Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Tuesday 16 May 2023

Morning (Time: 1 hour 30 minutes)

Paper reference **8CH0/01**

Chemistry

Advanced Subsidiary
PAPER 1: Core Inorganic and Physical Chemistry

You must have:
Scientific calculator, Data Booklet, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- For the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Check your answers if you have time at the end.

Turn over ▶

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P 7 1 9 2 6 A 0 1 2 8

Pearson

Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Atoms of silicon contain protons, neutrons and electrons.

(a) Which are the correct data for a proton and a neutron?

(1)

		Proton		Neutron	
		Relative charge	Relative mass	Relative charge	Relative mass
☒	**A**	+1	1	−1	0.0005
☒	**B**	+1	1	0	1
☒	**C**	−1	0.0005	0	1
☒	**D**	0	1	+1	1

(b) (i) State the shape of the 2s orbital of a silicon atom.

(1)

.....

(ii) State the difference between the two subatomic particles in the 2s orbital.

(1)

.....

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(c) Silicon has three stable isotopes.
A sample of silicon was found to have a relative atomic mass, A_r, of 28.11 due to the presence of only the three stable isotopes.
The abundance for two of the isotopes is given in the table.

Isotope	Abundance / %
^{28}Si	92.2
^{30}Si	3.1

Determine the relative isotopic mass of the third stable isotope.
You **must** show your working.

(2)

(d) Give the symbol, including the mass number and atomic number, for an atom of element **X** that has four fewer protons and three fewer neutrons than an atom of $^{28}_{14}Si$.

(1)

.....

(Total for Question 1 = 6 marks)

2 This question is about the double salt $K_2Mg(SO_4)_2 \cdot 6H_2O$.
A double salt is a salt containing more than one cation or more than one anion.

(a) (i) Give the reason why the term relative formula mass is used, rather than relative molecular mass, when discussing $K_2Mg(SO_4)_2 \cdot 6H_2O$.

(1)

(ii) Give the reason why relative formula mass has no mathematical units.

(1)

(iii) What is the relative formula mass of $K_2Mg(SO_4)_2 \cdot 6H_2O$?
Use the Periodic Table as a source of data.

(1)

- ☒ **A** 206.0
- ☒ **B** 322.7
- ☒ **C** 402.7
- ☒ **D** 595.3

(iv) Calculate the amount of substance, in mol, in 25.0 g of $K_2Mg(SO_4)_2 \cdot 6H_2O$.

(1)

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(b) Cations may be identified using a flame test on a solid or by the addition of aqueous sodium hydroxide to an aqueous solution containing the cation.

Describe the expected results of performing these tests on $K_2Mg(SO_4)_2 \cdot 6H_2O$. Include the observation for each cation in each test.

(4)

(c) The test used to show the presence of the **anion** in $K_2Mg(SO_4)_2 \cdot 6H_2O$ gives a white precipitate as the positive result.

(i) What are the reagents used for this test?

(1)

- ☒ **A** dilute hydrochloric acid and aqueous silver nitrate
- ☒ **B** dilute sulfuric acid and aqueous silver nitrate
- ☒ **C** dilute hydrochloric acid and aqueous barium chloride
- ☒ **D** dilute sulfuric acid and aqueous barium chloride

(ii) Write an ionic equation, including state symbols, for the formation of the white precipitate in the test for the anion in the double salt.

(1)

(Total for Question 2 = 10 marks)

3 This question is about elements in Group 7.

(a) Group 7 elements react with many metals.

(i) What happens to the atoms of a metal and the Group 7 element when they react together?

(1)

		Metal	Group 7 element
☒	**A**	gains electrons to form a positive ion	loses electrons to form a negative ion
☒	**B**	increases in oxidation number	gains electrons to form a negative ion
☒	**C**	loses electrons to form a negative ion	decreases in oxidation number
☒	**D**	loses electrons to form a positive ion	increases in oxidation number

(ii) Which is **not** true when calcium reacts with bromine?

(1)

☒ **A** bromine reacts less vigorously than chlorine

☒ **B** during the reaction bromine oxidises the calcium

☒ **C** the percentage by mass of calcium in the product is 33 %

☒ **D** the product gives a brick-red flame test

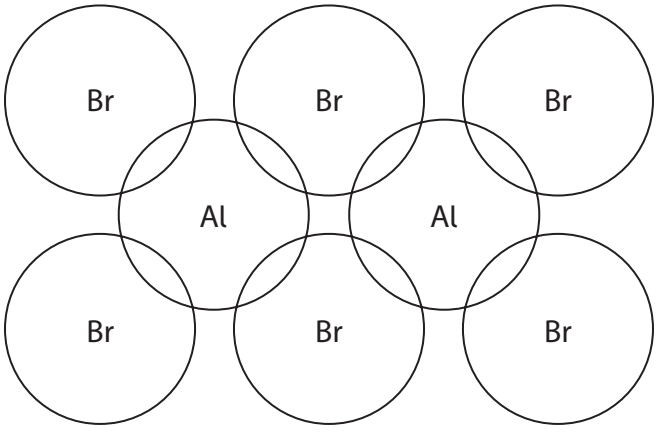
(iii) The equation for the reaction between aluminium and bromine is shown.

$$2Al + 3Br_2 \rightarrow Al_2Br_6$$

The compound is a dimer made up of two covalently bonded monomers joined by dative covalent bonds.

Complete the dot-and-cross diagram, showing outer shell electrons only, of this dimer.
Use • for bromine electrons and × for aluminium electrons.

(2)



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(iv) Platinum metal reacts with fluorine to give a compound of platinum with an oxidation number of +6.

Give the formula of this compound of platinum.

(1)

(v) Chromium reacts with iodine.
The only product contains 12.0 % chromium by mass.

Calculate the empirical formula of the chromium iodide formed.
You **must** show your working.

(2)

(b) Chlorine, bromine and iodine are three of the Group 7 elements. The bond length and bond enthalpies in molecules of these elements are shown in the table.

Bond	Bond length / nm	Bond enthalpy / kJ mol^{-1}
Cl—Cl	0.199	243.4
Br—Br	0.228	192.9
I—I	0.267	151.2

(i) Explain how the trend in bond length relates to the trend in bond strength on **descending** the group.

(2)

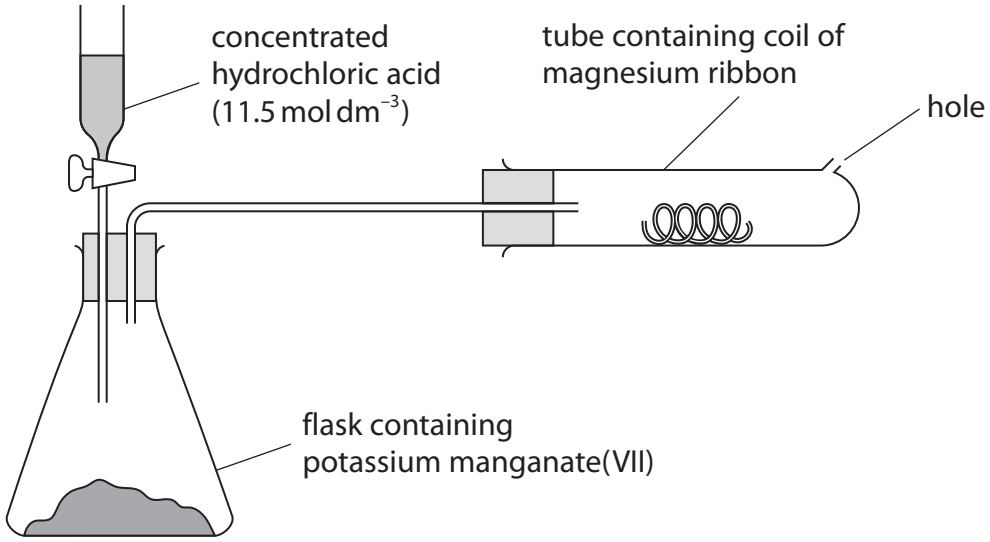
(ii) The relative reactivity of chlorine and iodine can be demonstrated using the reaction between one of these elements and the potassium salt of the other halogen.

Describe an experiment to show how this is deduced and give the expected observation for the reaction that occurs.
Include an ionic equation for this reaction.
State symbols are not required.

(3)

(Total for Question 3 = 12 marks)

4 The reaction between magnesium and chlorine can be carried out using the apparatus shown.



The coil of magnesium ribbon is first heated strongly until it just melts.
Chlorine gas is then produced by a chemical reaction in the conical flask.

The chlorine gas is passed over the heated magnesium, resulting in the formation of magnesium chloride.

(a) In order to melt the magnesium, it must be heated strongly.

Explain why the structure of magnesium gives it a high melting temperature.

(2)

(b) The equation for the reaction to produce chlorine is shown.

$$2KMnO_4 + 8HCl \rightarrow 3Cl_2 + 2KCl + 2MnO_2 + 4H_2O$$

The concentration of the hydrochloric acid is 11.5 mol dm^{-3}.

The equation for the reaction between the chlorine and the magnesium is shown.

$$Mg + Cl_2 \rightarrow MgCl_2$$

Calculate the minimum volume of concentrated hydrochloric acid, in **cm^3**, required to produce 4.00 g of magnesium chloride, $MgCl_2$.
Give your answer to an appropriate number of significant figures.

(4)

(c) Bottles of potassium manganate(VII), $KMnO_4$, have three hazard warning labels. One of these is shown.

This hazard symbol means that potassium manganate(VII) is liable to

(1)

- ☒ **A** burn easily in the presence of oxygen
- ☒ **B** explode
- ☒ **C** react dangerously with oxygen
- ☒ **D** react vigorously with reducing agents

(Total for Question 4 = 7 marks)

5 The question is about electronegativity and its influence on bonding.

(a) State what is meant by the term electronegativity.

(1)

(b) Explain the trend in electronegativity for the Group 7 elements.

(3)

(c) Describe what you understand by the term 'continuum of bonding type' in relation to electronegativities.

(2)

(d) The table gives data for chlorine and chlorine compounds of some Period 3 elements. The data show evidence that the type of bonding in compounds is a continuum across Period 3.

	Empirical formula	Melting temperature / °C	Electrical conductivity
Sodium chloride	NaCl	801	Yes, when molten
Magnesium chloride	$MgCl_2$	714	Yes, when molten
Aluminium chloride	$AlCl_3$	180 (sublimes)	No
Silicon tetrachloride	$SiCl_4$	–70	No
Phosphorus(III) chloride	PCl_3	–112	No
Chlorine	Cl_2	–102	No

Discuss the extent to which the data in the table demonstrate a continuum of bonding type.
Include reference to the data of **three** of the substances in the table with different types of bonding.

(3)

(Total for Question 5 = 9 marks)

6 Redox reactions can be understood in terms of electron transfer **or** in terms of changes of oxidation number.

(a) The equation for a redox reaction is shown.

$$8KI + 5H_2SO_4 \rightarrow 4I_2 + 4K_2SO_4 + H_2S + 4H_2O$$

(i) State, in terms of electron transfer, what you understand by the terms oxidation and reduction.

(1)

(ii) Explain, in terms of electron transfer, which of the species is the oxidising agent and which is the reducing agent.

(2)

(b) Bromine reacts with sodium hydroxide solution in a disproportionation reaction to form BrO_3^-.

Complete the equation for this disproportionation.
Justify the balancing of the equation in terms of the changes in oxidation number.

(4)

..... Br_2 + ... OH^- → ..... BrO_3^- + ... + ...

(Total for Question 6 = 7 marks)

7 This question is about ions.

(a) Draw a dot-and-cross diagram of the ionic compound potassium chloride.
Show outer shell electrons only.

(1)

(b) Deduce the order of increasing size of the ions:

Br^-, Ca^{2+}, Cl^-, K^+

Justify your answer.

(4)

(c) A saturated aqueous calcium hydroxide solution contains 17.3 g in 10.0 dm^3 of solution.
Under these conditions the calcium hydroxide is fully dissociated into ions.

What is the concentration of the calcium ions in this solution, in mol dm^{-3} ?

(1)

☒ **A** 0.0233

☒ **B** 0.0303

☒ **C** 0.0431

☒ **D** 0.0597

(Total for Question 7 = 6 marks)

8 Reactions between calcium carbonate and acids produce carbon dioxide gas.

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

This reaction can be used in an experiment to determine the molar volume of carbon dioxide.

Procedure

Step **1** Place 50 cm^3 of 1 mol dm^{-3} nitric acid in a conical flask.

Step **2** Set up the apparatus as shown in the diagram.

Step **3** Place approximately 0.4 g of calcium carbonate in a test tube and weigh the test tube and its contents accurately.

Step **4** Remove the bung from the conical flask.

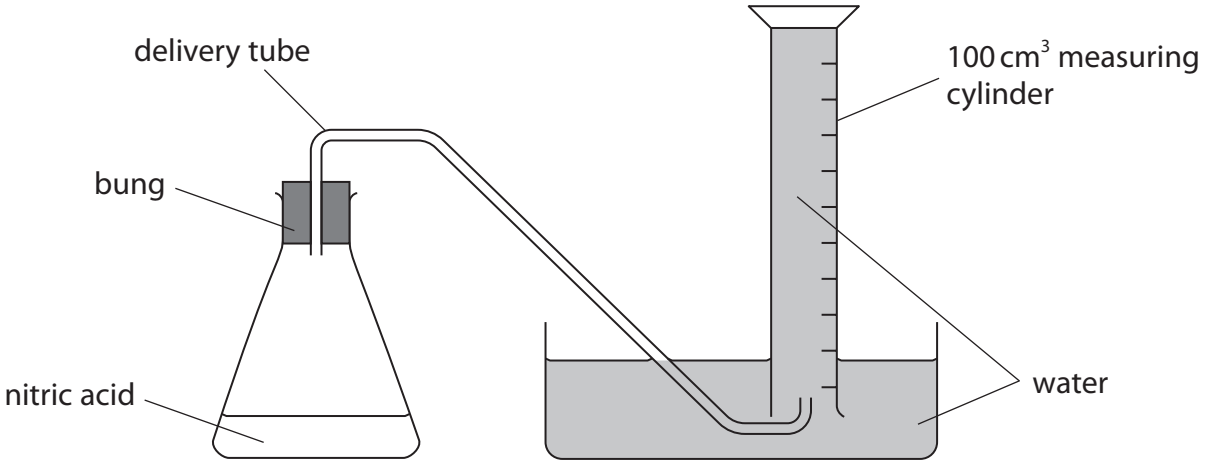
Step **5** Tip the calcium carbonate into the conical flask.

Step **6** Replace the bung in the conical flask.

Step **7** Once all the calcium carbonate has reacted, measure the volume of gas collected in the measuring cylinder.

Step **8** Reweigh the test tube that had contained the calcium carbonate.

Step **9** Repeat the experiment decreasing the mass of calcium carbonate added each time.



(a) A major source of inaccuracy in this experiment occurs between Steps **5** and **6** when carbon dioxide gas is lost before the bung is replaced.

(i) Identify a change to the acid in Step **1** that would reduce the volume of gas lost between Steps **5** and **6**. Justify your answer.

(2)

(ii) Identify a change to the procedure in Steps **5** and **6** that would prevent loss of gas.

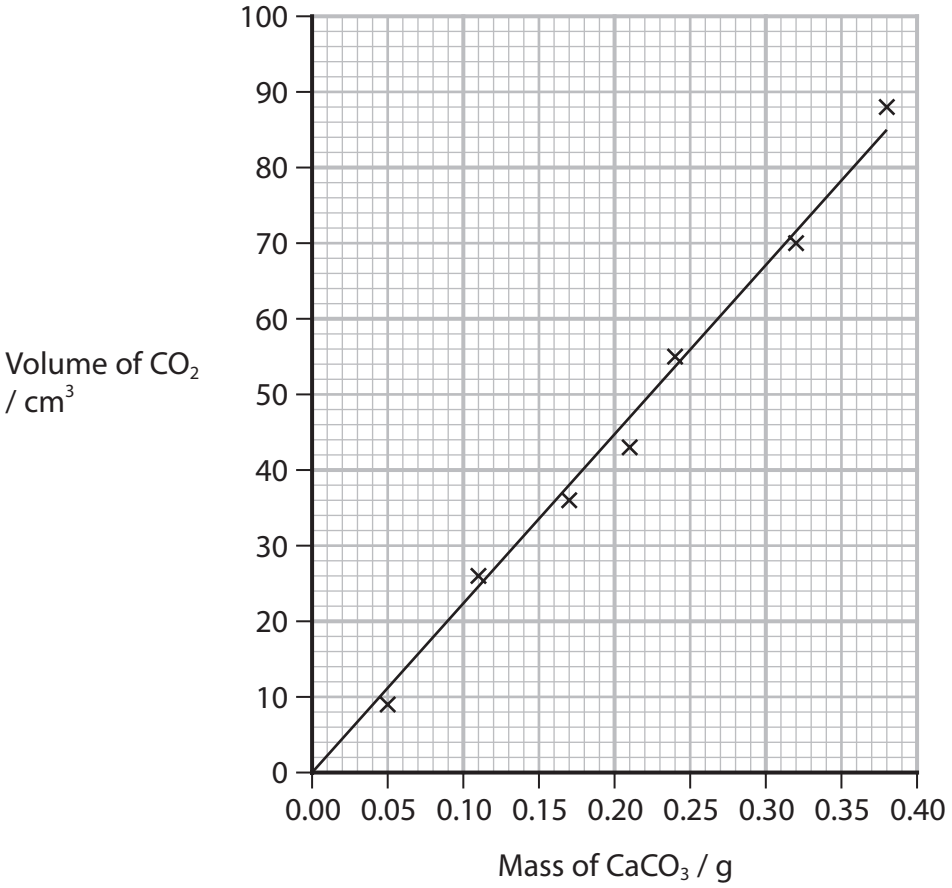
(2)

(b) A second source of inaccuracy results from the significant solubility in water of carbon dioxide.

Give **two** improvements which together prevent this problem.

(2)

(c) After appropriate improvements, the procedure was carried out and the results were plotted on a graph. A line of best fit was drawn.



(i) Use the graph to find the molar volume of carbon dioxide, in dm^3. You must show your working on the graph.

[Assume molar mass of $CaCO_3$ = 100 g mol^{-1}]

(3)

(ii) The procedure was carried out at a temperature of 22 °C and a pressure of 1.01×10^5 Pa.

Calculate the theoretical molar volume, giving units with your answer.

[The ideal gas equation is $pV = nRT$. Gas constant (R) = 8.31 J mol^{-1} K^{-1}]

(3)

(Total for Question 8 = 12 marks)

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9 This question is about ionisation energy.

(a) The first four ionisation energies, in kJ mol^{-1}, of four elements are shown.

Which element is in Group 3?

(1)

☒ **A** 738 1451 7753 10 541

☒ **B** 578 1817 2745 11 578

☒ **C** 789 1577 3232 4356

☒ **D** 1012 1903 2912 4957

(b) The second ionisation energy of beryllium is more endothermic than the first ionisation energy.

(i) Write an equation for the second ionisation of beryllium.
Include state symbols.

(2)

*(ii) Explain how the nuclear structure and the electronic structure of the Group 2 elements affect ionisation energies.

Include:

- an explanation of the trend of the first ionisation energies down the group
- a comparison of the first two ionisation energies for an element.

(6)

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(iii) The value of the sum of the first and second ionisation energies changes on descending Group 2.

Explain how this changing value might contribute to the relative reactivity of the elements with chlorine.

(2)

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.....

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.....

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.....

(Total for Question 9 = 11 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)						(8)					(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)		(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

* Lanthanide series

* Actinide 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
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