Cambridge International AS & A Level

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

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

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

*1914560653*

**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** Manganese and nitrogen can show a range of different oxidation states.

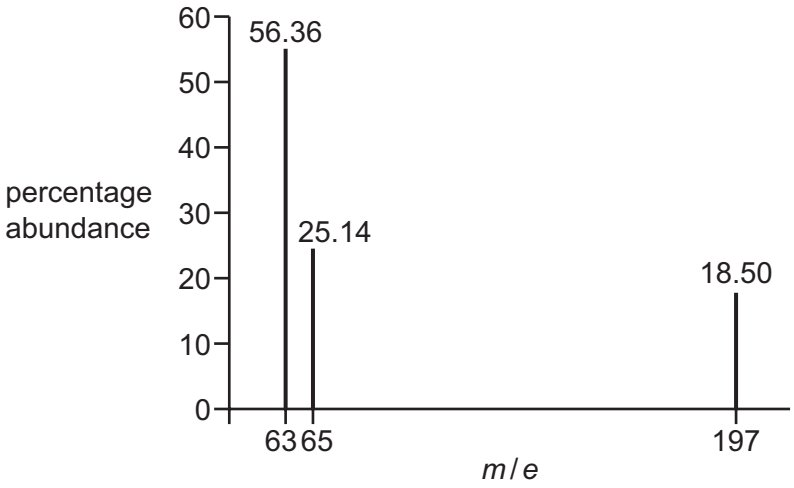
Calculate the sum of the oxidation states of Mn and N in each row of the table.

In which row is this sum the smallest?

| | manganese-containing species | nitrogen-containing species |
|---|---|---|
| **A** | $MnCl_4$ | $N_2$ |
| **B** | $MnCO_3$ | $NO_2^-$ |
| **C** | $K_2MnO_4$ | $NH_4^+$ |
| **D** | $Mn(OH)_3$ | $NH_2OH$ |

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**2** The mass spectrum of an alloy of copper and gold is shown.




Which expression can be used to calculate the relative atomic mass, $A_r$, of copper present in this sample?

**A** $\dfrac{(56.36 \times 63) + (25.14 \times 65)}{(56.36 + 25.14 + 18.50)}$

**B** $\dfrac{(56.36 \times 63) + (25.14 \times 65) + (18.50 \times 197)}{(56.36 + 25.14 + 18.50)}$

**C** $\dfrac{(56.36 \times 63) + (25.14 \times 65)}{(56.36 + 25.14)}$

**D** $\dfrac{(56.36 \times 63) + (25.14 \times 65)}{(63 + 65)}$

**3** Which atom has exactly three unpaired electrons?

**A** an isolated gaseous aluminium atom

**B** an isolated gaseous carbon atom

**C** an isolated gaseous chromium atom

**D** an isolated gaseous phosphorus atom

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**4** Element W is in period three of the Periodic Table and has a solid, white oxide, X. X is thermally stable and has a very high melting point.

X is slightly soluble in water.

Which row describes the structure and bonding of X?

| | structure | bonding |
|---|---|---|
| **A** | giant three dimensional lattice | covalent |
| **B** | strong double bonds within small molecules | covalent |
| **C** | giant three dimensional lattice | ionic |
| **D** | strong ionic bonds within small molecules | ionic |

**5** Ethane, $CH_3CH_3$, and fluoromethane, $CH_3F$, have the same number of electrons in their molecules.

Their boiling points are given.

| | |
|---|---|
| $CH_3CH_3$ | 184.5 K |
| $CH_3F$ | 194.7 K |

What is responsible for this difference in boiling points?

**A** $CH_3F$ has a larger $M_r$ than $CH_3CH_3$.

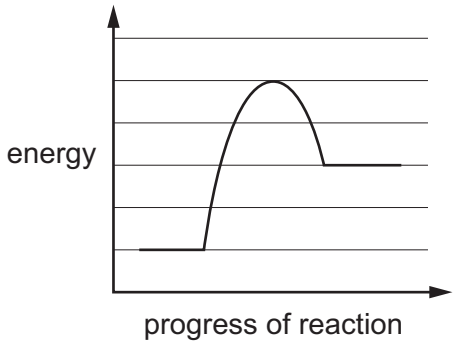
**B** $CH_3F$ has a permanent dipole, $CH_3CH_3$ does not.

**C** $CH_3F$ has a strong C–F bond, $CH_3CH_3$ does not.

**D** Hydrogen bonding occurs in $CH_3F$, but not in $CH_3CH_3$.

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**6** The reaction pathway diagram for a chemical reaction is shown.




Which statement is correct?

**A** The activation energy of the forward reaction and the enthalpy change of the backward reaction have the same sign.

**B** The activation energy of the forward reaction is more than twice the enthalpy change of the backward reaction and opposite in sign.

**C** The enthalpy change of the forward reaction and the activation energy of the backward reaction have the same sign.

**D** The enthalpy change of the forward reaction is more than twice the activation energy of the backward reaction.

**7** What changes in conditions or molecular properties make it more likely that gases approach ideal behaviour?

**A** higher pressure

**B** lower temperature

**C** more polar molecules

**D** weaker intermolecular forces

**8** Ethanol can be oxidised to ethanal by dilute acidified dichromate(VI) ions.

The oxidation reaction equation is $C_2H_5OH \rightarrow C_2H_4O + 2H^+ + 2e^-$.

The reduction reaction equation is $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$.

Which equation is correct?

**A** $Cr_2O_7^{2-} + 8H^+ + 3C_2H_5OH \rightarrow 2Cr^{3+} + 7H_2O + 3C_2H_4O$

**B** $Cr_2O_7^{2-} + 12H^+ + C_2H_5OH \rightarrow 2Cr^{3+} + 7H_2O + C_2H_4O$

**C** $Cr_2O_7^{2-} + 12H^+ + 3C_2H_5OH \rightarrow 2Cr^{3+} + 6H_2O + 3C_2H_4O$

**D** $Cr_2O_7^{2-} + 14H^+ + 3C_2H_5OH \rightarrow 2Cr^{3+} + 6H_2O + 3C_2H_4O$

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**9** What is the correct expression for $K_c$ for the reaction shown?

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

**A** $\dfrac{[2I^-][2Fe^{3+}]}{[I_2][2Fe^{2+}]}$ **B** $\dfrac{[I^-]^2[Fe^{3+}]^2}{[I_2][Fe^{2+}]^2}$ **C** $\dfrac{[I_2][2Fe^{2+}]}{[2I^-][2Fe^{3+}]}$ **D** $\dfrac{[I_2][Fe^{2+}]^2}{[I^-]^2[Fe^{3+}]^2}$

**10** X and Y react together to form Z in a reversible reaction.

The equilibrium yield of Z is lower at higher temperature.

The equilibrium yield of Z is lower at lower pressure.

Which equation could represent this reaction?

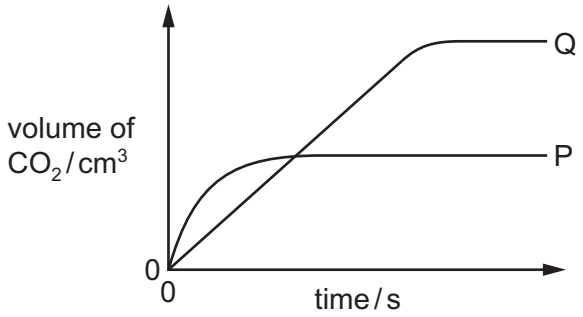
**A** $X(g) + Y(g) \rightleftharpoons Z(g) \quad \Delta H = -100\,kJ\,mol^{-1}$

**B** $X(g) + Y(g) \rightleftharpoons Z(g) \quad \Delta H = +100\,kJ\,mol^{-1}$

**C** $X(s) + Y(g) \rightleftharpoons 2Z(g) \quad \Delta H = -100\,kJ\,mol^{-1}$

**D** $X(s) + Y(g) \rightleftharpoons 2Z(g) \quad \Delta H = +100\,kJ\,mol^{-1}$

**11** The volume of carbon dioxide collected by reacting 0.100 mol of magnesium carbonate with 50.0 $cm^3$ of 1.00 mol $dm^{-3}$ sulfuric acid is measured against time. The volume produced is plotted against time and the line labelled P on the graph is obtained.




The experiment is repeated using 0.100 mol of the same magnesium carbonate, and a different sample of acid. All other conditions remain the same. Plotting these results gives the line labelled Q.

Which sample of acid could give the line labelled Q?

**A** 100 $cm^3$ of 0.500 mol $dm^{-3}$ sulfuric acid

**B** 100 $cm^3$ of 1.00 mol $dm^{-3}$ sulfuric acid

**C** 200 $cm^3$ of 0.500 mol $dm^{-3}$ hydrochloric acid

**D** 200 $cm^3$ of 1.00 mol $dm^{-3}$ hydrochloric acid

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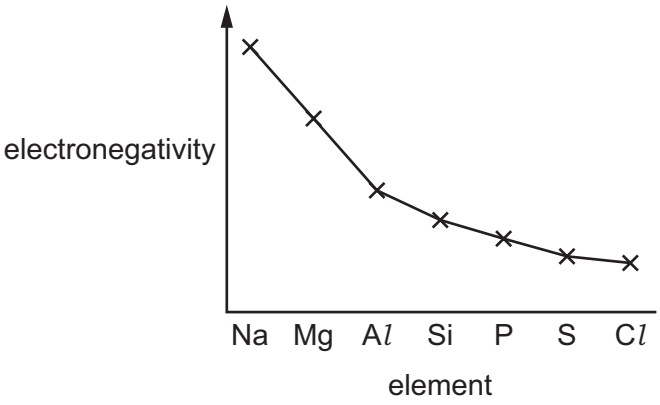
**12** Sodium and sulfur react together to form sodium sulfide, $Na_2S$.

How do the atomic radius and ionic radius of sodium compare with those of sulfur?

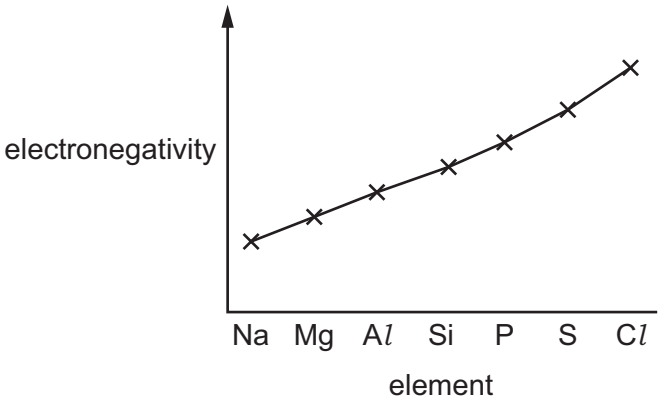
| | atomic radius | ionic radius |
|---|---|---|
| **A** | sodium < sulfur | sodium > sulfur |
| **B** | sodium < sulfur | sodium < sulfur |
| **C** | sodium > sulfur | sodium > sulfur |
| **D** | sodium > sulfur | sodium < sulfur |

**13** Which graph represents the variation in electronegativity for Period 3 elements?

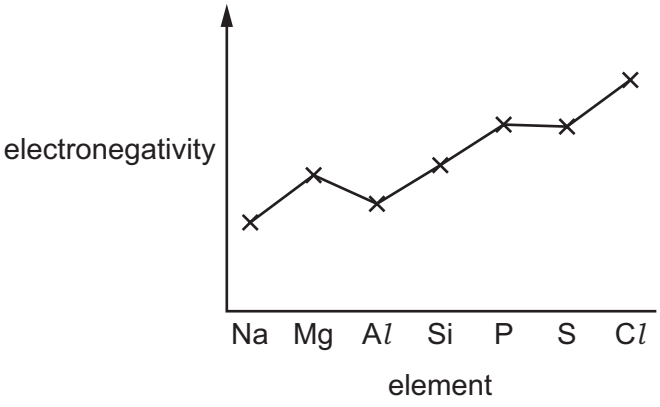
**A**



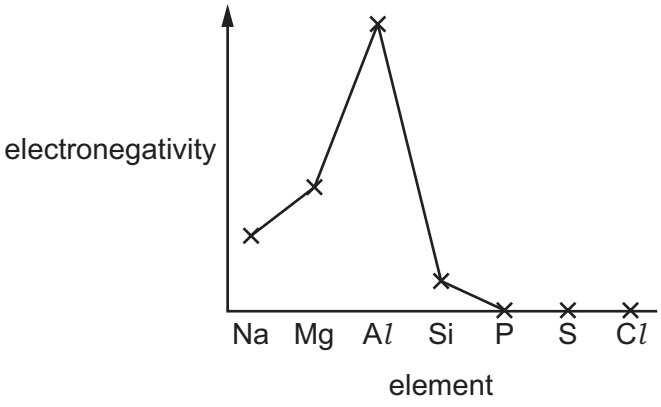

**B**




**C**




**D**



**14** Dilute hydrochloric acid is added to solid barium carbonate and solid magnesium carbonate in separate test-tubes.

Dilute sodium hydroxide is added to 0.1 mol $dm^{-3}$ barium chloride and 0.1 mol $dm^{-3}$ magnesium chloride in separate test-tubes.

Which row is correct?

| | $BaCO_3$(s) + HCl(aq) | $BaCl_2$(aq) + NaOH(aq) | $MgCO_3$(s) + HCl(aq) | $MgCl_2$(aq) + NaOH(aq) |
|---|---|---|---|---|
| **A** | no change | white ppt | no change | no change |
| **B** | effervescence | no change | effervescence | no change |
| **C** | effervescence | no change | effervescence | white ppt |
| **D** | effervescence | white ppt | effervescence | white ppt |

**15** River water in an agricultural area contains $NH_4^+$, $CO_3^{2-}$, $HCO_3^-$, $Cl^-$ and $NO_3^-$ ions. In a water treatment plant, this water is treated by adding a calculated quantity of calcium hydroxide.

What is precipitated from the river water when calcium hydroxide is added?

**A** $CaCl_2$ **B** $CaCO_3$ **C** $Ca(NO_3)_2$ **D** $NH_4OH$

**16** The solids sodium chloride and sodium iodide both react with concentrated sulfuric acid at room temperature.

With NaCl, the products are $NaHSO_4$ and HCl.
With NaI, the products are $NaHSO_4$, HI, $I_2$, $SO_2$, $H_2O$, S and $H_2S$.

What is the explanation for this difference in products?

**A** Chloride ions will displace iodine from solution.

**B** Hydrogen chloride is more volatile than hydrogen iodide.

**C** Iodide ions are better reducing agents than chloride ions.

**D** Sulfuric acid is able to act as a dehydrating agent with NaI.

**17** An aqueous solution of a calcium compound is treated with a mixture of dilute aqueous nitric acid and aqueous silver nitrate. The resulting white precipitate dissolves when dilute aqueous ammonia is added.

What is the relative molecular mass, $M_r$, of the calcium compound?

**A** 54.0 **B** 75.6 **C** 111.1 **D** 199.9

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**18** Which statement about the ammonium ion is correct?

**A** It can act as a Brønsted-Lowry base.

**B** It can react with $OH^-$ to give ammonia.

**C** It is pyramidal with bond angles of 107°.

**D** The nitrogen atom is $sp^2$ hybridised.

**19** In a catalytic converter 5.6 g of carbon monoxide reacts with an excess of nitrogen monoxide.

What is produced in this reaction?

**A** 2.4 g of C and 6.0 g of $NO_2$

**B** 2.4 g of C and 9.2 g of $NO_2$

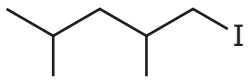
**C** 8.8 g of $CO_2$ and 1.4 g of $N_2$

**D** 8.8 g of $CO_2$ and 2.8 g of $N_2$

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

Which halogenoalkane produces compound X?

X




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

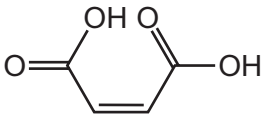
**B** $(CH_3)_2CHCH(CH_3)CH_2Br$

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

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

**21** The diagram shows the skeletal formula of compound Y.

Y




What is the empirical formula of Y?

**A** CHO **B** $CH_2O_2$ **C** $C_2HO_2$ **D** $C_4H_4O_4$

**22** In polymer Z every carbon atom in the polymer chain is bonded to one hydrogen atom and one methyl group.

Which alkene could be polymerised to make polymer Z?

**A** but-1-ene

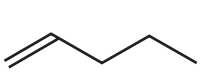
**B** but-2-ene

**C** methylpropene

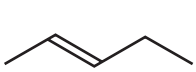
**D** propene

**23** Which compound would produce a carboxylic acid and a ketone when treated with hot, concentrated acidified manganate(VII) ions?

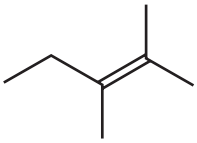
**A**



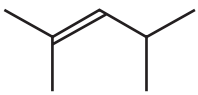
**B**



**C**



**D**



**24** Water is added to a sample of 2,3-dibromohexane.

Some of the 2,3-dibromohexane undergoes complete hydrolysis and some of it undergoes partial hydrolysis.

What is **not** present in the mixture of products?

**A** $CH_3CH(OH)CHBrCH_2CH_2CH_3$

**B** $CH_3CH(OH)CH(OH)CH_2CH_2CH_3$

**C** $CH_3CH_2CH(OH)CH(OH)CH_2CH_3$

**D** $CH_3CH_2CH_2CH(OH)CHBrCH_3$

**25** Which statement about the mechanism of an $S_N1$ reaction of a halogenoalkane is correct?

**A** A nucleophile is substituted by an electrophile.

**B** One intermediate is formed from two reacting molecules.

**C** The intermediate is stabilised by adjacent alkyl groups.

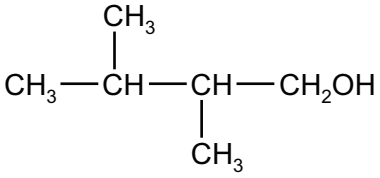
**D** The intermediate is uncharged.

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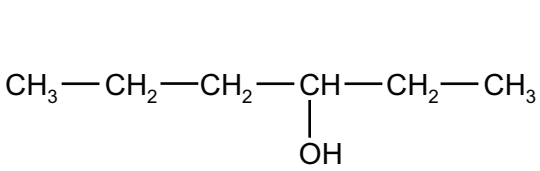
**26** Structural isomerism and stereoisomerism should be considered when answering this question.

Which isomer of $C_6H_{13}OH$ gives the greatest number of different alkenes when it is dehydrated?

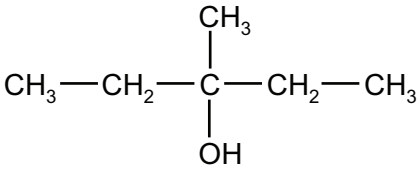
**A**



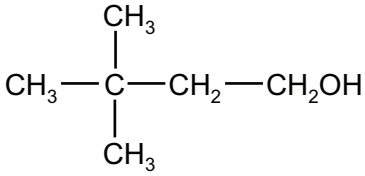
**B**



**C**



**D**



**27** Compound Q reacts with 2,4-dinitrophenylhydrazine to give a precipitate.

Compound Q does not produce a precipitate when warmed with Fehling's solution.

What could be the identity of compound Q?

**A** $CH_3COCH_3$

**B** $CH_2(OH)CH_2CH_3$

**C** $CH_3CH_2CO_2H$

**D** $CH_3CH_2CHO$

**28** Structural isomerism **only** should be considered when answering this question.

A set of isomeric compounds, with molecular formula $C_5H_{10}O$, all react in a 1 : 1 ratio with an excess of HCN by nucleophilic addition.

How many isomeric compounds are in the set?

**A** 5 **B** 6 **C** 7 **D** 8

**29** Which pair of substances could react to give the ester $CH_3CH_2CO_2CH_3$?

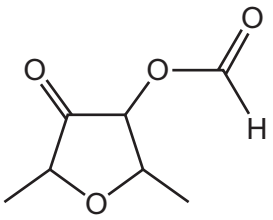
**A** ethanol and ethanoic acid

**B** methanol and ethanoic acid

**C** methanol and propanoic acid

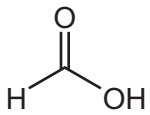
**D** propan-1-ol and methanoic acid

**30** An ester is shown.

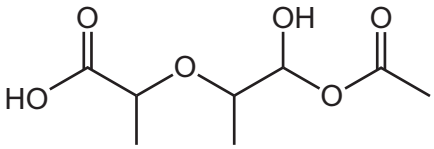


What is the structure of the carboxylic acid that would be obtained by acid hydrolysis of the ester linkage?

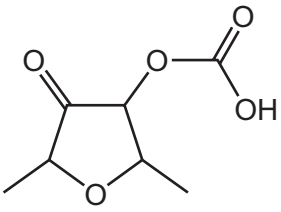
**A**



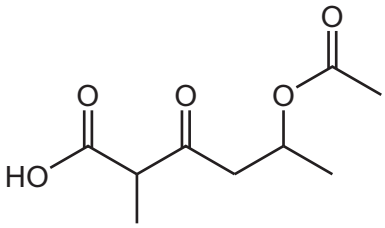
**B**



**C**



**D**



## 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** Which deductions about the $^{209}_{83}Bi$ atom are correct?

**1** It has 83 electrons.

**2** It has 126 nucleons.

**3** It has 83 neutrons.

**32** Which statements are correct when referring to the two common isotopes of chlorine?

**1** The isotopes have different masses.

**2** The isotopes have different numbers of nucleons.

**3** The isotopes have the same chemical reactions.

**33** For which enthalpy changes is the value of $\Delta H$ always negative?

**1** combustion

**2** hydration

**3** solution

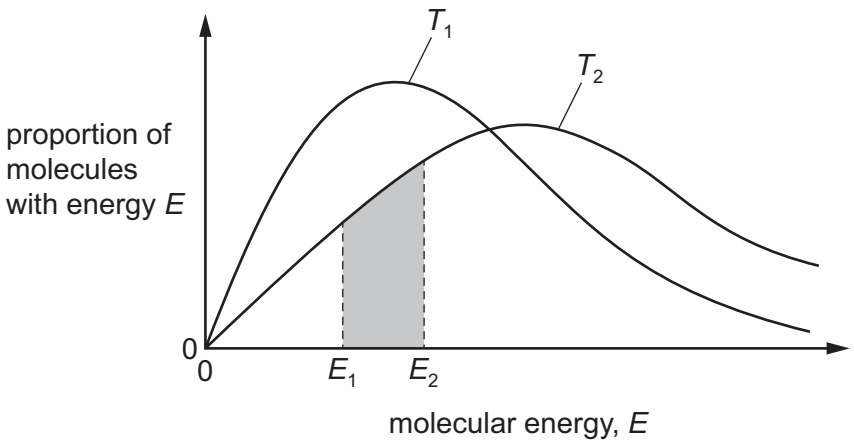
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The responses **A** to **D** should be selected on the basis of

| 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.

**34** The diagram shows the Boltzmann distribution of molecular energies in one mole of a gas at two temperatures, $T_1$ and $T_2$.




Which statements are correct?

**1** The shaded area represents the proportion of molecules with energies between $E_1$ and $E_2$ at temperature $T_2$.

**2** No particles have zero energy at either temperature.

**3** $T_2$ is a higher temperature than $T_1$.

**35** Which statements about sodium chloride are correct?

**1** It is a product of the reaction between chlorine and cold aqueous sodium hydroxide.

**2** It is a product of the reaction between chlorine and hot aqueous sodium hydroxide.

**3** It is a product of the reaction between chlorine and aqueous sodium bromide.

**36** Which gases will dissolve in water causing a lowering of the pH?

**1** ammonia

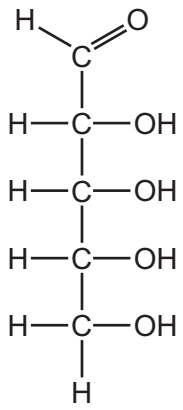
**2** sulfur dioxide

**3** nitrogen dioxide

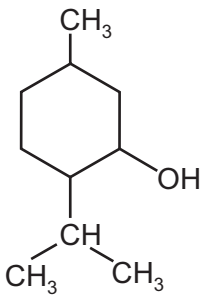
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**37** Which compounds have optical isomers?

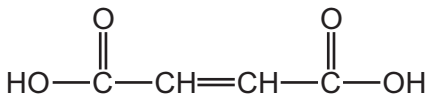
**1**



**2**



**3**



**38** Bromine reacts with ethene in an addition reaction.

Which statements about this reaction are correct?

**1** It is the basis of a test for unsaturation in alkenes.

**2** It leads to an increase in each of the H–C–H bond angles.

**3** A nucleophile attacks the C=C bond in ethene.

**39** An unknown organic compound Z reacts with sodium to give a combustible gas as one product. Z does **not** give a yellow precipitate with alkaline aqueous iodine.

What is a possible identity of Z?

**1** ethanoic acid

**2** pentan-3-ol

**3** propan-1-ol

**40** An organic molecule X has a molecular formula of $C_5H_{10}O_2$. Its infra-red spectrum has a strong peak at 1250 $cm^{-1}$, a strong peak at 1720 $cm^{-1}$ but no strong peak above 3100 $cm^{-1}$.

What could X be?

**1** ethyl propanoate

**2** methyl butanoate

**3** 1-hydroxypentan-3-one

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