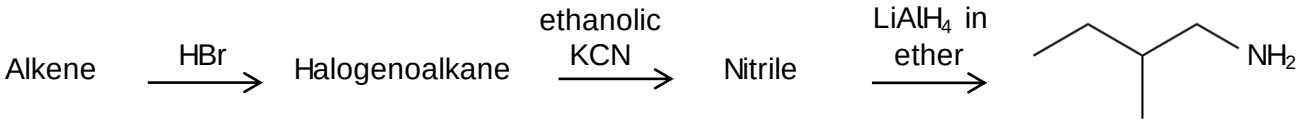
3 4 2-Methylbutylamine can be synthesised from an alkene.



What is the identity of the alkene?

[1 mark]

A But-2-ene ⬭

B Methylpropene ⬭

C 2-Methylbut-1-ene ⬭

D 2-Methylbut-2-ene ⬭

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END OF QUESTIONS

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED