Write your name here

| Surname | Other names |
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**Pearson Edexcel GCE**

| Centre Number | Candidate Number |
|---|---|
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# Chemistry

## Advanced Subsidiary
## Unit 2: Application of Core Principles of Chemistry

Friday 10 June 2016 – Afternoon
**Time: 1 hour 30 minutes**

Paper Reference
**6CH02/01**

**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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P 4 6 6 5 8 A 0 1 2 4

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** How many molecular ion peaks (parent ion peaks) are in the mass spectrum of 1,2-dibromoethane?

Assume the only isotopes present are $^{1}H$, $^{12}C$, $^{79}Br$ and $^{81}Br$.

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

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

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**2** Four compounds that contribute to global warming are given below.

**A** Sulfur hexafluoride

**B** Dichlorodifluoromethane

**C** Methane

**D** Carbon dioxide

(a) Which of these molecules is polar?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

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(b) Which of these compounds is emitted in the largest quantity by anthropogenic activity?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which of these compounds depletes the ozone layer?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) Which of these molecules has an octahedral structure?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 2 = 4 marks)**

**3** Which of the following is a tertiary alcohol?

☒ **A** 3-methylbutan-2-ol

☒ **B** 2-methylbutan-2-ol

☒ **C** 2-methylbutan-1-ol

☒ **D** 2,2-dimethylpropan-1-ol

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

**4** This question is about two isomeric alcohols and two isomeric carbonyl compounds.

Butan-1-ol, $CH_3CH_2CH_2CH_2OH$

Butan-2-ol, $CH_3CH_2CH(OH)CH_3$

Butanal, $CH_3CH_2CH_2CHO$

Butanone, $CH_3CH_2COCH_3$

(a) Which of these compounds would **not** produce a colour change when heated with acidified sodium dichromate(VI) solution?

**(1)**

☒ **A** Butan-1-ol

☒ **B** Butan-2-ol

☒ **C** Butanal

☒ **D** Butanone

(b) Which compound could give a peak at $m/e = 31$ in its mass spectrum?

**(1)**

☒ **A** Butan-1-ol

☒ **B** Butan-2-ol

☒ **C** Butanal

☒ **D** Butanone

(c) Which compound could **not** give a peak at $m/e = 43$ in its mass spectrum?

**(1)**

☒ **A** Butan-1-ol

☒ **B** Butan-2-ol

☒ **C** Butanal

☒ **D** Butanone

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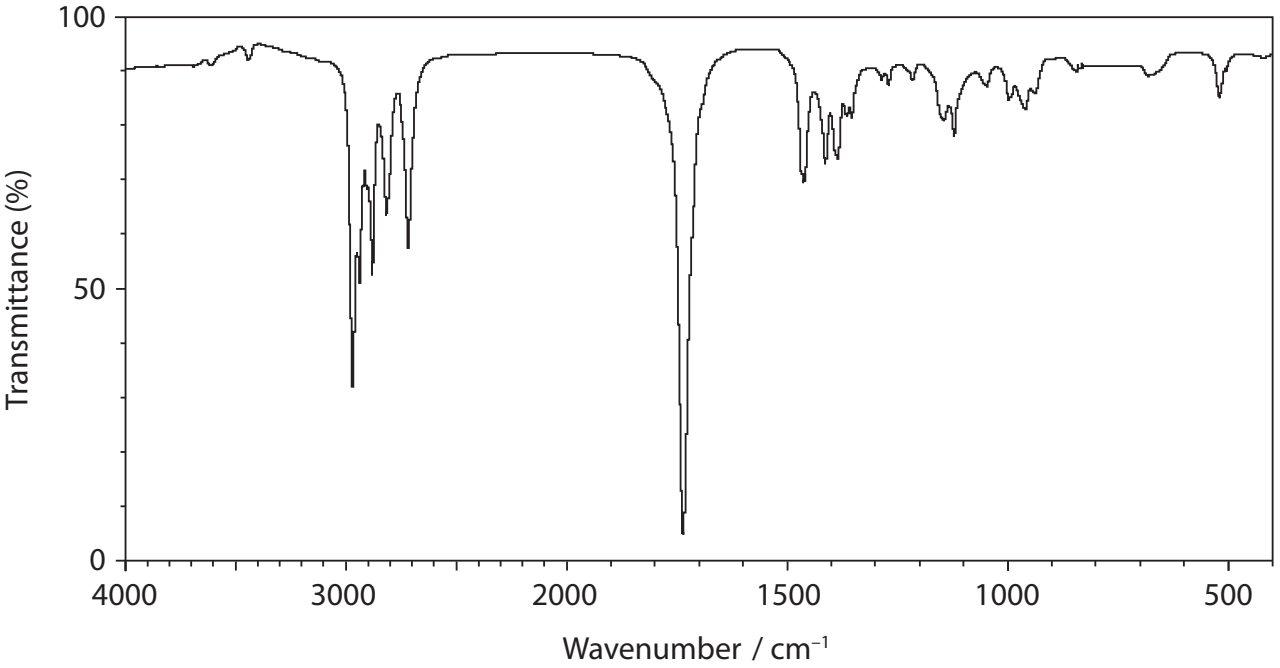
(d) The infrared spectrum of one of these compounds is given below.




Use the infrared absorptions, in wavenumbers, to identify the compound.

| Bond | Wavenumber range / $cm^{-1}$ |
|---|---|
| O—H (alcohol) | 3750 – 3200 |
| C—H (alkane) | 2962 – 2853 |
| C—H (aldehyde) | 2900 – 2820 and 2775 – 2700 |
| C=O (aldehyde or ketone) | 1740 – 1680 |

The compound with this IR spectrum is

**(1)**

☒ **A** butan-1-ol.

☒ **B** butan-2-ol.

☒ **C** butanal.

☒ **D** butanone.

**(Total for Question 4 = 4 marks)**

**5** A Maxwell-Boltzmann curve shows the distribution of molecular energies in a reaction system. When the temperature in this system is **increased**, the peak is

☒ **A** higher and further to the right.

☒ **B** higher and further to the left.

☒ **C** lower and further to the right.

☒ **D** lower and further to the left.

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

**6** This question is about the equilibrium reaction between hydrogen and carbon dioxide.

$$H_2(g) + CO_2(g) \rightleftharpoons H_2O(g) + CO(g) \qquad \Delta H^{\ominus} = +40 \text{ kJ mol}^{-1}$$

What effect would the following changes have on the rate of reaction and the yield of carbon monoxide?

(a) **Increase** in temperature.

**(1)**

| | Rate | Yield of CO |
|---|---|---|
| ☒ **A** | increase | increase |
| ☒ **B** | increase | decrease |
| ☒ **C** | increase | no change |
| ☒ **D** | no change | decrease |

(b) **Increase** in pressure.

**(1)**

| | Rate | Yield of CO |
|---|---|---|
| ☒ **A** | increase | increase |
| ☒ **B** | increase | decrease |
| ☒ **C** | increase | no change |
| ☒ **D** | no change | no change |

**(Total for Question 6 = 2 marks)**

**7** Which is the equation for the reaction when steam passes over strongly heated magnesium?

☒ **A** $Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g)$

☒ **B** $Mg(s) + 2H_2O(g) \rightarrow Mg(OH)_2(s) + H_2(g)$

☒ **C** $Mg(s) + H_2O(l) \rightarrow MgO(s) + H_2(g)$

☒ **D** $Mg(s) + H_2O(g) \rightarrow MgO(s) + H_2(g)$

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

**8** What happens to the solubilities of the hydroxides and sulfates as Group 2 is descended?

| | Solubility of hydroxides | Solubility of sulfates |
|---|---|---|
| ☒ **A** | decreases | decreases |
| ☒ **B** | decreases | increases |
| ☒ **C** | increases | decreases |
| ☒ **D** | increases | increases |

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

**9** Which one of the following substances forms when a few drops of concentrated sulfuric acid is added to sodium chloride?

☒ **A** $H_2O$

☒ **B** $Cl_2$

☒ **C** $NaHSO_4$

☒ **D** $SO_2$

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

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**10** 25.00 $cm^3$ of 1.00 mol $dm^{-3}$ sulfuric acid is fully neutralized by 50.00 $cm^3$ of 1.00 mol $dm^{-3}$ sodium hydroxide.

(a) What is the concentration of sodium sulfate solution produced by the reaction, in mol $dm^{-3}$?

**(1)**

☒ **A** 1.00

☒ **B** 0.67

☒ **C** 0.50

☒ **D** 0.33

(b) The volumes are measured using burettes, with each burette reading having an uncertainty of ±0.05 $cm^3$.

The percentage error in measuring the 25.00 $cm^3$ of the acid is

**(1)**

☒ **A** ±0.05%

☒ **B** ±0.10%

☒ **C** ±0.20%

☒ **D** ±0.40%

**(Total for Question 10 = 2 marks)**

**11** Pentan-1-ol is less soluble than ethanol in water. The best explanation for this is that

☒ **A** pentan-1-ol molecules cannot form hydrogen bonds with water molecules, but ethanol molecules can.

☒ **B** London forces are stronger between pentan-1-ol molecules than between ethanol molecules.

☒ **C** carbon-carbon bonds are stronger in pentan-1-ol than in ethanol.

☒ **D** permanent dipole forces are stronger in pentan-1-ol than in ethanol.

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

**Use this space for rough working. Anything you write in this space will gain no credit.**

**12** Along the series of the Group 5 hydrides ($NH_3$, $PH_3$ and $AsH_3$), the boiling temperatures

☒ **A** decrease.

☒ **B** decrease then increase.

☒ **C** increase.

☒ **D** increase then decrease.

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

**TOTAL FOR SECTION A = 20 MARKS**

## SECTION B

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

**13** This question is about the fluorides $BF_3$, $NF_3$, $OF_2$ and $O_2F_2$.

(a) (i) For $BF_3$, name the shape of the molecule and give the FBF bond angle.

**(2)**

Shape .....

Bond angle .....

*(ii) For the $NF_3$ molecule, draw the shape you would expect and suggest the FNF bond angle. Explain why the molecule has this shape and bond angle.

**(4)**

Shape

Bond angle .....

Explanation .....

.....

.....

.....

(iii) Draw a diagram to show the bonding in the single product of the reaction between $BF_3$ and $NF_3$.

Identify the type of bond that forms between these two molecules.

**(2)**

.....

(b) (i) What is the oxidation number of oxygen in $OF_2$?

**(1)**

.....

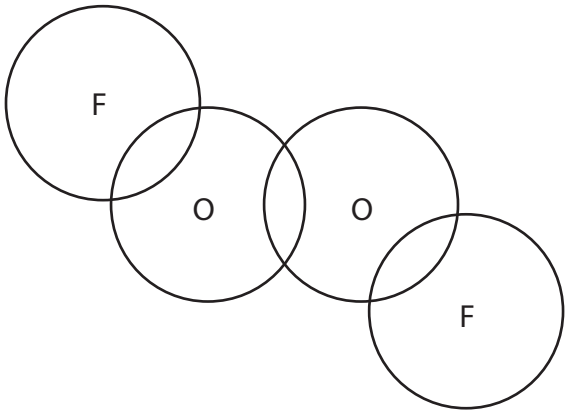
(ii) When water reacts with $OF_2$, oxygen is one of the products. Suggest an equation for this reaction.

State symbols are not required.

**(1)**

(c) Complete the diagram with dots and crosses to show the outer shell electrons in the $O_2F_2$ molecule.

**(1)**




**(Total for Question 13 = 11 marks)**

**14** (a) The rates of hydrolysis of three bromoalkanes are compared.

2 $cm^3$ of ethanol is added to three test tubes, **A**, **B** and **C**.

Three drops of bromoalkane are added to each of these three test tubes.

1-bromobutane is added to test tube **A**.
2-bromobutane is added to test tube **B**.
2-bromo-2-methylpropane is added to test tube **C**.

2 $cm^3$ of hot aqueous silver nitrate solution is added to each test tube.

(i) Explain why ethanol is added to each test tube.

**(1)**

.....

.....

(ii) Complete the general equation for the hydrolysis of these bromoalkanes.

State symbols are not required.

**(1)**

$C_4H_9Br + H_2O \rightarrow$

(iii) Eventually a precipitate is formed in each test tube. Give the colour of the precipitate formed and write the ionic equation, with state symbols, for its formation.

**(2)**

Colour .....

Ionic Equation

(iv) Identify the reagent you could add to dissolve the precipitate.

**(1)**

.....

(v) Give the order in which the precipitates form in the test tubes **A**, **B** and **C**, giving the fastest first.

**(1)**

.....

*(vi) State how the rates of hydrolysis depend on the structure of the bromoalkane. Suggest a reason for this difference. You are not required to give detailed mechanisms for the reactions.

**(2)**

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(b) (i) When 1-bromobutane reacts with an alcoholic solution of sodium hydroxide, a different reaction occurs.

Draw a fully labelled diagram to show the apparatus needed for carrying out this reaction in the laboratory and collecting the gaseous organic product.

**(2)**

(ii) Name the organic product for this reaction and draw its **skeletal** formula.

**(2)**

Name .....

**Skeletal** formula

(c) 1-bromobutane reacts with alcoholic ammonia when heated under pressure.

(i) State the type and mechanism of this reaction.

**(2)**

Type .....

Mechanism .....

(ii) Name the organic product of this reaction.

**(1)**

.....

**(Total for Question 14 = 15 marks)**

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**15** Hydrated magnesium nitrate, $Mg(NO_3)_2.6H_2O$, is heated in a boiling tube and the following observations are made.

Stage 1 The white solid forms a clear, colourless solution.

Stage 2 Condensation forms around the mouth of the boiling tube and a white solid starts to form at the bottom of the tube.

Stage 3 As the heating continues, the colourless solution disappears leaving a white solid.

Stage 4 The white solid melts.

Stage 5 A brown gas forms.

Stage 6 A glowing splint reignites when it is placed in the boiling tube.

Stage 7 A white solid is left in the boiling tube.

(a) Explain what is happening in stages 1 and 2.

**(3)**

(b) (i) Identify the products formed in stages 5, 6 and 7.

**(3)**

Stage 5 .....

Stage 6 .....

Stage 7 .....

(ii) Write the equation for the complete thermal decomposition of hydrated magnesium nitrate, $Mg(NO_3)_2.6H_2O$.

State symbols are not required.

**(2)**

(c) The chlorides of magnesium and calcium can be distinguished from each other by carrying out a flame test.

(i) Describe what you would see in each test.

**(2)**

Magnesium chloride .....

Calcium chloride .....

*(ii) Explain how flame colours arise in a flame test.

**(3)**

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.....

(iii) Suggest why the observations of the flame tests for magnesium chloride and calcium chloride are different.

**(2)**

.....

.....

.....

.....

.....

**(Total for Question 15 = 15 marks)**

**TOTAL FOR SECTION B = 41 MARKS**

## SECTION C

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

**16** Olive oil is an important edible oil. In many European countries, it is used as an alternative to butter for spreading on bread.

A useful method of comparing fats and oils is to measure their iodine values.
An iodine value is the amount of iodine in grams that reacts with 100 g of a fat or oil.
This measures the degree of unsaturation of the fat or oil.

The iodine value of olive oil can be determined in the following way.

Add 0.200 g of olive oil to a 250 $cm^3$ conical flask.

Add 10 $cm^3$ of solvent to dissolve the oil.

Add 10.0 $cm^3$ of a solution of iodine monochloride, called Wijs solution.

Stopper the flask and allow to stand in the dark for half an hour.

Add 15 $cm^3$ of 10% potassium iodide solution and 100 $cm^3$ of water and shake the mixture.

Titrate the liberated iodine with 0.100 mol $dm^{-3}$ sodium thiosulfate solution. This is the sample titre.

Carry out a blank titration using 10 $cm^3$ of solvent, 10.0 $cm^3$ of Wijs solution, 15 $cm^3$ of 10% potassium iodide solution and 100 $cm^3$ of water.

(a) For many years, 1,1,1-trichloroethane was used as the solvent for this reaction.

(i) Draw the **displayed** formula for 1,1,1-trichloroethane.

**(1)**

(ii) Explain why 1,1,1-trichloroethane has a higher boiling temperature than hexane.

**(2)**

(iii) Suggest why the solvent 1,1,1-trichloroethane is no longer used.

**(1)**

(b) (i) Iodine monochloride adds more readily than iodine to carbon-carbon double bonds. Using your knowledge of electrophilic addition, suggest why this is so.

**(1)**

(ii) Complete the formula of the product formed when iodine monochloride, ICl, reacts with oleic acid, $CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$, the most abundant unsaturated compound in olive oil.

**(1)**

$$CH_3(CH_2)_7{-}C{-}C{-}(CH_2)_7COOH$$

(iii) Suggest why the mixture must be kept in the dark.

**(1)**

(iv) Give the oxidation numbers of iodine in iodine monochloride, iodide ions and iodine.

Write the ionic equation for the reaction between iodide ions and iodine monochloride. State symbols are not required.

**(2)**

Oxidation number of iodine in

Iodine monochloride .....

Iodide ion .....

Iodine .....

Ionic equation for this reaction

(c) Suggest a suitable indicator for the titration. Give the colour change of the solution at the end point.

**(2)**

Indicator .....

Colour change from ..... to .....

(d) In the blank titration, 20.0 $cm^3$ of sodium thiosulfate solution reacted with 10.0 $cm^3$ of Wijs solution.

(i) Calculate the number of moles of 0.100 mol $dm^{-3}$ sodium thiosulfate that reacted with the **blank** titre.

**(1)**

(ii) Complete the ionic equation for the reaction between iodine and thiosulfate ions. Include state symbols.

**(1)**

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

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(iii) Calculate the number of moles of iodine, $I_2$, that reacted with the thiosulfate solution in the blank titration.

**(1)**

(iv) Using your answers to (b)(iv) and (d)(iii), write down the corresponding number of moles of iodine monochloride solution in 10 $cm^3$ of Wijs solution.

**(1)**

(v) The number of moles of iodine monochloride left after reacting the Wijs solution with the olive oil sample, calculated from the sample titre, is $3.65 \times 10^{-4}$ mol.

Use this, and your answer to (d)(iv), to calculate the amount of iodine monochloride that reacted with the sample.

**(1)**

(vi) Your answer to (d)(v) is equal to the number of moles of iodine that would have reacted with 0.200 g of olive oil.

Calculate the number of moles of iodine that would have reacted with 100 g of olive oil.

**(1)**

(vii) Calculate the mass of iodine, $I_2$, that would have reacted with 100 g of olive oil, which is the iodine value for the olive oil.

**(1)**

(e) Butter contains a smaller percentage of unsaturated molecules than olive oil.

Would the titre value and iodine value for butter be higher, lower or about the same as the values for olive oil?

**(1)**

Sample titre .....

Iodine value .....

**(Total for Question 16 = 19 marks)**

**TOTAL FOR SECTION C = 19 MARKS**
**TOTAL FOR PAPER = 80 MARKS**

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# 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

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 |

* Lanthanide series

* Actinide series