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

Wednesday 7 January 2015 – 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 ▶

P45041A

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6/6/6/6/2/

P 4 5 0 4 1 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 A solution contains 33 ppm of solute. The mass of solute dissolved in 1 kg of this solution is

☒ **A** 33 g

☒ **B** 0.33 g

☒ **C** 0.033 g

☒ **D** 0.000033 g

(Total for Question 1 = 1 mark)

2 The Avogadro constant is equal to the number of

☒ **A** grams of an element which contains 6.02×10^{23} atoms of that element.

☒ **B** atoms contained in one mole of any element.

☒ **C** atoms contained in one mole of any monatomic element.

☒ **D** particles (atoms, ions or molecules) required to make one gram of a substance.

(Total for Question 2 = 1 mark)

3 A hydrocarbon contains, by mass, 82.7% carbon and 17.3% hydrogen.

The **molecular** formula of the hydrocarbon is

☒ **A** CH_3

☒ **B** C_2H_6

☒ **C** C_2H_5

☒ **D** C_4H_{10}

(Total for Question 3 = 1 mark)

4 An ion, X^-, contains 36 electrons.

In which block of the Periodic Table would element **X** be found?

☒ **A** s

☒ **B** p

☒ **C** d

☒ **D** f

(Total for Question 4 = 1 mark)

5 Consider the following data:

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H^{\ominus} = -394$ kJ mol^{-1}

$Pb(s) + \frac{1}{2}O_2(g) \rightarrow PbO(s)$ $\Delta H^{\ominus} = -217$ kJ mol^{-1}

$PbO(s) + CO(g) \rightarrow Pb(s) + CO_2(g)$ $\Delta H^{\ominus} = -66$ kJ mol^{-1}

Calculate the value of the enthalpy change, in kJ mol^{-1}, for the following reaction.

$$C(s) + \tfrac{1}{2}O_2(g) \rightarrow CO(g)$$

☒ **A** –243

☒ **B** –111

☒ **C** +111

☒ **D** +243

(Total for Question 5 = 1 mark)

6 Which of the following enthalpy changes cannot be measured **directly** by experiment?

The enthalpy change of

☒ **A** formation of methane.

☒ **B** combustion of hydrogen.

☒ **C** formation of carbon dioxide.

☒ **D** combustion of carbon monoxide.

(Total for Question 6 = 1 mark)

7 Which of the following equations represents a step that is **not** involved in the Born-Haber cycle for lithium iodide, LiI?

☒ **A** $Li(s) + \frac{1}{2}I_2(s) \rightarrow LiI(s)$

☒ **B** $\frac{1}{2}I_2(s) \rightarrow I(g)$

☒ **C** $Li(s) \rightarrow Li(g)$

☒ **D** $I(g) \rightarrow I^+(g) + e^-$

(Total for Question 7 = 1 mark)

8 Which of the following results in the most polarizing cation?

	Cation radius	Cation charge
☒ **A**	small	small
☒ **B**	small	large
☒ **C**	large	small
☒ **D**	large	large

(Total for Question 8 = 1 mark)

9 Calcium carbonate reacts with dilute nitric acid as follows:

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

0.05 mol of calcium carbonate was added to a solution containing 0.08 mol of nitric acid.

Which of the following statements is true?

☒ **A** 0.05 mol of carbon dioxide is produced.

☒ **B** 0.08 mol of calcium nitrate is produced.

☒ **C** Calcium carbonate is in excess by 0.01 mol.

☒ **D** Nitric acid is in excess by 0.03 mol.

(Total for Question 9 = 1 mark)

10 In which of the following pairs does each gas occupy the same volume?

All volumes are measured at the same temperature and pressure.

☒ **A** 2 g of hydrogen and 14 g of nitrogen.

☒ **B** 32 g of methane and 88 g of carbon dioxide.

☒ **C** 7 g of carbon monoxide and 16 g of oxygen.

☒ **D** 10 g of hydrogen chloride and 10 g of sulfur dioxide.

(Total for Question 10 = 1 mark)

11 Consider the reaction below.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

What is the maximum volume, in dm^3, of nitrogen dioxide that could be obtained in the reaction occurring when 1 dm^3 of nitrogen monoxide is mixed with 2 dm^3 of oxygen, under suitable conditions?

All measurements are made at the same temperature and pressure.

☒ **A** 1

☒ **B** 2

☒ **C** 3

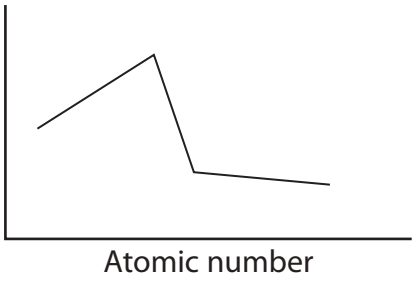
☒ **D** 4

(Total for Question 11 = 1 mark)

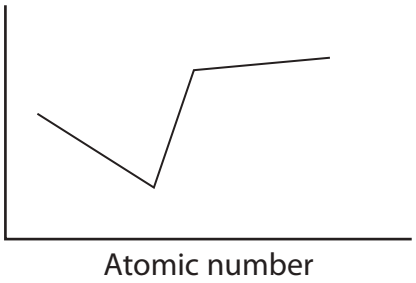
Use this space for any rough working. Anything you write in this space will gain no credit.

12 Which of the following graphs, not drawn to scale, best represents the trend in the melting temperatures of the elements across Period 3, from sodium to argon?

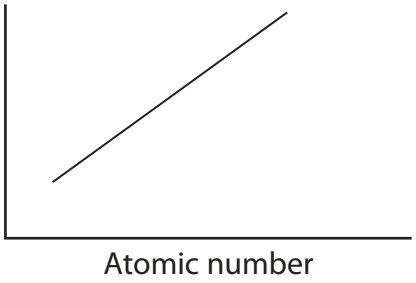
☒ **A**



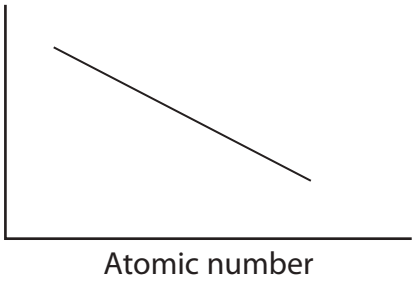
☒ **B**



☒ **C**



☒ **D**



(Total for Question 12 = 1 mark)

13 In an experiment, 3.425 g of lead oxide was reduced to form 3.105 g of lead.

The empirical formula of the lead oxide is

☒ **A** PbO

☒ **B** Pb_3O_2

☒ **C** Pb_3O_4

☒ **D** Pb_4O_3

(Total for Question 13 = 1 mark)

14 Which one of the following ions has the smallest radius?

☒ **A** F^-

☒ **B** Mg^{2+}

☒ **C** Na^+

☒ **D** O^{2-}

(Total for Question 14 = 1 mark)

15 Phenol, C_6H_5OH, is converted into trichlorophenol (known as TCP), $C_6H_2Cl_3OH$, according to the equation below.

$$C_6H_5OH + 3Cl_2 \rightarrow C_6H_2Cl_3OH + 3HCl$$

If 50.0 g of phenol produces 97.6 g of TCP, what is the percentage yield of the TCP?

[Molar masses: phenol = 94 g mol^{-1}; TCP = 197.5 g mol^{-1}]

☒ **A** 47.6%

☒ **B** 49.4%

☒ **C** 51.2%

☒ **D** 92.9%

(Total for Question 15 = 1 mark)

16 Which of the following contains a dative covalent bond?

☒ **A** N_2

☒ **B** NH_3

☒ **C** NH_2^-

☒ **D** NH_4^+

(Total for Question 16 = 1 mark)

17 If the price of one tonne (1000 kg) of sulfur, S, is £160, what is the cost (to the nearest pound) of the sulfur needed to make one tonne of sulfuric acid, H_2SO_4?

☒ **A** £52

☒ **B** £98

☒ **C** £160

☒ **D** £490

(Total for Question 17 = 1 mark)

18 Potassium combines with iodine to form potassium iodide.

Which of the following describes the bonding in the three substances?

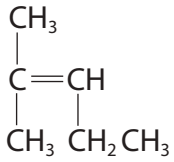
	Potassium	Iodine	Potassium iodide
☒ **A**	ionic	covalent	ionic
☒ **B**	metallic	ionic	covalent
☒ **C**	covalent	covalent	ionic
☒ **D**	metallic	covalent	ionic

(Total for Question 18 = 1 mark)

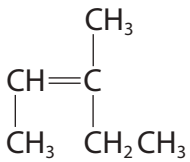
Use this space for any rough working. Anything you write in this space will gain no credit.

19 Which of the following does **not** represent the structure of the compound 2-methylpent-2-ene?

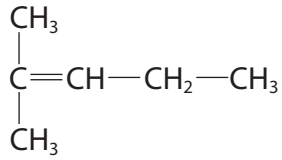
☒ **A**



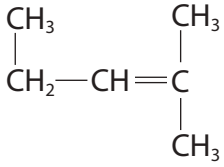
☒ **B**



☒ **C**



☒ **D**



(Total for Question 19 = 1 mark)

20 Ions with the same electronic configuration are said to be **isoelectronic**.

Which of the following compounds is made up of isoelectronic ions?

☒ **A** CaO

☒ **B** $CaBr_2$

☒ **C** Na_2O

☒ **D** LiF

(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 Crude oil is a source of alkanes.

(a) Name the process by which the hydrocarbons in crude oil are separated.

(1)

.....

(b) The alkane **X** is composed of straight-chain molecules, each with nine carbon atoms.

(i) Give the molecular formula of **X**.

(1)

.....

(ii) **Y** is a branched-chain isomer of **X**.
Y has eight carbon atoms in a straight-chain with **one** methyl group as a side-chain.

Draw the **skeletal formula** of **one** possible structure for **Y**.

Give the name of the structure that you have drawn.

(2)

Skeletal formula:

Name:

.....

(c) A reaction called cracking occurs when the alkane pentadecane, $C_{15}H_{32}$, is heated in the presence of a catalyst.

(i) Give an equation to show the cracking of one molecule of $C_{15}H_{32}$ to form one molecule of ethene and a molecule of **one** other product.
State symbols are not required.

(1)

(ii) In practice, cracking pentadecane forms a large number of products.

Suggest why this is so.

(1)

.....

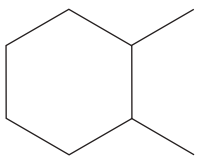
.....

(d) In the petroleum industry, some straight-chain alkanes are processed to form cyclic hydrocarbons.

When octane is processed, each molecule of octane produces one molecule of a cyclic hydrocarbon, C_8H_{12}, and three molecules of hydrogen as the only products.

(i) Complete the **skeletal** formula of one of the possible cyclic hydrocarbons.

(1)



(ii) Suggest why the petroleum industry processes straight-chain alkanes to form cyclic hydrocarbons.

(1)

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(Total for Question 21 = 8 marks)

22 For some reactions, the enthalpy change can be determined by experiment.

(a) Define the term **enthalpy change of reaction**.

(2)

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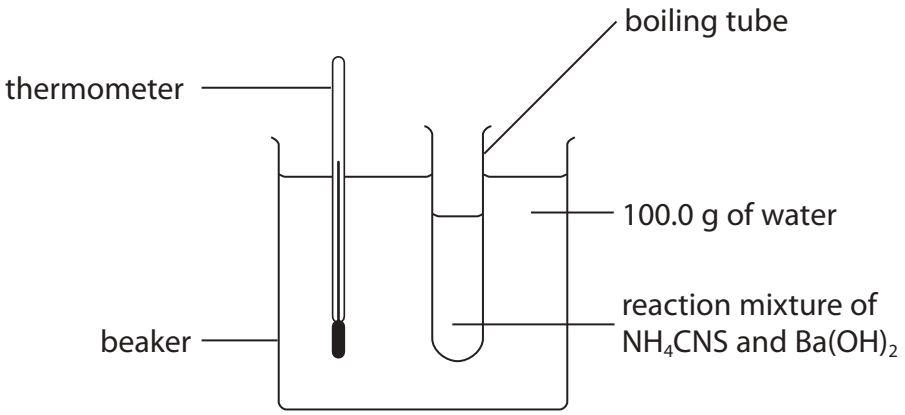
(b) An equation for the reaction between the two solids ammonium thiocyanate, NH_4CNS, and barium hydroxide, $Ba(OH)_2$, is shown below.

$$2NH_4CNS(s) + Ba(OH)_2(s) \rightarrow Ba(CNS)_2(s) + 2H_2O(l) + 2NH_3(g)$$

The following apparatus was set up in order to determine the enthalpy change for the reaction.



In the experiment, 15.22 g of NH_4CNS was reacted with an excess of $Ba(OH)_2$. The reaction absorbed heat energy from the surroundings. The temperature of the 100.0 g of water fell from 22.0 °C to 16.5 °C.

(i) Calculate the heat energy absorbed, in joules, during the reaction.

Use the equation

Heat energy absorbed (J) = mass of water × 4.2 × temperature change

(1)

(ii) Calculate the number of moles of NH_4CNS used in the experiment.

(1)

(iii) Calculate the enthalpy change of the reaction, in kJ mol^{-1}, to **two** significant figures. Include a sign in your answer.

$$2NH_4CNS(s) + Ba(OH)_2(s) \rightarrow Ba(CNS)_2(s) + 2H_2O(l) + 2NH_3(g)$$

(3)

(c) Standard enthalpy changes of reaction can also be calculated using mean bond enthalpies.

(i) What is meant by the term **mean bond enthalpy**?

(2)

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(ii) Describe the bonding in a C═C double bond in terms of the different ways in which the orbitals overlap.

You may draw a diagram if you wish.

(2)

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Space for diagram:

(iii) Suggest why the mean bond enthalpy of a C═C bond is less than twice the mean bond enthalpy of a C—C bond.

(1)

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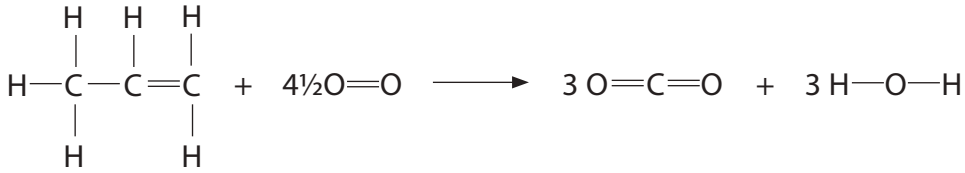
(iv) Use the mean bond enthalpy data in the table, and the equation given below, to calculate a value for the standard enthalpy change of combustion of propene.

(3)

Bond	Mean bond enthalpy / kJ mol^{-1}
C═C	612
C—C	347
C—H	413
O═O	498
C═O	805
O—H	464



Answer = ... kJ mol^{-1}

*(v) The Data Booklet value for the standard enthalpy change of combustion of propene is –2058 kJ mol^{-1}.

Explain why the value calculated in (c)(iv) is less exothermic than the Data Booklet value.

(2)

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(Total for Question 22 = 17 marks)

23 Iodine monochloride, ICl, is an interhalogen compound. Molecules of iodine monochloride have a permanent dipole. Alkenes react with ICl, under suitable conditions, in a similar way to the reaction of alkenes with hydrogen chloride, HCl.

(a) Propene reacts with ICl to form two possible organic products. One of these products is 2-chloro-1-iodopropane.

(i) Complete the mechanism below, by adding curly arrows and the intermediate species.

(3)

(ii) Classify the type and mechanism for the reaction in (a)(i).

(2)

.....

(iii) Draw the structure of the other possible organic product of the reaction of propene with ICl.

(1)

(b) Methane reacts with ICl, under suitable conditions, to form many products. Two of these products are iodomethane and hydrogen chloride.
The reaction between methane and ICl is similar to that between methane and chlorine, Cl_2.

(i) Suggest the essential condition needed for this reaction.

(1)

.....

*(ii) The mechanism for the reaction between methane and ICl involves three stages. One of these is the third and final stage, called termination.

Describe the mechanism of the reaction to form iodomethane and hydrogen chloride.

In your answer, include:

- the type of reaction and mechanism
- the type of bond fission occurring
- the name and equation for the **first** stage of the mechanism
- the name and equations for the **second** stage of the mechanism
- one equation for a termination step

Curly (half-) arrows and state symbols are **not** required in your equations.

(7)

Type of reaction and mechanism .....

Type of bond fission occurring .....

.....

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(Total for Question 23 = 14 marks)

24 A model of the atom describes a nucleus containing protons and neutrons surrounded by electrons in energy levels.

(a) Complete the table below.

(3)

Sub-atomic particle	Relative mass	Relative charge
proton		
neutron		
electron		

(b) State, in terms of the sub-atomic particles present, the meaning of the term **isotopes**.

(2)

.....

.....

(c) The element rubidium exists as the isotopes ^{85}Rb and ^{87}Rb.

(i) Explain how gaseous atoms of rubidium are ionized in a mass spectrometer.

(2)

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(ii) In a sample of rubidium, the isotope ^{85}Rb has an abundance 2.5 times greater than that of ^{87}Rb.

Calculate the relative atomic mass of rubidium in this sample. Give your answer to **one** decimal place.

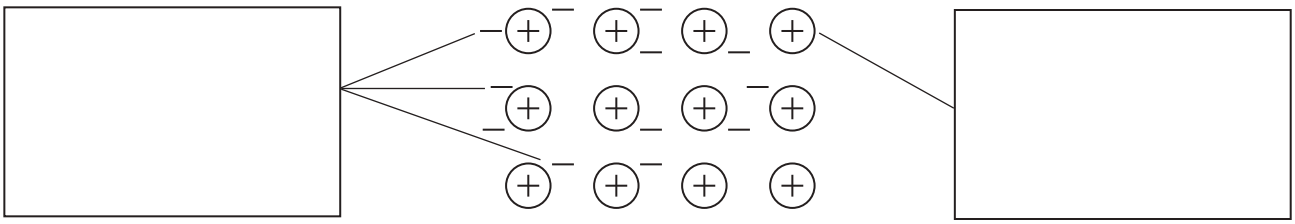
(3)

Relative atomic mass = ...

(d) The diagram below illustrates a model of the metallic bonding in rubidium.

Write appropriate labels in the two empty boxes in order to complete the diagram.

(2)



(Total for Question 24 = 12 marks)

25 Ionization energies provide evidence for the arrangement of electrons in atoms.

(a) (i) Write an equation, including state symbols, to show the **second** ionization energy of magnesium.

(2)

*(ii) Give **two** reasons why the second ionization energy of magnesium is greater than the first ionization energy of magnesium.

(2)

1 .....

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2 .....

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(iii) Complete the table by suggesting a value for the **third** ionization energy of magnesium.

(1)

Ionization number	First	Second	Third	Fourth	Fifth
Ionization energy / kJ mol^{-1}	738	1450		10 500	13 600

(b) (i) Give the electronic configurations of phosphorus and of sulfur in s, p and d notation.

(2)

Phosphorus (atomic number 15) .....

Sulfur (atomic number 16) .....

(ii) By reference to your answer in (b)(i), explain why the first ionization energy of sulfur is lower than that of phosphorus.

(2)

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(Total for Question 25 = 9 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

P 4 5 0 4 1 A 0 2 4 2 4

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	(18)
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name 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

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