Candidate surname | Other names

Pearson Edexcel
International
Advanced Level

Centre Number | Candidate Number

Wednesday 9 January 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **WCH11/01**

Chemistry
International Advanced Subsidiary
Unit 1: Structure, Bonding and Introduction to
Organic Chemistry

Candidates must have: Scientific calculator
Ruler

Total Marks

Instructions

- Use **black** ink or **black** 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*.
- 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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Pearson

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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 hydroxide ion, OH⁻, has a total of 9 protons.

How many neutrons and electrons are there in this ion?

	Number of neutrons	Number of electrons
☒ **A**	8	8
☒ **B**	8	10
☒ **C**	9	8
☒ **D**	9	9

(Total for Question 1 = 1 mark)

2 A sample of silicon contains the following isotopes.

Isotope	Percentage abundance
^{28}Si	81.21
^{29}Si	14.10
^{30}Si	4.69

What is the relative atomic mass of silicon, to one decimal place, in this sample?

☒ **A** 28.0

☒ **B** 28.2

☒ **C** 29.0

☒ **D** 29.8

(Total for Question 2 = 1 mark)

3 Which is the electronic configuration of a carbon atom in its ground state?

	1s	2s	2p
☒ **A**	↑	↑	↑↓ | ↑ | ↑
☒ **B**	↑↓	↑	↑ | ↑ | ↑
☒ **C**	↑↓	↑↓	↑↓ | |
☒ **D**	↑↓	↑↓	↑ | ↑ |

(Total for Question 3 = 1 mark)

4 What is the maximum number of electrons in the 3p subshell, and in the third quantum shell of an atom?

	Maximum number of electrons in the 3p subshell	Maximum number of electrons in the third quantum shell
☒ **A**	2	8
☒ **B**	2	18
☒ **C**	6	8
☒ **D**	6	18

(Total for Question 4 = 1 mark)

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

5 The first six ionisation energies of an element, in $kJ\,mol^{-1}$, are shown.

578   1817   2745   11578   14831   18378

Which group of the Periodic Table includes this element?

☒ **A** Group 2

☒ **B** Group 3

☒ **C** Group 4

☒ **D** Group 5

(Total for Question 5 = 1 mark)

6 The diagram shows the first ionisation energy for the elements from sodium to silicon.

First ionisation energy / $kJ\,mol^{-1}$
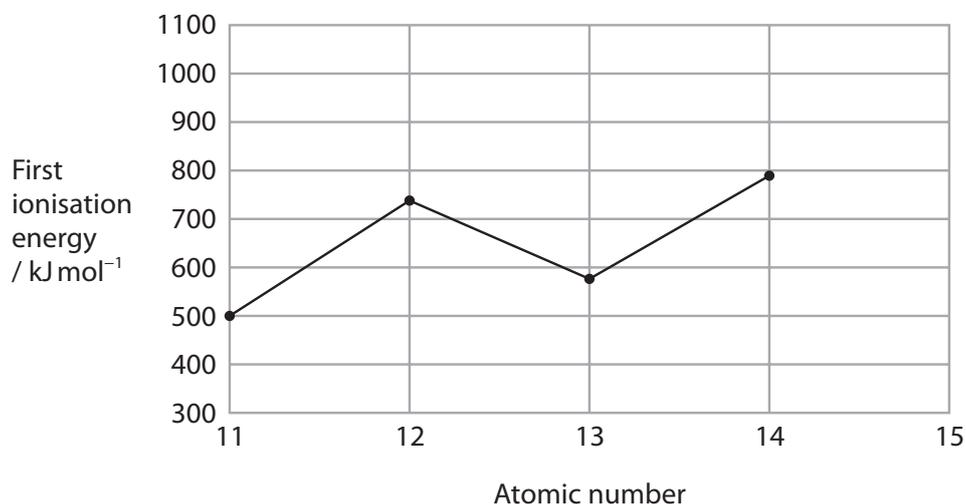
Atomic number

What is the approximate first ionisation energy, in $kJ\,mol^{-1}$, of phosphorus (atomic number 15)?

☒ **A** 400

☒ **B** 500

☒ **C** 700

☒ **D** 1000

(Total for Question 6 = 1 mark)

7 Which is the dot-and-cross diagram for magnesium chloride?

Only outer shell electrons are shown.

☒ **A**

☒ **B**

☒ **C**

☒ **D**
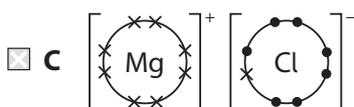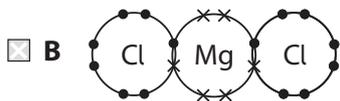
(Total for Question 7 = 1 mark)

8 Metallic bonding is the strong electrostatic attraction between

☒ **A** anions and cations

☒ **B** atoms and delocalised electrons

☒ **C** ions and delocalised electrons

☒ **D** two nuclei and a shared pair of electrons

(Total for Question 8 = 1 mark)

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

9 The ionic radius of Al^{3+} is smaller than that of N^{3-}.

This is because Al^{3+} has

☒ **A** fewer protons but more electrons than N^{3-}

☒ **B** more protons but fewer electrons than N^{3-}

☒ **C** more protons than N^{3-} but the same number of electrons as N^{3-}

☒ **D** the same number of protons as N^{3-} but fewer electrons

(Total for Question 9 = 1 mark)

10 Which ion has the greatest polarising power?

☒ **A** Cl^-

☒ **B** Mg^{2+}

☒ **C** Na^+

☒ **D** S^{2-}

(Total for Question 10 = 1 mark)

11 Which species is **not** tetrahedral?

☒ **A** CCl_4

☒ **B** CH_4

☒ **C** ICl_4^-

☒ **D** NH_4^+

(Total for Question 11 = 1 mark)

12 Members of the homologous series of alkanes have the same

☒ **A** boiling temperature

☒ **B** density

☒ **C** empirical formula

☒ **D** general formula

(Total for Question 12 = 1 mark)

P 6 0 7 8 9 A 0 6 2 4

13 An electrophile

☒ **A** accepts a pair of electrons

☒ **B** always has a negative charge

☒ **C** always has a positive charge

☒ **D** donates a pair of electrons

(Total for Question 13 = 1 mark)

14 What is the total number of structural isomers with the molecular formula C_6H_{14}?

☒ **A** 4

☒ **B** 5

☒ **C** 6

☒ **D** 7

(Total for Question 14 = 1 mark)

15 What is the systematic name of compound **X**?
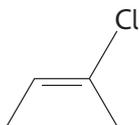
Compound **X**

☒ **A** *E*-2-chlorobut-2-ene

☒ **B** *Z*-2-chlorobut-2-ene

☒ **C** *E*-3-chlorobut-2-ene

☒ **D** *Z*-3-chlorobut-2-ene

(Total for Question 15 = 1 mark)

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

16 Ethene reacts with hydrogen in the presence of a heated nickel catalyst to form ethane.
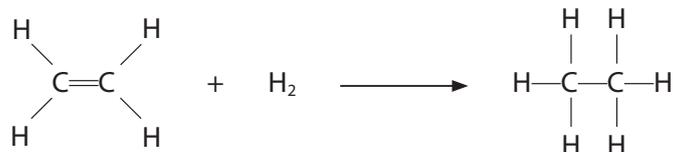
Which types of bond are broken and formed in this reaction?

	Bonds broken	Bonds formed
☒ **A**	σ only	π only
☒ **B**	π only	σ only
☒ **C**	σ and π	σ only
☒ **D**	σ and π	π only

(Total for Question 16 = 1 mark)

17 Calcium reacts with dilute nitric acid to form calcium nitrate and hydrogen.

Which is the balanced equation for this reaction?

☒ **A** $Ca + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2$

☒ **B** $Ca + H_2NO_3 \rightarrow CaNO_3 + H_2$

☒ **C** $Ca + 2H_2NO_3 \rightarrow Ca(NO_3)_2 + 2H_2$

☒ **D** $2Ca + 2HNO_3 \rightarrow 2CaNO_3 + H_2$

(Total for Question 17 = 1 mark)

18 What mass of anhydrous sodium carbonate is needed to make $50.0\,cm^3$ of a $0.0800\,mol\,dm^{-3}$ solution of sodium carbonate, Na_2CO_3?

[A_r values: C = 12.0, O = 16.0, Na = 23.0]

☒ **A** 0.332 g

☒ **B** 0.424 g

☒ **C** 5.30 g

☒ **D** 8.48 g

(Total for Question 18 = 1 mark)

19 A sample of air, with a mass of 5.0 kg, contained carbon monoxide with a concentration of 12 parts per million by mass.

What is the mass of carbon monoxide in this sample of air?

- ☒ **A** 6.0×10^{-2} g
- ☒ **B** 6.0×10^{-5} g
- ☒ **C** 2.4×10^{-6} g
- ☒ **D** 2.4×10^{-9} g

(Total for Question 19 = 1 mark)

20 What is the maximum volume of hydrogen formed, at room temperature and pressure (r.t.p.), when 0.207 g of lithium is added to excess water?

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$
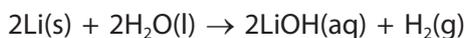
[A_r Li = 6.9   Molar volume of gas at r.t.p. = 24.0 dm^3 mol^{-1}]

- ☒ **A** 0.36 dm^3
- ☒ **B** 0.72 dm^3
- ☒ **C** 1.44 dm^3
- ☒ **D** 2.48 dm^3

(Total for Question 20 = 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.

21 Heptane, C_7H_{16}, is one of the compounds present in crude oil.

(a) When heptane is reformed, the products include 2,2,3-trimethylbutane and cycloheptane.

(i) Give a reason why petrol should **not** contain a high proportion of heptane.

(1)

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(ii) Draw the **skeletal** formula of 2,2,3-trimethylbutane.

(1)

(iii) Write the equation for reforming heptane into cycloheptane.
Use **molecular** formulae.

State symbols are not required.

(1)

(iv) When petrol is burned in a car engine, oxides of nitrogen are formed.

Explain how these compounds result in damage to trees.

(2)

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(b) Heptane reacts with chlorine in sunlight.

(i) Chlorine radicals are formed in the first step in the mechanism.

$$Cl_2 \rightarrow 2Cl\bullet$$
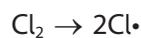
Name this step in the mechanism.

(1)

(ii) Give the **two** propagation steps for the formation of chloroheptane.
Use molecular formulae. Curly arrows are **not** required.

(2)

(iii) Give the termination step which forms a hydrocarbon.

(1)

(iv) Explain how some dichloroheptane, $C_7H_{14}Cl_2$, also forms during this reaction.
You may include equation(s) in your answer.

(2)

(Total for Question 21 = 11 marks)

22 This question is about nitrogen.

(a) The table shows the successive ionisation energies of nitrogen.

Ionisation number	Ionisation energy / kJ mol^{-1}	log (ionisation energy)
1	1 402	3.15
2	2 856	3.46
3	4 578	3.66
4	7 475	3.87
5	9 445	3.98
6	53 268	
7	64 362	

(i) Complete the table.

(1)

(ii) Plot a graph of log (ionisation energy) against ionisation number.

(3)

(iii) Give a reason why the logarithm of the ionisation energy, rather than just the ionisation energy, is used to plot this graph.

(1)

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(iv) Explain what can be deduced from the graph about the electronic structure of nitrogen.

(3)

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(v) Explain why the first ionisation energy of oxygen is lower than that of nitrogen.

(3)

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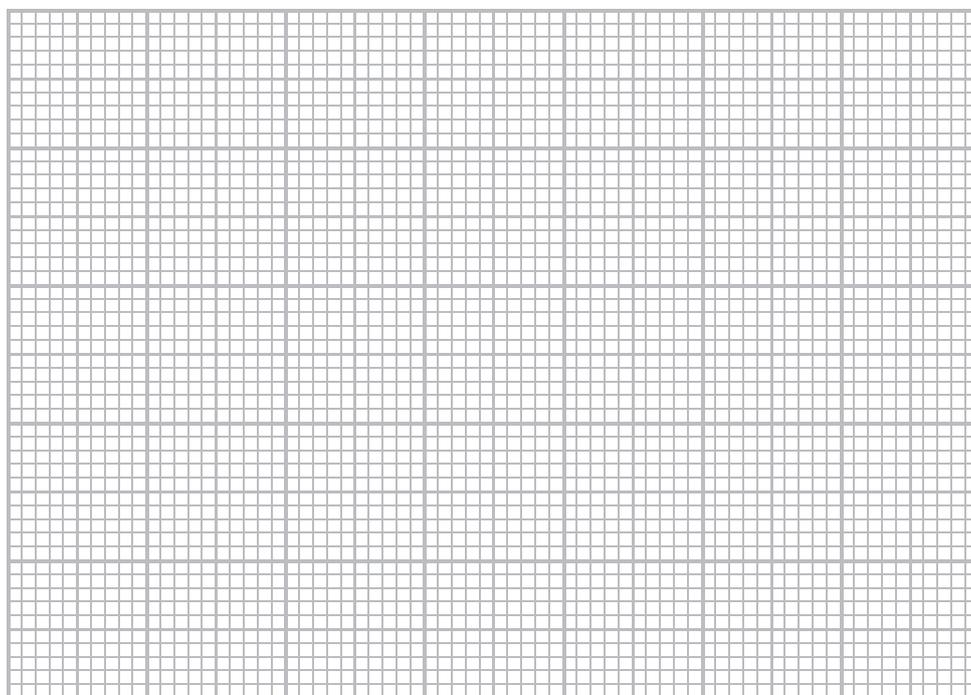
(b) Nitrogen gas consists of nitrogen molecules.

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

(1)

(ii) Calculate the number of nitrogen **atoms** in 5.60 g of nitrogen gas.

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

(2)

(iii) A sample of nitrogen gas occupied $108\,cm^3$ at a temperature of 25 °C and a pressure of $1.36 \times 10^5\,Pa$.

Using the ideal gas equation, calculate the number of moles of nitrogen gas in this sample.

$[pV = nRT \quad R = 8.31\,J\,mol^{-1}\,K^{-1}]$

(4)

(Total for Question 22 = 18 marks)

23 This question is about the alkene 2-methylpropene.

The formulae show two different ways of representing a molecule of 2-methylpropene.
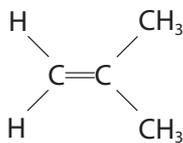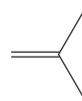
formula **1**   formula **2**

(a) Give the **empirical** formula of 2-methylpropene.

(1)

....

(b) Give a reason why 2-methylpropene does **not** show geometric isomerism.

(1)

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(c) Draw the mechanism for the reaction between 2-methylpropene and bromine, Br_2.
Include curly arrows, and relevant lone pairs and dipoles.
Use formula **1** to represent 2-methylpropene.

(4)

(d) Two reactions of 2-methylpropene are shown.

Reaction **1**
reagent **A**

Reaction **2**
reagent **B**

organic product **Q**

Br
major product
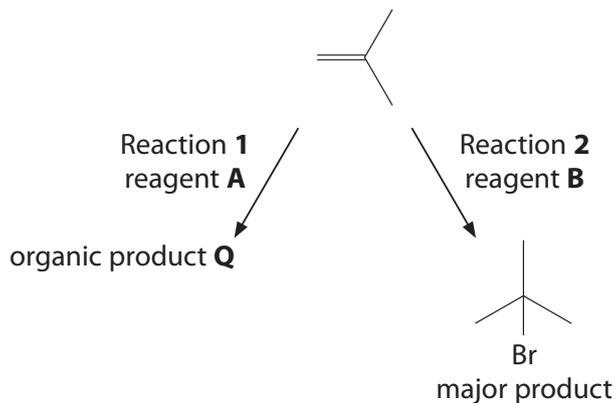
(i) In Reaction **1** the reagent **A** is acidified potassium manganate(VII).

Give the **skeletal** formula of organic product **Q**.

(1)

(ii) Give the colour change seen during Reaction **1**.

(1)

From .... to ....

(iii) Identify, by name or formula, reagent **B** in Reaction **2**.

(1)

(iv) Explain why 2-bromo-2-methylpropane is the major organic product in Reaction **2**.

(2)

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(e) Draw **two** repeat units of poly(2-methylpropene).
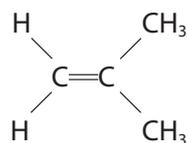
$$H \underset{H}{\overset{}{\diagdown}} C = C \overset{CH_3}{\underset{CH_3}{\diagup}}$$

2-methylpropene

(2)

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(f) A sample of 2-methylpropene was prepared from 2-methylpropan-2-ol.

2-methylpropan-2-ol   2-methylpropene
$M_r = 74.0$ $M_r = 56.0$

The yield of this reaction was 58.2%.

Calculate the mass of 2-methylpropene formed from 6.85 g of 2-methylpropan-2-ol. Give your answer to an appropriate number of significant figures.

(4)

(Total for Question 23 = 17 marks)

24 This question is about compounds containing chlorine.

(a) A precipitate of silver chloride is formed when silver nitrate solution reacts with sodium chloride solution.

A student wrote an ionic equation for the reaction.

$$Ag^{2+}(l) + 2Cl^-(l) \rightarrow AgCl_2(s)$$
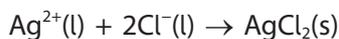
Explain why this equation is incorrect, even though it is balanced.

(2)

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(b) A sample of a compound is analysed and found to contain **only** 3.09 g carbon, 0.26 g hydrogen and 9.15 g chlorine.
The molar mass of the compound is $97.0\,g\,mol^{-1}$.

Calculate the molecular formula of this compound.
You **must** show your working.

(3)

(c) Nitrogen trichloride has the formula NCl_3.

(i) A sample of nitrogen trichloride contained only nitrogen atoms with mass number 14, and chlorine atoms with mass numbers 35 and 37.

Give the formula and mass/charge ratio for each of the **four** ions responsible for the molecular ion peaks in the mass spectrum of nitrogen trichloride.

(2)

(ii) Complete the table to predict the shape and Cl—N—Cl bond angle in nitrogen trichloride.

(3)

Number of bonding pairs of electrons on nitrogen	
Number of lone pairs of electrons on nitrogen	
Shape of molecule	
Cl—N—Cl bond angle	

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(d) Aluminium chloride exists as an ionic lattice in the solid state and as a covalent dimer, Al_2Cl_6, in the gas phase, just above its boiling temperature.

(i) Explain why aluminium chloride in the solid state has significant covalent character.

(2)

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(ii) Describe how two $AlCl_3$ molecules are joined together in the dimer.
Include a diagram in your answer.

(2)

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(Total for Question 24 = 14 marks)

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

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The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

(1)	(2)												(13)	(14)	(15)	(16)	(17)	0 (8) (18)
							1.0 **H** hydrogen 1											4.0 **He** helium 2
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