Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Thursday 23 May 2013 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01R

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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7/6/7/1/

P 4 2 9 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 The first five ionization energies of an element, **X**, are

578, 1817, 2745, 11578 and 14831 kJ mol^{-1}, respectively.

In which group of the Periodic Table is **X** found?

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(Total for Question 1 = 1 mark)

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2 Which of the following oxides would be expected to have the most exothermic lattice energy?

☒ **A** Na_2O

☒ **B** MgO

☒ **C** CaO

☒ **D** K_2O

(Total for Question 2 = 1 mark)

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3 In which of the following compounds is the **anion** most polarized?

☒ **A** LiF

☒ **B** LiI

☒ **C** KF

☒ **D** KI

(Total for Question 3 = 1 mark)

---

4 In the Born-Haber cycle for potassium iodide, which of the following steps is **exothermic**?

☒ **A** $K(s) \rightarrow K(g)$

☒ **B** $K(g) \rightarrow K^+(g) + e^-$

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

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

(Total for Question 4 = 1 mark)

5 Which of the following represents a pair of isotopes?

☒ **A** $^{14}_{6}C$ and $^{14}_{7}N$

☒ **B** $^{32}_{16}S$ and $^{32}_{16}S^{2-}$

☒ **C** O_2 and O_3

☒ **D** $^{206}_{82}Pb$ and $^{208}_{82}Pb$

(Total for Question 5 = 1 mark)

6 Which of the following equations represents the **second** ionization energy of chlorine?

☒ **A** $Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$

☒ **B** $Cl(g) \rightarrow Cl^{2+}(g) + 2e^-$

☒ **C** $Cl(g) \rightarrow Cl^{2-}(g) - 2e^-$

☒ **D** $Cl^-(g) \rightarrow Cl^{2-}(g) - e^-$

(Total for Question 6 = 1 mark)

7 For Period 3 of the Periodic Table, from sodium to argon, what is the trend in the melting temperatures of the elements?

☒ **A** A steady decrease

☒ **B** A steady increase

☒ **C** A decrease to silicon then an increase

☒ **D** An increase to silicon then a decrease

(Total for Question 7 = 1 mark)

8 Given the following information

$$CH_4(g) \rightarrow C(g) + 4H(g) \qquad \Delta H = +Q \text{ kJ mol}^{-1}$$

the mean bond enthalpy for the C—H bond in methane is

☒ **A** $+Q$

☒ **B** $+Q/4$

☒ **C** $-Q$

☒ **D** $-Q/4$

(Total for Question 8 = 1 mark)

9 Consider the following information:

Bond	Bond enthalpy / kJ mol^{-1}
H—H	+436
I—I	+151
H—I	+299

For the reaction

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

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

☒ **A** +288

☒ **B** +144

☒ **C** −11

☒ **D** −5.5

(Total for Question 9 = 1 mark)

10 The equation for the complete combustion of butanone, $C_2H_5COCH_3$, is

$$C_2H_5COCH_3(l) + 5\frac{1}{2}O_2(g) \rightarrow 4CO_2(g) + 4H_2O(l) \qquad \Delta H^{\ominus} = -2440 \text{ kJ mol}^{-1}$$

Substance	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CO_2(g)$	–394
$H_2O(l)$	–286

From the above data, the standard enthalpy change of formation of butanone, in kJ mol^{-1}, is

☒ **A** –280

☒ **B** +280

☒ **C** –1760

☒ **D** +1760

(Total for Question 10 = 1 mark)

11 A compound was found to contain 2.8 g of nitrogen and 8.0 g of oxygen.

What is the empirical formula of the compound?

Use the Periodic Table as a source of data.

☒ **A** NO

☒ **B** NO_2

☒ **C** N_2O_3

☒ **D** N_2O_5

(Total for Question 11 = 1 mark)

12 What is the total number of **atoms** in 1.8 g of water, H_2O?

DATA
- The molar mass of H_2O is 18 g mol^{-1}
- The Avogadro Constant is 6.0×10^{23} mol^{-1}

☒ **A** 6.0×10^{22}

☒ **B** 6.0×10^{23}

☒ **C** 1.8×10^{23}

☒ **D** 1.8×10^{24}

(Total for Question 12 = 1 mark)

13 Phosphorus(V) chloride, PCl_5, reacts with water according to the equation

$$PCl_5(s) + 4H_2O(l) \rightarrow H_3PO_4(aq) + 5HCl(aq)$$

If 1.04 g of phosphorus pentachloride (molar mass = 208 g mol^{-1}) is reacted completely with water and the solution made up to 1 dm^3, the concentration of the hydrochloric acid in mol dm^{-3} is

☒ **A** 0.001

☒ **B** 0.005

☒ **C** 0.025

☒ **D** 0.250

(Total for Question 13 = 1 mark)

14 A sample of sodium chlorate(V), $NaClO_3$, was heated and 120 cm^3 of oxygen gas was collected.

$$2NaClO_3(s) \rightarrow 2NaCl(s) + 3O_2(g)$$

Calculate the number of moles of sodium chlorate(V) that were decomposed in the above reaction.

[Molar volume of a gas under the conditions of the experiment = 24000 cm^3 mol^{-1}]

☒ **A** 2.50×10^{-3}

☒ **B** 3.33×10^{-3}

☒ **C** 5.00×10^{-3}

☒ **D** 7.50×10^{-3}

(Total for Question 14 = 1 mark)

15 In the ethene molecule, the C═C double bond is made up of

☒ **A** two sigma bonds.

☒ **B** one pi bond.

☒ **C** two pi bonds.

☒ **D** one sigma bond and one pi bond.

(Total for Question 15 = 1 mark)

16 3.0 dm^3 of sulfur dioxide reacts with 1.5 dm^3 of oxygen, under suitable conditions, according to the equation below.

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

What is the maximum volume of sulfur trioxide that can be formed in the above reaction?

[The volumes of the gases are measured at the same temperature and pressure.]

☒ **A** 6.0 dm^3

☒ **B** 4.5 dm^3

☒ **C** 3.0 dm^3

☒ **D** 1.5 dm^3

(Total for Question 16 = 1 mark)

17 Which of the following alkenes exhibits *E/Z* isomerism?

☒ **A** But-1-ene

☒ **B** But-2-ene

☒ **C** 2-Methylpropene

☒ **D** Propene

(Total for Question 17 = 1 mark)

18 An electrophile is **defined** as a species that

☒ **A** is an electron pair acceptor.

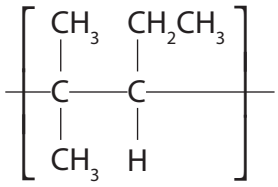
☒ **B** is an electron pair donor.

☒ **C** has a negative charge.

☒ **D** has a positive charge.

(Total for Question 18 = 1 mark)

19 The repeat unit of a polymer is shown below.



The systematic name of the alkene monomer that forms this polymer is

☒ **A** 2-methyl-3-ethylpropene

☒ **B** 2-methylpent-2-ene

☒ **C** 2-methylpent-3-ene

☒ **D** 4-methylpent-2-ene

(Total for Question 19 = 1 mark)

20 Cracking crude oil

☒ **A** separates the mixture into pure compounds.

☒ **B** separates the mixture into a number of fractions.

☒ **C** separates saturated compounds from unsaturated ones.

☒ **D** decreases the average number of carbon atoms per molecule.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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Section B begins on the next page.

SECTION B

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

21 In atoms, electrons fill up the sub-shells in order of increasing energy.

(a) Fill in the last two boxes in the table below to show the order in which the next two sub-shells are filled.

1s	**2s**	**2p**	**3s**	**3p**	**4s**		

energy increases →

(2)

(b) Electrons in atoms occupy orbitals.

(i) Explain the term **orbital**.

(1)

.....

.....

.....

(ii) Draw diagrams below to show the shape of an s-orbital and of a p-orbital.

(2)

s-orbital

p-orbital

(c) State the **total** number of electrons occupying **all** the p-orbitals in one atom of chlorine.

(1)

.....

(d) State the number of electrons present in an ion of calcium, Ca^{2+}.

(1)

.....

*(e) Define the term **first ionization energy**.

(3)

.....

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.....

.....

.....

(f) The ionization energies of sodium, Na, are shown in the table below.

Show with a tick (✓), in the third row of the table below, **all** the ionization numbers that involve the removal of an electron from an s-orbital.

(2)

Ionization energy / kJ mol^{-1}	496	4563	6913	9544	13352	16611	20115	25491	28934	141367	159079
Ionization number	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th

(Total for Question 21 = 12 marks)

22 (a) In a mass spectrometer being used to determine relative atomic masses, gaseous atoms are ionized. The ions are then accelerated and deflected before being detected.

(i) Explain how atoms are **ionized** in a mass spectrometer.

(1)

(ii) How are the ions **accelerated** in a mass spectrometer?

(1)

(iii) How are the ions **deflected** in a mass spectrometer?

(1)

(b) The following data were obtained from the mass spectrum of a sample of platinum.

Peak at *m/e*	%
194	32.8
195	30.6
196	25.4
198	11.2

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

(2)

(c) In which block of the Periodic Table is platinum found?

(1)

(d) Most solids exist as lattice structures.

(i) Complete the table, using a tick (✓) if the substance conducts electricity or a cross (✗) if the substance does not conduct electricity.

(2)

Substance	Conducts electricity in the SOLID state? (✓ or ✗)	Conducts electricity in the LIQUID state? (✓ or ✗)
Sodium, Na		
Sodium oxide, Na_2O		

*(ii) Explain the electrical conductivities of sodium and of sodium oxide in the solid and liquid states.

(3)

(Total for Question 22 = 11 marks)

23 Crude oil is a complex mixture of hydrocarbons. Initial separation is achieved by fractional distillation of the crude oil. The separate fractions are further refined to produce hydrocarbons such as decane, $C_{10}H_{22}$.

(a) Give the general formula of alkanes.

(1)

(b) Carbon monoxide, CO, is formed during the incomplete combustion of decane.

(i) Write an equation for the incomplete combustion of decane, forming carbon monoxide and water only.

(1)

(ii) Explain why incomplete combustion can occur.

(1)

.....

.....

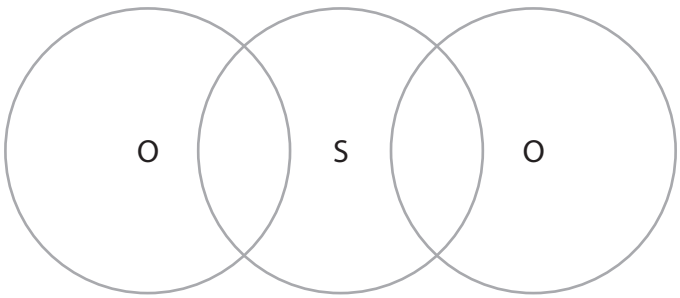
(c) 'Low-sulfur fuel' is now supplied to petrol stations. The removal of sulfur from diesel and petrol reduces the emission of toxic oxides of sulfur from vehicle exhausts. One such oxide is sulfur dioxide, SO_2.

The bonding in sulfur dioxide may be represented as shown below.

$$O = S \rightarrow O$$

Complete the dot and cross diagram below for the SO_2 molecule, showing only outer shell electrons. Use dots to represent the oxygen electrons and crosses to represent the sulfur electrons.

(3)



(d) Another alkane produced from crude oil is heptane, C_7H_{16}. The reforming of heptane produces methylcyclohexane and only one other product. A methylcyclohexane molecule is made from a ring of six carbon atoms bonded to a methyl group.

(i) Use the information given above to give the **skeletal** formula of methylcyclohexane.

(1)

(ii) Write a balanced equation, using **molecular** formulae, for the reforming of heptane into methylcyclohexane and one other product. State symbols are not required.

(1)

(iii) Suggest a reason why oil companies reform alkanes such as heptane.

(1)

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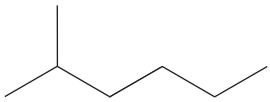
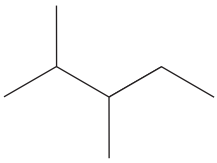
(e) Five branched-chain isomers of heptane are shown in the boxes below.

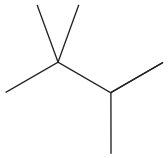
2-methylhexane



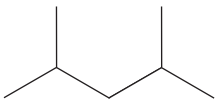
2,3-dimethylpentane



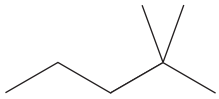
2,2,3-trimethylbutane



2,4-dimethylpentane



isomer **A**



(i) Give the systematic name of isomer **A**.

(1)

.....

(ii) In the empty boxes above, draw skeletal formulae for two other **branched-chain** isomers of C_7H_{16}, with no side-chain having more than one carbon atom.

(2)

(f) Butane, C_4H_{10}, reacts with chlorine, Cl_2, at room temperature and pressure.

$$C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$$

(i) What other condition is essential for this reaction?

(1)

.....

(ii) Write an equation for the initiation step of the mechanism for the above reaction. Curly arrows are not required.

(1)

(iii) State the type of bond fission involved in the initiation step.

(1)

.....

(iv) Write equations for the two propagation steps of this mechanism. Curly arrows are not required.

(2)

First propagation step:

Second propagation step:

(v) Write **one** equation for a reaction that would terminate this mechanism.

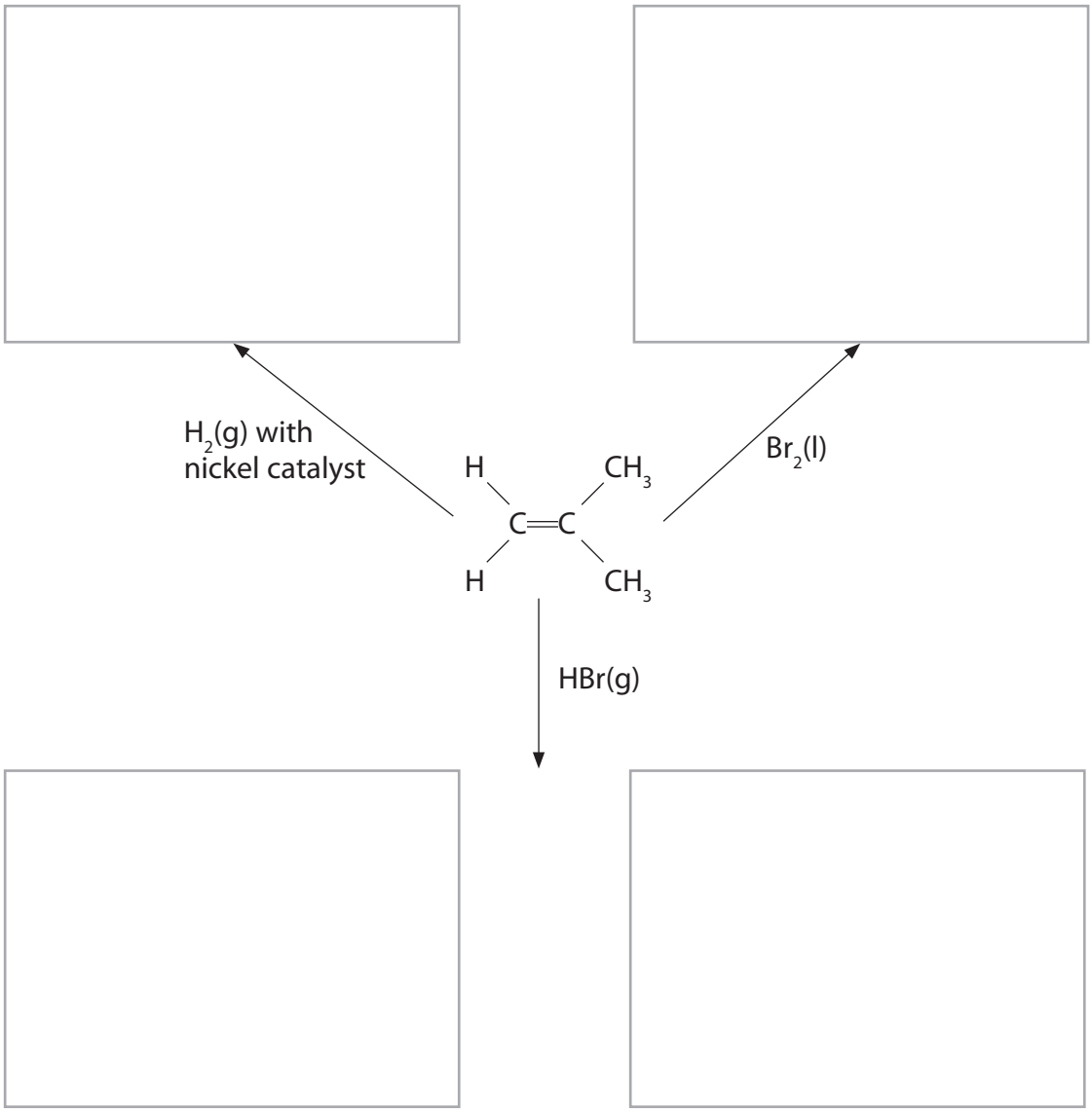
(1)

(Total for Question 23 = 18 marks)

24 Alkenes are unsaturated hydrocarbons. They are used in the industrial production of many organic compounds.

(a) Add structural formulae to the flowchart below to show the organic product formed in each addition reaction of 2-methylpropene.

(4)



mixture of isomers

(b) Suggest a mechanism for the reaction of 2-methylpropene with bromine, $Br_2(l)$.
Include curly arrows.

(3)

(c) Ethene, C_2H_4, was prepared from ethanol, C_2H_5OH, by the following reaction

$$C_2H_5OH \rightarrow C_2H_4 + H_2O$$

A chemist reacted 9.2 g of ethanol, C_2H_5OH, and obtained 4.2 g of ethene.

Calculate the percentage yield of ethene in the reaction.

(2)

(Total for Question 24 = 9 marks)

25 *(a) Define the term **enthalpy change of neutralization**.

(2)

.....

.....

.....

.....

(b) The enthalpy change of the neutralization reaction between hydrochloric acid, HCl(aq), and sodium hydroxide, NaOH(aq), can be determined by the following procedure.

Procedure:

- 50.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid is transferred to a polystyrene cup and its temperature recorded
- 50.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide solution is placed in another polystyrene cup and its temperature recorded
- The two solutions are mixed, with stirring, and the maximum temperature is recorded

Results:

Initial temperature of both the HCl(aq) and NaOH(aq) = 19.0 °C

Maximum temperature reached after mixing = 32.5 °C

Assumption:

- The specific heat capacity of all aqueous solutions is 4.18 J g^{-1} $°C^{-1}$
- The density of all aqueous solutions is 1.00 g cm^{-3}

(i) Calculate the heat energy released (in joules) on mixing the hydrochloric acid and the sodium hydroxide solutions.

Use the expression

energy released (J) = mass of solution $\times$ 4.18 $\times$ temperature change

(2)

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

(1)

(iii) Give the **ionic** equation, including state symbols, for the reaction between hydrochloric acid and sodium hydroxide solution.

(1)

(iv) Use your answers to (b)(i), (ii) and (iii) to calculate the enthalpy change of neutralization for the above reaction.
Include a sign and units in your answer.

(3)

(v) Explain why the enthalpy change of neutralization for the reaction between dilute nitric acid, $HNO_3(aq)$, and potassium hydroxide solution, KOH(aq), is predicted to be the same as the enthalpy change of neutralization for the reaction carried out in part (b).

(1)

.....

.....

.....

.....

(Total for Question 25 = 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)
							1.0 H hydrogen 1										(18) 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

* 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