Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 23 May 2014 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

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 ▶

P42970A

6/6/6/5/

P 4 2 9 7 0 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 The correct sequence for the processes that occur in a mass spectrometer is

☒ **A** vaporization, ionization, acceleration, deflection and detection.

☒ **B** vaporization, acceleration, ionization, deflection and detection.

☒ **C** ionization, vaporization, acceleration, deflection and detection.

☒ **D** ionization, vaporization, deflection, acceleration and detection.

(Total for Question = 1 mark)

2 Which of the following ions would be deflected **most** in a mass spectrometer?

☒ **A** $^{35}Cl^{+}$

☒ **B** $^{37}Cl^{+}$

☒ **C** $^{37}Cl^{2+}$

☒ **D** $(^{35}Cl —^{37}Cl)^{+}$

(Total for Question 2 = 1 mark)

3 A particle with a **single** positive charge and with the electronic configuration $1s^2\ 2s^2\ 2p^6$ is

☒ **A** a sodium ion.

☒ **B** a fluoride ion.

☒ **C** an oxide ion.

☒ **D** a potassium ion.

(Total for Question 3 = 1 mark)

4 In which of the following electronic configurations are only two of the electrons unpaired?

☒ **A** $1s^2\ 2s^2$

☒ **B** $1s^2\ 2s^2\ 2p^3$

☒ **C** $1s^2\ 2s^2\ 2p^4$

☒ **D** $1s^2\ 2s^2\ 2p^5$

(Total for Question 4 = 1 mark)

5 Which of the following contains a dative covalent bond?

☒ **A** N_2

☒ **B** NH_3

☒ **C** NH_2^-

☒ **D** NH_4^+

(Total for Question 5 = 1 mark)

6 Which of the following ions has the **largest** ionic radius?

☒ **A** F^-

☒ **B** Mg^{2+}

☒ **C** Na^+

☒ **D** O^{2-}

(Total for Question 6 = 1 mark)

7 Which of the following observations provides the best evidence for the presence of ionic bonding in an unknown substance?

The substance conducts electricity

☒ **A** in the solid state.

☒ **B** in the solid state and in aqueous solution.

☒ **C** in the solid state and when molten.

☒ **D** when molten but not in the solid state.

(Total for Question 7 = 1 mark)

8 Which of the following can be determined, for an unknown alkene, using **only** percentage composition by mass data?

☒ **A** Molecular formula

☒ **B** Empirical (simplest) formula

☒ **C** Both the molecular formula and the empirical (simplest) formula

☒ **D** Structural formula

(Total for Question 8 = 1 mark)

9 1.12 g of iron reacts with oxygen to form 1.60 g of an oxide of iron.
Use relative atomic masses: Fe = 56, O = 16.

What is the formula of this oxide of iron?

☒ **A** FeO_5

☒ **B** Fe_2O_{10}

☒ **C** Fe_3O_2

☒ **D** Fe_2O_3

(Total for Question 9 = 1 mark)

10 In an experiment, 1.226 g of potassium chlorate(V), $KClO_3$, was heated. A mass of 0.320 g of oxygen gas, O_2, was collected.

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

Use the molar mass of $KClO_3$ = 122.6 g mol^{-1} and relative atomic mass O = 16.

The percentage yield of oxygen in this experiment is

☒ **A** 17.4%

☒ **B** 26.1%

☒ **C** 66.7%

☒ **D** 100%

(Total for Question 10 = 1 mark)

11 Oxygen gas, O_2, can be converted into ozone, O_3, by passing it through an electric discharge.

$$3O_2(g) \rightarrow 2O_3(g)$$

In an experiment, a volume of 300 cm^3 of oxygen was used but only 10% of the oxygen was converted into ozone. All volumes were measured at the same temperature and pressure.

The **total** volume of gas present at the end of the experiment, in cm^3, was

☒ **A** 200

☒ **B** 210

☒ **C** 290

☒ **D** 300

(Total for Question 11 = 1 mark)

12 1.40 g of an alkene gave 3.77 g of a dichloroalkane on reaction with chlorine.

What is the molecular formula of the alkene?

☒ **A** C_2H_4

☒ **B** C_3H_6

☒ **C** C_4H_8

☒ **D** C_6H_{12}

(Total for Question 12 = 1 mark)

13 The standard enthalpy change for the combustion of graphite is –393.5 kJ mol^{-1} and that of diamond is –395.4 kJ mol^{-1}.

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

$$C(s, \text{graphite}) \rightarrow C(s, \text{diamond})$$

☒ **A** –1.9

☒ **B** +1.9

☒ **C** –788.9

☒ **D** +788.9

(Total for Question 13 = 1 mark)

14 The standard enthalpy change of neutralization when an acid reacts with an alkali is the number of kilojoules released by the

☒ **A** formation of one mole of salt.

☒ **B** formation of one mole of water.

☒ **C** neutralization of one mole of acid.

☒ **D** neutralization of one mole of alkali.

(Total for Question 14 = 1 mark)

15 Consider the following bond enthalpy values.

Bond	Bond enthalpy / kJ mol^{-1}
O—O	+146
O—H	+463
O═O	+496

For the reaction

$$H—O—O—H(g) \rightarrow H—O—H(g) + \tfrac{1}{2}O═O(g)$$

the enthalpy change, in kJ mol^{-1}, is

☒ **A** –102

☒ **B** +102

☒ **C** +350

☒ **D** +394

(Total for Question 15 = 1 mark)

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

16 Using the data in the table below, calculate the standard enthalpy change, in kJ mol^{-1}, for the reaction between carbon disulfide, CS_2, and oxygen shown in the following equation.

$$CS_2(g) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

Substance	Standard enthalpy change of formation, $\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CS_2(g)$	+110
$CO_2(g)$	–390
$SO_2(g)$	–290

☒ **A** –570

☒ **B** –790

☒ **C** –860

☒ **D** –1080

(Total for Question 16 = 1 mark)

17 (a) Which of the following represents a step in the mechanism during the reaction between ethene and hydrogen bromide?

(1)

☒ **A** $C_2H_4 + Br^+ \rightarrow C_2H_4Br^+$

☒ **B** $C_2H_4 + HBr \rightarrow C_2H_5^+ + Br^-$

☒ **C** $C_2H_4 + HBr \rightarrow C_2H_5^{\bullet} + Br^{\bullet}$

☒ **D** $C_2H_4 + HBr \rightarrow C_2H_4Br^- + H^+$

(b) The mechanism of the reaction between ethene and hydrogen bromide is

(1)

☒ **A** electrophilic addition.

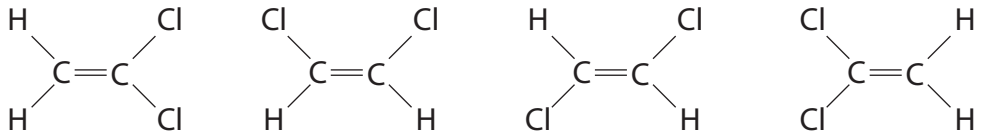
☒ **B** electrophilic substitution.

☒ **C** nucleophilic addition.

☒ **D** nucleophilic substitution.

(Total for Question 17 = 2 marks)

18 Which of the following pairs are *cis-trans* isomers?



1 **2** **3** **4**

☒ **A** **1** and **2**

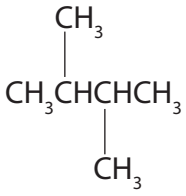
☒ **B** **1** and **4**

☒ **C** **2** and **3**

☒ **D** **3** and **4**

(Total for Question 18 = 1 mark)

19 What is the systematic name for the hydrocarbon shown below?



☒ **A** 1,4-dimethylbutane

☒ **B** 2,3-dimethylbutane

☒ **C** 2,3-dimethylhexane

☒ **D** 1,1,2,2-tetramethylethane

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

20 Crude oil is composed mainly of alkanes, which are saturated hydrocarbons.

(a) (i) Define the term **hydrocarbon**.

(1)

(ii) State what is meant by the term **saturated**, as applied to a hydrocarbon.

(1)

(b) Crude oil can be separated into fractions.

(i) What property allows crude oil to be separated by fractional distillation?

(1)

(ii) Many chemists are of the opinion that we should use fuels such as biodiesel rather than petrol and diesel.

Suggest **one** reason to support this opinion.

(1)

(c) A molecule of a hydrocarbon, **X**, can be cracked to form one molecule of pentane, C_5H_{12}, and two molecules of ethene only.

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

(1)

(ii) Give **one** reason why cracking reactions are carried out in industry and suggest why high temperatures are used in this process other than to speed up the reaction.

(2)

(d) Butane, C_4H_{10}, is a hydrocarbon which is used as a fuel. It is a gas under standard conditions.

(i) Explain what is meant by the term **fuel**.

(1)

(ii) Write an equation for the **complete** combustion of butane under standard conditions. Include state symbols in your answer.

(2)

(iii) Write an equation for the **incomplete** combustion of butane to form carbon monoxide and water only. State symbols are not required.

(1)

(iv) Under what conditions would you expect incomplete combustion to occur?

(1)

.....

.....

(e) Butane can react with bromine, in the presence of ultraviolet radiation, according to the following equation.

$$C_4H_{10} + Br_2 \rightarrow C_4H_9Br + HBr$$

(i) Calculate the atom economy by mass for the formation of C_4H_9Br.
Use the expression

$$\text{atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\ \%$$

Use the Periodic Table as a source of data.

(2)

Final answer.....%

*(ii) Describe the mechanism of the reaction between butane and bromine that forms the products given in the equation below.

$$C_4H_{10} + Br_2 \rightarrow C_4H_9Br + HBr$$

In your answer you should include

- equations for each step of the mechanism (curly arrows are **not** required)
- the name of each step occurring in the mechanism.

(7)

(Total for Question 20 = 21 marks)

21 Lattice energies can be calculated from experimental data using Born-Haber cycles.

In the table below are the enthalpy changes needed to calculate the lattice energy of sodium oxide, Na_2O.

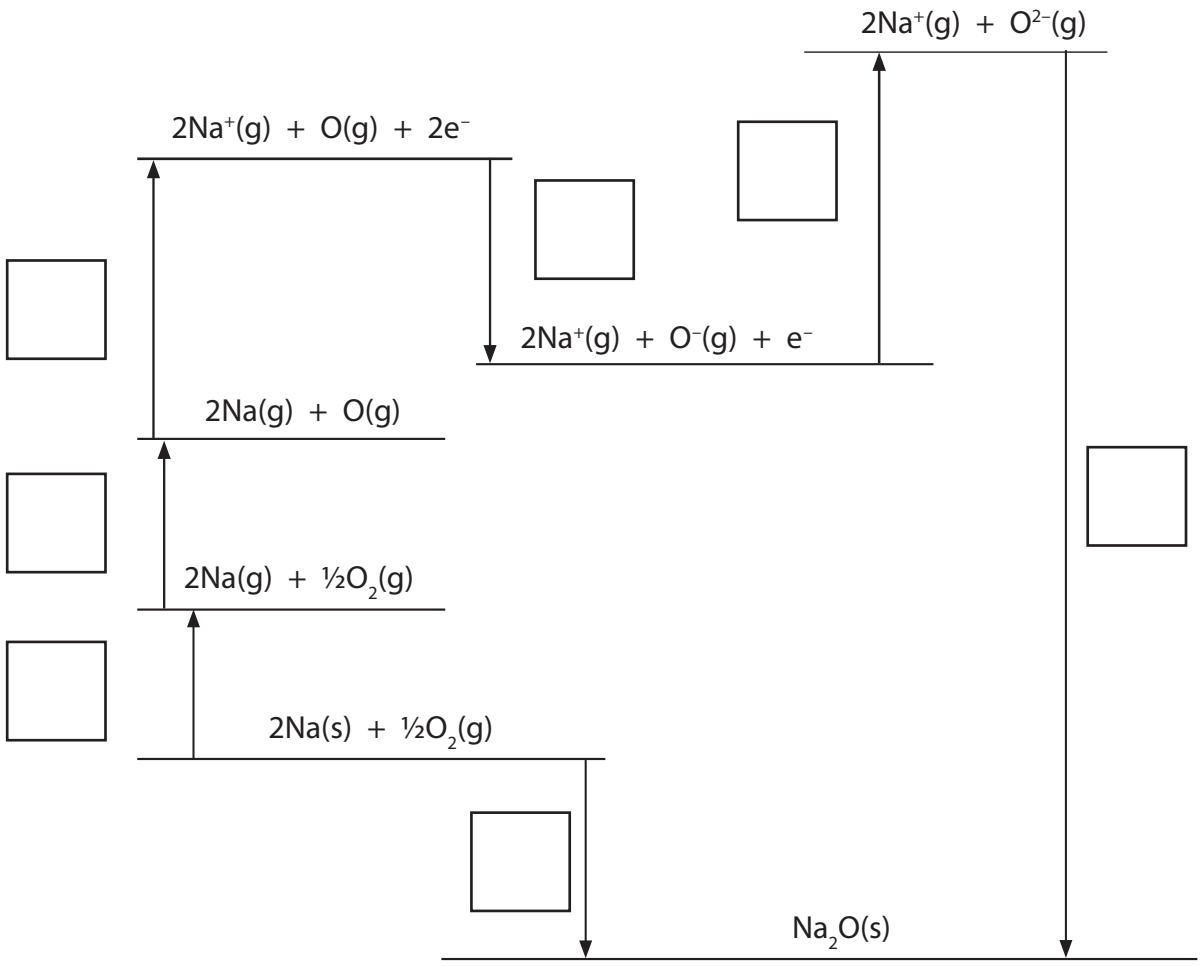
Letter	Enthalpy change	Value / kJ mol^{-1}
A	1st electron affinity of oxygen	–141
B	2nd electron affinity of oxygen	+790
C	1st ionization energy of sodium	+496
D	enthalpy change of atomization of sodium	+108
E	enthalpy change of atomization of oxygen, $\frac{1}{2}O_2(g)$	+249
F	enthalpy change of formation of sodium oxide	–414
G	lattice energy of sodium oxide	

(a) Define the term **lattice energy**.

(2)

(b) (i) Write the correct letters from the table of data to label the Born-Haber cycle below.

(3)



(ii) Calculate the lattice energy of sodium oxide, enthalpy change **G**, in kJ mol^{-1}.

(2)

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

*(c) Predict whether the lattice energy of magnesium oxide, MgO, is more or less exothermic than the lattice energy of magnesium sulfide, MgS.

Justify your answer in terms of the sizes and the charges of the ions involved.

(4)

(Total for Question 21 = 11 marks)

22 Nickel is an element in the d-block of the Periodic Table.

(a) Complete the electronic configuration of a nickel atom using the s, p, d notation.

(1)

$1s^2$ .....

(b) A sample of nickel is made up of three isotopes. The percentage abundances are shown in the table below.

Isotope	Percentage abundance
^{58}Ni	69.02
^{60}Ni	27.32
^{62}Ni	3.66

Calculate the relative atomic mass of nickel. Give your answer to **two** decimal places.

(2)

(c) Nickel reacts with carbon monoxide, CO, to give the compound nickel carbonyl, $Ni(CO)_4$.

$$Ni(s) + 4CO(g) \rightarrow Ni(CO)_4(g)$$

(i) Calculate the volume of carbon monoxide, in dm^3, measured at room temperature and pressure, that is required to react completely with 5.87 g of nickel.

[Relative atomic mass: Ni = 58.7
Molar volume of a gas = 24 $dm^3\ mol^{-1}$ at room temperature and pressure.]

(3)

(ii) Calculate the **number** of carbon monoxide molecules present in the volume of gas you have calculated in (c)(i).

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

(1)

(d) Nickel(II) nitrate, $Ni(NO_3)_2$, can be made by several different methods.

Method 1

Nickel(II) oxide, NiO, was reacted with dilute nitric acid according to the equation

$$NiO(s) + 2HNO_3(aq) \rightarrow Ni(NO_3)_2(aq) + H_2O(l)$$

(i) Calculate the volume of 2.00 mol dm^{-3} dilute nitric acid, in cm^3, that was required to exactly neutralize 1.494 g of nickel(II) oxide.

Use the relative atomic masses: Ni = 58.7, O = 16.0

(3)

Method 2

A volume of 25.0 cm^3 of 2.00 mol dm^{-3} nitric acid, HNO_3, was transferred to a beaker. Solid nickel(II) carbonate, $NiCO_3$, was added until it was in excess.

(ii) Why was **excess** nickel(II) carbonate used?

(1)

.....

.....

(iii) Why must the beaker be **much** larger than the volume of acid used?

(1)

.....

.....

.....

(iv) Write a balanced equation for the reaction between nickel(II) carbonate and dilute nitric acid, including state symbols.

(2)

*(v) For **Method 2**, describe the practical steps that you would take to obtain pure dry crystals of hydrated nickel(II) nitrate, $Ni(NO_3)_2.6H_2O$, from a mixture of nickel(II) nitrate solution and unreacted solid nickel(II) carbonate.

(4)

(Total for Question 22 = 18 marks)

23 This question concerns the Periodic Table.

(a) An atom of argon has mass number 40. Complete the table below showing the numbers of sub-atomic particles in this atom of argon. Use the Periodic Table as a source of data.

(1)

Sub-atomic particles present in one atom of ^{40}Ar	Number
protons	
electrons	
neutrons	

(b) An atom of potassium has mass number 39. Explain why argon is placed before potassium in the modern Periodic Table.

(1)

.....

.....

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.....

(c) In the context of the Periodic Table, explain what is meant by the term **periodicity**.

(2)

.....

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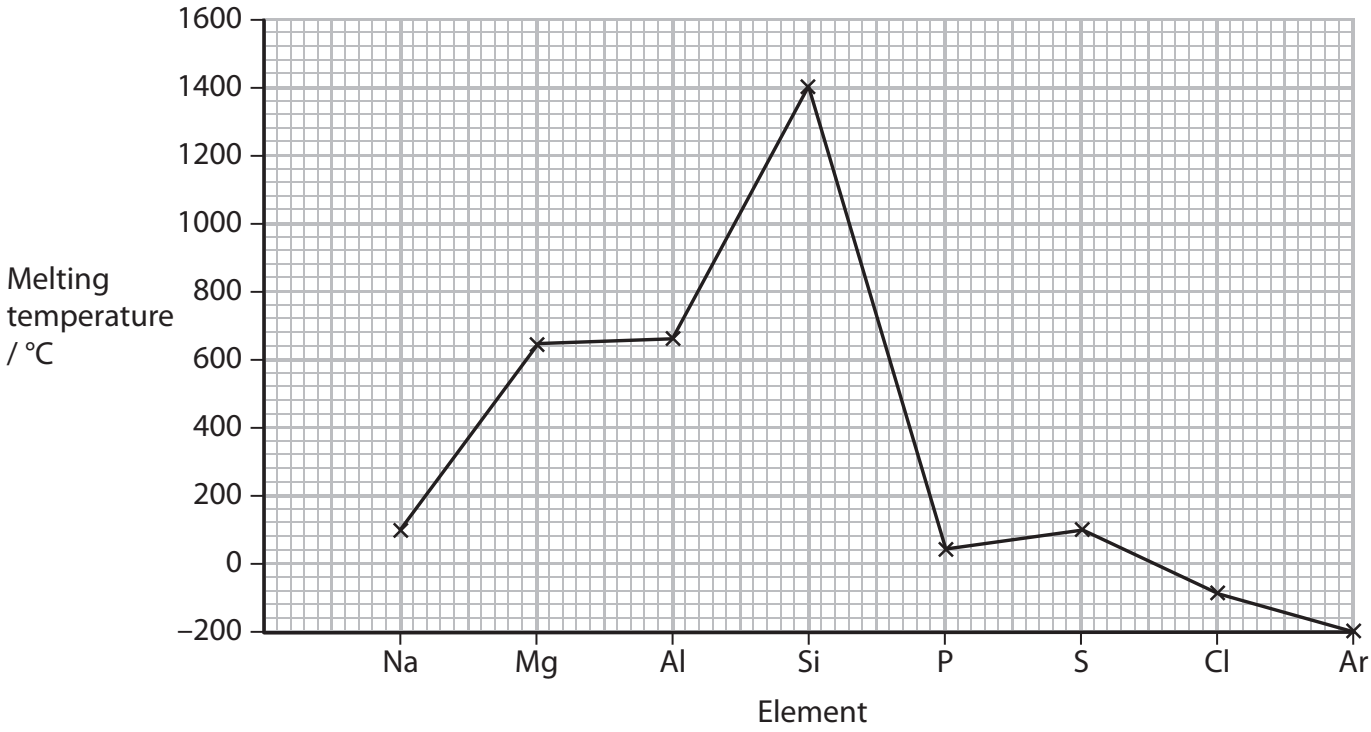
.....

.....

(d) The graph shows the variation in melting temperatures of the elements across Period 3 (Na to Ar) of the Periodic Table.



(i) Name **one** of the elements above that is composed of **simple molecules** at room temperature and pressure.

(1)

.....

(ii) Silicon has a giant atomic structure. Explain how this structure results in the high melting temperature shown on the graph.

(2)

.....

.....

.....

.....

(iii) Explain why the melting temperature of magnesium is higher than that of sodium.

(3)

(Total for Question 23 = 10 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									(13)	(14)	(15)	(16)	(17)	
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

* 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