



**Cambridge Assessment International Education**  
Cambridge International General Certificate of Secondary Education (9–1)

**CHEMISTRY**

**0971/22**

Paper 2 Multiple Choice (Extended)

**May/June 2019**

**45 minutes**

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



**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.

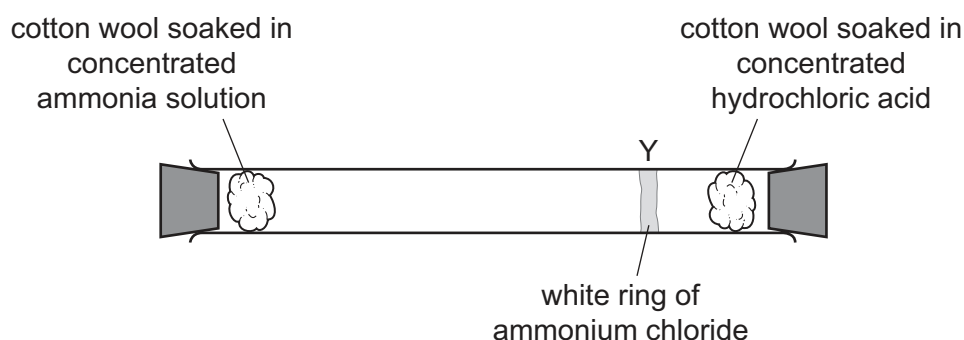
Any rough working should be done in this booklet.

A copy of the Periodic Table is printed on page 20.

Electronic calculators may be used.

This document consists of **17** printed pages and **3** blank pages.

- 1 The apparatus shown is set up. After 20 minutes a white ring of ammonium chloride is seen at position Y.



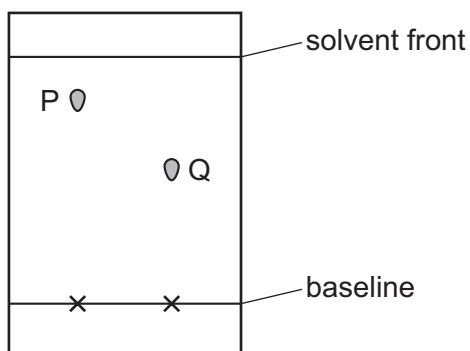
Which statement about the molecules of ammonia and hydrogen chloride is correct?

- A** Molecules in ammonia have a larger  $M_r$  than molecules of hydrogen chloride and so they move more slowly.
- B** Molecules in ammonia have a larger  $M_r$  than molecules of hydrogen chloride and so they move more quickly.
- C** Molecules in ammonia have a smaller  $M_r$  than molecules of hydrogen chloride and so they move more slowly.
- D** Molecules in ammonia have a smaller  $M_r$  than molecules of hydrogen chloride and so they move more quickly.
- 2 A student measures  $25.00\text{ cm}^3$  of dilute hydrochloric acid accurately.

Which apparatus is most suitable?

- A** beaker
- B** measuring cylinder
- C** burette
- D** dropping pipette

- 3 The chromatogram of solutions of two metal ions, P and Q, is shown.



P is coloured. A locating agent is used to find the position of Q.

The  $R_f$  value of each solution is calculated.

P is a .....1..... element and has an  $R_f$  value .....2..... than that of Q.

Which words complete gaps 1 and 2?

|          | 1              | 2       |
|----------|----------------|---------|
| <b>A</b> | non-transition | greater |
| <b>B</b> | non-transition | smaller |
| <b>C</b> | transition     | greater |
| <b>D</b> | transition     | smaller |

- 4 What is an isotope of  ${}^{31}_{15}\text{E}$ ?

**A**  ${}^{31}_{14}\text{E}$       **B**  ${}^{33}_{15}\text{E}$       **C**  ${}^{31}_{16}\text{E}$       **D**  ${}^{33}_{16}\text{E}$

- 5 Which row describes the formation of single covalent bonds in methane?

|          |  |   |
|----------|--|---|
| <b>A</b> | atoms share a pair of electrons                    | both atoms gain a noble gas electronic structure                  |
| <b>B</b> | atoms share a pair of electrons                    | both atoms have the same number of electrons in their outer shell |
| <b>C</b> | electrons are transferred from one atom to another | both atoms gain a noble gas electronic structure                  |
| <b>D</b> | electrons are transferred from one atom to another | both atoms have the same number of electrons in their outer shell |

6 Which statement describes the structure of an ionic compound?

- A It is a giant lattice of oppositely charged ions.
- B It is a giant lattice of positive ions in a 'sea' of electrons.
- C It is a giant molecule of oppositely charged ions.
- D It is a simple molecule of oppositely charged ions.

7 Calcium metal reacts with water to form a solution of calcium hydroxide and hydrogen gas.

Which equation is correct?

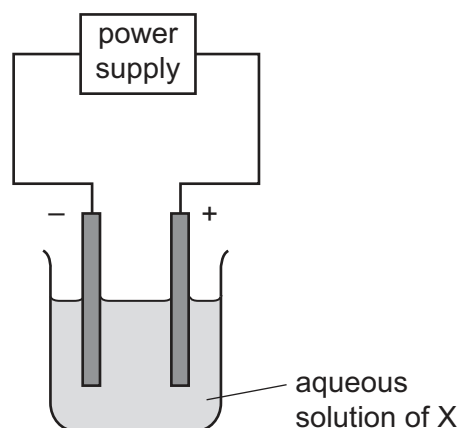
- A  $\text{Ca(s)} + \text{H}_2\text{O(aq)} \rightarrow \text{CaOH(aq)} + \text{H(g)}$
- B  $\text{Ca(s)} + 2\text{H}_2\text{O(aq)} \rightarrow \text{Ca(OH)}_2\text{(s)} + 2\text{H}_2\text{(g)}$
- C  $\text{Ca(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$
- D  $\text{Ca(s)} + \text{H}_2\text{O(l)} \rightarrow \text{CaOH(l)} + \text{H(g)}$

8  $25.0\text{ cm}^3$  of  $0.100\text{ mol/dm}^3$  aqueous sodium hydroxide is neutralised by  $24.6\text{ cm}^3$  of dilute sulfuric acid.

What is the concentration of the dilute sulfuric acid?

- A  $0.0508\text{ mol/dm}^3$
- B  $0.0984\text{ mol/dm}^3$
- C  $0.102\text{ mol/dm}^3$
- D  $0.203\text{ mol/dm}^3$

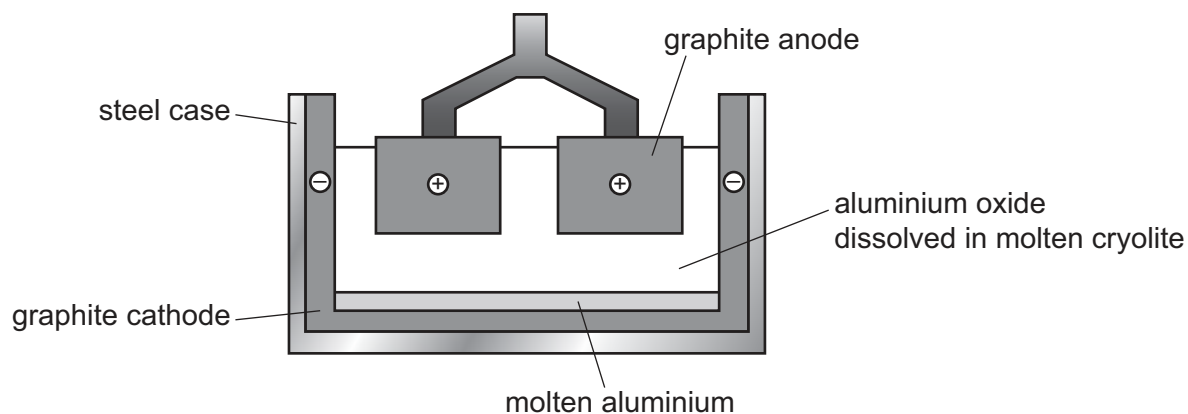
- 9 The diagram shows the electrolysis of an aqueous solution of X using inert electrodes.



Hydrogen is produced at the cathode and chlorine is produced at the anode.

What is X?

- A concentrated copper(II) chloride solution
  - B concentrated hydrochloric acid
  - C dilute hydrochloric acid
  - D dilute sodium chloride solution
- 10 Aluminium is extracted by electrolysis as shown.



Which row shows the ionic half-equations at the cathode and the anode?

|   | cathode                           | anode                              |
|---|-----------------------------------|------------------------------------|
| A | $Al^{3+} \rightarrow Al + 3e^{-}$ | $2O^{2-} \rightarrow O_2 + 4e^{-}$ |
| B | $Al^{3+} \rightarrow Al + 3e^{-}$ | $2O^{2-} + 4e^{-} \rightarrow O_2$ |
| C | $Al^{3+} + 3e^{-} \rightarrow Al$ | $2O^{2-} \rightarrow O_2 + 4e^{-}$ |
| D | $Al^{3+} + 3e^{-} \rightarrow Al$ | $2O^{2-} + 4e^{-} \rightarrow O_2$ |

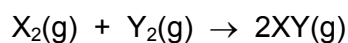
11 Fuel cells are used as energy sources in cars.

Which row gives a fuel used in a fuel cell and the products formed?

|          | fuel in a fuel cell | products formed          |
|----------|---------------------|--------------------------|
| <b>A</b> | hydrogen            | carbon dioxide and water |
| <b>B</b> | hydrogen            | water only               |
| <b>C</b> | petrol              | carbon dioxide and water |
| <b>D</b> | petrol              | water only               |

12 Two elements, X and Y, react together to form a covalent molecule as shown.

The reaction is exothermic.



The bond energies are shown in the table.

| bond | bond energy in kJ/mol |
|------|-----------------------|
| X–X  | 436                   |
| Y–Y  | 242                   |
| X–Y  | 431                   |

What is the energy change for the reaction?

**A** +184 kJ/mol    **B** –184 kJ/mol    **C** +247 kJ/mol    **D** –247 kJ/mol

13 Which change in reaction conditions increases both the collision rate and the proportion of molecules with sufficient energy to react?

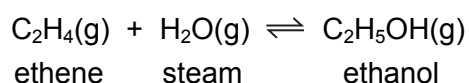
- A** addition of a catalyst
- B** increasing the concentration of a reactant
- C** increasing the surface area of a reactant
- D** increasing the temperature of the reaction

- 14 When blue-green crystals of nickel(II) sulfate are heated, water is produced and a yellow solid remains. When water is added to the yellow solid, the blue-green colour returns.

Which process describes these changes?

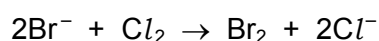
- A combustion
- B corrosion
- C neutralisation
- D reversible reaction

- 15 The equation for the manufacture of ethanol is shown.



What is the effect of doubling the pressure on this reaction?

- A decreases the rate of formation of ethanol
  - B increases the yield of ethene
  - C decreases the rate of formation of ethene
  - D increases the yield of ethanol
- 16 The ionic equation for the reaction of aqueous potassium bromide with chlorine gas is shown.



Which statement is correct?

- A Bromide ions are oxidised by gaining electrons.
- B Bromide ions are oxidised by losing electrons.
- C Chlorine is oxidised by gaining electrons.
- D Chlorine is oxidised by losing electrons.

- 17 Which type of oxide are carbon monoxide and aluminium oxide?

|   | carbon monoxide | aluminium oxide |
|---|-----------------|-----------------|
| A | acidic          | amphoteric      |
| B | acidic          | basic           |
| C | neutral         | amphoteric      |
| D | neutral         | basic           |

18 The positions of elements W, X, Y and Z in the Periodic Table are shown.

|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
|---|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|---|
|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
| W |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
|   |   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   |
|   | X |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Z |

Which elements form basic oxides?

- A** W, X and Y    **B** W and X only    **C** Y only    **D** Z only

19 Which row shows the difference between a weak acid and a strong acid?

|          | weak acid         | strong acid       |
|----------|-------------------|-------------------|
| <b>A</b> | fully ionised     | partially ionised |
| <b>B</b> | concentrated      | dilute            |
| <b>C</b> | dilute            | concentrated      |
| <b>D</b> | partially ionised | fully ionised     |

20 Part of the Periodic Table is shown.

|  |   |  |  |  |  |  |  |  |   |  |  |  |  |  |  |  |  |   |
|--|---|--|--|--|--|--|--|--|---|--|--|--|--|--|--|--|--|---|
|  |   |  |  |  |  |  |  |  |   |  |  |  |  |  |  |  |  |   |
|  |   |  |  |  |  |  |  |  |   |  |  |  |  |  |  |  |  | X |
|  |   |  |  |  |  |  |  |  |   |  |  |  |  |  |  |  |  |   |
|  | Y |  |  |  |  |  |  |  | Z |  |  |  |  |  |  |  |  |   |

Which row describes the properties of X, Y and Z?

|          | good conductor of electricity | high melting point |
|----------|-------------------------------|--------------------|
| <b>A</b> | X                             | Z                  |
| <b>B</b> | Y                             | Z and X            |
| <b>C</b> | Y and Z                       | Z                  |
| <b>D</b> | Z and X                       | X                  |



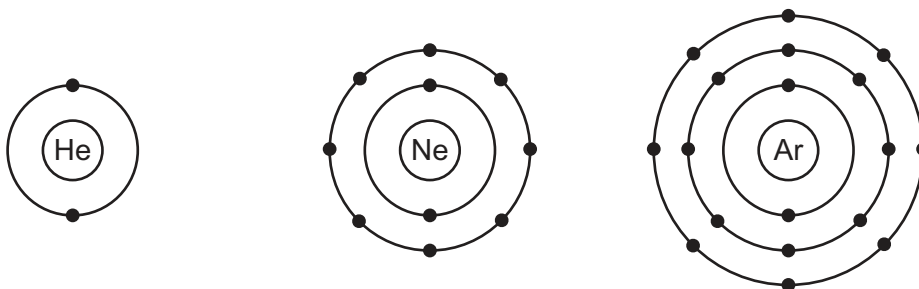
21 The melting points and boiling points of the elements of Group I of the Periodic Table are shown.

| element   | melting point /°C | boiling point /°C |
|-----------|-------------------|-------------------|
| lithium   | 181               | 1330              |
| sodium    | 98                | 883               |
| potassium | 63                | 759               |
| rubidium  | 39                | 688               |
| caesium   | 28                | 671               |

Which pair of elements are liquid at 800 °C?

- A caesium and rubidium
- B potassium and sodium
- C lithium and sodium
- D potassium and caesium

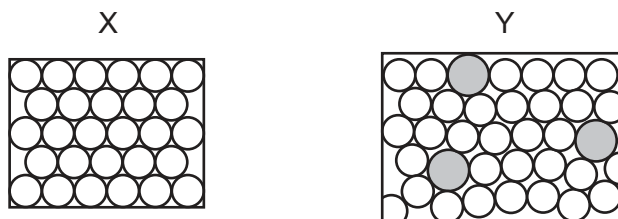
22 The electronic structures of helium, neon and argon are shown.



Which row describes these gases?

|          | reactivity | form of the gas | electronic structure                |
|----------|------------|-----------------|-------------------------------------|
| <b>A</b> | reactive   | monoatomic      | incomplete outer shell of electrons |
| <b>B</b> | unreactive | diatomic        | complete outer shell of electrons   |
| <b>C</b> | unreactive | diatomic        | incomplete outer shell of electrons |
| <b>D</b> | unreactive | monoatomic      | complete outer shell of electrons   |

23 The diagrams show the structure of two substances used to make electrical conductors.



Which statement correctly describes X and Y?

- A X is a pure metal and Y is a compound.
- B X is a pure metal and Y is an alloy.
- C X is a solid and Y is a liquid.
- D X is harder and stronger than Y.

24 A student heated the carbonates and nitrates of sodium and copper.

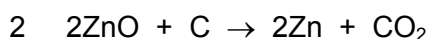
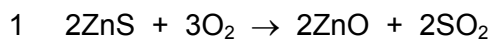
The results are shown.

|   | compound heated      | gases released              | solid formed     |
|---|----------------------|-----------------------------|------------------|
| 1 | sodium carbonate     | carbon monoxide             | sodium oxide     |
| 2 | copper(II) carbonate | carbon dioxide              | copper           |
| 3 | sodium nitrate       | oxygen only                 | sodium nitrite   |
| 4 | copper(II) nitrate   | nitrogen dioxide and oxygen | copper(II) oxide |

Which rows describe the correct results?

- A 1 and 3
- B 2 and 3
- C 3 and 4
- D 4 only

25 Zinc is extracted from its ore, zinc blende, using two chemical reactions.



Which substance is reduced in reactions 1 and 2?

|   | reaction 1     | reaction 2 |
|---|----------------|------------|
| A | O <sub>2</sub> | C          |
| B | O <sub>2</sub> | ZnO        |
| C | ZnS            | C          |
| D | ZnS            | ZnO        |

- 26 Four metals, zinc, M, copper and magnesium, are reacted with aqueous solutions of their nitrates.

The results are shown.

| metal     | magnesium nitrate | M nitrate | copper nitrate | zinc nitrate |                 |
|-----------|-------------------|-----------|----------------|--------------|-----------------|
| magnesium |                   | ✓         | ✓              | ✓            | key             |
| zinc      | X                 | ✓         | ✓              |              | ✓ = reacts      |
| M         | X                 |           | ✓              | X            | X = no reaction |
| copper    | X                 | X         |                | X            |                 |

What is the order of reactivity of these four metals starting with the most reactive?

- A copper → zinc → M → magnesium  
 B copper → M → zinc → magnesium  
 C magnesium → M → zinc → copper  
 D magnesium → zinc → M → copper
- 27 Which property of aluminium makes it useful in the manufacture of aircraft?
- A conducts electricity  
 B high boiling point  
 C low density  
 D silver colour
- 28 The exhaust gases from cars contain oxides of nitrogen.

How are these oxides of nitrogen formed?

- A Nitrogen and oxygen from the air react together at the high temperatures in the engine.  
 B Nitrogen and oxygen from the petrol react together in the car exhaust.  
 C Nitrogen from the petrol reacts with oxygen at the high temperatures in the engine.  
 D Nitrogen reacts with oxygen from the air in the catalytic converter.

29 Water can be treated by filtration then chlorination.

Which uses do **not** need water of this quality?

- 1 water for cooling in industry
- 2 water for washing clothes
- 3 water for drinking

**A** 1, 2 and 3    **B** 1 and 2 only    **C** 1 and 3 only    **D** 2 and 3 only

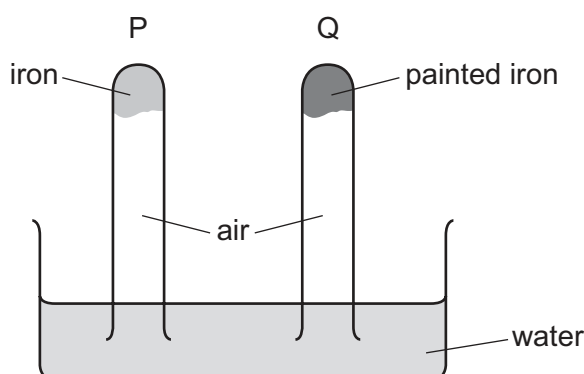
30 Some of the processes involved in the carbon cycle are shown.

- 1 glucose + oxygen → carbon dioxide + water
- 2 carbon dioxide + water → glucose + oxygen
- 3 methane + oxygen → carbon dioxide + water

What are the names of these processes?

|          | 1              | 2              | 3              |
|----------|----------------|----------------|----------------|
| <b>A</b> | combustion     | respiration    | photosynthesis |
| <b>B</b> | photosynthesis | combustion     | respiration    |
| <b>C</b> | respiration    | combustion     | photosynthesis |
| <b>D</b> | respiration    | photosynthesis | combustion     |

31 The diagram shows an experiment to investigate how paint affects the rusting of iron.

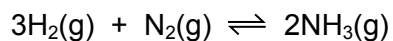


What happens to the water level in tubes P and Q?

|          | tube P    | tube Q    |
|----------|-----------|-----------|
| <b>A</b> | falls     | rises     |
| <b>B</b> | no change | rises     |
| <b>C</b> | rises     | falls     |
| <b>D</b> | rises     | no change |

32 Ammonia is produced in the Haber process.

The equation for the reaction is shown.



The forward reaction is exothermic.

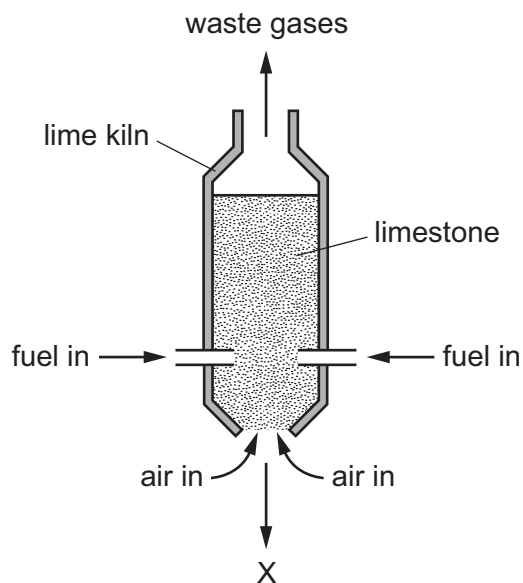
Which conditions of temperature and pressure produce the highest yield of ammonia?

|          | temperature | pressure |
|----------|-------------|----------|
| <b>A</b> | high        | high     |
| <b>B</b> | high        | low      |
| <b>C</b> | low         | high     |
| <b>D</b> | low         | low      |

33 Which row shows the conditions used in the Contact process?

|          | temperature<br>/°C | pressure<br>/atm | catalyst          |
|----------|--------------------|------------------|-------------------|
| <b>A</b> | 25                 | 2                | iron              |
| <b>B</b> | 25                 | 200              | iron              |
| <b>C</b> | 450                | 2                | vanadium(V) oxide |
| <b>D</b> | 450                | 200              | vanadium(V) oxide |

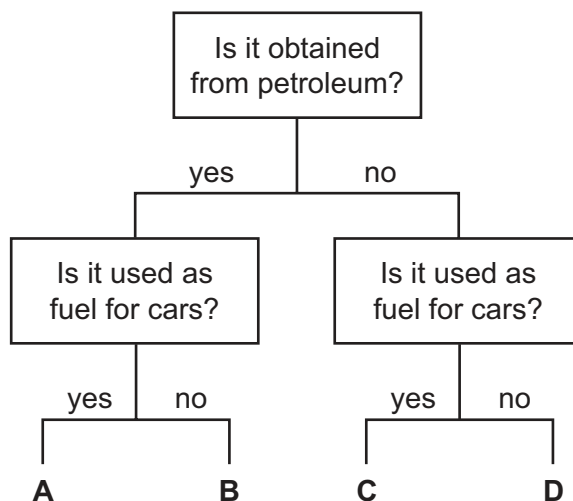
34 The diagram represents a lime kiln used to heat limestone to a very high temperature.



What leaves the kiln at X?

- A calcium carbonate
- B calcium hydroxide
- C calcium oxide
- D calcium sulfate

35 Which fuel could be gasoline?



36 Which statement about homologous series is **not** correct?

- A All homologous series are hydrocarbons.
- B Members of a homologous series have the same functional group.
- C Members of a homologous series have similar chemical properties.
- D The alkanes are an example of a homologous series.

37 In bright sunlight, ethane and chlorine combine in substitution reactions.

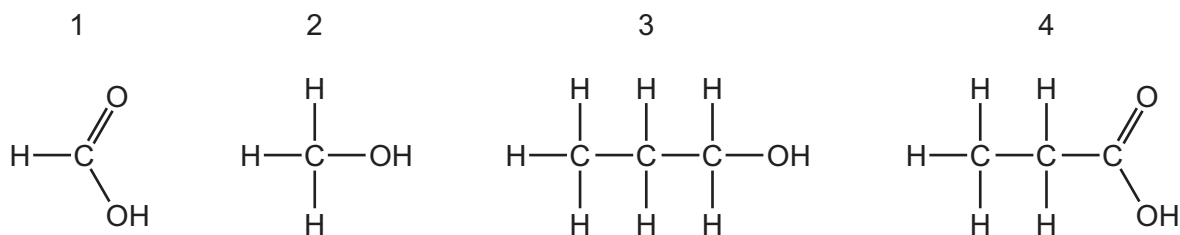
Which compound is **not** formed in these reactions?

- A  $C_2H_3Cl$       B  $C_2H_5Cl$       C  $C_2H_4Cl_2$       D  $HCl$

38 What are the properties of aqueous ethanoic acid?

|   | decolourises bromine water | reacts with calcium carbonate to make carbon dioxide | turns damp red litmus blue |
|---|----------------------------|--|----------------------------|
| A | ✓                          | ✓  | x                          |
| B | ✓                          | x  | ✓                          |
| C | x                          | ✓  | x                          |
| D | x                          | x  | ✓                          |

39 The structures of four molecules are shown.

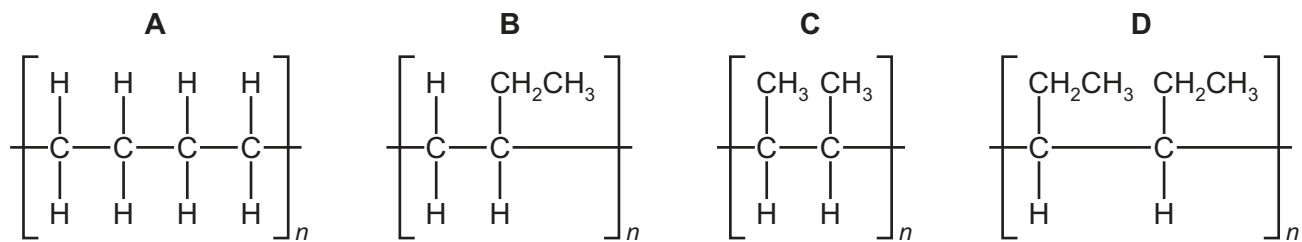


Which molecules react together to form the ester propyl methanoate?

- A 1 and 2      B 1 and 3      C 2 and 4      D 3 and 4

40 But-1-ene has the structure  $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$ .

What is the structure of poly(but-1-ene)?









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## The Periodic Table of Elements

|                                   |                                    | Group                              |  |                                    |                                     |                                     |                                     |                                     |                                       |                                      |                                      |                                    |                                      |                                    |                                     |                                  |                                  |                               |
|-----------------------------------|------------------------------------|------------------------------------|--|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---------------------------------------|--------------------------------------|--------------------------------------|------------------------------------|--------------------------------------|------------------------------------|-------------------------------------|----------------------------------|----------------------------------|-------------------------------|
| I                                 | II                                 | III                                | IV                                     | V                                  | VI                                  | VII                                 | VIII                                |                                     |                                       |                                      |                                      |                                    |                                      |                                    |                                     |                                  |                                  |                               |
| 3<br><b>Li</b><br>lithium<br>7    | 4<br><b>Be</b><br>beryllium<br>9   | 5<br><b>B</b><br>boron<br>11       | 6<br><b>C</b><br>carbon<br>12          | 7<br><b>N</b><br>nitrogen<br>14    | 8<br><b>O</b><br>oxygen<br>16       | 9<br><b>F</b><br>fluorine<br>19     | 10<br><b>Ne</b><br>neon<br>20       |                                     |                                       |                                      |                                      | 2<br><b>He</b><br>helium<br>4      |                                      |                                    |                                     |                                  |                                  |                               |
| 11<br><b>Na</b><br>sodium<br>23   | 12<br><b>Mg</b><br>magnesium<br>24 | 13<br><b>Al</b><br>aluminium<br>27 | 14<br><b>Si</b><br>silicon<br>28       | 15<br><b>P</b><br>phosphorus<br>31 | 16<br><b>S</b><br>sulfur<br>32      | 17<br><b>Cl</b><br>chlorine<br>35.5 | 18<br><b>Ar</b><br>argon<br>40      |                                     |                                       |                                      |                                      | 36<br><b>Kr</b><br>krypton<br>84   |                                      |                                    |                                     |                                  |                                  |                               |
| 19<br><b>K</b><br>potassium<br>39 | 20<br><b>Ca</b><br>calcium<br>40   | 21<br><b>Sc</b><br>scandium<br>45  | 22<br><b>Ti</b><br>titanium<br>48      | 23<br><b>V</b><br>vanadium<br>51   | 24<br><b>Cr</b><br>chromium<br>52   | 25<br><b>Mn</b><br>manganese<br>55  | 26<br><b>Fe</b><br>iron<br>56       | 27<br><b>Co</b><br>cobalt<br>59     | 28<br><b>Ni</b><br>nickel<br>59       | 29<br><b>Cu</b><br>copper<br>64      | 30<br><b>Zn</b><br>zinc<br>65        | 31<br><b>Ga</b><br>gallium<br>70   | 32<br><b>Ge</b><br>germanium<br>73   | 33<br><b>As</b><br>arsenic<br>75   | 34<br><b>Se</b><br>selenium<br>79   | 35<br><b>Br</b><br>bromine<br>80 | 36<br><b>Kr</b><br>krypton<br>84 |                               |
| 37<br><b>Rb</b><br>rubidium<br>85 | 38<br><b>Sr</b><br>strontium<br>88 | 39<br><b>Y</b><br>yttrium<br>89    | 40<br><b>Zr</b><br>zirconium<br>91     | 41<br><b>Nb</b><br>niobium<br>93   | 42<br><b>Mo</b><br>molybdenum<br>96 | 43<br><b>Tc</b><br>technetium<br>—  | 44<br><b>Ru</b><br>ruthenium<br>101 | 45<br><b>Rh</b><br>rhodium<br>103   | 46<br><b>Pd</b><br>palladium<br>106   | 47<br><b>Ag</b><br>silver<br>108     | 48<br><b>Cd</b><br>cadmium<br>112    | 49<br><b>In</b><br>indium<br>115   | 50<br><b>Sn</b><br>tin<br>119        | 51<br><b>Sb</b><br>antimony<br>122 | 52<br><b>Te</b><br>tellurium<br>128 | 53<br><b>I</b><br>iodine<br>127  | 54<br><b>Xe</b><br>xenon<br>131  | 86<br><b>Rn</b><br>radon<br>— |
| 55<br><b>Cs</b><br>caesium<br>133 | 56<br><b>Ba</b><br>barium<br>137   | 57–71<br>lanthanoids               | 72<br><b>Hf</b><br>hafnium<br>178      | 73<br><b>Ta</b><br>tantalum<br>181 | 74<br><b>W</b><br>tungsten<br>184   | 75<br><b>Re</b><br>rhenium<br>186   | 76<br><b>Os</b><br>osmium<br>190    | 77<br><b>Ir</b><br>iridium<br>192   | 78<br><b>Pt</b><br>platinum<br>195    | 79<br><b>Au</b><br>gold<br>197       | 80<br><b>Hg</b><br>mercury<br>201    | 81<br><b>Tl</b><br>thallium<br>204 | 82<br><b>Pb</b><br>lead<br>207       | 83<br><b>Bi</b><br>bismuth<br>209  | 84<br><b>Po</b><br>polonium<br>—    | 85<br><b>At</b><br>astatine<br>— | 86<br><b>Rn</b><br>radon<br>—    |                               |
| 87<br><b>Fr</b><br>francium<br>—  | 88<br><b>Ra</b><br>radium<br>—     | 89–103<br>actinoids                | 104<br><b>Rf</b><br>rutherfordium<br>— | 105<br><b>Db</b><br>dubnium<br>—   | 106<br><b>Sg</b><br>seaborgium<br>— | 107<br><b>Bh</b><br>bohrium<br>—    | 108<br><b>Hs</b><br>hassium<br>—    | 109<br><b>Mt</b><br>meitnerium<br>— | 110<br><b>Ds</b><br>darmstadtium<br>— | 111<br><b>Rg</b><br>roentgenium<br>— | 112<br><b>Cn</b><br>copernicium<br>— | 114<br><b>Fl</b><br>flerovium<br>— | 116<br><b>Lv</b><br>livermorium<br>— | —                                  | —                                   | —                                | —                                | —                             |

## Key

|                      |
|----------------------|
| atomic number        |
| atomic symbol        |
| name                 |
| relative atomic mass |

|   |          |          |   |
|---|----------|----------|---|
| 1 | <b>H</b> | hydrogen | 1 |
|---|----------|----------|---|

|             |                                     |                                   |  |                                     |                                    |                                    |                                    |                                      |                                   |                                      |                                     |                                  |                                      |                                     |                                     |
|-------------|-------------------------------------|-----------------------------------|--|-------------------------------------|------------------------------------|------------------------------------|------------------------------------|--------------------------------------|-----------------------------------|--------------------------------------|-------------------------------------|----------------------------------|--------------------------------------|-------------------------------------|-------------------------------------|
| lanthanoids | 57<br><b>La</b><br>lanthanum<br>139 | 58<br><b>Ce</b><br>cerium<br>140  | 59<br><b>Pr</b><br>praseodymium<br>141 | 60<br><b>Nd</b><br>neodymium<br>144 | 61<br><b>Pm</b><br>promethium<br>— | 62<br><b>Sm</b><br>samarium<br>150 | 63<br><b>Eu</b><br>europium<br>152 | 64<br><b>Gd</b><br>gadolinium<br>157 | 65<br><b>Tb</b><br>terbium<br>159 | 66<br><b>Dy</b><br>dysprosium<br>163 | 67<br><b>Ho</b><br>holmium<br>165   | 68<br><b>Er</b><br>erbium<br>167 | 69<br><b>Tm</b><br>thulium<br>169    | 70<br><b>Yb</b><br>ytterbium<br>173 | 71<br><b>Lu</b><br>lutetium<br>175  |
| actinoids   | 89<br><b>Ac</b><br>actinium<br>—    | 90<br><b>Th</b><br>thorium<br>232 | 91<br><b>Pa</b><br>protactinium<br>231 | 92<br><b>U</b><br>uranium<br>238    | 93<br><b>Np</b><br>neptunium<br>—  | 94<br><b>Pu</b><br>plutonium<br>—  | 95<br><b>Am</b><br>americium<br>—  | 96<br><b>Cm</b><br>curium<br>—       | 97<br><b>Bk</b><br>berkelium<br>— | 98<br><b>Cf</b><br>californium<br>—  | 99<br><b>Es</b><br>einsteinium<br>— | 100<br><b>Fm</b><br>fermium<br>— | 101<br><b>Md</b><br>mendelevium<br>— | 102<br><b>No</b><br>nobelium<br>—   | 103<br><b>Lr</b><br>lawrencium<br>— |

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).