Cambridge International AS & A Level

**Cambridge Assessment International Education**
Cambridge International Advanced Subsidiary and Advanced Level

**CHEMISTRY** **9701/12**

Paper 1 Multiple Choice **May/June 2019**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet



**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

**Read the instructions on the Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
Electronic calculators may be used.



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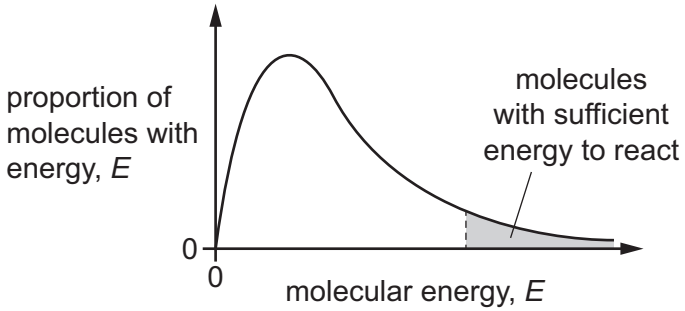
## Section A

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

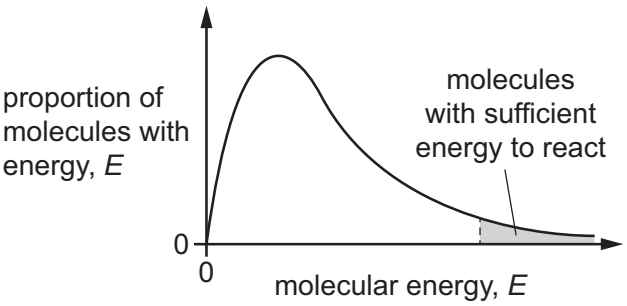
Use of the Data Booklet may be appropriate for some questions.

**1** The Boltzmann distribution of molecular energies in a sample of aqueous hydrogen peroxide at room temperature is shown.




Which diagram shows the Boltzmann distribution of molecular energies of aqueous hydrogen peroxide maintained at room temperature when a catalyst, manganese(IV) oxide, is added?

**A**

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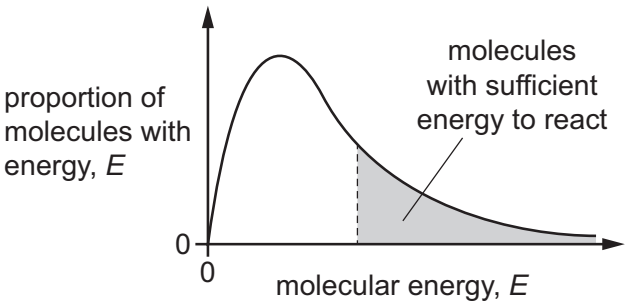
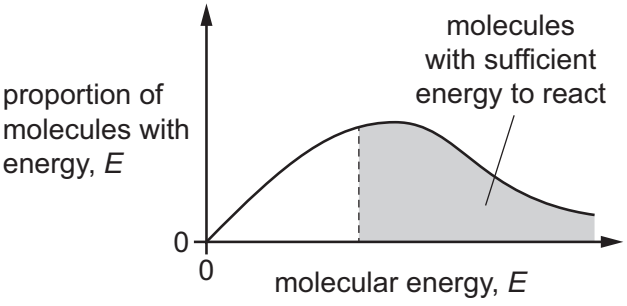
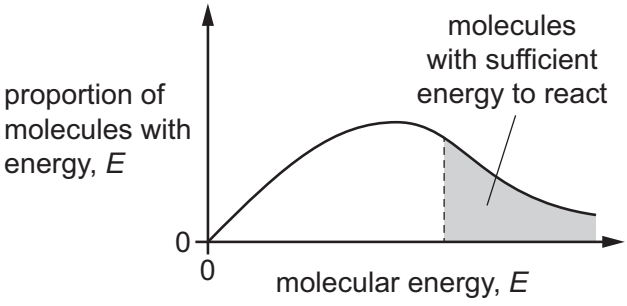



**C**




**D**

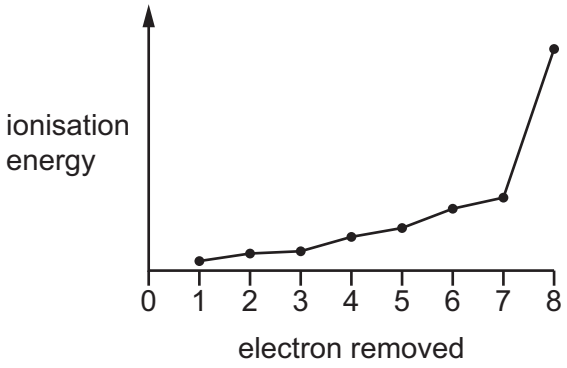


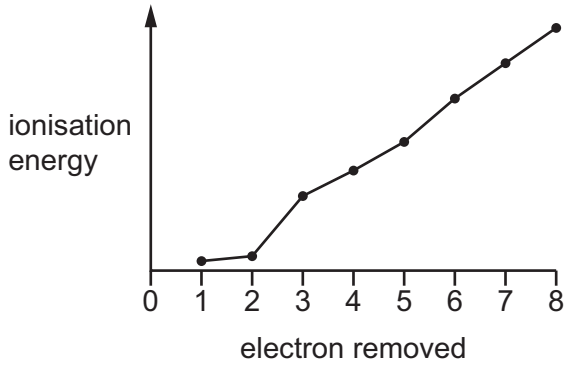

**2** Oxygen has three stable isotopes, $^{16}O$, $^{17}O$ and $^{18}O$. All three isotopes are present in a sample of oxygen gas, $O_2$, which was analysed using a mass spectrometer.

How many peaks associated with the $O_2^+$ ion would be expected?

**A** 3 **B** 5 **C** 6 **D** 9

**3** The first eight successive ionisation energies for two elements of Period 3 of the Periodic Table are shown in the graphs.



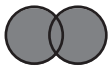

What is the formula of the ionic compound formed from these elements?

**A** $MgCl_2$ **B** $CaBr_2$ **C** $Na_2S$ **D** $K_2Se$

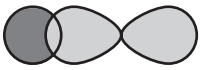
**4** A σ bond is made between two carbon atoms in a molecule of ethene.

Which diagram shows the orbital overlap that occurs to form this bond?

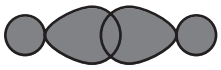
**A**



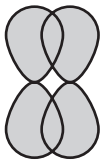
**B**



**C**



**D**



**5** The table shows some properties of four substances.

Which substance could be potassium iodide?

| | melting point of solid / °C | electrical conductivity when molten |
|---|---|---|
| **A** | –66 | poor |
| **B** | –39 | good |
| **C** | 680 | good |
| **D** | 1600 | poor |





**[Turn over**

**6** X, Y and Z are all gases that behave ideally and react according to the equation shown.

$$X(g) + 2Y(g) \rightarrow 2Z(g)$$

When 3.0 mol of X and 3.0 mol of Y are placed inside a container with a volume of 1.0 $dm^3$, they react to form the maximum amount of Z.

The final temperature of the reaction vessel is 120 °C.

What is the final pressure inside the reaction vessel?

**A** $4.49 \times 10^6$ Pa

**B** $9.80 \times 10^6$ Pa

**C** $1.47 \times 10^7$ Pa

**D** $1.96 \times 10^7$ Pa

**7** Which pair of substances are both simple molecular?

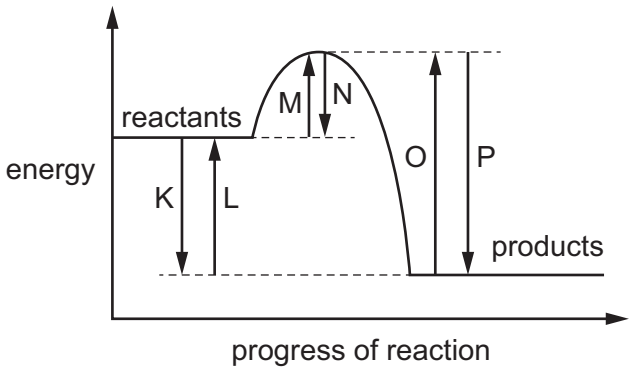
**A** $C_{60}$ and graphene

**B** $C_{60}$ and iodine

**C** graphene and graphite

**D** graphite and iodine

**8** A reaction pathway diagram is shown.




Which row is correct?

| | enthalpy change of the forward reaction | activation energy of the reverse reaction |
|---|---|---|
| **A** | K | M |
| **B** | K | O |
| **C** | L | O |
| **D** | P | M |

**9** X is either chlorine or an oxide of chlorine.

X reacts with water, under suitable conditions, to form the two acids HC$l$ and HC$l$O$_3$ in the mole ratio of 1 (HC$l$) : 5 (HC$l$O$_3$).

What could be X?

**A** C$l_2$ **B** C$l_2$O **C** C$l$O$_2$ **D** C$l_2$O$_7$

**10** Ethyl ethanoate undergoes the following reaction.

$$CH_3CO_2C_2H_5 + H_2O \rightleftharpoons C_2H_5OH + CH_3CO_2H \qquad K_c = 0.27$$

Equal amounts of ethanoic acid and ethanol were mixed together and allowed to reach equilibrium.

At equilibrium, the concentrations of both ethanoic acid and ethanol were 0.42 mol dm$^{-3}$.

What is the concentration of ethyl ethanoate at equilibrium?

**A** 0.22 mol dm$^{-3}$

**B** 0.65 mol dm$^{-3}$

**C** 0.81 mol dm$^{-3}$

**D** 1.54 mol dm$^{-3}$

**11** Which row is an example of heterogeneous catalysis?

| | reaction | catalyst |
|---|---|---|
| **A** | esterification | sulfuric acid |
| **B** | the Contact process | divanadium pentoxide |
| **C** | destruction of the ozone layer | chlorine radicals |
| **D** | atmospheric formation of sulfur trioxide | nitrogen dioxide |

**12** Element Q readily oxidises in air. The oxide produced reacts with water to form a solution of very low pH.

Where could element Q be found in the Periodic Table?

| | period | group |
|---|---|---|
| **A** | 2 | 1 |
| **B** | 2 | 14 |
| **C** | 3 | 14 |
| **D** | 3 | 15 |

**13** The eight elements sodium to argon are in the same period of the Periodic Table.

The equation corresponding to the first ionisation energy is shown.

$$X(g) \rightarrow X^{+}(g) + e^{-}$$

For which of these eight elements is the electron in this equation removed from a filled orbital?

**A** Mg, A*l*, Si, P, S, C*l* and Ar

**B** A*l*, Si, P, S, C*l* and Ar only

**C** Mg, S, C*l* and Ar only

**D** S, C*l* and Ar only

**14** Elements D and E are both in Period 3. Element D has the smallest atomic radius in Period 3. There are only two elements in Period 3 which have a lower melting point than element E. Elements D and E react together to form compound L.

Which compound could be L?

**A** $MgCl_2$ **B** MgS **C** $Na_2S$ **D** $PCl_3$

**15** How many of the solutions shown, when added to separate portions of magnesium sulfate solution, produce a white precipitate?

$HCl(aq)$ $NH_3(aq)$ $(NH_4)_2CO_3(aq)$ $Ba(NO_3)_2(aq)$

**A** 0 **B** 1 **C** 2 **D** 3

**16** A white solid, Z, is soluble in water. A sample of Z is heated with a Bunsen burner until there is no further change. When the residue is shaken with water a solution is formed with no solid remaining.

What could Z be?

**A** $MgCO_3$ **B** $Mg(NO_3)_2$ **C** $BaCO_3$ **D** $Ba(NO_3)_2$

**17** An excess of chlorine was bubbled into 100 $cm^3$ of hot 6.0 mol $dm^{-3}$ sodium hydroxide.

How many moles of sodium chloride would be produced in the reaction?

**A** 0.3 **B** 0.5 **C** 0.6 **D** 1.2

**18** Ammonium sulfate, $(NH_4)_2SO_4$, and ammonium nitrate, $NH_4NO_3$, are used as fertilisers.

These salts have different percentages by mass of nitrogen. They have the same effect as each other on the pH of wet neutral soil.

Which row is correct?

| | higher percentage of nitrogen by mass | effect on pH of soil |
|---|---|---|
| **A** | ammonium nitrate | decrease |
| **B** | ammonium nitrate | increase |
| **C** | ammonium sulfate | decrease |
| **D** | ammonium sulfate | increase |

**19** Which reaction gives a product that is an atmospheric pollutant causing acid rain?

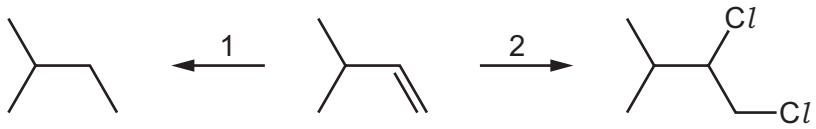
**A** $3Mg(s) + SO_2(g) \rightarrow MgS(s) + 2MgO(s)$

**B** $(NH_4)_2SO_4(s) + Ca(OH)_2(s) \rightarrow 2NH_3(g) + CaSO_4(s) + 2H_2O(l)$

**C** $2MnO_4^-(aq) + 5SO_2(g) + 2H_2O(l) \rightarrow 2Mn^{2+}(aq) + 4H^+(aq) + 5SO_4^{2-}(aq)$

**D** $2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$

**20** 3-methylbut-1-ene can undergo different types of reaction.




Which row correctly identifies the reaction types?

| | reaction 1 | reaction 2 |
|---|---|---|
| **A** | oxidation | electrophilic addition |
| **B** | oxidation | nucleophilic addition |
| **C** | reduction | electrophilic addition |
| **D** | reduction | nucleophilic addition |





**[Turn over**

**21** Compound X does **not** show cis-trans isomerism.

What could be the identity of compound X?

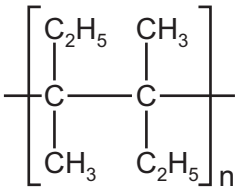
**A** 1,1,2-trichloropropene

**B** 1,2,3-trichloropropene

**C** 1-chlorobut-1-ene

**D** 1-chlorobut-2-ene

**22** The diagram shows the repeat unit of an addition polymer.




What is the correct name for the monomer that would form this polymer?

**A** cis-1,2-diethyl-1,2-dimethylethene

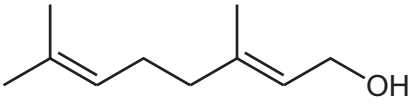
**B** cis-2-ethyl-3-methylpent-2-ene

**C** trans-2-ethyl-3-methylpent-2-ene

**D** trans-3,4-dimethylhex-3-ene

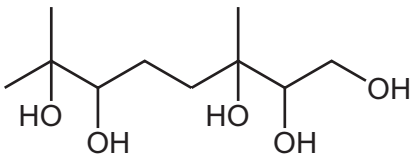
**23** A molecule of geraniol is shown.

geraniol

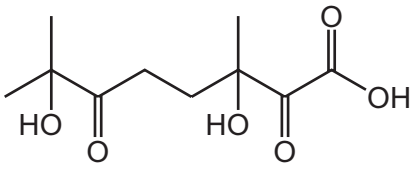



What is formed when geraniol is reacted with an excess of cold, dilute, acidified manganate(VII) ions?

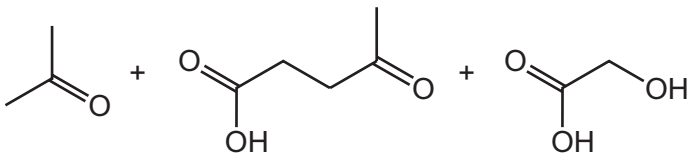
**A**



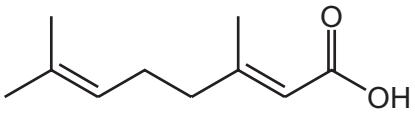

**B**




**C**




**D**




**24** Alcohol W **cannot** be made by reducing a carboxylic acid with $LiAlH_4$. Alcohol W gives only one product when dehydrated with concentrated sulfuric acid.

What could be the identity of W?

**A** butan-1-ol

**B** butan-2-ol

**C** propan-1-ol

**D** propan-2-ol

**25** Which product can be made from bromoethane by an elimination reaction?

**A** ethanol

**B** ethene

**C** ethylamine

**D** propanenitrile





**[Turn over**

**26** Propene, bromine and hydrogen bromide are mixed in the dark.

A number of products are formed, some in very small quantities.

Which substance will **not** be present in the mixture of products?

**A** 1-bromopropane

**B** 2-bromopropane

**C** 1,1-dibromopropane

**D** 1,2-dibromopropane

**27** Which reagent could be used to distinguish between ethanal and propanal?

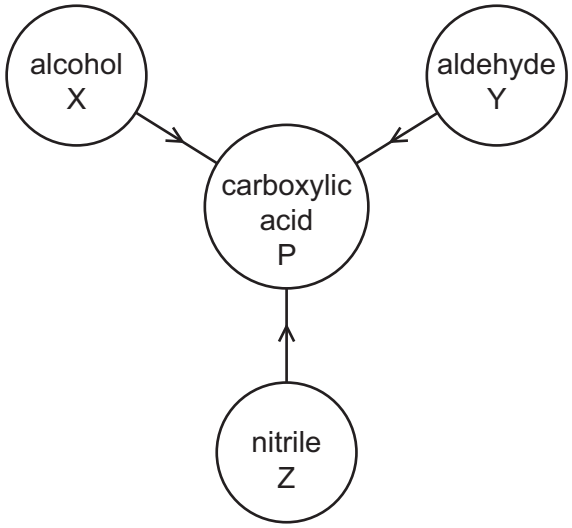
**A** 2,4-dinitrophenylhydrazine

**B** $I_2$ / NaOH(aq)

**C** $K_2Cr_2O_7$ / $H_2SO_4$(aq)

**D** Tollens' reagent

**28** The diagram shows that a carboxylic acid P may be formed from X, Y or Z.

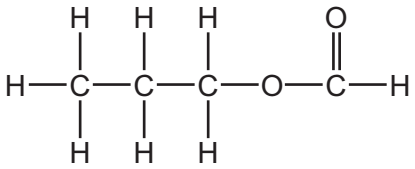



Which row is correct?

| | alcohol X is | the change in $M_r$ is greatest for |
|---|---|---|
| **A** | primary | Y to P |
| **B** | primary | Z to P |
| **C** | secondary | Y to P |
| **D** | secondary | Z to P |

**29** One molecule of compound R is shown.

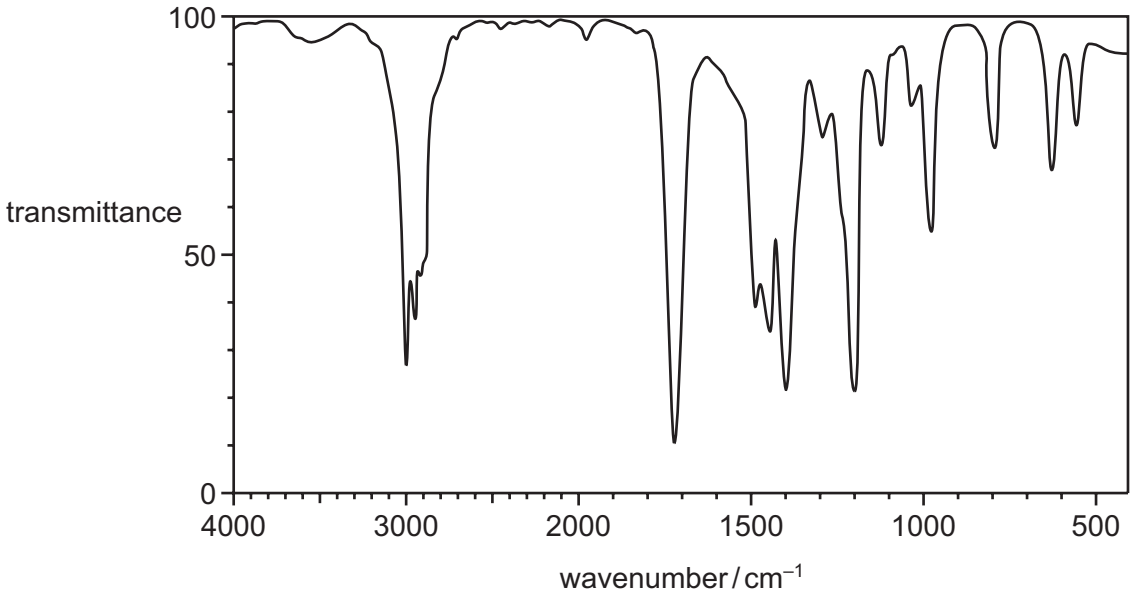
compound R



What is the name of compound R and how does its boiling point compare with that of butanoic acid?

| | name of R | boiling point of R |
|---|---|---|
| **A** | methyl propanoate | higher than butanoic acid |
| **B** | methyl propanoate | lower than butanoic acid |
| **C** | propyl methanoate | higher than butanoic acid |
| **D** | propyl methanoate | lower than butanoic acid |

**30** The diagram shows the infra-red spectrum of Q.




What could be Q?

**A** butan-1-ol

**B** butanoic acid

**C** butanone

**D** 3-hydroxybutanal





**[Turn over**

## Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

| A | B | C | D |
|---|---|---|---|
| **1**, **2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

**31** When $O_2$ reacts with $H_2S$ the products are $SO_2$ and $H_2O$.

Mixture Y contains an equal number of the two molecules shown, and **no other molecules**.

$^{16}_{8}O = {}^{18}_{8}O$ $\qquad$ $^{1}_{1}H - {}^{32}_{16}S - {}^{1}_{1}H$

Which statements about Y are correct?

**1** The average $M_r$ in Y is 34.

**2** If some oxygen molecules are removed from Y, the average $M_r$ of the mixture remains the same.

**3** When mixture Y is ignited, some $H_2S$ remains unreacted.

**32** Which statements about an atom of $^{99}Tc$ are correct?

**1** It has 13 fewer protons than neutrons.

**2** It forms $^{99}Tc^{2+}$ which has 45 electrons.

**3** It has 56 nucleons.

**33** In which reactions are nitrogen atoms reduced?

**1** $2NO_2 \rightarrow N_2 + 2O_2$

**2** $4NO_2 \rightarrow 2N_2O + 3O_2$

**3** $4NO_2 + 6H_2O \rightarrow 4NH_3 + 7O_2$

**34** The manufacture of ammonia from nitrogen and hydrogen is an important industrial process.

Which of the following would leave the equilibrium constant, $K_p$, for the formation of ammonia unchanged?

**1** addition of an iron catalyst

**2** addition of ammonia

**3** an increase in pressure

**35** Which reactions involving calcium and its compounds produce two gaseous products?

**1** heating solid anhydrous calcium nitrate

**2** heating solid anhydrous calcium carbonate

**3** adding calcium metal to water

**36** A small quantity of hot, concentrated sulfuric acid is added separately to solid samples of potassium halides, KX.

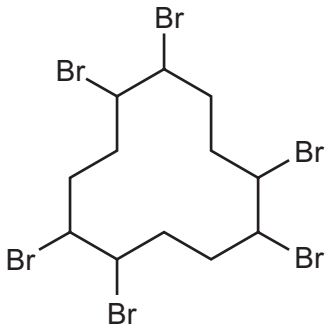
Which potassium halides react and produce a mixture of products that include a halogen, $X_2$?

**1** potassium iodide

**2** potassium bromide

**3** potassium chloride

**37** The diagram shows a compound used as a flame retardant.




Which statements about this structure are correct?

**1** The empirical formula is $C_2H_3Br$.

**2** The $C_{12}$ ring is not planar.

**3** There are six chiral carbon atoms.

The responses **A** to **D** should be selected on the basis of

| A | B | C | D |
|---|---|---|---|
| **1**, **2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

No other combination of statements is used as a correct response.

**38** Halogenoalkanes can be hydrolysed using aqueous sodium hydroxide.

Which compounds tend to be hydrolysed by an $S_N1$ mechanism?

**1** $CH_3CH_2CCl(CH_3)CH_2CH_3$

**2** $CH_3CH_2CBr(CH_3)CH_2CH_3$

**3** $CH_3CH_2CH(CH_3)CH_2CH_2Br$

**39** In an organic synthesis, a 62% yield of product is achieved.

Which conversions are consistent with this information?

**1** 74.00 g of butan-2-ol $\rightarrow$ 44.64 g of butanone

**2** 74.00 g of butan-1-ol $\rightarrow$ 54.56 g of butanoic acid

**3** 74.00 g of 2-methylpropan-1-ol $\rightarrow$ 54.56 g of 2-methylpropanoic acid

**40** An oxidising agent that can oxidise ethanal to ethanoic acid or ethanoate ions will also oxidise methanoic acid, $HCO_2H$, to carbon dioxide and water.

Which reagents, on heating, will react differently with $HCO_2H$ and $CH_3CO_2H$?

**1** $Na_2CO_3(aq)$

**2** Fehling's reagent

**3** dilute acidified $KMnO_4$

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