

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Ordinary Level

**CHEMISTRY**

**5070/01**

Paper 1 Multiple Choice

October/November 2006

**1 hour**

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, highlighters, 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.

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 16.

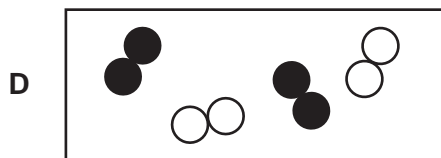
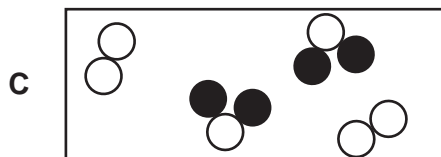
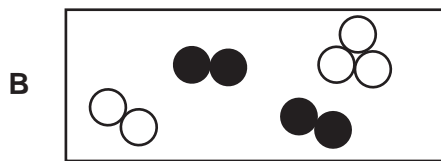
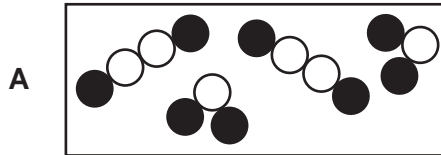
This document consists of **16** printed pages.



- 1 At which temperature does a concentrated aqueous solution of sodium chloride begin to boil?  
**A** 96°C            **B** 99°C            **C** 100°C            **D** 104°C

- 2 The symbols  and  represent atoms of different elements.

Which diagram shows a mixture of an element and a compound?

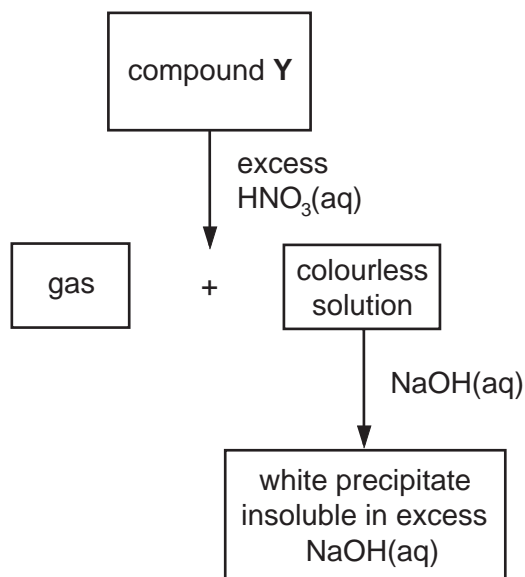


- 3 An aqueous solution of compound **X** reacts with aqueous sodium hydroxide to form a green precipitate and then aluminium powder is added. The mixture is heated and a gas that turns damp red litmus paper blue is given off.

What is **X**?

- A** ammonium nitrate  
**B** copper(II) chloride  
**C** iron(II) nitrate  
**D** iron(III) chloride

- 4 Which of the following reagents could be used to distinguish between dilute nitric acid and dilute hydrochloric acid?
- A aqueous barium chloride
  - B copper(II) carbonate
  - C aqueous silver nitrate
  - D aqueous sodium hydroxide
- 5 The scheme shows some reactions of a compound Y.



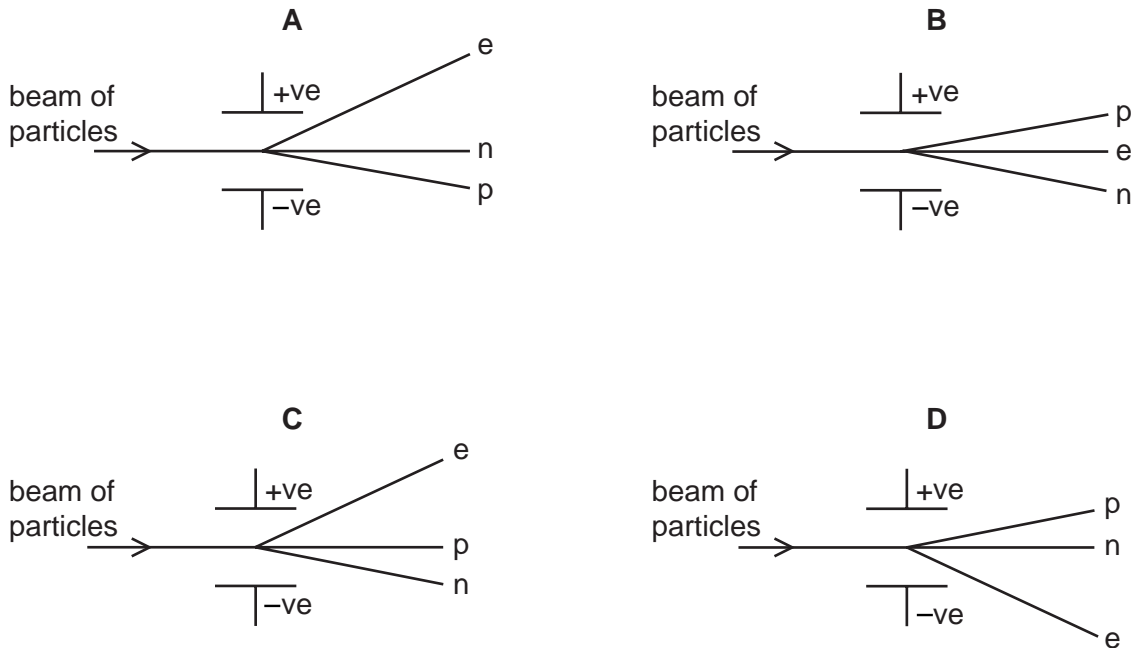
What could the compound Y be?

- A aluminium sulphate
- B calcium carbonate
- C copper(II) carbonate
- D zinc carbonate

- 6 A beam of particles contains neutrons, n, protons, p, and electrons, e.

The beam is passed between charged plates.

Which diagram shows how the particles are affected by the plates?

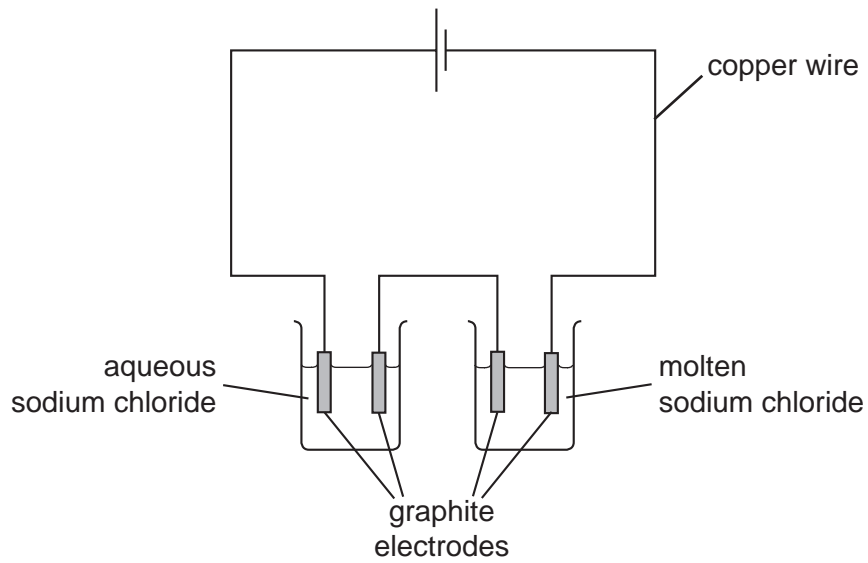


- 7 The table shows the properties of some substances.

Which substance is a covalent compound?

|          | melting point<br>/°C | electrical conductivity |                  |
|----------|----------------------|-------------------------|------------------|
|          |                      | of solid                | of liquid        |
| <b>A</b> | -38                  | conducts                | conducts         |
| <b>B</b> | -7                   | does not conduct        | does not conduct |
| <b>C</b> | 801                  | does not conduct        | conducts         |
| <b>D</b> | 1540                 | conducts                | conducts         |

- 8 The diagram shows the electrolysis of aqueous sodium chloride and of molten sodium chloride.



Which substance has both positive ions and mobile electrons?

- A aqueous sodium chloride
  - B copper wire
  - C graphite electrodes
  - D molten sodium chloride
- 9 Hydrogen can form both ionic and covalent compounds.
- With which element will hydrogen form an ionic compound?
- A carbon
  - B chlorine
  - C nitrogen
  - D sodium
- 10 Which quantity is the same for one mole of ethanol and one mole of ethane?
- A mass
  - B number of atoms
  - C number of molecules
  - D volume at r.t.p.

11 In an experiment 264 g of strontium reacts with 213 g of chlorine.

What is the formula of strontium chloride?

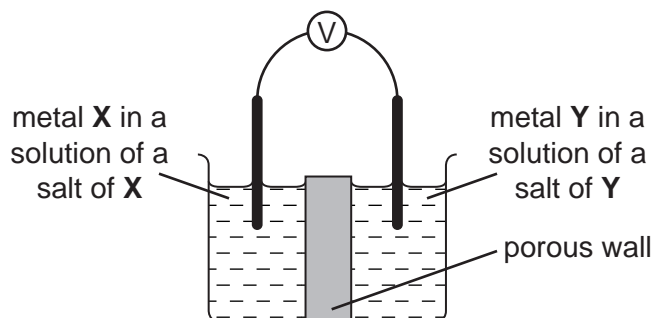
- A  $\text{SrCl}$             B  $\text{SrCl}_2$             C  $\text{SrCl}_3$             D  $\text{Sr}_2\text{Cl}$

12 Aqueous copper(II) sulphate is electrolysed using copper electrodes.

Which observations will be made?

|          | at anode (+ve)       | at cathode (-ve)     | electrolyte       |
|----------|----------------------|----------------------|-------------------|
| <b>A</b> | anode dissolves      | pink solid forms     | blue colour fades |
| <b>B</b> | anode dissolves      | pink solid forms     | no change         |
| <b>C</b> | colourless gas forms | colourless gas forms | no change         |
| <b>D</b> | colourless gas forms | pink solid forms     | blue colour fades |

13 Which pair of metals **X** and **Y** will produce the highest voltage when used as electrodes in a simple cell?

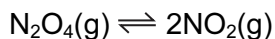


|          | metal X   | metal Y |
|----------|-----------|---------|
| <b>A</b> | copper    | silver  |
| <b>B</b> | magnesium | silver  |
| <b>C</b> | magnesium | zinc    |
| <b>D</b> | zinc      | copper  |

14 On combustion, which fuel **never** produces pollutants?

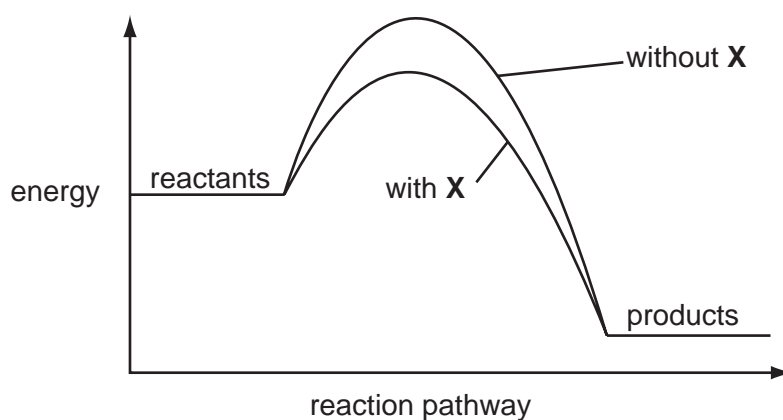
- A diesel  
B hydrogen  
C methane  
D petrol

- 15 The reversible reaction below has reached dynamic equilibrium.



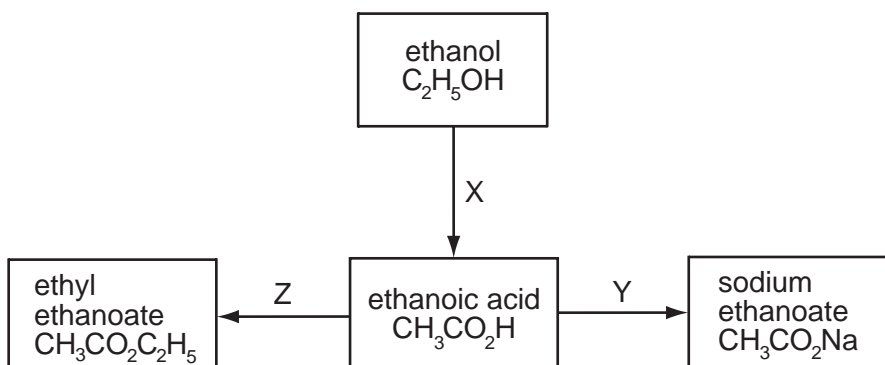
What does the term *dynamic equilibrium* mean?

- A** The reaction has stopped.  
**B** The rate of the forward reaction is now zero.  
**C** The concentrations of  $\text{NO}_2$  and  $\text{N}_2\text{O}_4$  are equal.  
**D** The rates of the forward and backward reactions are equal.
- 16 The energy profile diagrams show how adding a substance **X** to a reaction mixture changes the reaction pathway.



Which change occurs when **X** is added to the reaction mixture?

- A** The rate of reaction decreases.  
**B** The rate of reaction increases.  
**C** The reaction becomes less exothermic.  
**D** The reaction becomes more exothermic.
- 17 Which of the reactions X, Y and Z involve oxidation?



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





22 Why is nickel used in the hydrogenation of alkenes?

- A It increases the yield of products.
- B It lowers the activation energy of the reaction.
- C It makes the reaction more exothermic.
- D It prevents a reverse reaction from occurring.

23 Three elements X, Y and Z have consecutive, increasing proton numbers.

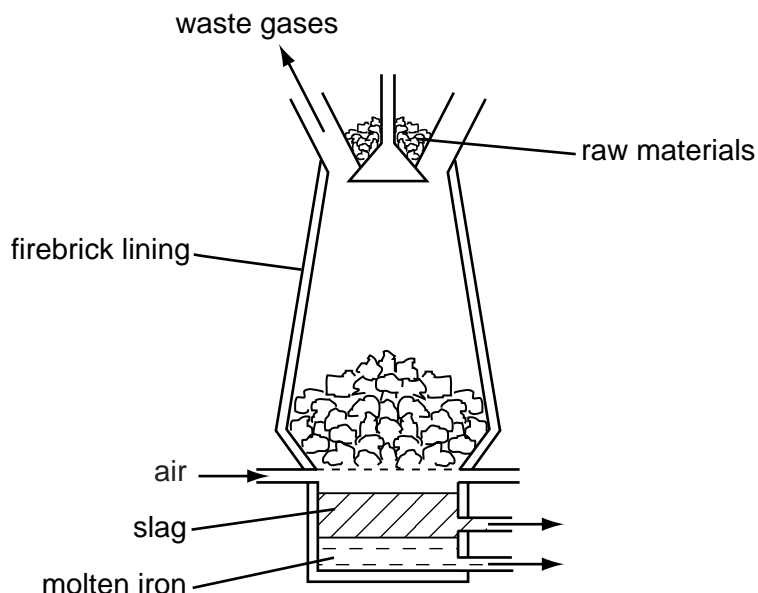
If element X is a noble gas, what will be the symbol for the ions of element Z in its compounds?

- A  $Z^{2-}$                       B  $Z^{+}$                       C  $Z^{2+}$                       D  $Z^{3+}$

24 Which substance reacts with water to form a soluble compound and an insoluble gas?

- A ammonium sulphate
- B caesium
- C calcium carbonate
- D copper

25 Iron is extracted in the blast furnace using the raw materials haematite, coke and limestone.



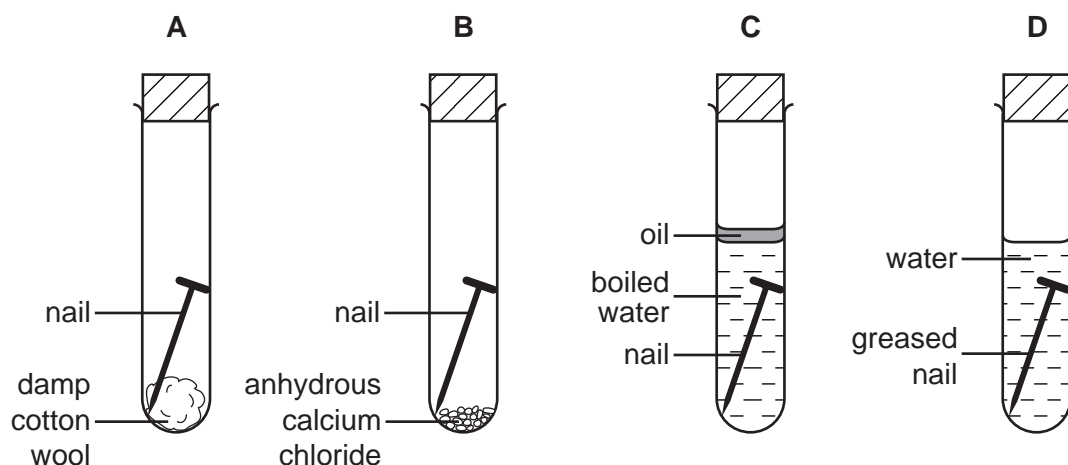
Which substance undergoes thermal decomposition?

- A limestone
- B carbon dioxide
- C haematite
- D slag

26 Which gas is **not** formed during the manufacture of aluminium?

- A carbon dioxide
- B carbon monoxide
- C oxygen
- D sulphur dioxide

27 In which test-tube is the iron nail **most** likely to rust?



28 The carbonate of metal **X** is a white solid.

It decomposes when heated to form carbon dioxide and a yellow solid oxide.

What is metal **X**?

- A copper
- B iron
- C lead
- D sodium

29 Which metal will displace hydrogen from aqueous solutions of acids but not from cold water?

- A calcium
- B copper
- C sodium
- D zinc

30 The table shows the solubility of some salts of metal **Y** in cold water.

| salt      | solubility in cold water |
|-----------|--------------------------|
| carbonate | insoluble                |
| chloride  | soluble                  |
| sulphate  | insoluble                |

What is metal **Y**?

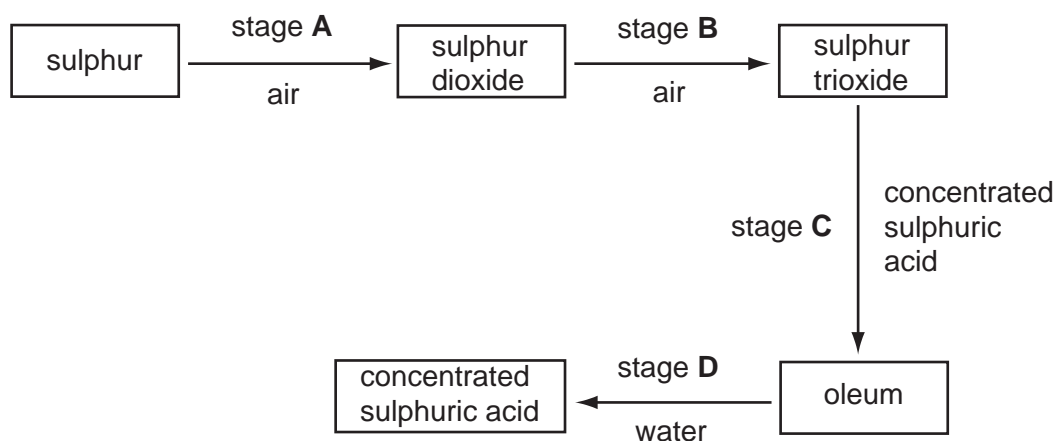
- A barium
- B lead
- C magnesium
- D sodium

31 Which method would **not** produce ammonia gas?

- A heating concentrated aqueous ammonia
- B heating ammonium chloride with calcium hydroxide
- C heating ammonium sulphate with sodium hydroxide
- D heating ammonium sulphate with dilute hydrochloric acid

32 The following scheme shows four stages in the conversion of sulphur to sulphuric acid.

In which stage is a catalyst used?



33 Vegetable matter is biodegradable.

Which gas is released into the atmosphere when vegetable matter biodegrades?

- A carbon monoxide
- B methane
- C nitrogen dioxide
- D sulphur dioxide

34 To reduce atmospheric pollution, the waste gases from a coal-burning power station are passed through powdered calcium carbonate.

Which waste gas will **not** be removed by the powdered calcium carbonate?

- A carbon monoxide, CO
- B nitrogen dioxide, NO<sub>2</sub>
- C phosphorus(V) oxide, P<sub>2</sub>O<sub>5</sub>
- D sulphur dioxide, SO<sub>2</sub>

35 A compound, **X**, has a molecular formula C<sub>4</sub>H<sub>8</sub>O<sub>2</sub> and can be prepared by the reactions shown.



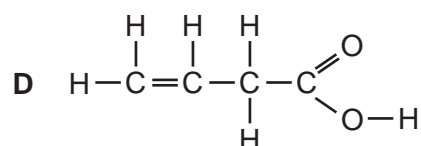
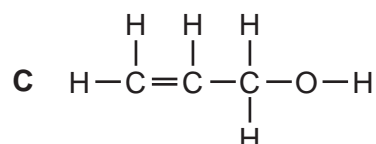
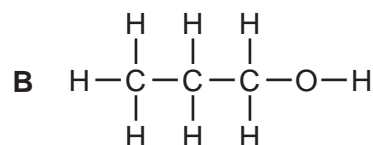
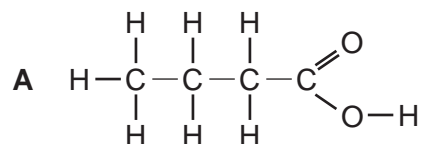
What is the structural formula of **X**?

- A HCO<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>
- B CH<sub>3</sub>CO<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>
- C CH<sub>3</sub>CH<sub>2</sub>CO<sub>2</sub>CH<sub>3</sub>
- D CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CO<sub>2</sub>H

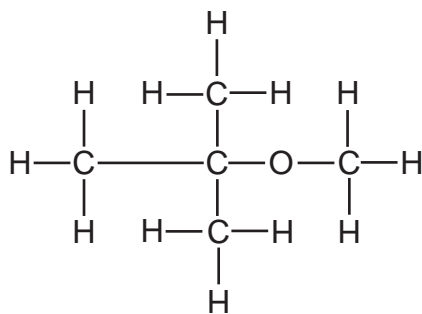
36 The results of tests on compound **Z** are shown.

| test                         | result                |
|------------------------------|-----------------------|
| add bromine water            | turns colourless      |
| add aqueous sodium carbonate | carbon dioxide formed |

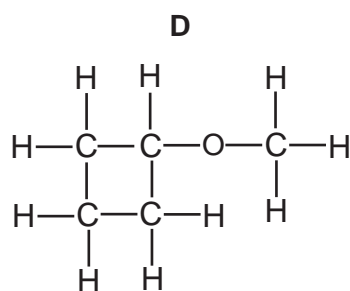
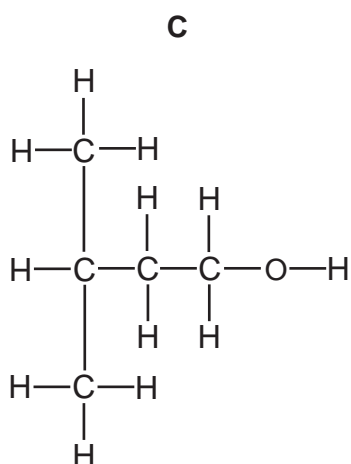
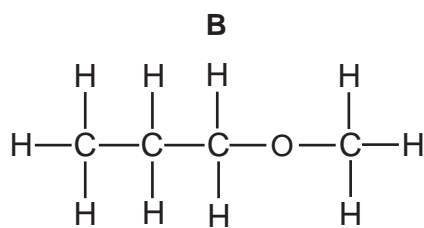
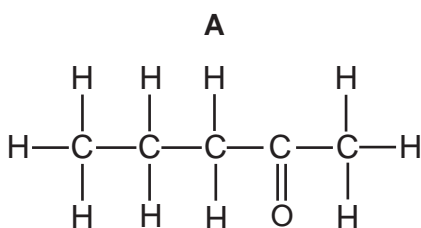
What is compound **Z**?



- 37 A compound known in industry as 'MTBE' is used as an additive in 'lead-free' petrol. The structural formula of MTBE is shown.



Which compound is an isomer of MTBE?

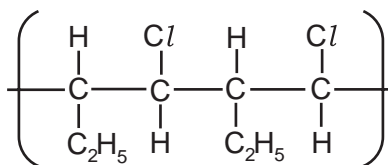


- 38 A liquid reacts with each of sodium carbonate, potassium hydroxide and ethanol.

What is the liquid?

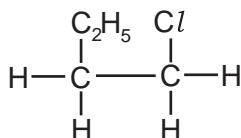
- A aqueous ammonia
- B ethanoic acid
- C ethyl ethanoate
- D hydrochloric acid

39 The structural formula of a polymer is shown below.

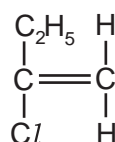


Which one of the following will form this polymer?

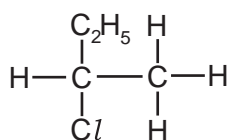
**A**



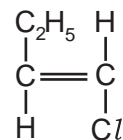
**B**



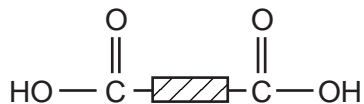
**C**



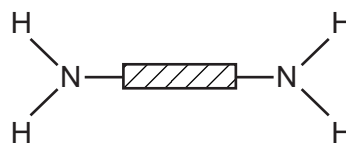
**D**



40 A polymer **X** was hydrolysed and the two products were



and



What can be deduced about **X**?

- A** It was a condensation polymer.
- B** It was starch.
- C** It was made by addition polymerisation.
- D** It was *Terylene*.

**DATA SHEET**  
**The Periodic Table of the Elements**

|                       |                        | Group                          |                        |                      |                         |                         |                        |                      |                        |                        |                      |                        |                     |                       |                        |                       |                      |                       |                       |                        |                       |                           |                        |                         |                       |                       |                         |                      |                         |                      |                       |                      |                        |                       |                       |                     |                       |                      |                           |                     |                        |                        |                        |                     |                        |                          |                          |                      |                          |                       |                         |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    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|                       |                        | 1<br><b>H</b><br>Hydrogen<br>1 |                        |                      |                         |                         |                        |                      |                        |                        |                      |                        |                     |                       |                        |                       |                      |                       |                       |                        |                       |                           |                        |                         |                       |                       |                         |                      |                         |                      |                       |                      |                        |                       |                       |                     |                       |                      |                           |               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   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | 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|                       |                        | 4<br><b>He</b><br>Helium<br>2  |                        |                      |                         |                         |                        |                      |                        |                        |                      |                        |                     |                       |                        |                       |                      |                       |                       |                        |                       |                           |                        |                         |                       |                       |                         |                      |                         |                      |                       |                      |                        |                       |                       |                     |                       |                      |                           |               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   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |      |
| 7                     | 9                      | 3                              | 4                      | 5                    | 6                       | 7                       | 8                      | 9                    | 10                     | 11                     | 12                   | 13                     | 14                  | 15                    | 16                     | 17                    | 18                   | 19                    | 20                    |                        |                       |                           |                        |                         |                       |                       |                         |                      |                         |                      |                       |                      |                        |                       |                       |                     |                       |                      |                           |                     |                        |                        |                        |                     |                        |                          |                          |                      |                          |                       |                         |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |      |
| <b>Li</b><br>Lithium  | <b>Be</b><br>Beryllium | <b>B</b><br>Boron              | <b>C</b><br>Carbon     | <b>N</b><br>Nitrogen | <b>O</b><br>Oxygen      | <b>F</b><br>Fluorine    | <b>Ne</b><br>Neon      | <b>Na</b><br>Sodium  | <b>Mg</b><br>Magnesium | <b>Al</b><br>Aluminium | <b>Si</b><br>Silicon | <b>P</b><br>Phosphorus | <b>S</b><br>Sulphur | <b>Cl</b><br>Chlorine | <b>Ar</b><br>Argon     | <b>K</b><br>Potassium | <b>Ca</b><br>Calcium | <b>Sc</b><br>Scandium | <b>Ti</b><br>Titanium | <b>V</b><br>Vanadium   | <b>Cr</b><br>Chromium | <b>Mn</b><br>Manganese    | <b>Fe</b><br>Iron      | <b>Co</b><br>Cobalt     | <b>Ni</b><br>Nickel   | <b>Cu</b><br>Copper   | <b>Zn</b><br>Zinc       | <b>Ga</b><br>Gallium | <b>Ge</b><br>Germanium  | <b>As</b><br>Arsenic | <b>Se</b><br>Selenium | <b>Br</b><br>Bromine | <b>Kr</b><br>Krypton   |                       |                       |                     |                       |                      |                           |                     |                        |                        |                        |                     |                        |                          |                          |                      |                          |                       |                         |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |      |
| 19                    | 37                     | 38                             | 39                     | 40                   | 41                      | 42                      | 43                     | 44                   | 45                     | 46                     | 47                   | 48                     | 49                  | 50                    | 51                     | 52                    | 53                   | 54                    | 55                    | 56                     | 57                    | 58                        | 59                     | 60                      | 61                    | 62                    | 63                      | 64                   | 65                      | 66                   | 67                    | 68                   | 69                     | 70                    | 71                    | 72                  | 73                    | 74                   | 75                        | 76                  | 77                     | 78                     | 79                     | 80                  | 81                     | 82                       | 83                       | 84                   | 85                       | 86                    |                         |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |      |
| <b>Rb</b><br>Rubidium | <b>Sr</b><br>Strontium | <b>Y</b><br>Yttrium            | <b>Zr</b><br>Zirconium | <b>Nb</b><br>Niobium | <b>Mo</b><br>Molybdenum | <b>Tc</b><br>Technetium | <b>Ru</b><br>Ruthenium | <b>Rh</b><br>Rhodium | <b>Pd</b><br>Palladium | <b>Ag</b><br>Silver    | <b>Cd</b><br>Cadmium | <b>In</b><br>Indium    | <b>Sn</b><br>Tin    | <b>Sb</b><br>Antimony | <b>Te</b><br>Tellurium | <b>I</b><br>Iodine    | <b>Xe</b><br>Xenon   | <b>Cs</b><br>Caesium  | <b>Ba</b><br>Barium   | <b>La</b><br>Lanthanum | <b>Ce</b><br>Cerium   | <b>Pr</b><br>Praseodymium | <b>Nd</b><br>Neodymium | <b>Pm</b><br>Promethium | <b>Sm</b><br>Samarium | <b>Eu</b><br>Europium | <b>Gd</b><br>Gadolinium | <b>Tb</b><br>Terbium | <b>Dy</b><br>Dysprosium | <b>Ho</b><br>Holmium | <b>Er</b><br>Erbium   | <b>Tm</b><br>Thulium | <b>Yb</b><br>Ytterbium | <b>Lu</b><br>Lutetium | <b>Fr</b><br>Francium | <b>Ra</b><br>Radium | <b>Ac</b><br>Actinium | <b>Th</b><br>Thorium | <b>Pa</b><br>Protactinium | <b>U</b><br>Uranium | <b>Np</b><br>Neptunium | <b>Pu</b><br>Plutonium | <b>Am</b><br>Americium | <b>Cm</b><br>Curium | <b>Bk</b><br>Berkelium | <b>Cf</b><br>Californium | <b>Es</b><br>Einsteinium | <b>Fm</b><br>Fermium | <b>Md</b><br>Mendelevium | <b>No</b><br>Nobelium | <b>Lr</b><br>Lawrencium |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    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| 87                    | 88                     | 89                             | 90                     | 91                   | 92                      | 93                      | 94                     | 95                   | 96                     | 97                     | 98                   | 99                     | 100                 | 101                   | 102                    | 103                   | 104                  | 105                   | 106                   | 107                    | 108                   | 109                       | 110                    | 111                     | 112                   | 113                   | 114                     | 115                  | 116                     | 117                  | 118                   | 119                  | 120                    | 121                   | 122                   | 123                 | 124                   | 125                  | 126                       | 127                 | 128                    | 129                    | 130                    | 131                 | 132                    | 133                      | 134                      | 135                  | 136                      | 137                   | 138                     | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 | 211 | 212 | 213 | 214 | 215 | 216 | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 | 241 | 242 | 243 | 244 | 245 | 246 | 247 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 | 257 | 258 | 259 | 260 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 269 | 270 | 271 | 272 | 273 | 274 | 275 | 276 | 277 | 278 | 279 | 280 | 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 | 301 | 302 | 303 | 304 | 305 | 306 | 307 | 308 | 309 | 310 | 311 | 312 | 313 | 314 | 315 | 316 | 317 | 318 | 319 | 320 | 321 | 322 | 323 | 324 | 325 | 326 | 327 | 328 | 329 | 330 | 331 | 332 | 333 | 334 | 335 | 336 | 337 | 338 | 339 | 340 | 341 | 342 | 343 | 344 | 345 | 346 | 347 | 348 | 349 | 350 | 351 | 352 | 353 | 354 | 355 | 356 | 357 | 358 | 359 | 360 | 361 | 362 | 363 | 364 | 365 | 366 | 367 | 368 | 369 | 370 | 371 | 372 | 373 | 374 | 375 | 376 | 377 | 378 | 379 | 380 | 381 | 382 | 383 | 384 | 385 | 386 | 387 | 388 | 389 | 390 | 391 | 392 | 393 | 394 | 395 | 396 | 397 | 398 | 399 | 400 | 401 | 402 | 403 | 404 | 405 | 406 | 407 | 408 | 409 | 410 | 411 | 412 | 413 | 414 | 415 | 416 | 417 | 418 | 419 | 420 | 421 | 422 | 423 | 424 | 425 | 426 | 427 | 428 | 429 | 430 | 431 | 432 | 433 | 434 | 435 | 436 | 437 | 438 | 439 | 440 | 441 | 442 | 443 | 444 | 445 | 446 | 447 | 448 | 449 | 450 | 451 | 452 | 453 | 454 | 455 | 456 | 457 | 458 | 459 | 460 | 461 | 462 | 463 | 464 | 465 | 466 | 467 | 468 | 469 | 470 | 471 | 472 | 473 | 474 | 475 | 476 | 477 | 478 | 479 | 480 | 481 | 482 | 483 | 484 | 485 | 486 | 487 | 488 | 489 | 490 | 491 | 492 | 493 | 494 | 495 | 496 | 497 | 498 | 499 | 500 | 501 | 502 | 503 | 504 | 505 | 506 | 507 | 508 | 509 | 510 | 511 | 512 | 513 | 514 | 515 | 516 | 517 | 518 | 519 | 520 | 521 | 522 | 523 | 524 | 525 | 526 | 527 | 528 | 529 | 530 | 531 | 532 | 533 | 534 | 535 | 536 | 537 | 538 | 539 | 540 | 541 | 542 | 543 | 544 | 545 | 546 | 547 | 548 | 549 | 550 | 551 | 552 | 553 | 554 | 555 | 556 | 557 | 558 | 559 | 560 | 561 | 562 | 563 | 564 | 565 | 566 | 567 | 568 | 569 | 570 | 571 | 572 | 573 | 574 | 575 | 576 | 577 | 578 | 579 | 580 | 581 | 582 | 583 | 584 | 585 | 586 | 587 | 588 | 589 | 590 | 591 | 592 | 593 | 594 | 595 | 596 | 597 | 598 | 599 | 600 | 601 | 602 | 603 | 604 | 605 | 606 | 607 | 608 | 609 | 610 | 611 | 612 | 613 | 614 | 615 | 616 | 617 | 618 | 619 | 620 | 621 | 622 | 623 | 624 | 625 | 626 | 627 | 628 | 629 | 630 | 631 | 632 | 633 | 634 | 635 | 636 | 637 | 638 | 639 | 640 | 641 | 642 | 643 | 644 | 645 | 646 | 647 | 648 | 649 | 650 | 651 | 652 | 653 | 654 | 655 | 656 | 657 | 658 | 659 | 660 | 661 | 662 | 663 | 664 | 665 | 666 | 667 | 668 | 669 | 670 | 671 | 672 | 673 | 674 | 675 | 676 | 677 | 678 | 679 | 680 | 681 | 682 | 683 | 684 | 685 | 686 | 687 | 688 | 689 | 690 | 691 | 692 | 693 | 694 | 695 | 696 | 697 | 698 | 699 | 700 | 701 | 702 | 703 | 704 | 705 | 706 | 707 | 708 | 709 | 710 | 711 | 712 | 713 | 714 | 715 | 716 | 717 | 718 | 719 | 720 | 721 | 722 | 723 | 724 | 725 | 726 | 727 | 728 | 729 | 730 | 731 | 732 | 733 | 734 | 735 | 736 | 737 | 738 | 739 | 740 | 741 | 742 | 743 | 744 | 745 | 746 | 747 | 748 | 749 | 750 | 751 | 752 | 753 | 754 | 755 | 756 | 757 | 758 | 759 | 760 | 761 | 762 | 763 | 764 | 765 | 766 | 767 | 768 | 769 | 770 | 771 | 772 | 773 | 774 | 775 | 776 | 777 | 778 | 779 | 780 | 781 | 782 | 783 | 784 | 785 | 786 | 787 | 788 | 789 | 790 | 791 | 792 | 793 | 794 | 795 | 796 | 797 | 798 | 799 | 800 | 801 | 802 | 803 | 804 | 805 | 806 | 807 | 808 | 809 | 810 | 811 | 812 | 813 | 814 | 815 | 816 | 817 | 818 | 819 | 820 | 821 | 822 | 823 | 824 | 825 | 826 | 827 | 828 | 829 | 830 | 831 | 832 | 833 | 834 | 835 | 836 | 837 | 838 | 839 | 840 | 841 | 842 | 843 | 844 | 845 | 846 | 847 | 848 | 849 | 850 | 851 | 852 | 853 | 854 | 855 | 856 | 857 | 858 | 859 | 860 | 861 | 862 | 863 | 864 | 865 | 866 | 867 | 868 | 869 | 870 | 871 | 872 | 873 | 874 | 875 | 876 | 877 | 878 | 879 | 880 | 881 | 882 | 883 | 884 | 885 | 886 | 887 | 888 | 889 | 890 | 891 | 892 | 893 | 894 | 895 | 896 | 897 | 898 | 899 | 900 | 901 | 902 | 903 | 904 | 905 | 906 | 907 | 908 | 909 | 910 | 911 | 912 | 913 | 914 | 915 | 916 | 917 | 918 | 919 | 920 | 921 | 922 | 923 | 924 | 925 | 926 | 927 | 928 | 929 | 930 | 931 | 932 | 933 | 934 | 935 | 936 | 937 | 938 | 939 | 940 | 941 | 942 | 943 | 944 | 945 | 946 | 947 | 948 | 949 | 950 | 951 | 952 | 953 | 954 | 955 | 956 | 957 | 958 | 959 | 960 | 961 | 962 | 963 | 964 | 965 | 966 | 967 | 968 | 969 | 970 | 971 | 972 | 973 | 974 | 975 | 976 | 977 | 978 | 979 | 980 | 981 | 982 | 983 | 984 | 985 | 986 | 987 | 988 | 989 | 990 | 991 | 992 | 993 | 994 | 995 | 996 | 997 | 998 | 999 | 1000 |

\*58-71 Lanthanoid series  
†90-103 Actinoid series

Key  
 a = relative atomic mass  
 X = atomic symbol  
 b = proton (atomic) number

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

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