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Cambridge International AS & A Level

**Cambridge International Examinations**
Cambridge International Advanced Subsidiary and Advanced Level

**CHEMISTRY** **9701/13**

Paper 1 Multiple Choice **May/June 2015**

**1 hour**

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

* 5 2 9 4 3 1 4 5 4 *

**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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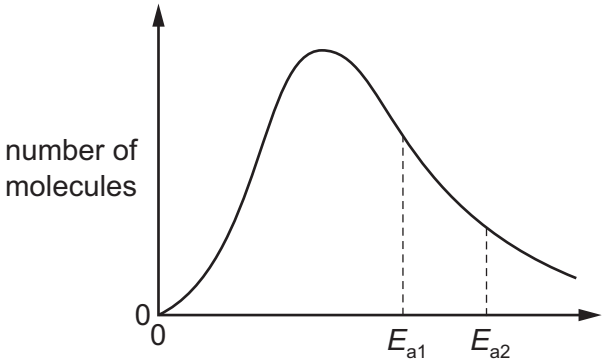
## Section A

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

**1** The diagram shows the Boltzmann energy distribution curve for molecules of a mixture of two gases at a given temperature. For a reaction to occur the molecules must collide together with sufficient energy.




$E_a$ is used to represent the activation energy for the reaction between the gases. Of the two values shown, one is the activation energy for a catalysed reaction, the other for an uncatalysed reaction.

Which statement about $\boldsymbol{E_{a1}}$ is correct?

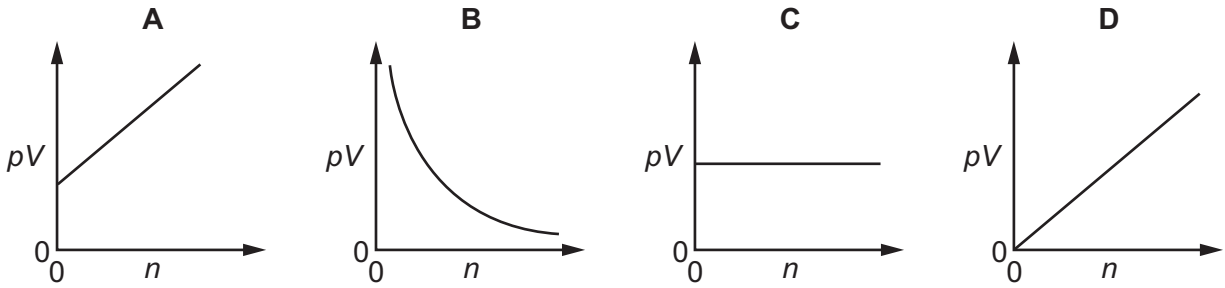
**A** $E_{a1}$ corresponds to a catalysed reaction with fewer effective collisions than the uncatalysed reaction.

**B** $E_{a1}$ corresponds to an uncatalysed reaction with fewer effective collisions than the catalysed reaction.

**C** $E_{a1}$ corresponds to a catalysed reaction with a greater number of effective collisions than the uncatalysed reaction.

**D** $E_{a1}$ corresponds to an uncatalysed reaction with a greater number of effective collisions than the catalysed reaction.

**2** Which diagram shows the correct graph of $pV$ against $n$ for an ideal gas at constant temperature?

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**3** A student performed an experiment to measure the enthalpy change of combustion of ethane.

He used the following values for the standard enthalpy changes of combustion of carbon and hydrogen.

$\Delta H_c^{\ominus}$ carbon = –394 kJ mol$^{-1}$

$\Delta H_c^{\ominus}$ hydrogen = –286 kJ mol$^{-1}$

He calculated the enthalpy change of formation of ethane to be –140 kJ mol$^{-1}$.

What was his experimental value for the standard enthalpy change of combustion of ethane?

**A** –2364 kJ mol$^{-1}$

**B** –1506 kJ mol$^{-1}$

**C** –1112 kJ mol$^{-1}$

**D** –540 kJ mol$^{-1}$

**4** Which pair has species with different shapes?

**A** $BeCl_2$ and $CO_2$

**B** $CH_4$ and $NH_4^+$

**C** $NH_3$ and $BF_3$

**D** $SCl_2$ and $H_2O$

**5** In which reaction does an element have the largest change in oxidation number?

**A** $Cr_2O_7^{2-} + 6Fe^{2+} + 14H^+ \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$

**B** $3OCl^- \rightarrow ClO_3^- + 2Cl^-$

**C** $5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

**D** $PbO_2 + Sn^{2+} + 4H^+ \rightarrow Sn^{4+} + Pb^{2+} + 2H_2O$

**6** Which statement can be explained by intermolecular hydrogen bonding?

**A** Ethanol has a higher boiling point than propane.

**B** Hydrogen chloride has a higher boiling point than silane, $SiH_4$.

**C** Hydrogen iodide forms an acidic solution when dissolved in water.

**D** Propanone has a higher boiling point than propane.

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**[Turn over**

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**7** Carbon monoxide and methanol can react together to form ethanoic acid.

$$CO(g) + CH_3OH(l) \xrightarrow{\Delta H_r^{\ominus}} CH_3CO_2H(l)$$

Standard enthalpy changes of combustion are given in the table.

| compound | standard enthalpy change of combustion, $\Delta H_c^{\ominus}$ |
|---|---|
| CO | $-283.0\,kJ\,mol^{-1}$ |
| $CH_3OH$ | $-726.0\,kJ\,mol^{-1}$ |
| $CH_3CO_2H$ | $-874.1\,kJ\,mol^{-1}$ |

What is the value for $\Delta H_r^{\ominus}$ for the reaction between carbon monoxide and methanol?

**A** $-1883.1\,kJ\,mol^{-1}$

**B** $-134.9\,kJ\,mol^{-1}$

**C** $+134.9\,kJ\,mol^{-1}$

**D** $+1883.1\,kJ\,mol^{-1}$

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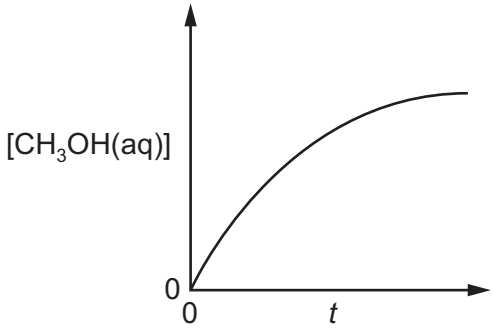
**8** The following reaction was carried out.

$$HCO_2CH_3(aq) + NaOH(aq) \rightarrow HCO_2Na(aq) + CH_3OH(aq)$$

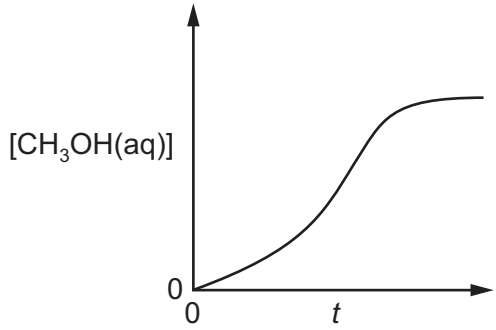
The concentration of methanol, $[CH_3OH(aq)]$, was measured with time, *t*.

Which graph shows the relationship between $[CH_3OH(aq)]$ and *t*?

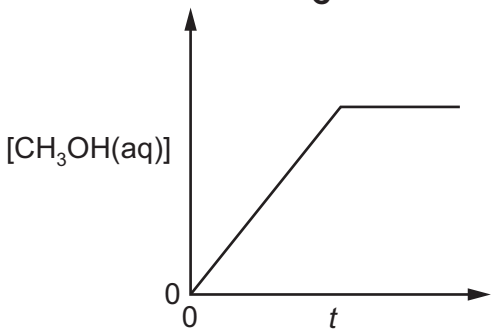
**A**



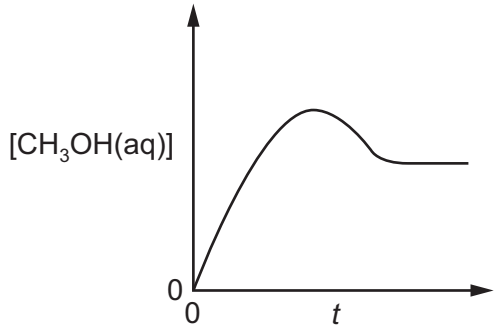

**B**




**C**




**D**




**9** Brine is concentrated aqueous sodium chloride. Brine is electrolysed in a diaphragm cell.

What is the purpose of the diaphragm?

**A** to prevent $Cl_2$ reacting with $H_2$

**B** to prevent $HCl$ reacting with Na

**C** to prevent NaOH reacting with $Cl_2$

**D** to prevent NaOH reacting with $HCl$

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**[Turn over**

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**10** *Use of the Data Booklet is relevant to this question.*

1.00 g of a metallic element reacts completely with 300 $cm^3$ of oxygen at 298 K and 1 atm pressure to form an oxide which contains $O^{2-}$ ions.

The volume of one mole of gas at this temperature and pressure is 24.0 $dm^3$.

What could be the identity of the metal?

**A** calcium

**B** magnesium

**C** potassium

**D** sodium

**11** *Use of the Data Booklet is relevant to this question.*

The gas laws can be summarised in the ideal gas equation below.

$$pV = nRT$$

When an evacuated tube of volume 400 $cm^3$ is filled with gas at 300 K and 101 kPa, the mass of the tube increases by 0.65 g.

Assume the gas behaves as an ideal gas.

What could be the identity of the gas?

**A** argon

**B** helium

**C** krypton

**D** neon

**12** Which oxide will produce the solution with the highest pH when it is mixed with water?

**A** $Al_2O_3$ **B** $CO_2$ **C** $Na_2O$ **D** $SO_2$

**13** Barium is a more reactive metal than aluminium.

Which method could be suitable for the extraction of barium?

**A** electrolysing aqueous barium chloride

**B** electrolysing molten barium chloride

**C** reducing barium oxide with aluminium

**D** reducing barium oxide with carbon

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**14** The compound $(CH_3)_3NAlCl_3$ has a simple molecular structure.

Which statement about $(CH_3)_3NAlCl_3$ is correct?

**A** $(CH_3)_3NAlCl_3$ molecules attract each other by hydrogen bonds.

**B** The Al atom has an incomplete valance shell of electrons.

**C** The bonds around the Al atom are planar.

**D** The molecules contain coordinate and covalent bonding

**15** The labels had become detached from four bottles in the laboratory. A student realised that the contents of one of them could easily be identified, because on addition of water it would **not** give fumes of hydrogen chloride.

Which did **not** give the HCl fumes?

**A** $Al_2Cl_6$ **B** $MgCl_2$ **C** $PCl_5$ **D** $SiCl_4$

**16** Transition elements and their compounds are widely used as catalysts.

What is the identity and what is the oxidation number of the element present in the catalyst used in the Contact process?

| | element | oxidation number |
|---|---|---|
| **A** | iron | 0 |
| **B** | iron | +3 |
| **C** | vanadium | 0 |
| **D** | vanadium | +5 |

**17** This question refers to isolated gaseous species.

The species $F^-$, Ne and $Na^+$ are isoelectronic. This means they have the same number of electrons.

In which order do their radii increase?

| | smallest ⟶ | | largest |
|---|---|---|---|
| **A** | $Na^+$ | $F^-$ | Ne |
| **B** | $F^-$ | Ne | $Na^+$ |
| **C** | $Na^+$ | Ne | $F^-$ |
| **D** | Ne | $F^-$ | $Na^+$ |

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**[Turn over**

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**18** Due to their similar ionic radii, the reactions of lithium and magnesium and their corresponding compounds are very similar.

Which statement about the reactions of lithium or its compounds can be predicted from this statement?

**A** Lithium burns very slowly in oxygen.

**B** Lithium carbonate decomposes on heating in a blue Bunsen burner flame, forming lithium oxide and carbon dioxide.

**C** Lithium nitrate decomposes on heating, forming lithium nitrite, $LiNO_2$, and oxygen.

**D** Lithium reacts very violently with cold water, liberating hydrogen.

**19** Two separate tests were carried out on an aqueous solution of a salt which contains only two ions.

In each test, the resulting mixtures were filtered and the filtrate solution was collected.

| | reagent | result | filtrate collected |
|---|---|---|---|
| test 1 | aqueous silver nitrate acidified with dilute nitric acid | yellow precipitate forms | solution P |
| test 2 | dilute sulfuric acid | white precipitate forms | solution Q |

Which ions are present in the filtrates?

| | solution P | solution Q |
|---|---|---|
| **A** | $Ba^{2+}(aq)$ | $Cl^{-}(aq)$ |
| **B** | $Ba^{2+}(aq)$ | $I^{-}(aq)$ |
| **C** | $Mg^{2+}(aq)$ | $Cl^{-}(aq)$ |
| **D** | $Mg^{2+}(aq)$ | $I^{-}(aq)$ |

**20** An organic compound **Z**

- is oxidised by hot acidified potassium manganate(VII),
- reacts with sodium to give hydrogen.

What could be compound **Z**?

**A** $(CH_3)_3COH$

**B** $CH_3CH_2CH_2CHO$

**C** $CH_3CH_2CH(OH)CH_3$

**D** $CH_3CH_2COCH_3$

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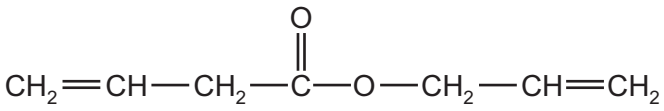
**21** The diagram shows a molecule that has σ bonds and π bonds.

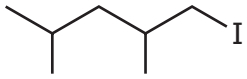


How many σ bonds are present in this molecule?

**A** 15 **B** 17 **C** 18 **D** 21

**22** The Finkelstein reaction occurs when NaI in propanone reacts with a chloroalkane or bromoalkane. The halogen is directly replaced by I and the reaction only works for primary halogenoalkanes.

Which halogenoalkane would produce compound X?



compound X

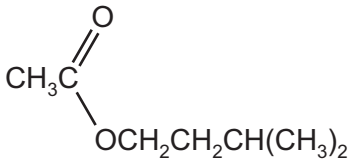
**A** $(CH_3)_2CHCH(CH_3)CH_2CH_2Br$

**B** $(CH_3)_2CHCH(CH_3)CH_2Br$

**C** $(CH_3)_2CHCH_2CH_2CH(CH_3)Cl$

**D** $(CH_3)_2CHCH_2CH(CH_3)CH_2Cl$

**23** An ester P with a fruity odour has the following structural formula.



Which compounds are produced when P is hydrolysed using hydrochloric acid?

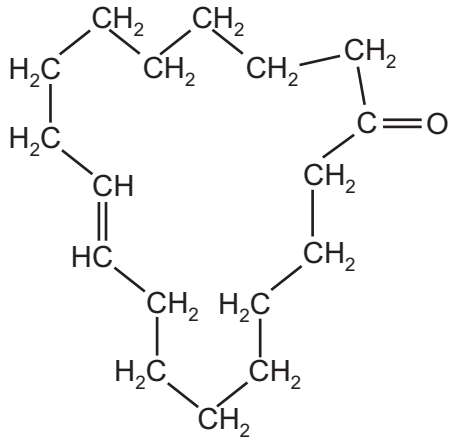
**A** $CH_3COCl$ and $(CH_3)_2CHCH_2CH_2OH$

**B** $CH_3CHO$ and $(CH_3)_2CHCH_2CH_2OH$

**C** $CH_3CO_2H$ and $(CH_3)_2CHCH_2CH_2CHO$

**D** $CH_3CO_2H$ and $(CH_3)_2CHCH_2CH_2OH$

**24** The naturally-occurring molecule civetone is found in a gland of the African civet cat and has been used in perfumery.



civetone

Which reagent will **not** react with civetone?

**A** 2,4-dinitrophenylhydrazine reagent

**B** Fehling's reagent

**C** hydrogen bromide

**D** sodium tetrahydridoborate(III), $NaBH_4$

**25** Compound **X**, $C_5H_{12}O$, is oxidised by acidified sodium dichromate(VI) to compound **Y**.

Compound **Y** reacts with butan-2-ol in the presence of a little concentrated sulfuric acid to give liquid **Z**.

What could be the formula of **Z**?

**A** $CH_3(CH_2)_3CO_2CH(CH_3)CH_2CH_3$

**B** $CH_3(CH_2)_3CO_2(CH_2)_3CH_3$

**C** $CH_3(CH_2)_2CO_2CH(CH_3)CH_2CH_3$

**D** $(CH_3)_2CHCH_2CO_2C(CH_3)_3$

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**26** Alkane X has molecular formula $C_4H_{10}$.

X reacts with $Cl_2$(g) in the presence of sunlight to produce only two different monochloroalkanes, $C_4H_9Cl$. Both of these monochloroalkanes produce the same alkene Y, and no other organic products, when they are treated with hot ethanolic KOH.

What is produced when Y is treated with hot concentrated acidified $KMnO_4$?

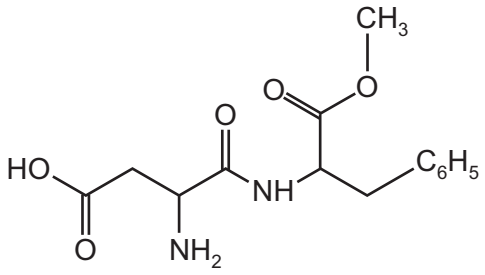
**A** $CO_2$ and $CH_3CH_2CO_2H$

**B** $CO_2$ and $CH_3COCH_3$

**C** $HCO_2H$ and $CH_3COCH_3$

**D** $CH_3CO_2H$ only

**27** The compound *aspartame* is widely used as a sweetener in 'diet' soft drinks.




*aspartame*

Aspartame is chiral. (There are no chiral carbon atoms in $C_6H_5$.)

How many chiral carbon atoms are present in a molecule of *aspartame*?

**A** 1 **B** 2 **C** 3 **D** 4

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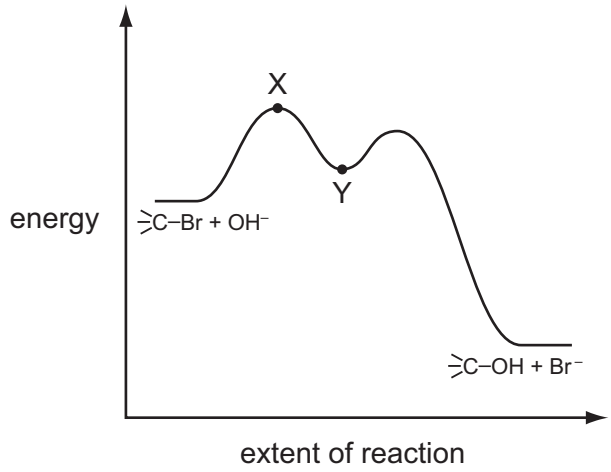
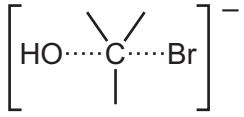
**28** A tertiary bromoalkane, indicated here by $\geq C-Br$, reacts with aqueous NaOH. The mechanism has the reaction pathway below.

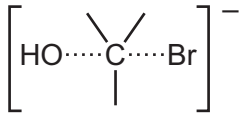



Which point in the diagram is correctly identified?

**A** X is $\geq C+$

**B** X is 


**C** Y is $\geq C+$

**D** Y is 


**29** Four drops of 1-chlorobutane, 1-bromobutane and 1-iodobutane were put separately into three test-tubes containing 1.0 $cm^3$ of aqueous silver nitrate at 60 °C.

In each case, a hydrolysis reaction occurred. R represents the butane chain $C_4H_9$ and X the halogen atom.

$$H_2O(l) + R–X(l) + Ag^+(aq) \rightarrow R–OH(aq) + AgX(s) + H^+(aq)$$

The rate of formation of cloudiness in the test-tubes was in the order RC*l* < RBr < RI.

Why is this?

**A** The bond energy of R–X decreases from RC*l* to RI.

**B** The first ionisation energy of the halogen decreases from C*l* to I.

**C** The solubility of AgX(s) decreases from AgC*l* to AgI.

**D** The R–X bond polarity decreases from RC*l* to RI.

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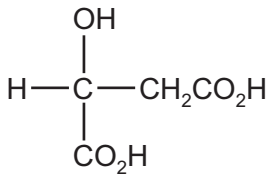
**30** Malic acid occurs in apples.



malic acid

Under suitable conditions, which substance will react with only one of the –OH groups in the malic acid molecule?

**A** $Cr_2O_7^{2-}/H^+(aq)$

**B** Na(s)

**C** NaOH(aq)

**D** $PCl_5(s)$

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## 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.

**31** The technetium-99 isotope, $^{99}Tc$, is radioactive and has been found in lobsters and seaweed near to nuclear fuel reprocessing plants.

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.

**32** Nitrogen exists in air as covalently bonded diatomic molecules, $N_2$.

Which features are present in one $N_2$ molecule?

**1** three $\pi$ bonds

**2** three shared pairs of electrons

**3** two lone pairs of electrons

**33** When dilute acid is added to an aqueous solution containing nitrite ions, $NO_2^-$, a mixture of gases is produced.

$$2H^+(aq) + 2NO_2^-(aq) \rightarrow H_2O(l) + NO(g) + NO_2(g)$$

Which statements correctly describe the process?

**1** Some nitrogen atoms are oxidised and some nitrogen atoms are reduced.

**2** The $H^+(aq)$ ion is oxidised by $NO_2^-(aq)$.

**3** The $H^+(aq)$ ion acts as a catalyst.

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**34** Which physical properties are due to hydrogen bonding between water molecules?

**1** Water has a higher boiling point than $H_2S$.

**2** Ice floats on water.

**3** The H–O–H bond angle in water is approximately 104°.

**35** Under atmospheric conditions, in which transformations is sulfur dioxide involved as either a reagent or a catalyst?

**1** $NO_2$ to NO

**2** NO to $NO_2$

**3** CO to $CO_2$

**36** The element astatine, At, is below iodine in Group VII of the Periodic Table.

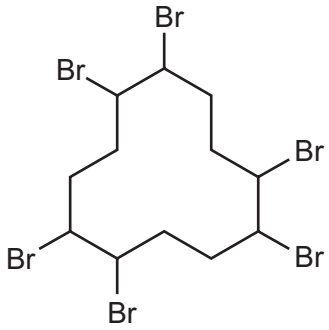
Which statements concerning At can be predicted to be correct?

**1** $At_2$ reacts with hydrogen more slowly than $I_2$ does.

**2** $At^-$ ions react with $I_2(aq)$ to form $At_2$ molecules.

**3** $At_2$ is a dark coloured solid at room temperature.

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




Which statements about this structure are correct?

**1** Each brominated C atom is chiral.

**2** The molecular formula is $C_{12}H_{20}Br_6$.

**3** The C–C–C bond angles are all 120°.

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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** Which changes in bonding occur during the reaction of propanal and hydrogen cyanide?

**1** A carbon-hydrogen bond is broken.

**2** An oxygen-hydrogen bond is formed.

**3** A carbon-carbon bond is formed.

**39** Which pairs of reagents will react together in a redox reaction?

**1** $CH_3CHO$ + Fehling's reagent

**2** $C_2H_4$ + $Br_2$(aq)

**3** $CH_4$ + $Cl_2$(g)

**40** Which types of reaction are undergone by $CH_2BrCHCH_2$?

**1** hydrolysis

**2** free radical substitution

**3** nucleophilic addition

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