Write your name here

| Surname | Other names |
|---|---|
| | |

**Pearson Edexcel**
**International**
**Advanced Level**

Centre Number | | | | | |

Candidate Number | | | | |

# Chemistry

## Advanced Subsidiary
## Unit 1: The Core Principles of Chemistry

Friday 26 May 2017 – Morning
**Time: 1 hour 30 minutes**

Paper Reference
**WCH01/01**

**Candidates may use a calculator.**

Total Marks

### Instructions

- Use **black** ink or **black** 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 8 3 8 2 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** Sea water contains 2.7 mg of sulfate ions per kilogram.

What is the concentration of sulfate ions in parts per million by mass?

☒ **A** $2.7 \times 10^{-6}$

☒ **B** $2.7 \times 10^{-3}$

☒ **C** 2.7

☒ **D** $2.7 \times 10^{3}$

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

**2** How many **ions** are in 284 g of sodium sulfate, $Na_2SO_4$?

Avogadro constant = $6.0 \times 10^{23}$ mol$^{-1}$

Molar mass of sodium sulfate = 142 g mol$^{-1}$

☒ **A** $1.2 \times 10^{24}$

☒ **B** $2.4 \times 10^{24}$

☒ **C** $3.6 \times 10^{24}$

☒ **D** $8.4 \times 10^{24}$

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

**3** Calculate the empirical formula of the compound with the percentage composition by mass: Li = 17.9%; P = 26.8%; O = 55.3%

Molar masses / g mol$^{-1}$ Li = 6.9, P = 31.0, O = 16.0

☒ **A** $Li_2P_3O_6$

☒ **B** $Li_3PO_3$

☒ **C** $LiPO_3$

☒ **D** $Li_3PO_4$

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

**4** What is the empirical formula of the oxide formed when 2.6 g of chromium produces 3.8 g of chromium oxide?

Molar masses / g mol$^{-1}$ Cr = 52.0, O = 16.0

☒ **A** CrO

☒ **B** $CrO_2$

☒ **C** $Cr_2O_3$

☒ **D** $Cr_3O_4$

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

**5** Consider the reaction

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

What is the maximum volume, in dm$^3$, of sulfur trioxide that could be obtained when 0.5 dm$^3$ of sulfur dioxide is mixed with 1 dm$^3$ of oxygen, under suitable conditions?

All measurements are made at the same temperature and pressure.

☒ **A** 0.5

☒ **B** 1.5

☒ **C** 2.0

☒ **D** 2.5

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

**6** Identify the atom with two unpaired electrons in its lowest energy state (ground state).

☒ **A** Be

☒ **B** C

☒ **C** Cl

☒ **D** Ca

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

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

**7** Which ion has the **largest** ionic radius?

- ☒ **A** $Ca^{2+}$
- ☒ **B** $Cl^-$
- ☒ **C** $K^+$
- ☒ **D** $S^{2-}$

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

**8** The compound with the greatest covalent character is

- ☒ **A** NaF
- ☒ **B** NaI
- ☒ **C** $AlF_3$
- ☒ **D** $AlI_3$

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

**9** What is the sequence of the orbitals from which electrons are removed in the first four ionisations of boron?

| | 1st Ionisation | 2nd Ionisation | 3rd Ionisation | 4th Ionisation |
|---|---|---|---|---|
| ☒ **A** | 1s | 1s | 2s | 2s |
| ☒ **B** | 1s | 2s | 2s | 2p |
| ☒ **C** | 2p | 2s | 2s | 1s |
| ☒ **D** | 2p | 2s | 1s | 1s |

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

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

**10** Calcium chloride can be prepared by reacting calcium carbonate with dilute hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

(a) The ionic equation for the reaction is

**(1)**

☒ **A** $Ca^{2+}(s) + 2Cl^-(aq) \rightarrow CaCl_2(aq)$

☒ **B** $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

☒ **C** $CO_3^{2-}(s) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$

☒ **D** $CaCO_3(s) + 2H^+(aq) + 2Cl^-(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

(b) An excess of calcium carbonate is used in the preparation. The sequence of processes needed to obtain crystals of calcium chloride from the reaction mixture is

**(1)**

☒ **A** filtering, concentrating the solution, slowly evaporating.

☒ **B** filtering, slowly evaporating, distilling.

☒ **C** concentrating the solution, filtering, distilling.

☒ **D** concentrating the solution, slowly evaporating, filtering.

(c) The excess calcium carbonate was added to 100 $cm^3$ of 2.00 mol $dm^{-3}$ hydrochloric acid. The mass of calcium chloride crystals obtained was 10.4 g.

Molar mass of calcium chloride crystals, $CaCl_2.2H_2O$ = 147 g $mol^{-1}$.

The percentage yield, by mass, of calcium chloride crystals is

**(1)**

☒ **A** 71.2

☒ **B** 70.7

☒ **C** 35.4

☒ **D** 17.7

**(Total for Question 10 = 3 marks)**

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

**11** Which of the following series shows the elements in order of increasing melting temperature?

☒ **A** Li, Na, K

☒ **B** Al, Si, P

☒ **C** Na, Mg, Al

☒ **D** S, Cl, Ar

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

**12** Consider the reaction

$$H_2(g) + I_2(g) \rightarrow 2HI\ (g) \qquad \Delta H = -9.0\ kJ\,mol^{-1}$$

The bond energy of H—H = 436 $kJ\,mol^{-1}$

The bond energy of H—I = 298 $kJ\,mol^{-1}$

It can be deduced that the bond energy of I—I, in $kJ\,mol^{-1}$, is

☒ **A** 75.5

☒ **B** 84.5

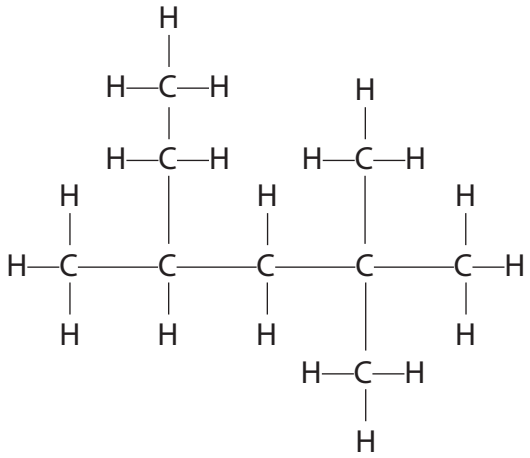
☒ **C** 151

☒ **D** 169

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

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

**13** What is the systematic name for the hydrocarbon shown?



- ☒ **A** 2,2-dimethyl-4-ethylpentane
- ☒ **B** 2-ethyl-4,4-dimethylpentane
- ☒ **C** 3,5,5-trimethylhexane
- ☒ **D** 2,2,4-trimethylhexane

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

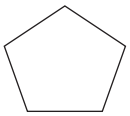
**14** Which compound has *E-Z* isomers?

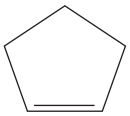
- ☒ **A** but-1-ene
- ☒ **B** but-2-ene
- ☒ **C** 1,1-dichloroethene
- ☒ **D** 2-methylbut-2-ene

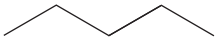
**(Total for Question 14 = 1 mark)**

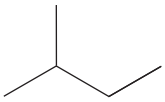
**Use this space for any rough working. Anything you write in this space will gain no credit.**

**15** Which compound has an empirical formula different from its molecular formula?

☒ **A** 

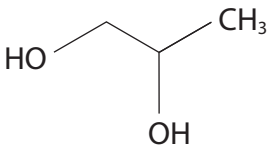
☒ **B** 

☒ **C** 

☒ **D** 

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

**16** Which reagent reacts with propene to form this compound?




☒ **A** hydrogen peroxide solution

☒ **B** oxygen and water

☒ **C** aqueous sodium hydroxide

☒ **D** acidified potassium manganate(VII)

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

**17** Propene reacts with hydrogen bromide to form

☒ **A** a mixture of 1-bromopropane and 2-bromopropane

☒ **B** 1,2-dibromopropane

☒ **C** 2-bromopropan-1-ol

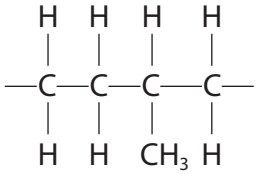
☒ **D** 1-bromopropan-2-ol

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

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

**18** Copolymers are formed from two different monomers.

The repeat unit of a copolymer is



This copolymer is formed from ethene and

☒ **A** propane.

☒ **B** propene.

☒ **C** 2-methylbutane.

☒ **D** 2-methylbut-1-ene.

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

**TOTAL FOR SECTION A = 20 MARKS**

## SECTION B

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

**19** A sample of an element, **X**, was extracted from a meteorite.

The table gives the percentage abundance of the isotopes of **X** obtained from the mass spectrum of the sample.

| *m*/*e* | % abundance |
|---|---|
| 54 | 6.10 |
| 56 | 92.0 |
| 57 | 1.90 |

(a) (i) Calculate the relative atomic mass of the element in this sample.

Give your answer to **three** significant figures.

**(2)**

(ii) Identify **X** and hence give the numbers of subatomic particles present in the species at *m*/*e* = 56 in the mass spectrum.

**(2)**

**X** .....

| Number of particles present in the species at *m*/*e* = 56 | | |
|---|---|---|
| protons | electrons | neutrons |
| | | |

(iii) A peak at $m/e = 28$ was also detected in the mass spectrum of **X**.

Identify the species which produced this peak.

**(1)**

(iv) Explain why the three isotopes of **X** have the same chemical properties.

**(2)**

(b) (i) Outline how a solid sample of element **X** is converted into ions in a mass spectrometer.

**(2)**

(ii) Following the formation of ions, there are three steps in the production of a spectrum in the mass spectrometer.

Name the three steps **in order** and state how the first two are carried out.

**(3)**

**(Total for Question 19 = 12 marks)**

**20** (a) The element sodium and the compound sodium bromide are both solid at room temperature.

(i) Name the type of bonding in sodium and explain how this bonding holds the structure together.

**(2)**

(ii) Name the type of bonding in sodium bromide and explain how this bonding holds the structure together.

**(1)**

(iii) The table shows the melting temperatures of sodium and of sodium bromide.

| Substance | Sodium | Sodium bromide |
|---|---|---|
| Melting temperature / K | 371 | 1020 |

What can you deduce from these data about the bonding in the two substances?

**(1)**

(iv) Name **one** physical property, other than melting or boiling temperature, in which sodium and sodium bromide differ due to the difference in their bonding.

Describe how this property differs for each of the two substances.

**(2)**

(b) The ammonium ion, $NH_4^+$, contains covalent bonds and a dative covalent bond.

(i) Describe the difference between a covalent bond and a dative covalent bond.

**(2)**

(ii) Draw a dot and cross diagram for an ammonium ion. Use the symbol **x** for electrons from the hydrogen atoms and ● for electrons from the outer shell of the nitrogen atom.

**(2)**

(iii) Suggest how an electron density map of ammonium chloride would provide evidence for the presence of ions in the compound.

**(1)**

**(Total for Question 20 = 11 marks)**

**21** (a) The table below shows some of the ionisation energies of magnesium.

| | First | Second | Third | Fourth | Fifth |
|---|---|---|---|---|---|
| Ionisation energy / kJ mol$^{-1}$ | 738 | 1451 | | 10541 | 13629 |

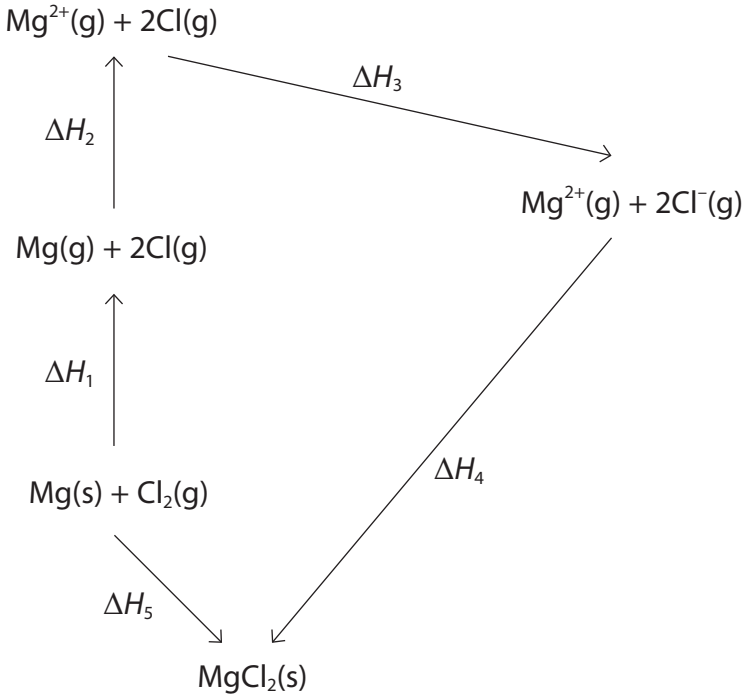
(i) Complete the table by predicting a value for the **third** ionisation energy of magnesium.

**(1)**

(ii) Write the equation for the third ionisation of magnesium. Include state symbols.

**(2)**

(b) A version of the Born-Haber cycle for magnesium chloride is shown below.



(i) Identify the enthalpy changes from the Born-Haber cycle by completing the table.

$\Delta H_1$ is the sum of **two** enthalpy changes and you should give both.

**(3)**

| Enthalpy change | Identity of enthalpy change |
|---|---|
| $\Delta H_1$ | |
| $\Delta H_3$ | |
| $\Delta H_5$ | |

(ii) Use the data in (a) to calculate the value of $\Delta H_2$.

**(1)**

$\Delta H_2 =$

(iii) Use your answer to (ii) and the following data to calculate the lattice energy of magnesium chloride, $\Delta H_4$.

| Enthalpy change | Value of enthalpy change / kJ mol$^{-1}$ |
|---|---|
| $\Delta H_1$ | +391.1 |
| $\Delta H_3$ | –697.6 |
| $\Delta H_5$ | –641.3 |

**(2)**

(c) A similar Born-Haber cycle can be drawn for calcium chloride.

*(i) In the calcium chloride cycle, the corresponding value for $\Delta H_2$ is less positive. Explain why this is so.

**(2)**

*(ii) Explain why the value for the lattice energy, $\Delta H_4$, is less negative for calcium chloride than for magnesium chloride.

**(2)**

**(Total for Question 21 = 13 marks)**

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**22** Sodium hydrogencarbonate decomposes on heating to form sodium carbonate, carbon dioxide and water.

**Reaction 1** $2NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(l) + CO_2(g)$

(a) Suggest why it is difficult to measure the enthalpy change of this reaction directly.

**(1)**

.....

.....

.....

(b) The enthalpy change can be measured indirectly using the enthalpy changes for the following two reactions and applying Hess's Law.

**Reaction 2** $NaHCO_3(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

**Reaction 3** $Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$.

An experiment was carried out to measure the enthalpy change of **Reaction 2**.

100 $cm^3$ of 1.25 mol $dm^{-3}$ hydrochloric acid was placed in a polystyrene beaker with capacity 200 $cm^3$. The initial temperature of the acid was 21.5 °C.

8.00 g of solid sodium hydrogencarbonate was added, a lid was placed on the beaker and the mixture was stirred. The lowest temperature of the mixture was 14.2 °C.

(i) Explain why the beaker used in this experiment is large.

**(1)**

.....

.....

(ii) Show by calculation that the hydrochloric acid is present in excess.

**(2)**

(iii) Calculate the energy transferred and hence the enthalpy change of the reaction in kJ mol$^{-1}$.

Include a sign and units in your answer.

Use the equation: Energy transferred (J) = 100 × 4.18 × temperature change.

**(3)**

(iv) The enthalpy change for **Reaction 3** was found to be –36.3 kJ mol$^{-1}$.

Complete the Hess cycle by adding the appropriate arrows and formulae to the outline.

Use your completed cycle to calculate the enthalpy change for **Reaction 1**.

**(4)**

| | | |
|---|---|---|
| $2NaHCO_3(s)$ | **Reaction 1** → | $Na_2CO_3(s) + H_2O(l) + CO_2(g)$ |

$\Delta H$ for **Reaction 1** = ..... kJ mol$^{-1}$

**(Total for Question 22 = 11 marks)**

**23** (a) Ethane reacts with chlorine in the presence of ultraviolet light forming chloroethane, $C_2H_5Cl$ and other products.

(i) Ultraviolet light causes **homolytic fission** of chlorine molecules.

Draw a dot and cross diagram of a chlorine molecule and use it to explain what happens to the molecule when homolytic fission occurs, naming the species produced.

**(2)**

(ii) Write the equations for the **two** propagation steps which occur in the reaction producing chloroethane.

**(2)**

Equation 1:

Equation 2:

(iii) Write the equation for the termination step which produces a hydrocarbon as a product in this reaction.

**(1)**

(b) Ethene also reacts with chlorine but by a different mechanism.

*(i) Describe how the $\pi$ bond in ethene forms and explain why this bond causes ethene to take part in addition reactions with halogens.

**(2)**

*(ii) Write the mechanism for the reaction of ethene with chlorine.

Use curly arrows to show movements of electron pairs.

**(3)**

(iii) Name the product of the reaction of chlorine with ethene.

**(1)**

.....

(c) The halogenoalkene,1-chloroethene, is used to make a widely used polymer, poly(chloroethene), commonly known as PVC.

Write a balanced equation for the polymerisation of 1-chloroethene to PVC.

Use displayed formulae to show the bonds in both the monomer and the polymer.

**(2)**

**(Total for Question 23 = 13 marks)**

**TOTAL FOR SECTION B = 60 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) | | | | | | | | | | | (13) | (14) | (15) | (16) | (17) | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | | | | | | | | | | | 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 | | | | | | | |

Key: relative atomic mass / atomic symbol / name / atomic (proton) number

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