



*Rewarding Learning*

General Certificate of Secondary Education  
2024–2025

Centre Number

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Candidate Number

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# Single Award Science: Chemistry

Unit 2

Higher Tier



[GSA22]

\*GSA22\*

**MONDAY 19 MAY 2025, MORNING**

TIME

1 hour.

## INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

**You must answer the questions in the spaces provided.**

**Do not write outside the boxed area on each page or on blank pages.**

Complete questions in black ink and use a dark HB pencil for drawings and graphs.

**Do not write with a gel pen.**

Answer **all nine** questions.

## INFORMATION FOR CANDIDATES

The total mark for this paper is 60.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

You may use a scientific calculator.

Quality of written communication will be assessed in Question 2.

A Data Leaflet, which includes a Periodic Table of the Elements, is included in this question paper.

14886



\*20GSA2201\*

- 1 In recent years local councils have tried to reduce the amount of waste produced. In 2005, **1 064 090** tonnes of waste were produced and in 2020, **913 546** tonnes of waste were produced.

(a) Calculate the decrease in the amount of waste produced from 2005 to 2020.

\_\_\_\_\_ tonnes [1]

- (b) Local councils also tried to increase the amount of waste that is recycled. The table below shows the recycling targets that were set by local councils and the percentages of waste actually recycled between 2005 and 2020.

| Year | Waste recycling target /% | Waste actually recycled /% |
|------|---------------------------|----------------------------|
| 2005 | 15.0                      | 17.0                       |
| 2010 | 35.0                      | 35.5                       |
| 2015 | 40.0                      | 41.0                       |
| 2020 | 45.0                      | 52.0                       |

- (i) Give **one** trend shown by this information.

\_\_\_\_\_  
\_\_\_\_\_ [1]

- (ii) In which year did local councils **exceed** their target by the greatest percentage?

\_\_\_\_\_ [1]



(c) It is important to recycle plastics because most are non-biodegradable.

(i) What is meant by the term **non-biodegradable**?

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[1]

(ii) Explain why it is important to reduce the amount of waste being sent to landfill.

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[1]

[Turn over



**2** Sodium and potassium are alkali metals that react with cold water. Describe how a teacher could demonstrate these reactions to their students.

Your answer should include:

- how to carry out the demonstration safely;
- **two** similarities in the observations made during these reactions; and
- **two** differences in the observations made during these reactions.

**In this question you will be assessed on the quality of your written communication skills, including the use of specialist scientific terms.**

[illegible]



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**(Questions continue overleaf)**

14886

**[Turn over**



**\*20GSA2205\***

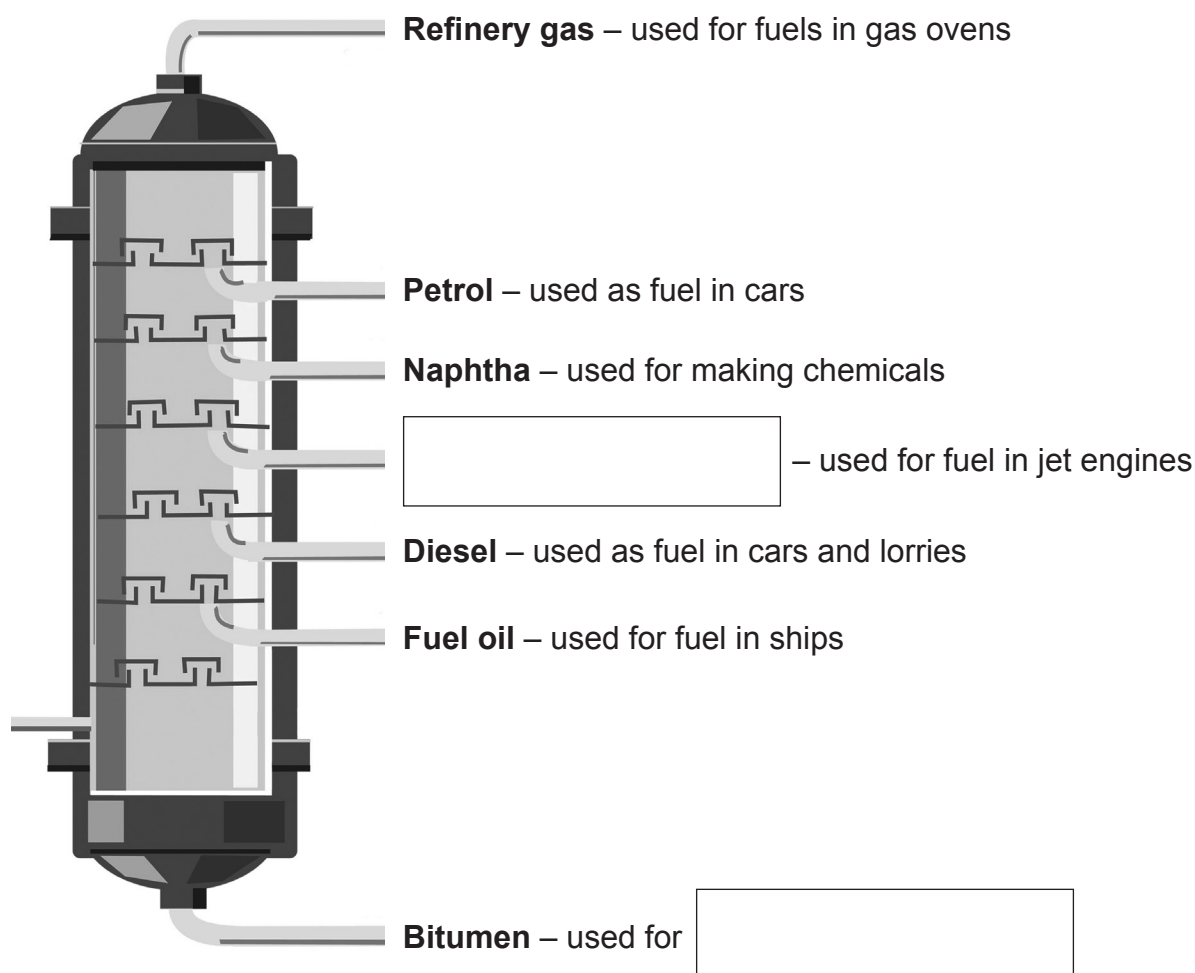
3 (a) Complete the following sentences about crude oil.

Crude oil is a fossil fuel formed from the remains of animals that died \_\_\_\_\_ of years ago. It is a mixture of hydrocarbons which are compounds that contain only the elements \_\_\_\_\_ and \_\_\_\_\_.

[2]

Different hydrocarbons are separated from crude oil by fractional distillation.

(b) Complete the diagram below to name the chemical used for fuel in jet engines and **one** use for bitumen. [2]



(c) (i) Complete the table below about some hydrocarbons.

| Name    | Molecular formula | Structural formula                                                                                   |
|---------|-------------------|------------------------------------------------------------------------------------------------------|
| butane  | $C_4H_{10}$       |                                                                                                      |
|         | $C_2H_6$          | <pre>       H   H                 H-C-C-H                   H   H           </pre>                   |
| propane |                   | <pre>       H   H   H                     H-C-C-C-H                       H   H   H           </pre> |

[3]

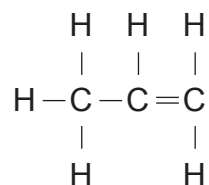
(ii) Pentane is a hydrocarbon that contains five carbon atoms.  
How many hydrogen atoms will be in a molecule of pentane?

\_\_\_\_\_ [1]

[Turn over



(d) The diagram below shows the structural formula of propene ( $C_3H_6$ ).



(i) Name the homologous series that propene belongs to.

\_\_\_\_\_ [1]

(ii) What is the general formula for this group of hydrocarbons?

\_\_\_\_\_ [1]

(iii) Polypropene can be formed when monomers of propene join together. What name is given to this **type** of reaction?

\_\_\_\_\_ [1]



- 4 In 1869 the Russian chemist Dmitri Mendeleev created the framework that would become the modern Periodic Table. Below is part of his table of elements.

| I  |    |     |    |    |    |     |    |    |    |
|----|----|-----|----|----|----|-----|----|----|----|
| H  | II | III | IV | V  | VI | VII |    |    |    |
| Li | Be | B   | C  | N  | O  | F   |    |    |    |
| Na | Mg | Al  | Si | P  | S  | Cl  |    |    |    |
| K  | Ca |     | Ti | V  | Cr | Mn  | Fe | Co | Ni |
| Cu | Zn |     |    | As | Se | Br  |    |    |    |
| Rb | Sr | Y   | Zr | Nb | Mo |     | Ru | Rh | Pd |

One feature of Mendeleev's periodic table was that the elements were placed in groups.

- (a) Give **two** other features of Mendeleev's table.

1. \_\_\_\_\_  
\_\_\_\_\_
2. \_\_\_\_\_  
\_\_\_\_\_ [2]

One group of elements in the modern Periodic Table was **not** included in Mendeleev's table.

- (b) Name this group of elements and explain why they had not been discovered by 1869.

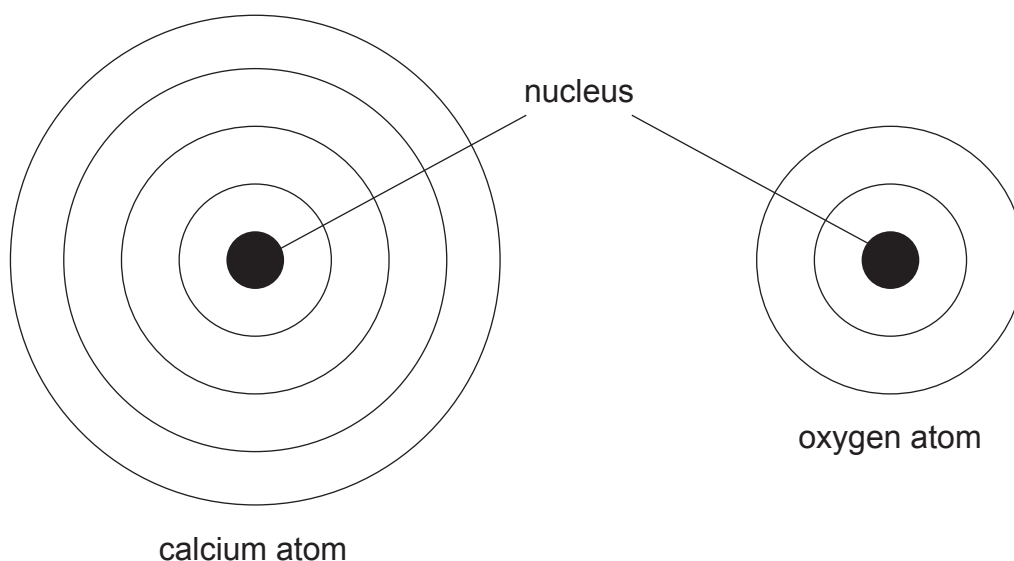
- \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

[Turn over



5 (a) An atom of calcium has 20 electrons and an atom of oxygen has 8 electrons.

(i) Complete the diagrams below to show how the electrons are arranged in a calcium atom and an oxygen atom.



[2]

(ii) Explain, in terms of electrons, how the atoms of calcium and oxygen react to form the compound calcium oxide.

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[2]

(b) Calcium and oxygen react together to form an ionic bond.

(i) Balance the symbol equation below for this reaction.



[1]

(ii) Explain why ionic bonds are strong.

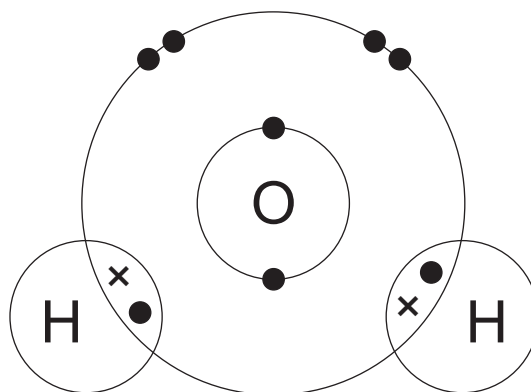
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[1]



- (c) The diagram below shows the bonding between hydrogen and oxygen in a molecule of water.



- (i) Name the type of bonding in a molecule of water.

\_\_\_\_\_ [1]

- (ii) How many lone pairs of electrons are shown in the diagram above?

\_\_\_\_\_ [1]



- 6 (a) Thermochromic and photochromic materials are two examples of smart materials.

(i) What is meant by the term **smart material**?

\_\_\_\_\_  
\_\_\_\_\_ [2]

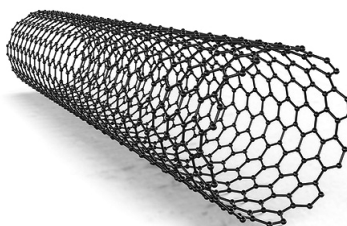
(ii) One similarity between thermochromic and photochromic materials is that they can both change colour. Explain the **difference** between these materials.

\_\_\_\_\_  
\_\_\_\_\_ [1]

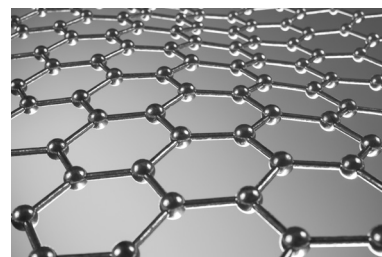
(b) Shown below are the structures of three nanomaterials.



A



B



C

(i) Which structure, **A**, **B** or **C**, is graphene?

\_\_\_\_\_ [1]

(ii) Name the element that graphene is made from.

\_\_\_\_\_ [1]

(iii) Nanomaterials contain nanoparticles which are 1–100 nanometres in size. What size is a nanometre?

\_\_\_\_\_ m [1]



7 Aluminium carbonate,  $\text{Al}_2(\text{CO}_3)_3$ , is a compound containing three elements.

- (a) Complete the table below giving the number of atoms of each element represented by the formula,  $\text{Al}_2(\text{CO}_3)_3$ .

| Element   | Number of atoms |
|-----------|-----------------|
| carbon    | 3               |
| oxygen    |                 |
| aluminium |                 |

[2]

Sodium oxide,  $\text{Na}_2\text{O}$ , is another compound. It contains the elements sodium and oxygen.

- (b) Complete the table below about the number of protons, electrons and neutrons in an atom of sodium (Na), in an atom of oxygen (O) and in sodium oxide ( $\text{Na}_2\text{O}$ ).

|           | Sodium<br>(Na) | Oxygen<br>(O) | Sodium oxide<br>( $\text{Na}_2\text{O}$ ) |
|-----------|----------------|---------------|-------------------------------------------|
| protons   | 11             | 8             | 30                                        |
| electrons |                |               |                                           |
| neutrons  | 12             | 8             |                                           |

[2]

[Turn over

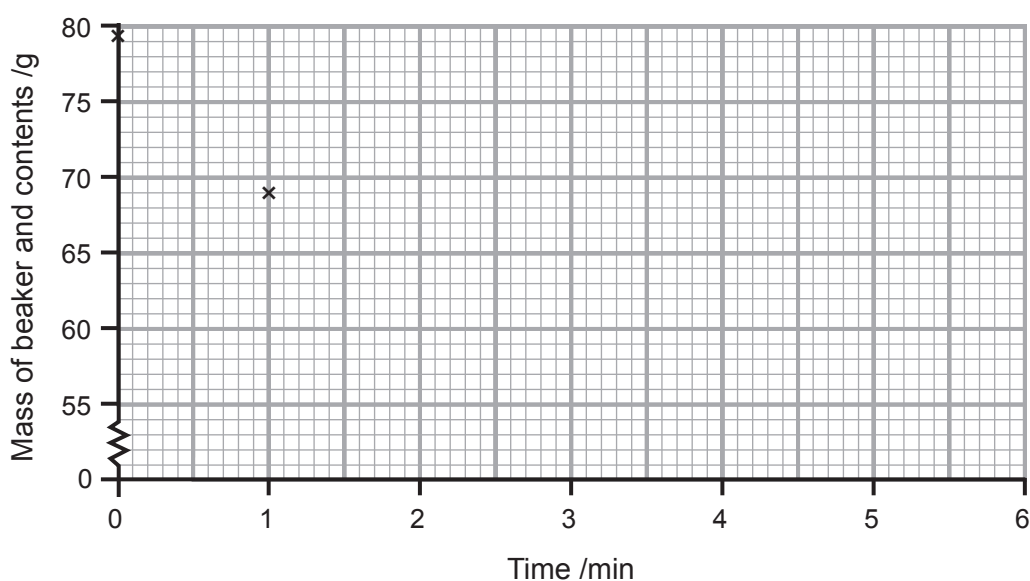


- 8 (a) A student investigated the reaction between sodium hydrogencarbonate and hydrochloric acid in a beaker. He measured the mass of the beaker and its contents at the start and then every minute for six minutes.

His results are shown below.

| Time /min                      | 0    | 1    | 2    | 3    | 4    | 5    | 6    |
|--------------------------------|------|------|------|------|------|------|------|
| Mass of beaker and contents /g | 79.5 | 69.0 | 64.5 | 61.0 | 59.0 | 58.5 | 58.0 |

- (i) On the grid below, plot and draw a line graph for these results. The first two points are plotted for you.



[3]

- (ii) Use the results to explain how the student knows the reaction is **not** finished.

\_\_\_\_\_

\_\_\_\_\_ [1]

- (iii) Calculate the change in mass during this reaction.

\_\_\_\_\_ g [1]



The reaction produces carbon dioxide.

(b) Describe the chemical test used to identify carbon dioxide.

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---

[2]

The student repeated this investigation using sodium hydrogencarbonate and ethanoic acid.

(c) Give **one** similarity and **one** difference between the reaction of sodium hydrogencarbonate with ethanoic acid and with hydrochloric acid.

Similarity \_\_\_\_\_

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Difference \_\_\_\_\_

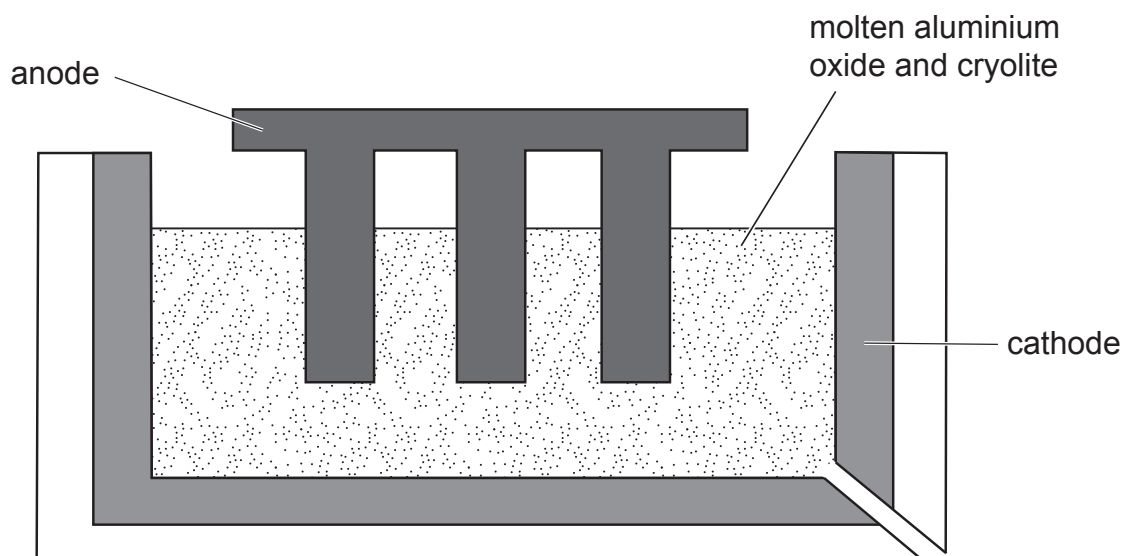
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[2]

[Turn over



- 9 Electricity can be used to extract aluminium from aluminium oxide. Some of the electricity provides energy to melt the aluminium oxide and keep it molten. The chemical cryolite is added to make the process more cost effective.



- (a) What name is given to the process of using electricity to extract aluminium?

\_\_\_\_\_ [1]

- (b) Explain, in terms of ions, why the aluminium oxide must be **molten**.

\_\_\_\_\_  
\_\_\_\_\_ [1]



The table below gives the melting points of some chemicals involved in this process.

| Chemical                             | Melting point /°C |
|--------------------------------------|-------------------|
| aluminium                            | 660               |
| aluminium oxide                      | 2072              |
| cryolite                             | 1012              |
| aluminium oxide and cryolite mixture | 960               |

- (c) Use this information to explain why the addition of cryolite makes this process more cost effective.

\_\_\_\_\_  
\_\_\_\_\_ [2]

- (d) Aluminium is produced at the cathode and oxygen is produced at the anode.

- (i) Name a suitable material from which the anode and cathode could be made.

\_\_\_\_\_ [1]

- (ii) Complete the ionic equation for the production of aluminium at the cathode.

\_\_\_\_\_ + \_\_\_\_\_  $\rightarrow$  Al [2]

\_\_\_\_\_  
**THIS IS THE END OF THE QUESTION PAPER**  
\_\_\_\_\_



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|-------------------------|-------|
| Question Number         | Marks |
| 1                       |       |
| 2                       |       |
| 3                       |       |
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| 5                       |       |
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| Total Marks |  |
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Examiner Number

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## SYMBOLS OF SELECTED IONS

### Positive ions

| Name          | Symbol           |
|---------------|------------------|
| Ammonium      | $\text{NH}_4^+$  |
| Chromium(III) | $\text{Cr}^{3+}$ |
| Copper(II)    | $\text{Cu}^{2+}$ |
| Iron(II)      | $\text{Fe}^{2+}$ |
| Iron(III)     | $\text{Fe}^{3+}$ |
| Lead(II)      | $\text{Pb}^{2+}$ |
| Silver        | $\text{Ag}^+$    |
| Zinc          | $\text{Zn}^{2+}$ |

### Negative ions

| Name              | Symbol                             |
|-------------------|------------------------------------|
| Butanoate         | $\text{C}_3\text{H}_7\text{COO}^-$ |
| Carbonate         | $\text{CO}_3^{2-}$                 |
| Dichromate        | $\text{Cr}_2\text{O}_7^{2-}$       |
| Ethanoate         | $\text{CH}_3\text{COO}^-$          |
| Hydrogencarbonate | $\text{HCO}_3^-$                   |
| Hydroxide         | $\text{OH}^-$                      |
| Methanoate        | $\text{HCOO}^-$                    |
| Nitrate           | $\text{NO}_3^-$                    |
| Propanoate        | $\text{C}_2\text{H}_5\text{COO}^-$ |
| Sulfate           | $\text{SO}_4^{2-}$                 |
| Sulfite           | $\text{SO}_3^{2-}$                 |

## Data Leaflet

### Including the Periodic Table of the Elements

For the use of candidates taking  
Science: Chemistry,  
Science: Double Award  
or Science: Single Award

Copies must be free from notes or additions of any  
kind. No other type of data booklet or information  
sheet is authorised for use in the examinations

### SOLUBILITY IN COLD WATER OF COMMON SALTS, HYDROXIDES AND OXIDES

| Soluble                                                                                        |
|------------------------------------------------------------------------------------------------|
| All sodium, potassium and ammonium salts                                                       |
| All nitrates                                                                                   |
| Most chlorides, bromides and iodides<br>EXCEPT silver and lead chlorides, bromides and iodides |
| Most sulfates EXCEPT lead and barium sulfates<br>Calcium sulfate is slightly soluble           |
| Insoluble                                                                                      |
| Most carbonates<br>EXCEPT sodium, potassium and ammonium carbonates                            |
| Most hydroxides<br>EXCEPT sodium, potassium and ammonium hydroxides                            |
| Most oxides<br>EXCEPT sodium, potassium and calcium oxides which react with water              |

# gcse examinations chemistry

THE PERIODIC TABLE OF ELEMENTS  
Group

|                      |  |                       |  |                        |  |                            |  |                      |  |                         |  |                        |  |                       |  |                         |  |                           |  |                          |  |                          |  |                      |  |                       |  |                      |  |                       |  |                      |  |                     |  |
|----------------------|--|-----------------------|--|------------------------|--|----------------------------|--|----------------------|--|-------------------------|--|------------------------|--|-----------------------|--|-------------------------|--|---------------------------|--|--------------------------|--|--------------------------|--|----------------------|--|-----------------------|--|----------------------|--|-----------------------|--|----------------------|--|---------------------|--|
|                      |  |                       |  |                        |  |                            |  |                      |  |                         |  |                        |  |                       |  |                         |  |                           |  |                          |  |                          |  |                      |  | 0                     |  |                      |  |                       |  |                      |  |                     |  |
|                      |  |                       |  |                        |  |                            |  |                      |  |                         |  |                        |  |                       |  |                         |  |                           |  |                          |  |                          |  |                      |  |                       |  |                      |  |                       |  |                      |  |                     |  |
| 1                    |  | 2                     |  |                        |  |                            |  |                      |  |                         |  |                        |  |                       |  |                         |  |                           |  |                          |  |                          |  |                      |  |                       |  |                      |  | 4                     |  |                      |  |                     |  |
| 7                    |  | 9                     |  |                        |  |                            |  |                      |  |                         |  |                        |  |                       |  |                         |  |                           |  |                          |  |                          |  |                      |  |                       |  |                      |  | 2                     |  |                      |  |                     |  |
| Li<br>Lithium<br>3   |  | Be<br>Beryllium<br>4  |  |                        |  |                            |  |                      |  |                         |  |                        |  |                       |  |                         |  |                           |  |                          |  |                          |  |                      |  |                       |  |                      |  | He<br>Helium<br>10    |  |                      |  |                     |  |
| 23                   |  | 24                    |  |                        |  |                            |  |                      |  |                         |  |                        |  |                       |  |                         |  |                           |  |                          |  |                          |  |                      |  |                       |  |                      |  | 40                    |  |                      |  |                     |  |
| Na<br>Sodium<br>11   |  | Mg<br>Magnesium<br>12 |  |                        |  |                            |  |                      |  |                         |  |                        |  |                       |  |                         |  |                           |  |                          |  |                          |  |                      |  |                       |  |                      |  | Ar<br>Argon<br>18     |  |                      |  |                     |  |
| 39                   |  | 40                    |  | 45                     |  | 48                         |  | 51                   |  | 52                      |  | 55                     |  | 56                    |  | 59                      |  | 59                        |  | 64                       |  | 65                       |  | 70                   |  | 73                    |  | 75                   |  | 79                    |  | 80                   |  | 84                  |  |
| K<br>Potassium<br>19 |  | Ca<br>Calcium<br>20   |  | Sc<br>Scandium<br>21   |  | Ti<br>Titanium<br>22       |  | V<br>Vanadium<br>23  |  | Cr<br>Chromium<br>24    |  | Mn<br>Manganese<br>25  |  | Fe<br>Iron<br>26      |  | Co<br>Cobalt<br>27      |  | Ni<br>Nickel<br>28        |  | Cu<br>Copper<br>29       |  | Zn<br>Zinc<br>30         |  | Ga<br>Gallium<br>31  |  | Ge<br>Germanium<br>32 |  | As<br>Arsenic<br>33  |  | Se<br>Selenium<br>34  |  | Br<br>Bromine<br>35  |  | Kr<br>Krypton<br>36 |  |
| 85                   |  | 88                    |  | 89                     |  | 91                         |  | 93                   |  | 96                      |  | 98                     |  | 101                   |  | 103                     |  | 106                       |  | 108                      |  | 112                      |  | 115                  |  | 119                   |  | 122                  |  | 128                   |  | 127                  |  | 131                 |  |
| Rb<br>Rubidium<br>37 |  | Sr<br>Strontium<br>38 |  | Y<br>Yttrium<br>39     |  | Zr<br>Zirconium<br>40      |  | Nb<br>Niobium<br>41  |  | Mo<br>Molybdenum<br>42  |  | Tc<br>Technetium<br>43 |  | Ru<br>Ruthenium<br>44 |  | Rh<br>Rhodium<br>45     |  | Pd<br>Palladium<br>46     |  | Ag<br>Silver<br>47       |  | Cd<br>Cadmium<br>48      |  | In<br>Indium<br>49   |  | Sn<br>Tin<br>50       |  | Sb<br>Antimony<br>51 |  | Te<br>Tellurium<br>52 |  | I<br>Iodine<br>53    |  | Xe<br>Xenon<br>54   |  |
| 133                  |  | 137                   |  | 139                    |  | 178                        |  | 181                  |  | 184                     |  | 186                    |  | 190                   |  | 192                     |  | 195                       |  | 197                      |  | 201                      |  | 204                  |  | 207                   |  | 209                  |  | 210                   |  | 210                  |  | 222                 |  |
| Cs<br>Caesium<br>55  |  | Ba<br>Barium<br>56    |  | La*<br>Lanthanum<br>57 |  | Hf<br>Hafnium<br>72        |  | Ta<br>Tantalum<br>73 |  | W<br>Tungsten<br>74     |  | Re<br>Rhenium<br>75    |  | Os<br>Osmium<br>76    |  | Ir<br>Iridium<br>77     |  | Pt<br>Platinum<br>78      |  | Au<br>Gold<br>79         |  | Hg<br>Mercury<br>80      |  | Tl<br>Thallium<br>81 |  | Pb<br>Lead<br>82      |  | Bi<br>Bismuth<br>83  |  | Po<br>Polonium<br>84  |  | At<br>Astatine<br>85 |  | Rn<br>Radon<br>86   |  |
| 223                  |  | 226                   |  | 227                    |  | 261                        |  | 262                  |  | 266                     |  | 264                    |  | 277                   |  | 268                     |  | 271                       |  | 272                      |  | 285                      |  |                      |  |                       |  |                      |  |                       |  |                      |  |                     |  |
| Fr<br>Francium<br>87 |  | Ra<br>Radium<br>88    |  | Ac†<br>Actinium<br>89  |  | Rf<br>Rutherfordium<br>104 |  | Db<br>Dubnium<br>105 |  | Sg<br>Seaborgium<br>106 |  | Bh<br>Bohrium<br>107   |  | Hs<br>Hassium<br>108  |  | Mt<br>Meitnerium<br>109 |  | Ds<br>Darmstadtium<br>110 |  | Rg<br>Roentgenium<br>111 |  | Cn<br>Copernicium<br>112 |  |                      |  |                       |  |                      |  |                       |  |                      |  |                     |  |

1

H

Hydrogen

1

\* 58 – 71 Lanthanum series  
† 90 – 103 Actinium series



**a** = relative atomic mass (approx)  
**x** = atomic symbol  
**b** = atomic number

|     |                            |     |                                 |     |                              |     |                               |     |                              |     |                              |     |                               |     |                              |     |                                |     |                                |     |                             |     |                                 |     |                              |     |                                |
|-----|----------------------------|-----|---------------------------------|-----|------------------------------|-----|-------------------------------|-----|------------------------------|-----|------------------------------|-----|-------------------------------|-----|------------------------------|-----|--------------------------------|-----|--------------------------------|-----|-----------------------------|-----|---------------------------------|-----|------------------------------|-----|--------------------------------|
| 140 | <b>Ce</b><br>Cerium<br>58  | 141 | <b>Pr</b><br>Praseodymium<br>59 | 144 | <b>Nd</b><br>Neodymium<br>60 | 145 | <b>Pm</b><br>Promethium<br>61 | 150 | <b>Sm</b><br>Samarium<br>62  | 152 | <b>Eu</b><br>Europium<br>63  | 157 | <b>Gd</b><br>Gadolinium<br>64 | 159 | <b>Tb</b><br>Terbium<br>65   | 162 | <b>Dy</b><br>Dysprosium<br>66  | 165 | <b>Ho</b><br>Holmium<br>67     | 167 | <b>Er</b><br>Erbium<br>68   | 169 | <b>Tm</b><br>Thulium<br>69      | 173 | <b>Yb</b><br>Ytterbium<br>70 | 175 | <b>Lu</b><br>Lutetium<br>71    |
| 232 | <b>Th</b><br>Thorium<br>90 | 231 | <b>Pa</b><br>Protactinium<br>91 | 238 | <b>U</b><br>Uranium<br>92    | 237 | <b>Np</b><br>Neptunium<br>93  | 242 | <b>Pu</b><br>Plutonium<br>94 | 243 | <b>Am</b><br>Americium<br>95 | 247 | <b>Cm</b><br>Curium<br>96     | 245 | <b>Bk</b><br>Berkelium<br>97 | 251 | <b>Cf</b><br>Californium<br>98 | 254 | <b>Es</b><br>Einsteinium<br>99 | 253 | <b>Fm</b><br>Fermium<br>100 | 256 | <b>Md</b><br>Mendelevium<br>101 | 254 | <b>No</b><br>Nobelium<br>102 | 257 | <b>Lr</b><br>Lawrencium<br>103 |