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

Thursday 14 January 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

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 9 3 7 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 Which row in the table shows the number of protons, neutrons and electrons in a fluoride ion, F^-?

Use the Periodic Table as a source of data.

	Protons	Neutrons	Electrons
☒ **A**	8	9	9
☒ **B**	9	9	10
☒ **C**	9	10	9
☒ **D**	9	10	10

(Total for Question 1 = 1 mark)

2 A sample of oxygen contains the isotopes ^{16}O, ^{17}O, ^{18}O.

How many peaks would there be for the O_2^+ ions in the mass spectrum of this sample of oxygen?

☒ **A** 3

☒ **B** 5

☒ **C** 6

☒ **D** 9

(Total for Question 2 = 1 mark)

3 2000 g of a solution contains 0.015 g of solute.

In the solution, the concentration of the solute in parts per million (ppm) is

☒ **A** 3.0

☒ **B** 7.5

☒ **C** 30

☒ **D** 75

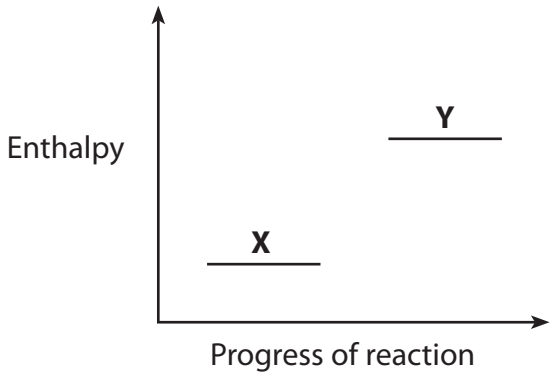
(Total for Question 3 = 1 mark)

4 What is the concentration, in mol dm^{-3}, of a solution of 10.6 g of sodium carbonate, Na_2CO_3, in 250 cm^3 of solution?

- ☒ **A** 0.40
- ☒ **B** 0.25
- ☒ **C** 0.10
- ☒ **D** 0.025

(Total for Question 4 = 1 mark)

5 An enthalpy level diagram for a reaction is



Which row in the table shows the correct terms for **X** and **Y** and the enthalpy change for this reaction?

	X	Y	Enthalpy change
☒ **A**	products	reactants	endothermic
☒ **B**	products	reactants	exothermic
☒ **C**	reactants	products	endothermic
☒ **D**	reactants	products	exothermic

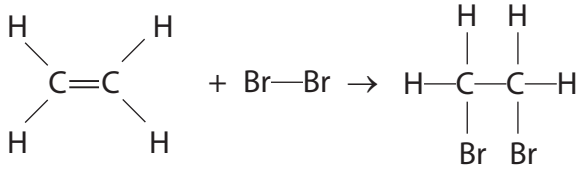
(Total for Question 5 = 1 mark)

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

6 The table shows the mean bond enthalpies for some covalent bonds.

Covalent bond	C—C	C═C	Br—Br	C—Br	C—H
Mean bond enthalpy / kJ mol^{-1}	347	612	193	290	413

What is the approximate enthalpy change, in kJ mol^{-1}, for the reaction shown?



☒ **A** −225

☒ **B** −122

☒ **C** +122

☒ **D** +225

(Total for Question 6 = 1 mark)

7 The first six ionization energies, in kJ mol^{-1}, of an element are

1086, 2353, 4621, 6223, 37832, 47278

In which group of the Periodic Table is this element?

☒ **A** 2

☒ **B** 3

☒ **C** 4

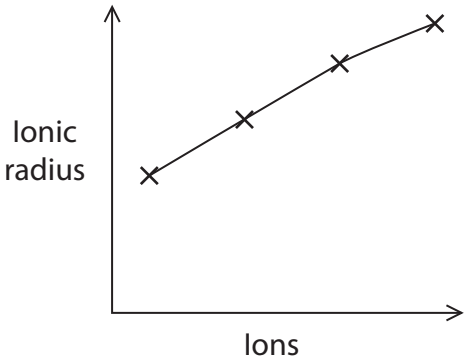
☒ **D** 5

(Total for Question 7 = 1 mark)

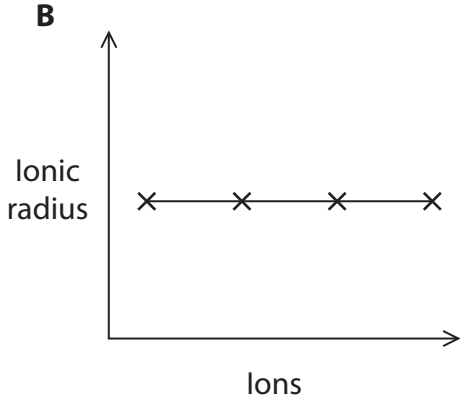
Use this space for rough working. Anything you write in this space will gain no credit.

8 Each diagram shows the trend in the ionic radius for four sequences of ions.
The diagrams are not to scale.

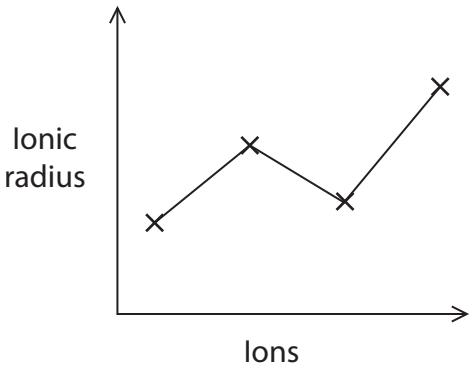
A



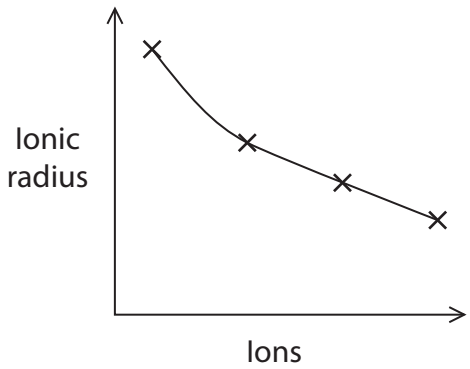
B



C



D



(a) Which diagram shows the trend in the ionic radius for the sequence Li^+, Na^+, K^+, Rb^+?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which diagram shows the trend in the ionic radius for the sequence Na^+, Mg^{2+}, Al^{3+}, Si^{4+}?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 8 = 2 marks)

9 Some energy changes involved in a Born-Haber cycle are

A electron affinity

B lattice energy

C standard enthalpy change of atomization

D standard enthalpy change of formation

(a) Which enthalpy or energy change is represented by **p**?

$$K(s) \rightarrow K(g) \qquad \Delta H^{\ominus} = \mathbf{p}$$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which enthalpy or energy change is represented by **q**?

$$K(s) + \tfrac{1}{2}Cl_2(g) \rightarrow KCl(s) \qquad \Delta H^{\ominus} = \mathbf{q}$$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which enthalpy or energy change is represented by **r**?

$$\tfrac{1}{2}Cl_2(g) \rightarrow Cl(g) \qquad \Delta H^{\ominus} = \mathbf{r}$$

(1)

☒ **A**

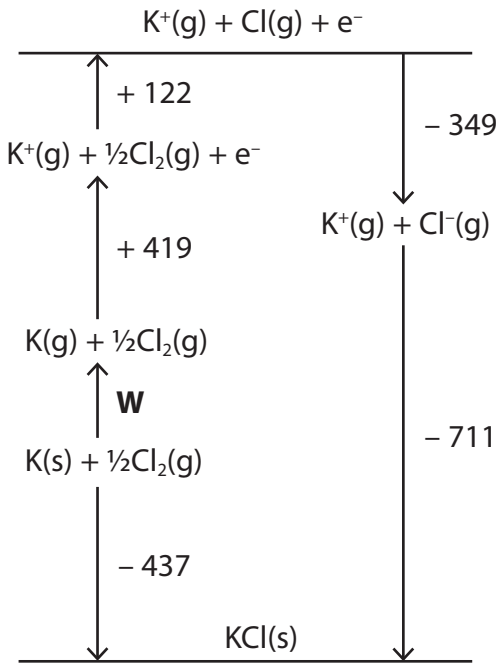
☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 3 marks)

10 The diagram, which is not drawn to scale, shows the Born-Haber cycle for potassium chloride. The energy changes given are in kJ mol^{-1}.



What is the value for **W**, in kJ mol^{-1}?

- ☒ **A** −956
- ☒ **B** −82
- ☒ **C** +82
- ☒ **D** +956

(Total for Question 10 = 1 mark)

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

11 Which row in the table shows the lattice energies, in kJ mol^{-1}, of calcium fluoride, potassium fluoride and potassium iodide?

	Calcium fluoride	Potassium fluoride	Potassium iodide
☒ **A**	–2630	–817	–651
☒ **B**	–2630	–651	–817
☒ **C**	–651	–817	–2630
☒ **D**	–817	–2630	–651

(Total for Question 11 = 1 mark)

12 The experimental value for the lattice energy of beryllium iodide is −2800 kJ mol^{-1} and the theoretical value is –2653 kJ mol^{-1}.

The best explanation for the difference is that the

☒ **A** beryllium ion is large and polarizes the iodide ion.

☒ **B** beryllium ion is small and polarizes the iodide ion.

☒ **C** iodide ion is large and polarizes the beryllium ion.

☒ **D** iodide ion is small and polarizes the beryllium ion.

(Total for Question 12 = 1 mark)

13 Carbon (diamond) and oxygen both form covalent bonds between their atoms in the element.

What is the **best** reason for the fact that diamond has a much higher melting temperature than oxygen?

☒ **A** Diamond is a solid but oxygen is a gas at room temperature.

☒ **B** Diamond has a giant atomic structure but oxygen has a simple molecular structure.

☒ **C** The covalent bonds between carbon atoms in diamond are stronger than those between oxygen atoms.

☒ **D** There is a single covalent bond between carbon atoms in diamond but a double covalent bond between oxygen atoms.

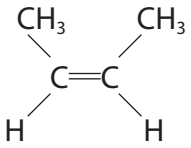
(Total for Question 13 = 1 mark)

14 The bonding in solid ammonium chloride is

- ☒ **A** ionic only.
- ☒ **B** ionic and covalent only.
- ☒ **C** ionic and dative covalent only.
- ☒ **D** ionic, covalent and dative covalent only.

(Total for Question 14 = 1 mark)

15 One of the isomers with the formula C_4H_8 is



Possible names for this isomer are

- ☒ **A** *cis*-but-2-ene and *E*-but-2-ene.
- ☒ **B** *cis*-but-2-ene and *Z*-but-2-ene.
- ☒ **C** *trans*-but-2-ene and *E*-but-2-ene.
- ☒ **D** *trans*-but-2-ene and *Z*-but-2-ene.

(Total for Question 15 = 1 mark)

16 An electrophile is a species that

- ☒ **A** can accept a pair of electrons to form a covalent bond.
- ☒ **B** can donate a pair of electrons to form a covalent bond.
- ☒ **C** always has a negative charge.
- ☒ **D** always has a positive charge.

(Total for Question 16 = 1 mark)

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

17 Alkenes react with hydrogen gas in the presence of a nickel catalyst.

0.2 mol of an alkene reacted completely with 19.2 dm^3 of hydrogen gas at room temperature and pressure.

How many C═C bonds are there in a molecule of this alkene?

[The molar volume of a gas is 24.0 dm^3 mol^{-1} at room temperature and pressure]

☒ **A** 4

☒ **B** 3

☒ **C** 2

☒ **D** 1

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

18 (a) The relative atomic masses of elements can be determined using a mass spectrometer.

(i) Define the term **relative atomic mass**.

(3)

(ii) Describe fully how positive ions are formed from gaseous atoms in a mass spectrometer.

(2)

(iii) The following data were obtained from the mass spectrum of a sample of strontium.

Mass / charge ratio	% abundance
84.0	0.56
86.0	9.86
87.0	7.02
88.0	82.56

Calculate the relative atomic mass of strontium in this sample.

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

(2)

(b) In which block of the Periodic Table is strontium found?

(1)

(c) Draw the dot and cross diagram for strontium chloride.

Show **outer** electrons only.

(2)

(d) A solution of strontium nitrate was prepared from strontium oxide and dilute nitric acid.

Write the equation for this reaction, including state symbols.

(2)

(e) A compound of strontium contains 49.9% strontium, 13.7% carbon and 36.4% oxygen, by mass.

Calculate the empirical formula for this compound.

[Use relative atomic masses: Sr = 87.6, C = 12.0, O = 16.0]

(3)

(Total for Question 18 = 15 marks)

19 The first ionization energies for the elements in Period 3 of the Periodic Table are

Element	Na	Mg	Al	Si	P	S	Cl	Ar
First ionization energy / kJ mol^{-1}	496	738	578	789	1012	1000	1251	1521

(a) (i) Complete the electronic configuration of phosphorus, using the electrons-in-boxes notation.

Write the symbols for the sub-shells on the dotted lines.

(2)

1s ....

*(ii) The first ionization energies generally increase from left to right across the period.

Explain why the first ionization energy of sulfur is **lower** than that of phosphorus.

(2)

.....

.....

.....

.....

.....

.....

(iii) Write an equation, with state symbols, to show the **third** ionization energy of phosphorus.

(2)

*(b) (i) Explain why the first ionization energy of nitrogen is greater than the first ionization energy of phosphorus.

(3)

(ii) Draw a dot and cross diagram to show the bonding in a molecule of nitrogen.

Show **outer** electrons only.

(2)

(c) Solid white phosphorus exists as P_4 molecules.

Calculate the number of molecules in 24.8 g of white phosphorus.

[The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}]

(2)

(Total for Question 19 = 13 marks)

20 Compound **X** has the molecular formula C_5H_{12}.

(a) Draw the **displayed** formulae of the **three** structural isomers of C_5H_{12}.

(2)

(b) C_5H_{12} reacts with chlorine to form a mixture of products.

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

(2)

(ii) Write the equations for the two propagation steps for this mechanism. Use the molecular formula, C_5H_{12}, in your first equation. Curly arrows are not required.

(2)

(iii) Write the equation for **one** termination step for this mechanism. Curly arrows are not required.

(1)

(c) An experiment was carried out to determine the enthalpy change of combustion of compound **X**, C_5H_{12}.

100.0 g of water was heated by burning 0.144 g of compound **X**.

The temperature rise of the water was 14.5 °C.

(i) Calculate the energy transferred, in **kJ**, in this experiment.

Use the equation

heat energy produced (J) = mass of water × 4.18 × temperature change

(1)

energy transferred = ... kJ

(ii) Calculate the number of moles of compound **X** used in this experiment.

(1)

moles of **X** = ...

(iii) Calculate the enthalpy change of combustion of compound **X**. Include a sign and units in your answer.

(2)

enthalpy change of combustion = ...

(iv) The Data Book values for the enthalpy changes of combustion of the three structural isomers with the formula C_5H_{12} are:

$-3509.1\ kJ\ mol^{-1}$

$-3503.4\ kJ\ mol^{-1}$

$-3492.5\ kJ\ mol^{-1}$

The experimental value calculated in (c)(iii) is very different from these values. Give **two** reasons, other than heat loss, for this large difference.

(2)

(v) Explain why it is **not** possible to deduce which of the isomers is compound **X** by comparing this experimental value and the Data Book values.

(1)

*(d) Complete the Hess cycle and use it to calculate the enthalpy change of combustion of C_5H_{12} from the following data.

Show all of your working.

Standard enthalpy change of formation of $C_5H_{12}(l)$	–173.2 kJ mol^{-1}
Standard enthalpy change of combustion of $H_2(g)$	–285.8 kJ mol^{-1}
Standard enthalpy change of combustion of carbon(s, graphite)	–393.5 kJ mol^{-1}

(4)

$C_5H_{12}(l) + 8O_2(g) \longrightarrow 5CO_2(g) + 6H_2O(l)$

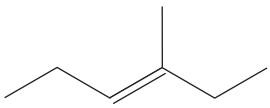
..... + ... + ...

(Total for Question 20 = 18 marks)

21 This question is about alkenes.

(a) (i) Give the molecular formula of this alkene.

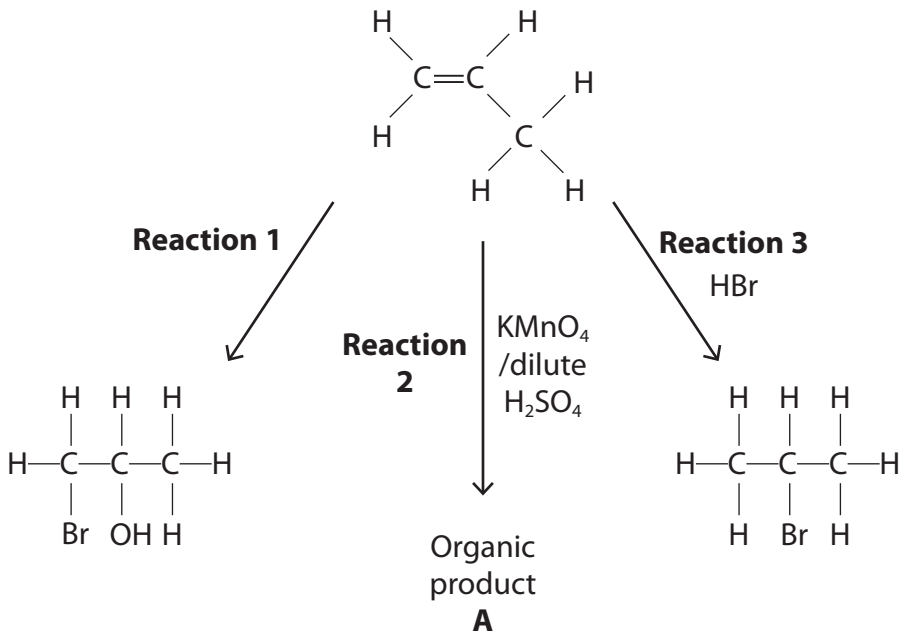
(1)



(ii) Explain why the alkene in (a)(i) exhibits geometric isomerism.

(2)

(b) Propene reacts with three different reagents.



(i) Give the reagent needed for **Reaction 1**.

(1)

(ii) Identify, by name or formula, the organic product **A** formed in **Reaction 2**.

(1)

(iii) State the colour change that you would see when **Reaction 2** is carried out.

(1)

From ..... to .....

(iv) Give the mechanism for **Reaction 3**. Use curly arrows and show any relevant dipoles and lone pairs.

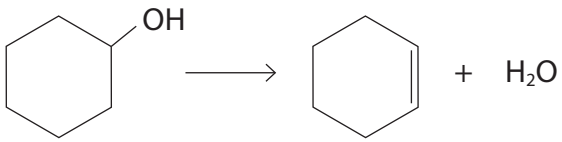
(4)

(c) But-2-ene polymerizes to form poly(but-2-ene).

Draw a section of this polymer, showing **two** repeat units.

(1)

(d) Cyclohexanol forms cyclohexene in the following reaction.



(i) Calculate the percentage atom economy by mass for the production of cyclohexene.

(1)

(ii) Calculate the percentage yield if 10.20 g of cyclohexanol produced 6.15 g of cyclohexene.

(2)

(Total for Question 21 = 14 marks)

TOTAL FOR SECTION B = 60 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: relative atomic mass / atomic symbol / name / atomic (proton) number									(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							

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