Write your name here

| Surname | Other names |
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**Pearson Edexcel**
**International**
**Advanced Level**

Centre Number | | | | | |

Candidate Number | | | | |

# Chemistry

## Advanced Subsidiary

## Unit 2: Application of Core Principles of Chemistry

Thursday 16 January 2014 – Morning
**Time: 1 hour 30 minutes**

Paper Reference
**WCH02/01**

**Candidates may use a calculator.**

Total Marks

## Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

## Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

## Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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6/6/6/6/3/

P 4 2 9 8 7 A 0 1 2 0

PEARSON

## SECTION A

**Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.**

**1** The H–O–H bond angle in an oxonium ion, $H_3O^+$, is approximately

☒ **A** 104.5°

☒ **B** 107°

☒ **C** 109.5°

☒ **D** 120°

**(Total for Question 1 = 1 mark)**

**2** The bond angles within a molecule of tetrachloromethane result from repulsion between

☒ **A** atoms.

☒ **B** bonded pairs of electrons.

☒ **C** atomic nuclei.

☒ **D** lone pairs of electrons.

**(Total for Question 2 = 1 mark)**

**3** The term **electronegativity** is best described as the ability of an atom to

☒ **A** attract the electrons within a covalent bond.

☒ **B** repel the electrons within a covalent bond.

☒ **C** attract the electrons within an ionic bond.

☒ **D** repel the electrons within an ionic bond.

**(Total for Question 3 = 1 mark)**

**4** Consider the following reaction.

$$Ca(OH)_2(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$$

This reaction can be classified as

☒ **A** acid-base.

☒ **B** precipitation.

☒ **C** redox.

☒ **D** thermal decomposition.

**(Total for Question 4 = 1 mark)**

**5** The greenhouse gas with the largest average concentration in the atmosphere is

☒ **A** carbon dioxide.

☒ **B** methane.

☒ **C** nitrogen.

☒ **D** water vapour.

**(Total for Question 5 = 1 mark)**

**6** Low molecular mass alkanes are now used as propellants in aerosols. Which environmental problem does this aim to reduce?

☒ **A** Acid rain

☒ **B** Global warming

☒ **C** Non-biodegradability

☒ **D** Ozone depletion

**(Total for Question 6 = 1 mark)**

**7** Sustainable chemistry aims to involve processes which use

☒ **A** non-renewable resources.

☒ **B** a catalyst.

☒ **C** high pressure.

☒ **D** high temperature.

**(Total for Question 7 = 1 mark)**

**8** There is serious concern over climate change brought about by anthropogenic effects. Which of the following is **not** one of these?

☒ **A** Burning of fossil fuels.

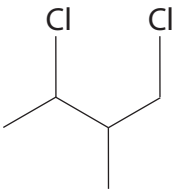
☒ **B** Deforestation.

☒ **C** Intensive agriculture.

☒ **D** Volcanic eruptions.

**(Total for Question 8 = 1 mark)**

**9** The halogenoalkane shown below




can be classified as

☒ **A** just primary.

☒ **B** primary and secondary.

☒ **C** just secondary.

☒ **D** secondary and tertiary.

**(Total for Question 9 = 1 mark)**

**10** When 2-bromopropane is heated with concentrated, alcoholic potassium hydroxide, the major product is

☒ **A** propene.

☒ **B** propan-1-ol.

☒ **C** propan-2-ol.

☒ **D** potassium propoxide.

**(Total for Question 10 = 1 mark)**

**11** The rates of hydrolysis of different halogenoalkanes can be compared by carrying out the reaction in the presence of aqueous silver nitrate solution.
When an iodoalkane is used, the experimental observation would be

☒ **A** effervescence.

☒ **B** a white precipitate and bubbles.

☒ **C** a yellow precipitate.

☒ **D** a dark grey solid.

**(Total for Question 11 = 1 mark)**

**12** Consider the following equilibrium.

$$\underset{\text{Dark brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{Colourless}}{N_2O_4(g)}$$

If the above equilibrium is initially set up so that the mixture is dark brown, then a gradual **decrease** in pressure would result in

☒ **A** no visible change.

☒ **B** a change to yellow.

☒ **C** a change to yellow then colourless.

☒ **D** a change to colourless.

**(Total for Question 12 = 1 mark)**

**13** In the reaction of concentrated sulfuric acid with solid sodium iodide, the sulfur is **finally** reduced to

☒ **A** hydrogen sulfide.

☒ **B** hydrogen sulfate.

☒ **C** sulfur dioxide.

☒ **D** sulfur trioxide.

**(Total for Question 13 = 1 mark)**

**14** Flame colours can be used to detect some metal ions. The **emission** of these flame colours arises when electrons

- ☒ **A** are lost from the ions.
- ☒ **B** absorb light energy.
- ☒ **C** are excited to higher energy levels.
- ☒ **D** drop back down to lower energy levels.

**(Total for Question 14 = 1 mark)**

**15** When lithium chloride is heated in a Bunsen flame, the colour of the flame is

- ☒ **A** lilac.
- ☒ **B** bright yellow.
- ☒ **C** bright red.
- ☒ **D** pale green.

**(Total for Question 15 = 1 mark)**

**16** Which of the following is the equation for the reaction of calcium with excess water?

- ☒ **A** $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$
- ☒ **B** $Ca(s) + H_2O(l) \rightarrow CaO(s) + H_2(g)$
- ☒ **C** $Ca(s) + H_2O(l) \rightarrow CaOH(aq) + \frac{1}{2}H_2(g)$
- ☒ **D** $Ca(s) + 2H_2O(l) \rightarrow CaO_2(s) + 2H_2(g)$

**(Total for Question 16 = 1 mark)**

**17** The thermal stability of the Group 2 carbonates, $MgCO_3$ to $BaCO_3$, increases down the group because

- ☒ **A** the charge on the cation increases.
- ☒ **B** the charge density of the ions increases.
- ☒ **C** the cation is less able to polarize the anion.
- ☒ **D** the anion is less reactive than the cation.

**(Total for Question 17 = 1 mark)**

**18** Graphite is made up of hexagonal rings of carbon atoms in a layered arrangement. The carbon atoms in the same layer are 0.14 nm apart. What is the distance between adjacent layers of carbon atoms?

☒ **A** 0.04 nm

☒ **B** 0.13 nm

☒ **C** 0.15 nm

☒ **D** 0.34 nm

**(Total for Question 18 = 1 mark)**

**19** Some ionic solids, such as sodium chloride, are soluble in water because

☒ **A** there are only weak ionic bonds within the lattice.

☒ **B** there are strong London forces created on dissolving.

☒ **C** the ions are strongly hydrated by the water molecules.

☒ **D** strong hydrogen bonds are formed with the water molecules.

**(Total for Question 19 = 1 mark)**

**20** When using a solid to make a solution of accurately known concentration for use in a titration, the solid must

☒ **A** dissolve slowly.

☒ **B** have variable water of crystallization.

☒ **C** not absorb moisture from the air.

☒ **D** have a small molar mass to increase the accuracy of weighing.

**(Total for Question 20 = 1 mark)**

**TOTAL FOR SECTION A = 20 MARKS**

## SECTION B

**Answer ALL the questions. Write your answers in the spaces provided.**

**21** Iodine pentoxide, $I_2O_5$, is a white crystalline solid. It is formed by heating $HIO_3$ to about 200 °C in a stream of dry air. The reaction is shown below.

$$2HIO_3 \rightleftharpoons I_2O_5 + H_2O$$

(a) (i) Is this production of iodine pentoxide a redox reaction? Justify your answer by stating the oxidation number of iodine in both of these compounds.

**(1)**

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(ii) Suggest why it is important to have a stream of **dry** air.

**(1)**

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(iii) Above 300 °C, iodine pentoxide decomposes to form iodine and oxygen. Write the equation for this decomposition. State symbols are not required.

**(1)**

(iv) In iodine pentoxide, each iodine atom is bonded to three oxygen atoms and one of these oxygen atoms is bonded to both iodine atoms as shown in the layout below.

Complete the dot and cross diagram for the molecule, using dots for the oxygen electrons and crosses for the iodine electrons.

In this molecule, each iodine atom has twelve electrons in its outer shell. Show outer shell electrons only.

**(2)**

O O

I O I

O O

(v) The shape around the iodine is similar to that around the nitrogen in ammonia, $NH_3$. Suggest a value for the O – I – O bond angle and the name of the shape around the iodine atom.

**(2)**

O – I – O bond angle .....

Shape .....

(b) Iodine pentoxide is used as a reagent to determine the amount of carbon monoxide present in a gaseous sample. The sample is passed over heated iodine pentoxide. The products of this process are carbon dioxide and iodine.

The iodine formed is extracted and added to an excess of sodium thiosulfate solution of known concentration. The remaining sodium thiosulfate is then determined by titration with a solution of iodine of known concentration.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

In an analysis, a 2.00 $m^3$ sample of gas was used and the resultant iodine extracted and added to 20 $cm^3$ of a 0.0400 mol $dm^{-3}$ solution of sodium thiosulfate, an excess.

The resultant solution was then titrated against a solution of iodine of concentration 0.0100 mol $dm^{-3}$. The volume of iodine solution required for complete reaction was 21.60 $cm^3$.

(i) Calculate the number of moles of iodine present in 21.60 $cm^3$ of the iodine solution. Give your answer to **three** significant figures.

**(1)**

(ii) Deduce the number of moles of sodium thiosulfate that reacted with this titrated amount of iodine.

**(1)**

(iii) Calculate the number of moles of sodium thiosulfate to which the iodine was **initially** added.

**(1)**

(iv) From your answers to parts (b)(ii) and (b)(iii), determine the number of moles of sodium thiosulfate that reacted with the extracted iodine.

**(1)**

(v) Use your answer to part (b)(iv) to determine the number of moles of extracted iodine.

**(1)**

(vi) Write the balanced equation for the reaction between iodine pentoxide and carbon monoxide. State symbols are not required.

**(1)**

(vii) Calculate the volume, in $dm^3$, of carbon monoxide in the original gaseous sample.

Assume that the molar gas volume of any gas under the experimental conditions is 24 $dm^3\ mol^{-1}$.

**(2)**

(viii) State how this procedure could be amended to produce results that are more reliable.

**(1)**

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*(c) Carbon monoxide is an atmospheric pollutant arising from the incomplete combustion of fossil fuels.

(i) State how motor vehicles have been adapted to reduce the production of this pollutant.

**(1)**

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(ii) Explain the meaning of the term 'carbon-neutral' and give an example of a motor vehicle fuel that can be classified in this way.

**(2)**

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**(Total for Question 21 = 19 marks)**

**22** The thermit reaction is a 'classic' chemical demonstration. It is also a chemical reaction which has a number of important industrial uses.

(a) The thermit reaction is between iron(III) oxide and aluminium powder and produces aluminium oxide and iron. Complete the balanced equation. State symbols are not required.

**(1)**

$$Fe_2O_3 + 2Al \rightarrow \text{.....} + \text{.....}$$

(b) For the thermit reaction to work successfully, the iron(III) oxide and aluminium must be mixed in the correct stoichiometric ratio.

Calculate the mass of aluminium that would be required to react with 34.0 g of iron(III) oxide.

**(3)**

(c) The iron(III) oxide needs to be dried before it can be used in the thermit reaction. Suggest how this could be carried out.

**(1)**

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(d) The iron(III) oxide and aluminium must be thoroughly mixed. Suggest why this is essential for the reaction to work.

**(1)**

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(e) The thermit reaction requires a source of ignition in order to start. This source needs to generate a lot of heat. Simply heating to 'red-heat' is insufficient, as heating to 'white-heat' is necessary. Often a strip of magnesium ribbon is used as a fuse to ignite the thermit mixture.

(i) What would be seen when the magnesium ribbon is first lit?

**(1)**

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(ii) What is the chemical product of this reaction?

**(1)**

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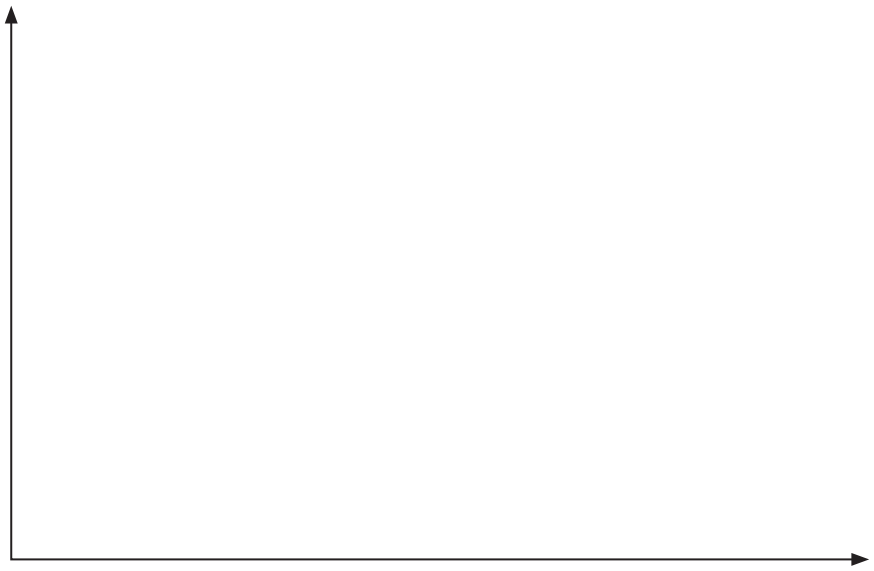
(iii) The lighting of the magnesium fuse creates enough heat energy to initiate the thermit reaction.

Draw a fully labelled reaction profile diagram for the thermit reaction.

The enthalpy change for this reaction is –825 kJ $mol^{-1}$.

**(4)**



(iv) Use your reaction profile to explain the role of the magnesium fuse in initiating the thermit reaction.

**(1)**

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(v) Explain why the magnesium fuse is **not** acting as a catalyst for the reaction.

**(1)**

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(vi) Only a small quantity of magnesium is required to start the reaction. Suggest why this is the case.

**(1)**

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(f) Occasionally, the thermit mixture can fail to ignite. Suggest why extreme caution should be exercised under such a situation.

**(1)**

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(g) One industrial application of the thermit reaction is the welding, or the joining, of railway lines. How does the thermit reaction achieve this function?

**(1)**

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(h) Many alternative chemicals can be used in a 'thermit-type' of reaction. In principle, other reactive metals could be used in place of aluminium, but this is rarely the case in real-life situations. Suggest why.

**(1)**

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**(Total for Question 22 = 18 marks)**

**TOTAL FOR SECTION B = 37 MARKS**

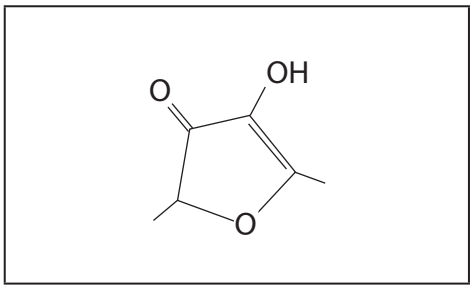
## SECTION C

**Answer ALL the questions. Write your answers in the spaces provided.**

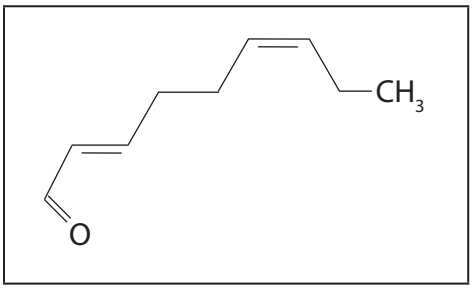
**23** The sensation of flavour arises from a combination of both taste, detected by chemical receptors on the tongue, and smell, detected by chemical receptors in the nose.

Some chemicals are commonly called after one particular flavour or aroma, such as:

'strawberry furanone'




'cucumber aldehyde'




However, a flavour such as strawberry is not created from just one chemical but can be from a mixture containing many different chemicals, all of which can interact with various receptors in the mouth and the nose. For example, one strawberry milkshake product contains 59 different ingredients in order to achieve the required strawberry flavour.

In order to detect the different chemical components of a particular flavour, a number of chemical techniques can be employed. One such technique is GCMS, Gas Chromatography Mass Spectometry. The volatile chemicals are first separated by gas chromatography and then detected and analysed by mass spectrometry.

The flavour of various chemicals and their mixtures can be altered by the ways in which they are processed or cooked. For example, the Maillard reaction is promoted by heating and is responsible for the browning of bread and results in the formation of toast, which has a different flavour to the uncooked bread.

(a) Give the molecular formula of the 'strawberry furanone'.

**(1)**

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(b) Name **one** functional group, other than ketone, present in the 'strawberry furanone' molecule.

**(1)**

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(c) The presence of an OH group can be detected by the use of sodium or by the use of phosphorus(V) chloride, $PCl_5$.

Using the formula R-OH, complete the balanced equations for both of these reactions and give one observation for each of them. State symbols are not required.

(i) The reaction with sodium

**(2)**

Equation ROH +

Observation .....

(ii) The reaction with phosphorus(V) chloride

**(2)**

Equation ROH +

Observation .....

(iii) In each reaction a hazardous gas is produced. By considering the hazards associated with each of these gases, suggest which poses the greater risk. Justify your answer.

**(2)**

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(d) The 'cucumber aldehyde' can be formed from the oxidation of the corresponding alcohol.

(i) Identify by names or formulae, the two reagents that could be used together to oxidize an alcohol to an aldehyde. State the essential reaction condition.

**(3)**

Reagents for oxidation .....

Condition .....

*(ii) Infrared spectroscopy can be used to distinguish different functional groups, such as alcohols and aldehydes.

State how this analytical technique is used to do this and explain the effect of the radiation on the molecule.

Specific values and experimental details are not required.

**(3)**

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*(e) Differences in volatility can be exploited to achieve the separation of molecules. Alkanes have a higher volatility than the corresponding alcohol and so can be effectively separated on this basis.

Explain how the intermolecular forces present in alkanes arise and how the predominant intermolecular force in alcohols is formed, and then why alkanes have a higher volatility.

**(7)**

Intermolecular forces in alkanes .....

How they arise .....

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Predominant intermolecular forces in alcohols .....

How they arise .....

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Why alkanes have a higher volatility .....

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(f) Explain how it is possible to distinguish between individual chemicals using their mass spectra.

**(1)**

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(g) The browning of apples, which can occur when they are bruised, is due to the action of enzymes which create brown polymers. However, this does not affect the aroma of the apples. Suggest why this is so.

**(1)**

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**(Total for Question 23 = 23 marks)**

**TOTAL FOR SECTION C = 23 MARKS**
**TOTAL FOR PAPER = 80 MARKS**

# The Periodic Table of Elements

| 1 | 2 | | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 (8) (18) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1.0 H hydrogen 1 | | | | | | | | | | 4.0 He helium 2 |
| (1) | (2) | | Key | | | | | | | | | (13) | (14) | (15) | (16) | (17) | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | | relative atomic mass<br>atomic symbol<br>name<br>atomic (proton) number | | | | | | | | | 10.8 B boron 5 | 12.0 C carbon 6 | 14.0 N nitrogen 7 | 16.0 O oxygen 8 | 19.0 F fluorine 9 | 20.2 Ne neon 10 |
| 23.0 Na sodium 11 | 24.3 Mg magnesium 12 | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | 27.0 Al aluminium 13 | 28.1 Si silicon 14 | 31.0 P phosphorus 15 | 32.1 S sulfur 16 | 35.5 Cl chlorine 17 | 39.9 Ar argon 18 |
| 39.1 K potassium 19 | 40.1 Ca calcium 20 | 45.0 Sc scandium 21 | 47.9 Ti titanium 22 | 50.9 V vanadium 23 | 52.0 Cr chromium 24 | 54.9 Mn manganese 25 | 55.8 Fe iron 26 | 58.9 Co cobalt 27 | 58.7 Ni nickel 28 | 63.5 Cu copper 29 | 65.4 Zn zinc 30 | 69.7 Ga gallium 31 | 72.6 Ge germanium 32 | 74.9 As arsenic 33 | 79.0 Se selenium 34 | 79.9 Br bromine 35 | 83.8 Kr krypton 36 |
| 85.5 Rb rubidium 37 | 87.6 Sr strontium 38 | 88.9 Y yttrium 39 | 91.2 Zr zirconium 40 | 92.9 Nb niobium 41 | 95.9 Mo molybdenum 42 | [98] Tc technetium 43 | 101.1 Ru ruthenium 44 | 102.9 Rh rhodium 45 | 106.4 Pd palladium 46 | 107.9 Ag silver 47 | 112.4 Cd cadmium 48 | 114.8 In indium 49 | 118.7 Sn tin 50 | 121.8 Sb antimony 51 | 127.6 Te tellurium 52 | 126.9 I iodine 53 | 131.3 Xe xenon 54 |
| 132.9 Cs caesium 55 | 137.3 Ba barium 56 | 138.9 La* lanthanum 57 | 178.5 Hf hafnium 72 | 180.9 Ta tantalum 73 | 183.8 W tungsten 74 | 186.2 Re rhenium 75 | 190.2 Os osmium 76 | 192.2 Ir iridium 77 | 195.1 Pt platinum 78 | 197.0 Au gold 79 | 200.6 Hg mercury 80 | 204.4 Tl thallium 81 | 207.2 Pb lead 82 | 209.0 Bi bismuth 83 | [209] Po polonium 84 | [210] At astatine 85 | [222] Rn radon 86 |
| [223] Fr francium 87 | [226] Ra radium 88 | [227] Ac* actinium 89 | [261] Rf rutherfordium 104 | [262] Db dubnium 105 | [266] Sg seaborgium 106 | [264] Bh bohrium 107 | [277] Hs hassium 108 | [268] Mt meitnerium 109 | [271] Ds darmstadtium 110 | [272] Rg roentgenium 111 | | | | | | | |

Elements with atomic numbers 112-116 have been reported but not fully authenticated

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * Lanthanide series | 140 Ce cerium 58 | 141 Pr praseodymium 59 | 144 Nd neodymium 60 | [147] Pm promethium 61 | 150 Sm samarium 62 | 152 Eu europium 63 | 157 Gd gadolinium 64 | 159 Tb terbium 65 | 163 Dy dysprosium 66 | 165 Ho holmium 67 | 167 Er erbium 68 | 169 Tm thulium 69 | 173 Yb ytterbium 70 | 175 Lu lutetium 71 |
| * Actinide series | 232 Th thorium 90 | [231] Pa protactinium 91 | 238 U uranium 92 | [237] Np neptunium 93 | [242] Pu plutonium 94 | [243] Am americium 95 | [247] Cm curium 96 | [245] Bk berkelium 97 | [251] Cf californium 98 | [254] Es einsteinium 99 | [253] Fm fermium 100 | [256] Md mendelevium 101 | [254] No nobelium 102 | [257] Lr lawrencium 103 |