



**TANJONG KATONG GIRLS' SCHOOL  
PRELIMINARY EXAMINATION  
SECONDARY FOUR EXPRESS**

CANDIDATE  
NAME

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CLASS

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INDEX  
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**CHEMISTRY**

Paper 1 Multiple Choice

**6092/01**

**21 August 2023**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.

Write your name, index number on the Answer Sheet.

There are **forty** questions in 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.

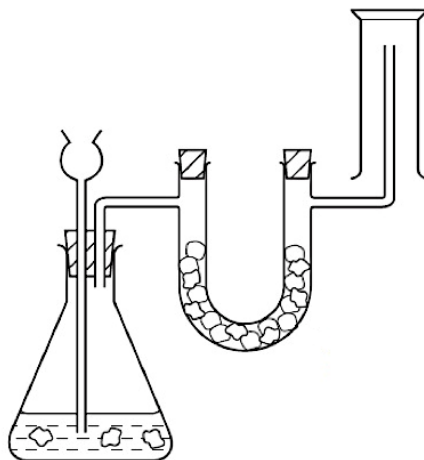
A copy of the Periodic Table is printed on page 19.

The use of an approved scientific calculator is expected, where appropriate.

Setter: Dr S Munira

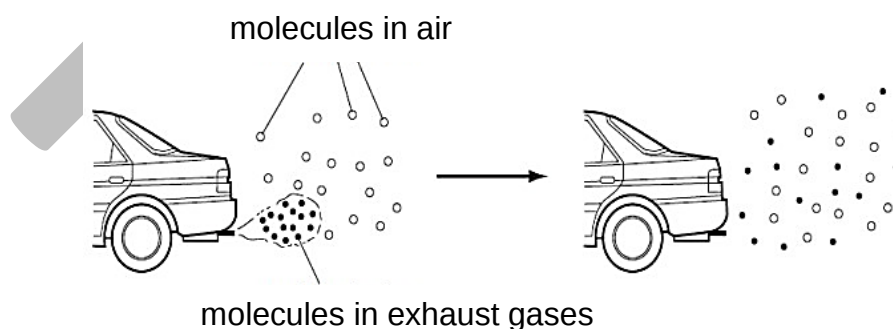
Marker: Dr S Munira

- 1 The diagram shows an experimental setup for the preparation and collection of a dry gas.



What could the gas be?

- A ammonia
  - B carbon dioxide
  - C hydrogen
  - D chlorine
- 2 The diagram shows how molecules in car exhaust gases diffuse into the air.



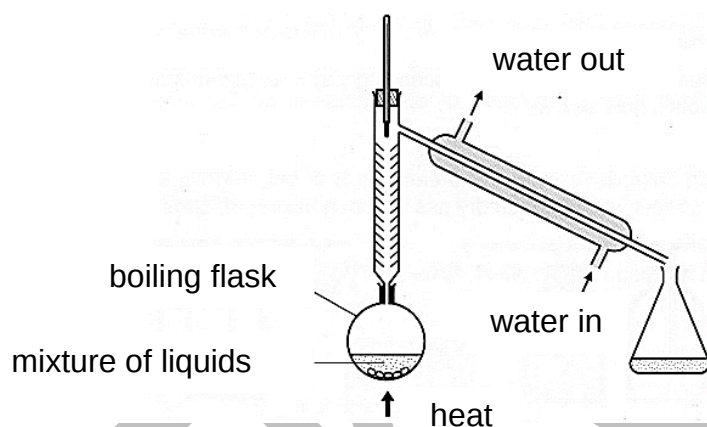
Which statement describes what happens to these molecules next?

- A The molecules sink closer to the ground because they are heavier than air molecules.
- B The molecules move back together as they cool.
- C The molecules spread further into the air.
- D The molecules stay suspended where they are.

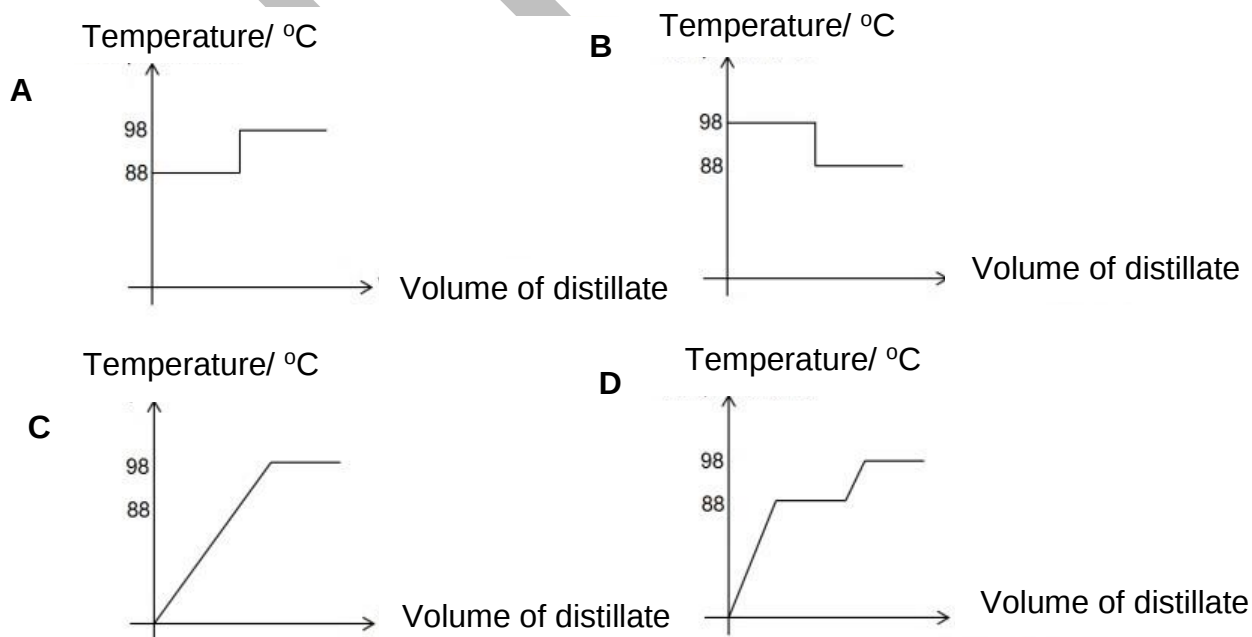
- 3 When 50 cm<sup>3</sup> of pure ethanol is mixed with 50 cm<sup>3</sup> of pure water in a measuring cylinder, the mixture is immediately found to have a volume of about 97 cm<sup>3</sup>.

What is the best explanation for this observation?

- A A small volume of the ethanol has evaporated.  
B The water molecules move into empty spaces between the ethanol molecules.  
C The ethanol molecules have a random arrangement in water.  
D Water and ethanol react together to form a compound.
- 4 The diagram shows a setup to distil a mixture of propanol (boiling point 88 °C) and heptane (boiling point 98 °C).



Which graph correctly shows the changes in volume of distillate in the conical flask as the distillation proceeds?



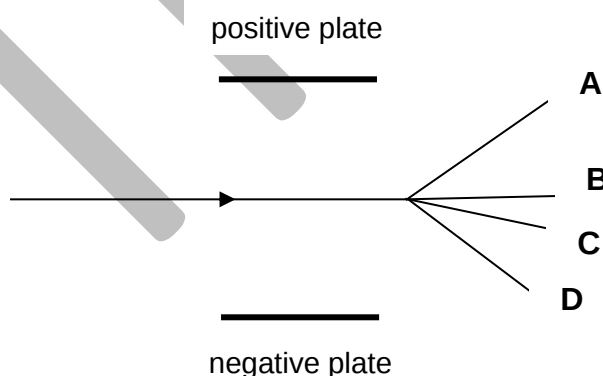
- 5 Camphor is a substance used in skin ointments. A natural sample of camphor is found to contain impurities like iron(III) oxide, iron and sodium chloride.

The table shows the effects of these substances with three different types of liquids.

| substance       | water     | ethanol   | dilute nitric acid      |
|-----------------|-----------|-----------|-------------------------|
| camphor         | no effect | dissolves | no effect               |
| iron            | no effect | no effect | reacts to give solution |
| iron(III) oxide | no effect | no effect | reacts to give solution |
| sodium oxide    | dissolves | no effect | dissolves               |

Which is the best method to obtain pure camphor?

- A Add ethanol, filter, rinse and dry.  
B Add dilute nitric acid, filter and crystallise.  
C Add dilute nitric acid, filter, rinse and dry.  
D Add water, filter, rinse and dry.
- 6 A beam of particles containing electrons is passed through charged plates.  
Which path shows how the electrons move through the plates?



- 7 A giant molecule is made up of a large number of carbon atoms, mainly isotopes carbon-12 and carbon-13. It was found that the relative atomic mass of carbon in the molecule is 12.2.

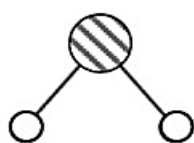
What is the ratio by mass of carbon-12 to carbon-13?

- A 4 : 1                      B 1 : 4                      C 3 : 4                      D 3 : 1

- 8 Chlorine gas,  $\text{Cl}_2$ , at  $40^\circ\text{C}$  diffuses more slowly than neon,  $\text{Ne}$ , at  $20^\circ\text{C}$ .

Which statement correctly explains the difference in diffusion rate of  $\text{Cl}_2$  and  $\text{Ne}$ ?

- A Chlorine has a relative molecular mass of 71 whilst neon has a relative atomic mass of 20.
  - B Chlorine is at a higher temperature than neon.
  - C Chlorine is diatomic, and neon is monatomic.
  - D Chlorine is more reactive than neon.
- 9 The structural diagrams of two molecules,  $\text{X}_2\text{Y}$  and  $\text{ZY}_2$ , are shown.

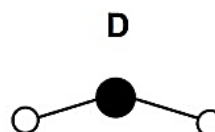
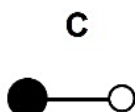
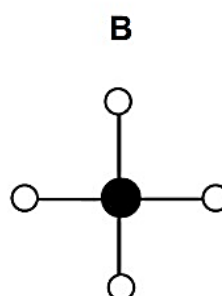
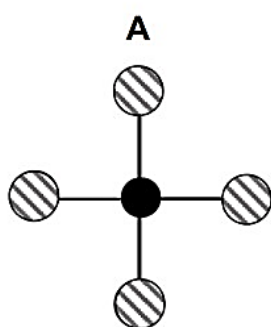


$\text{X}_2\text{Y}$



$\text{ZY}_2$

Which diagram represents a molecule of a compound formed between **X** and **Z**?



**10** A student recorded four statements about elements, compounds and mixtures.

- 1 Elements and compounds have fixed melting points.
- 2 The properties of a compound are similar to that of its elements.
- 3 A mixture can be separated into its components by physical means.
- 4 Elements can exist either in the form of atoms or molecules.

How many of the above statement(s) is/are **incorrect**?

- A** one
- B** two
- C** three
- D** four

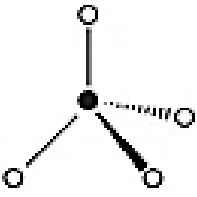
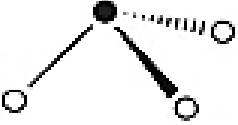
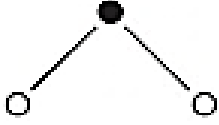
**11** The table shows information about particles **X** and **Y**.

|          | number of<br>protons | number of<br>neutrons | electronic structure |
|----------|----------------------|-----------------------|----------------------|
| <b>X</b> | 9                    | 10                    | 2, 8                 |
| <b>Y</b> | 17                   | 20                    | 2, 8, 8              |

Which statement is correct for both **X** and **Y**?

- A** They are atoms of metals.
- B** They are atoms of noble gases.
- C** They are negative ions.
- D** They are isotopes of the same element.

- 12 The shapes and names of some molecules are shown.

|                                                                                   |                                                                                   |                                                                                    |                                                                                     |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|  |  |  |  |
| tetrahedral                                                                       | pyramidal                                                                         | bent                                                                               | linear                                                                              |

key

● : P atom and ○ : other atom

Phosphine is a compound of phosphorus, an element in Group V, and hydrogen.

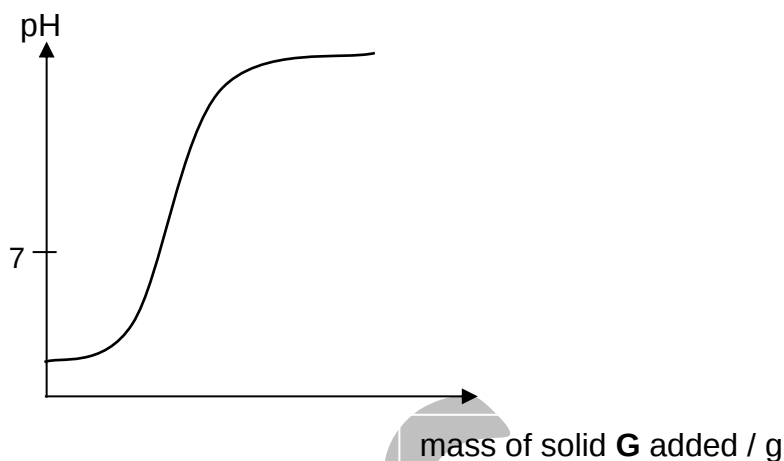
What is the shape of a molecule of phosphine likely to be?

- A bent
  - B linear
  - C pyramidal
  - D tetrahedral
- 13 Which statement explains why potassium chloride,  $\text{KCl}$ , has a lower melting point than calcium oxide,  $\text{CaO}$ ?
- A Potassium is a more reactive metal than calcium.
  - B Potassium chloride is covalent and calcium oxide is ionic.
  - C The melting point of potassium is lower than that of calcium.
  - D The attraction between  $\text{K}^+$  and  $\text{Cl}^-$  is weaker than  $\text{Ca}^{2+}$  and  $\text{O}^{2-}$ .
- 14 A mixture of the oxides of two elements from Period 3 of the Periodic Table is dissolved in water. This solution is approximately neutral.

What could be the constituents of the mixture?

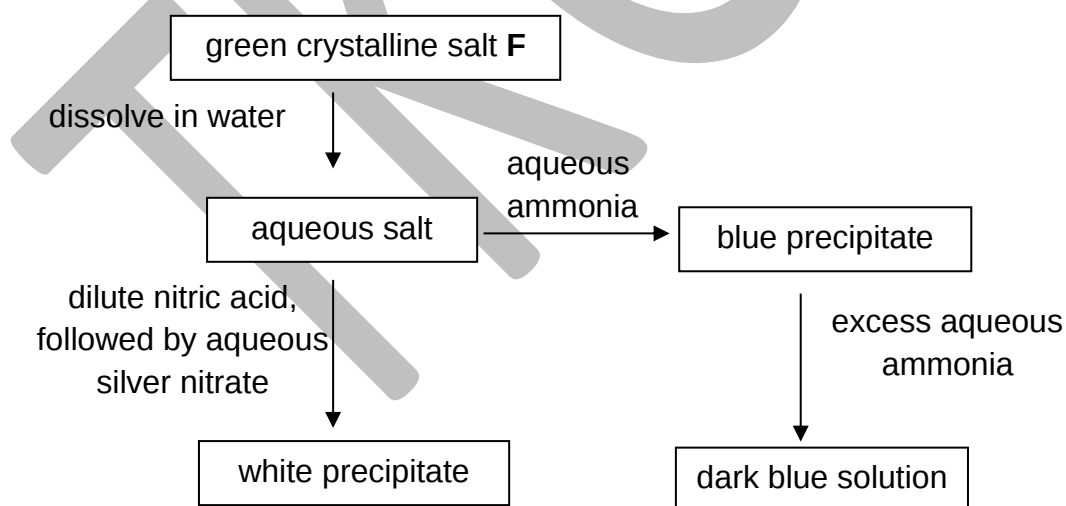
- A  $\text{Al}_2\text{O}_3$  and  $\text{MgO}$
- B  $\text{Na}_2\text{O}$  and  $\text{MgO}$
- C  $\text{SO}_3$  and  $\text{P}_4\text{O}_{10}$
- D  $\text{Na}_2\text{O}$  and  $\text{P}_4\text{O}_{10}$

- 15 Solid **G** is added in excess to dilute hydrochloric acid. The pH of the solution was monitored during the experiment and a graph was obtained.



What could solid **G** be?

- A zinc oxide
  - B potassium oxide
  - C sodium sulfate
  - D calcium carbonate
- 16 The scheme shows the reactions of salt **F**.



What is the identity of salt **F**?

- A iron(III) chloride
- B iron(III) iodide
- C copper(II) chloride
- D copper(II) iodide

- 17 Which reagent can be used to distinguish a solution containing  $\text{Zn}^{2+}$  ions from a solution containing  $\text{Al}^{3+}$ ?

A aqueous ammonia  
 B aqueous lead(II) nitrate  
 C aqueous sodium hydroxide  
 D dilute sulfuric acid

- 18 In each of three experiments, a halogen was added to separate solutions containing ions of one of the other two halogens.

The results are shown in the table.

| experiment | halogen added  | solution of halide |                |                 |
|------------|----------------|--------------------|----------------|-----------------|
|            |                | U <sup>-</sup>     | V <sup>-</sup> | W <sup>-</sup>  |
| 1          | U <sub>2</sub> | -                  | no reaction    | reaction occurs |
| 2          | V <sub>2</sub> | reaction occurs    | -              | reaction occurs |
| 3          | W <sub>2</sub> | no reaction        | no reaction    | -               |

What are the identities of U, V and W?

|   | U               | V               | W               |
|---|-----------------|-----------------|-----------------|
| A | Br <sub>2</sub> | Cl <sub>2</sub> | I <sub>2</sub>  |
| B | Br <sub>2</sub> | I <sub>2</sub>  | Cl <sub>2</sub> |
| C | Cl <sub>2</sub> | Br <sub>2</sub> | I <sub>2</sub>  |
| D | I <sub>2</sub>  | Cl <sub>2</sub> | Br <sub>2</sub> |

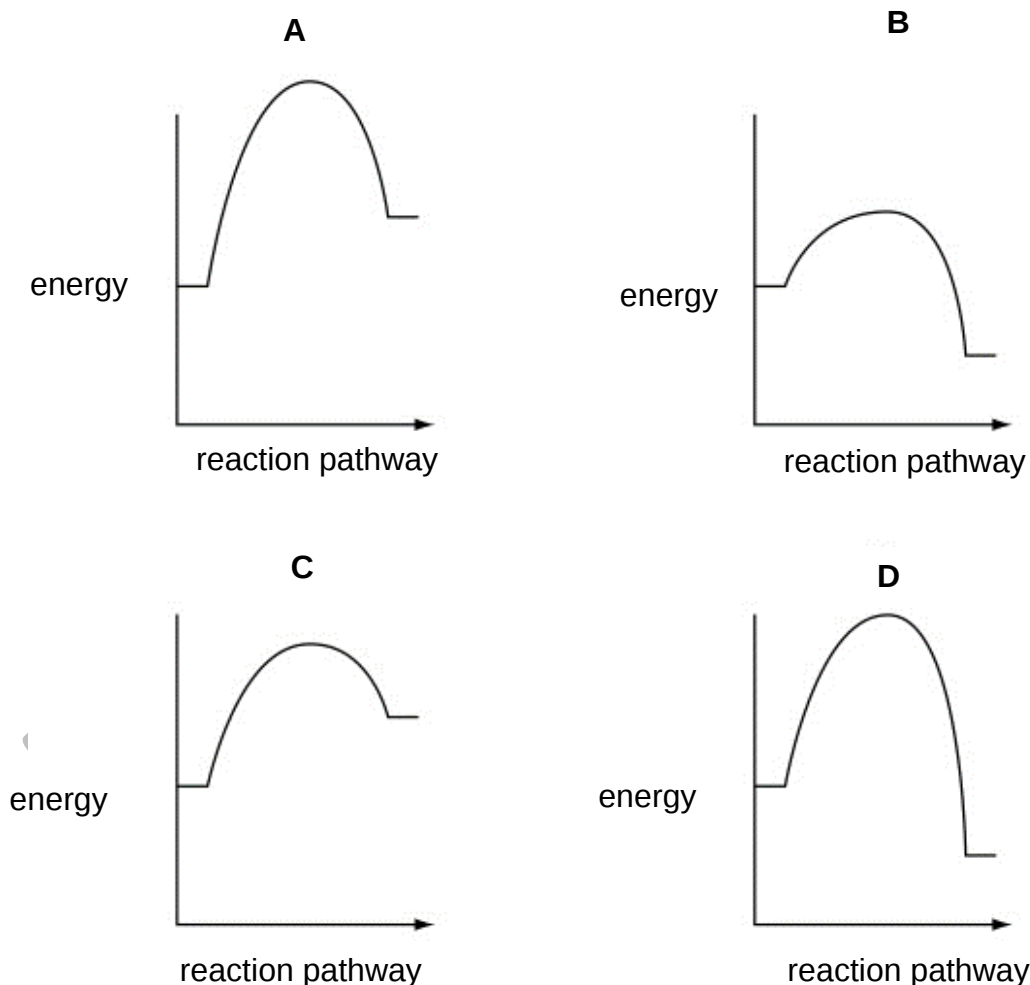
- 19 Which property generally decreases when going across a period of the Periodic Table from Group I to Group VII?

A the acidity of the oxides  
 B the reducing ability of the elements  
 C the number of electrons in the valence shell  
 D the tendency of the elements to form negative ions

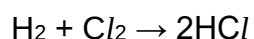
20 Which statement about the elements in the Periodic Table is **incorrect**?

- A Halogens,  $X_2$  combine with calcium metal to form  $CaX_2$ .
- B Alkali metals react vigorously with cold water.
- C Noble gases are diatomic atoms with low melting points.
- D The number of protons decides the order of the elements in the Periodic Table.

21 Which reaction profile shows the fastest exothermic reaction?



22 Hydrogen reacts with chlorine as shown.



$$\Delta H = -184 \text{ kJ}$$

Why does  $\Delta H$  of this reaction shows a negative sign?

- A More bonds are formed than are broken.
- B Total energy of bond formation is greater than that of bond breaking.
- C The ionic bonds in  $HCl$  are stronger than the covalent bonds in  $H_2$  and  $Cl_2$ .
- D This reaction has very high activation energy.

**23** Which gas does **not** contribute to global warming?

- A** carbon dioxide
- B** CFCs
- C** hydrocarbons
- D** carbon monoxide

**24** Nitrogen monoxide, NO, is a primary pollutant produced by petrol engines and is found in their exhaust gases.

Which reaction occurs in a catalytic converter and decreases the emission of nitrogen dioxide?

- A**  $\text{NO} + \text{CO} \rightarrow \text{NO}_2 + \text{C}$
- B**  $\text{NO} + \text{CO}_2 \rightarrow \text{N}_2 + \text{CO}$
- C**  $2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$
- D**  $2\text{NO} + \text{CO}_2 \rightarrow 2\text{NO}_2 + \text{C}$

**25** The formula of sodium thiosulfate is  $\text{Na}_2\text{S}_2\text{O}_3$  and the formula of niobium oxide is NbO.

What is the formula of niobium thiosulfate?

- A**  $\text{NbS}_2\text{O}_3$
- B**  $\text{Nb}_2\text{S}_2\text{O}_3$
- C**  $\text{Nb}(\text{S}_2\text{O}_3)_2$
- D**  $\text{Nb}_2(\text{S}_2\text{O}_3)_2$

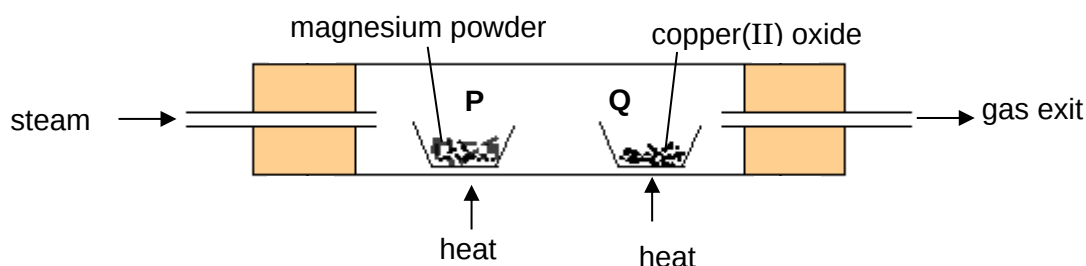
**26** Element **X** exists as gaseous molecules with the molecular formula  $\text{X}_2$  at room temperature and pressure.

50 cm<sup>3</sup> of element **X** combines with 100 cm<sup>3</sup> of hydrogen gas to form 100 cm<sup>3</sup> of the gaseous hydride of **X**.

What is the molecular formula of the hydride of **X** formed?

- A** HX
- B**  $\text{HX}_2$
- C**  $\text{H}_2\text{X}$
- D**  $\text{H}_2\text{X}_2$

- 27 In an experiment, steam is passed into the combustion tube for some time.



What are the products at **P** and **Q**?

|          | <b>P</b>            | <b>Q</b>             |
|----------|---------------------|----------------------|
| <b>A</b> | magnesium oxide     | copper               |
| <b>B</b> | magnesium hydroxide | copper               |
| <b>C</b> | magnesium oxide     | copper(II) hydroxide |
| <b>D</b> | magnesium hydroxide | copper(II) hydroxide |

- 28 A piece of iron was each added to solutions **M** and **S**.

The table shows the results of adding weighed pieces of iron to solutions **M** and **S**.

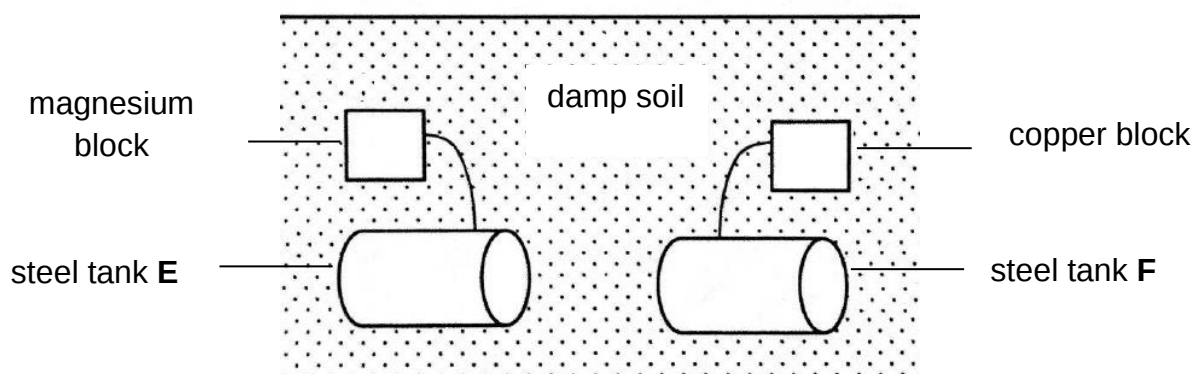
| solution | initial mass of iron/g | final mass of iron after 15 minutes/g |
|----------|------------------------|---------------------------------------|
| <b>M</b> | 5                      | 4                                     |
| <b>S</b> | 5                      | 4                                     |

What could the aqueous solutions **M** and **S** be?

|          | <b>M</b>                 | <b>S</b>             |
|----------|--------------------------|----------------------|
| <b>A</b> | copper(II) sulfate       | silver nitrate       |
| <b>B</b> | iron(II) chloride        | calcium chloride     |
| <b>C</b> | dilute hydrochloric acid | sodium chloride      |
| <b>D</b> | magnesium chloride       | dilute sulfuric acid |

**29** A block of magnesium is attached to steel tank **E**.

A block of copper is attached to steel tank **F**.



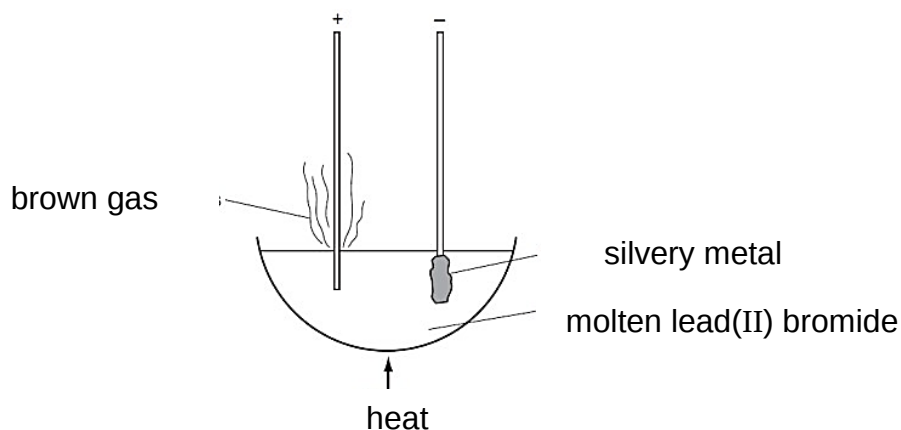
What are the reactions occurring at tank **E** and **F**?

|          | steel tank <b>E</b>                                  | steel tank <b>F</b>                                  |
|----------|------------------------------------------------------|------------------------------------------------------|
| <b>A</b> | $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$ | $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$ |
| <b>B</b> | $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$ | $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ |
| <b>C</b> | $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$ | $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$ |
| <b>D</b> | $\text{Mg} \rightarrow \text{Mg}^{2+} + 2\text{e}^-$ | $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$ |

**30** Which row is correct?

|          | electric cell                             | electrolytic cell                            |
|----------|-------------------------------------------|----------------------------------------------|
| <b>A</b> | generates electricity by chemical changes | brings about chemical changes by electricity |
| <b>B</b> | redox reaction occurs                     | does not involve redox reactions             |
| <b>C</b> | positive electrode is anode               | positive electrode is anode                  |
| <b>D</b> | reduction occurs at cathode               | oxidation occurs at cathode                  |

- 31** The diagram shows the electrolysis of molten lead(II) bromide using inert electrodes.

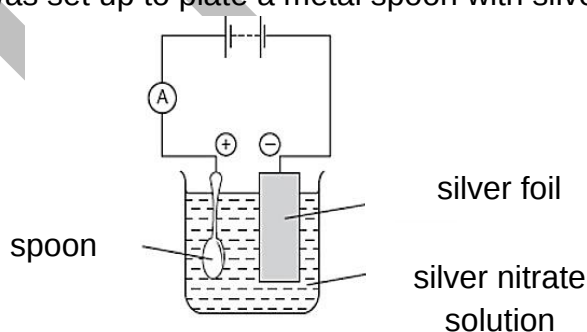


The following students make conclusions about what happens during the electrolysis.

Gary: Ions change to atoms.  
Ann : Covalent bonds are broken.  
John: New compounds are formed.

Who is/are correct?

- A** John only
  - B** Gary only
  - C** Gary and John
  - D** John and Ann
- 32** The apparatus was set up to plate a metal spoon with silver.



The experiment did not work.

What was the mistake made in the apparatus?

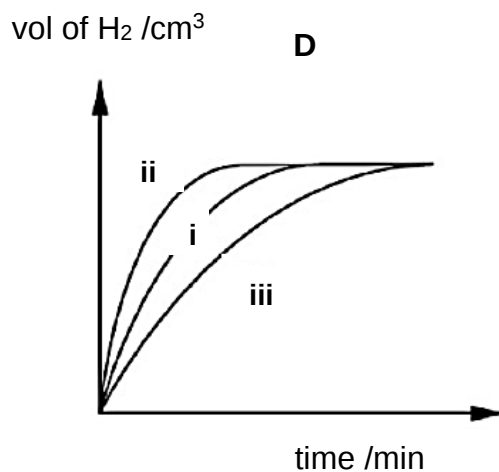
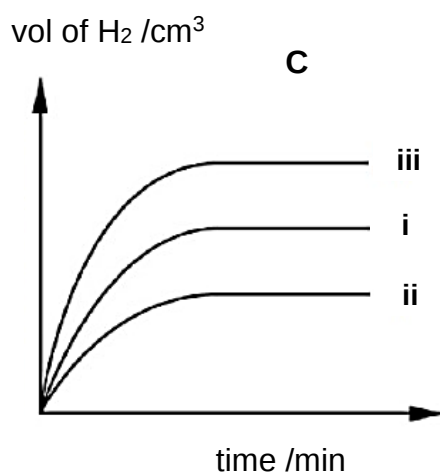
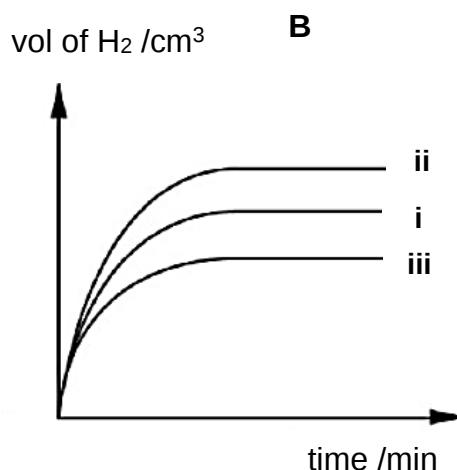
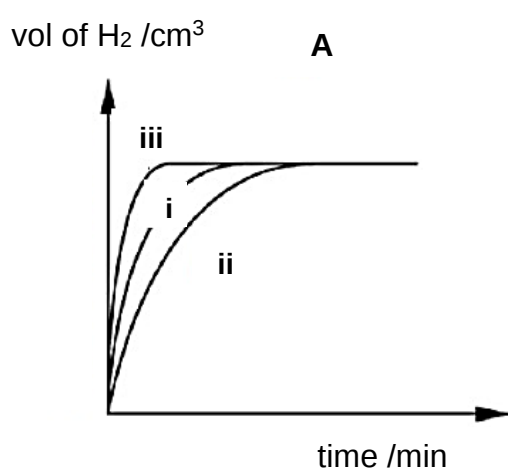
- A** The spoon should be at the negative electrode.
- B** A variable resistor should have been included in the circuit.
- C** Dilute sulfuric acid should have been used as the electrolyte.
- D** The silver foil should have been entirely immersed in the solution.

- 33** In the graphs, curve (i) was obtained when 3 g of zinc granules was reacted with excess 2.0 M hydrochloric acid. Curves (ii) and (iii) were obtained after making changes to the acid.

Curve (ii): excess 1.0 M nitric acid

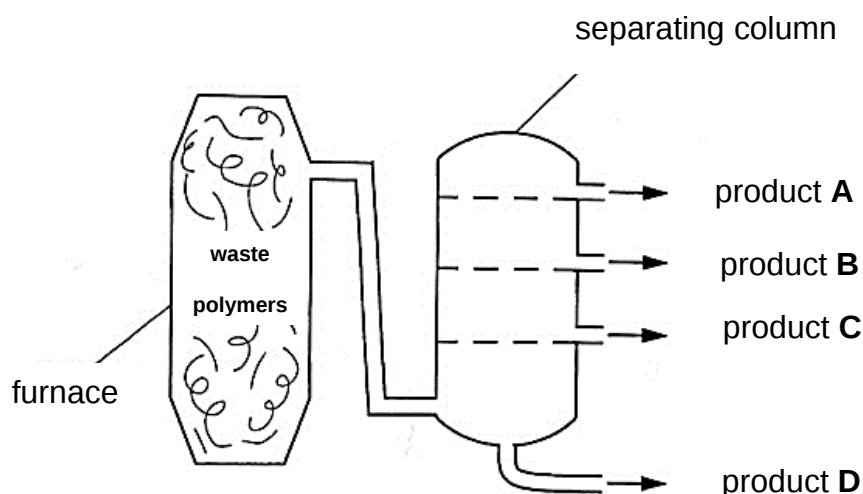
Curve (iii): excess 1.5 M sulfuric acid

Which graph matches the rate curves (i), (ii) and (iii) correctly?



- 34** Waste polymers can be recycled. One way of recycling waste polymers is by heating in a furnace. The waste decomposes into a mixture of hydrocarbons which can be separated in a separating column.

Which product has the smallest number of carbon atoms?



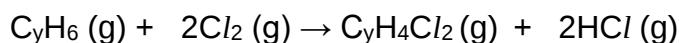
- 35** The table shows the composition of four different types of petroleum (crude oil).

| fraction | Arabian Heavy (%) | Arabian Light (%) | Iranian Heavy (%) | North Sea (%) |
|----------|-------------------|-------------------|-------------------|---------------|
| gasoline | 18                | 21                | 21                | 23            |
| kerosene | 12                | 13                | 13                | 15            |
| diesel   | 18                | 20                | 20                | 24            |
| bitumen  | 52                | 46                | 46                | 38            |

Which type of petroleum is most suitable for the land motor vehicle industry?

- A** Arabian Heavy
- B** Arabian Light
- C** Iranian Heavy
- D** North Sea

- 36 The reaction between a hydrocarbon  $C_yH_6$  and chlorine is shown.



Which statement is correct?

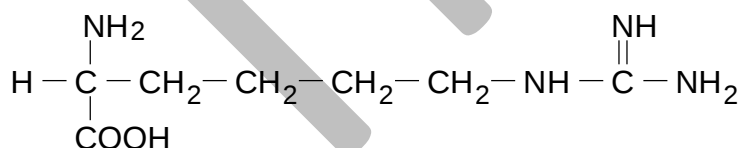
- A It is an addition reaction.  
B The molecular formula of the hydrocarbon is  $C_3H_6$ .  
C The presence of UV light is essential for the reaction to take place.  
D High temperature, high pressure and a catalyst are required in the reaction.
- 37 Carbohydrates can be converted to poly(ethene) in different stages as shown.



Which row correctly labels the processes X and Y?

|   | X              | Y                           |
|---|----------------|-----------------------------|
| A | Photosynthesis | Oxidation                   |
| B | Fermentation   | Addition polymerisation     |
| C | Fermentation   | Condensation polymerisation |
| D | Photosynthesis | Addition polymerisation     |

- 38 The diagram shows the structure of the amino acid, arginine.

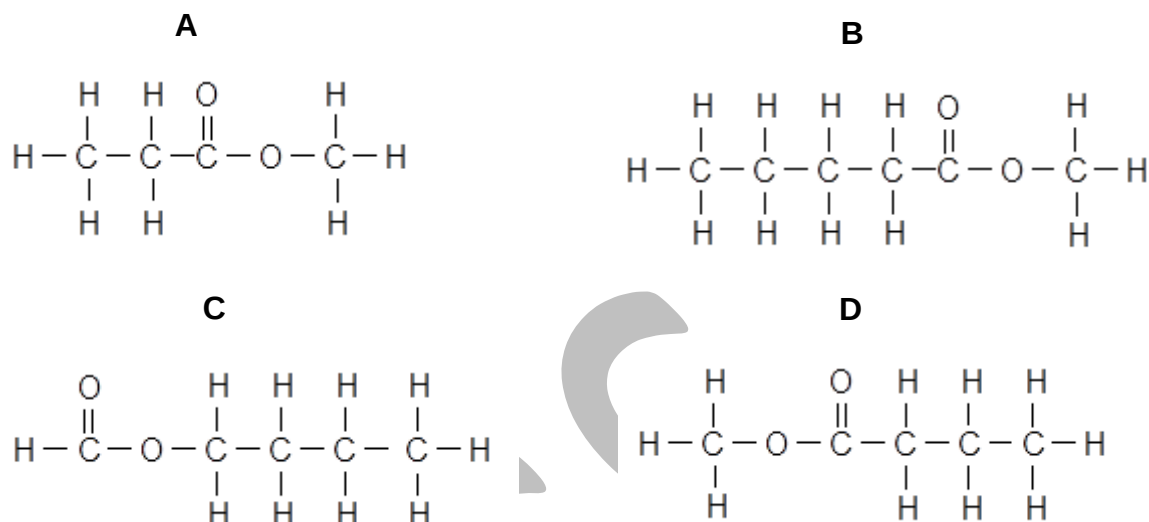


Which statement about arginine is true?

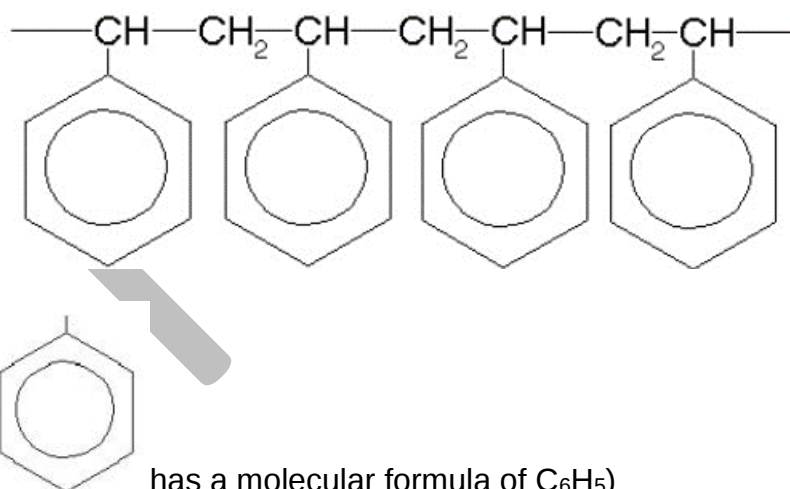
- A It forms a polymer with the same linkage as nylon.  
B It forms an addition polymer with other amino acids.  
C It readily decolourises acidified potassium manganate(VII) solution.  
D It burns in air to produce carbon dioxide and water only.

- 39 An ester was produced by the condensation reaction of methanol and butanoic acid.

Which structure represents the ester compound?



- 40 Polystyrene has a structure as shown.



What is the molecular formula of the monomer of polystyrene?

- A** (C<sub>6</sub>H<sub>5</sub>)CH<sub>2</sub>CH<sub>3</sub>  
**B** (C<sub>6</sub>H<sub>5</sub>)CHCH<sub>2</sub>  
**C** (C<sub>6</sub>H<sub>5</sub>)CHCH(C<sub>6</sub>H<sub>5</sub>)  
**D** (C<sub>6</sub>H<sub>5</sub>)CHCH<sub>2</sub>CH(C<sub>6</sub>H<sub>5</sub>)

## The Periodic Table of Elements

| Group                      |                             |                                                                                                                           |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                           |
|----------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|------------------------------|---------------------------|
| I                          | II                          |                                                                                                                           |                                 |                             |                              |                             |                              |                              |                                |                               |                               | III                         | IV                          | V                           | VI                            | VII                          | 0                         |
|                            |                             |                                                                                                                           |                                 |                             |                              |                             | 1<br>H<br>hydrogen<br>1      |                              |                                |                               |                               |                             |                             |                             |                               | 2<br>He<br>helium<br>4       |                           |
| 3<br>Li<br>lithium<br>7    | 4<br>Be<br>beryllium<br>9   | <div>Key</div> <div>proton (atomic) number</div> <div>atomic symbol</div> <div>name</div> <div>relative atomic mass</div> |                                 |                             |                              |                             |                              |                              |                                |                               |                               | 5<br>B<br>boron<br>11       | 6<br>C<br>carbon<br>12      | 7<br>N<br>nitrogen<br>14    | 8<br>O<br>oxygen<br>16        | 9<br>F<br>fluorine<br>19     | 10<br>Ne<br>neon<br>20    |
| 11<br>Na<br>sodium<br>23   | 12<br>Mg<br>magnesium<br>24 |                                                                                                                           |                                 |                             |                              |                             |                              |                              |                                |                               |                               | 13<br>Al<br>aluminium<br>27 | 14<br>Si<br>silicon<br>28   | 15<br>P<br>phosphorus<br>31 | 16<br>S<br>sulfur<br>32       | 17<br>Cl<br>chlorine<br>35.5 | 18<br>Ar<br>argon<br>40   |
| 19<br>K<br>potassium<br>39 | 20<br>Ca<br>calcium<br>40   | 21<br>Sc<br>scandium<br>45                                                                                                | 22<br>Ti<br>titanium<br>48      | 23<br>V<br>vanadium<br>51   | 24<br>Cr<br>chromium<br>52   | 25<br>Mn<br>manganese<br>55 | 26<br>Fe<br>iron<br>56       | 27<br>Co<br>cobalt<br>59     | 28<br>Ni<br>nickel<br>59       | 29<br>Cu<br>copper<br>64      | 30<br>Zn<br>zinc<br>65        | 31<br>Ga<br>gallium<br>70   | 32<br>Ge<br>germanium<br>73 | 33<br>As<br>arsenic<br>75   | 34<br>Se<br>selenium<br>79    | 35<br>Br<br>bromine<br>80    | 36<br>Kr<br>krypton<br>84 |
| 37<br>Rb<br>rubidium<br>85 | 38<br>Sr<br>strontium<br>88 | 39<br>Y<br>yttrium<br>89                                                                                                  | 40<br>Zr<br>zirconium<br>91     | 41<br>Nb<br>niobium<br>93   | 42<br>Mo<br>molybdenum<br>96 | 43<br>Tc<br>technetium<br>— | 44<br>Ru<br>ruthenium<br>101 | 45<br>Rh<br>rhodium<br>103   | 46<br>Pd<br>palladium<br>106   | 47<br>Ag<br>silver<br>108     | 48<br>Cd<br>cadmium<br>112    | 49<br>In<br>indium<br>115   | 50<br>Sn<br>tin<br>119      | 51<br>Sb<br>antimony<br>122 | 52<br>Te<br>tellurium<br>128  | 53<br>I<br>iodine<br>127     | 54<br>Xe<br>xenon<br>131  |
| 55<br>Cs<br>caesium<br>133 | 56<br>Ba<br>barium<br>137   | 57 – 71<br>lanthanoids                                                                                                    | 72<br>Hf<br>hafnium<br>178      | 73<br>Ta<br>tantalum<br>181 | 74<br>W<br>tungsten<br>184   | 75<br>Re<br>rhenium<br>186  | 76<br>Os<br>osmium<br>190    | 77<br>Ir<br>iridium<br>192   | 78<br>Pt<br>platinum<br>195    | 79<br>Au<br>gold<br>197       | 80<br>Hg<br>mercury<br>201    | 81<br>Tl<br>thallium<br>204 | 82<br>Pb<br>lead<br>207     | 83<br>Bi<br>bismuth<br>209  | 84<br>Po<br>polonium<br>—     | 85<br>At<br>astatine<br>—    | 86<br>Rn<br>radon<br>—    |
| 87<br>Fr<br>francium<br>—  | 88<br>Ra<br>radium<br>—     | 89 – 103<br>actinoids                                                                                                     | 104<br>Rf<br>rutherfordium<br>— | 105<br>Db<br>dubnium<br>—   | 106<br>Sg<br>seaborgium<br>— | 107<br>Bh<br>bohrium<br>—   | 108<br>Hs<br>hassium<br>—    | 109<br>Mt<br>meitnerium<br>— | 110<br>Ds<br>darmstadtium<br>— | 111<br>Rg<br>roentgenium<br>— | 112<br>Cn<br>copernicium<br>— |                             | 114<br>Fl<br>flerovium<br>— |                             | 116<br>Lv<br>livermorium<br>— |                              |                           |

lanthanoids

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

actinoids

The volume of one mole of any gas is  $24 \text{ dm}^3$  at room temperature and pressure (r.t.p.)

