

Please check the examination details below before entering your candidate information

Candidate surname

Other names

**Pearson Edexcel**  
**International**  
**Advanced Level**

Centre Number

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Candidate Number

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**Tuesday 8 October 2019**

Afternoon (Time: 1 hour 30 minutes)

Paper Reference **WCH11/01**

**Chemistry**

**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.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- 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

## 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 element is in the d-block of the Periodic Table?

- A argon
- B chlorine
- C iron
- D sodium

(Total for Question 1 = 1 mark)

2 What is the equation for the **third** ionisation energy of aluminium?

- A  $\text{Al(g)} \rightarrow \text{Al}^{3+}(\text{g}) + 3\text{e}^{-}$
- B  $\text{Al(s)} \rightarrow \text{Al}^{3+}(\text{s}) + 3\text{e}^{-}$
- C  $\text{Al}^{2+}(\text{g}) \rightarrow \text{Al}^{3+}(\text{g}) + \text{e}^{-}$
- D  $\text{Al}^{2+}(\text{s}) \rightarrow \text{Al}^{3+}(\text{s}) + \text{e}^{-}$

(Total for Question 2 = 1 mark)

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3 The first three ionisation energies of carbon are shown.

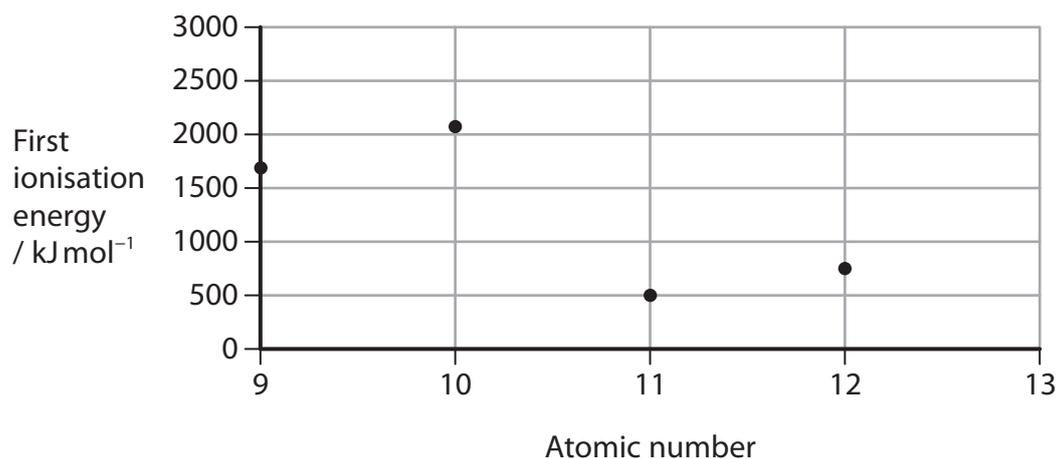
	1st	2nd	3rd
Ionisation energy / $\text{kJ mol}^{-1}$	1086	2353	4621

Which is the approximate fourth ionisation energy, in  $\text{kJ mol}^{-1}$ , of carbon?

- A 3500
- B 6200
- C 11 000
- D 38 000

(Total for Question 3 = 1 mark)

4 The chart shows the first ionisation energy of each of the elements from fluorine to magnesium.



Which is the approximate first ionisation energy, in  $\text{kJ mol}^{-1}$ , of aluminium (atomic number 13)?

- A 300
- B 600
- C 900
- D 1200

(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 decrease in first ionisation energy down Group 1 in the Periodic Table is caused by the **increase** in

- A force of attraction between the nucleus and outer electron
- B number of neutrons in the nucleus
- C number of protons in the nucleus
- D shielding of the outer electron from the nuclear charge

(Total for Question 5 = 1 mark)

6 What is the relative formula mass of hydrated ammonium iron(II) sulfate,  $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ ?

[Relative atomic masses ( $A_r$ ): H = 1.0 N = 14.0 O = 16.0 S = 32.1 Fe = 55.8]

- A 284
- B 302
- C 312
- D 392

(Total for Question 6 = 1 mark)

7 How many **atoms** are there in 36.0 g of water?

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

- A  $3.010 \times 10^{23}$
- B  $1.204 \times 10^{24}$
- C  $2.408 \times 10^{24}$
- D  $3.612 \times 10^{24}$

(Total for Question 7 = 1 mark)

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



8 Some ionic radii are shown.

Ion	Ionic radius / nm
Na <sup>+</sup>	0.102
K <sup>+</sup>	0.138
F <sup>-</sup>	0.133
Cl <sup>-</sup>	0.180

Which compound has the strongest ionic bonding?

- A sodium fluoride
- B sodium chloride
- C potassium fluoride
- D potassium chloride

(Total for Question 8 = 1 mark)

9 In which pair are the ions isoelectronic?

- A Ca<sup>2+</sup> and S<sup>2-</sup>
- B K<sup>+</sup> and Br<sup>-</sup>
- C Li<sup>+</sup> and F<sup>-</sup>
- D Mg<sup>2+</sup> and Cl<sup>-</sup>

(Total for Question 9 = 1 mark)

10 The bonding **within** an ammonium ion, NH<sub>4</sub><sup>+</sup>, is formed by

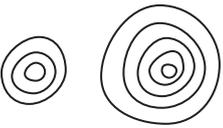
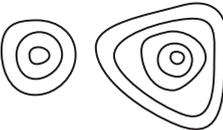
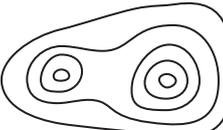
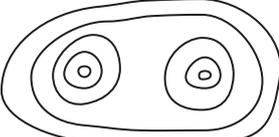
- A covalent bonding only
- B covalent and dative covalent bonding only
- C covalent and ionic bonding only
- D covalent, dative covalent and ionic bonding

(Total for Question 10 = 1 mark)

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11 Which diagram best represents the electron density map of a hydrogen chloride molecule?

- A 
- B 
- C 
- D 

(Total for Question 11 = 1 mark)

12 What is the polarity of the Al—Cl bond and the polarity of a trigonal planar  $\text{AlCl}_3$  molecule?

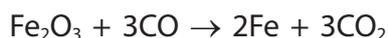
	Polarity of Al—Cl bond	Polarity of $\text{AlCl}_3$ molecule
<input type="checkbox"/> A	non-polar	non-polar
<input type="checkbox"/> B	non-polar	polar
<input type="checkbox"/> C	polar	non-polar
<input type="checkbox"/> D	polar	polar

(Total for Question 12 = 1 mark)

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



13 What is the atom economy, by mass, for the formation of iron in this reaction?



[A<sub>r</sub> values: C = 12.0 O = 16.0 Fe = 55.8]

- A 29.7%
- B 45.8%
- C 55.9%
- D 71.7%

(Total for Question 13 = 1 mark)

14 A 2 kg sample of water contains 40 parts per million (ppm) by mass of nitrate ions.

What is the mass, in g, of nitrate ions in this sample?

- A  $8 \times 10^{-2}$
- B  $5 \times 10^{-5}$
- C  $8 \times 10^{-5}$
- D  $5 \times 10^{-8}$

(Total for Question 14 = 1 mark)

15 A sample of hydrated calcium sulfate,  $\text{CaSO}_4 \cdot x\text{H}_2\text{O}$ , was heated to constant mass. 3.405 g of anhydrous calcium sulfate and 0.900 g of water were formed.

What is the value of  $x$ ?

[Relative formula mass:  $\text{CaSO}_4 = 136.2$ ]

- A 0.5
- B 2
- C 3
- D 4

(Total for Question 15 = 1 mark)

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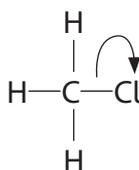
16 During a cracking reaction, each molecule of an alkane with formula  $C_{10}H_{22}$  formed only two molecules of ethene and one molecule of hydrocarbon **A**.

What is the molecular formula of **A**?

- A**  $C_6H_{10}$
- B**  $C_6H_{14}$
- C**  $C_8H_{16}$
- D**  $C_8H_{18}$

(Total for Question 16 = 1 mark)

17 Curly arrows are used in reaction mechanisms.

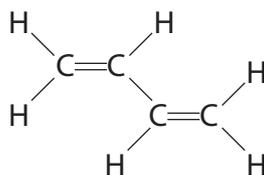


The curly arrow shown represents the movement of

- A** an electron from a bond to an atom, forming free radicals
- B** an electron from a bond to an atom, forming ions
- C** a pair of electrons from a bond to an atom, forming free radicals
- D** a pair of electrons from a bond to an atom, forming ions

(Total for Question 17 = 1 mark)

18 The structure of a diene is shown.



How many  $\sigma$  bonds and  $\pi$  bonds are there in one molecule of this diene?

	$\sigma$ bonds	$\pi$ bonds
<input type="checkbox"/> <b>A</b>	7	2
<input type="checkbox"/> <b>B</b>	7	4
<input type="checkbox"/> <b>C</b>	9	2
<input type="checkbox"/> <b>D</b>	9	4

(Total for Question 18 = 1 mark)



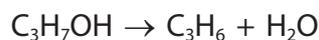
19 When hydrogen bromide, HBr, reacts with propene, a higher percentage of 2-bromopropane forms than 1-bromopropane.

Which is the best explanation for this?

- A 1-bromopropane is more stable than 2-bromopropane
- B 2-bromopropane is more stable than 1-bromopropane
- C a primary carbocation is more stable than a secondary carbocation
- D a secondary carbocation is more stable than a primary carbocation

(Total for Question 19 = 1 mark)

20 Propene, C<sub>3</sub>H<sub>6</sub>, is produced in the dehydration of propanol.



What is the mass, in g, of propene formed from 3.42 g of propanol when the yield is 85.2%?

[Relative molecular masses ( $M_r$ ): C<sub>3</sub>H<sub>7</sub>OH = 60 C<sub>3</sub>H<sub>6</sub> = 42]

- A 2.04
- B 2.39
- C 2.91
- D 4.16

(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.

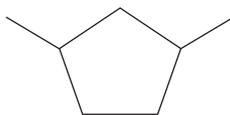
21 This question is about cycloalkanes.

(a) When alkanes from crude oil are reformed, the products include cycloalkanes.

Write the equation for reforming hexane into cyclohexane using **skeletal** formulae for the organic compounds.

(2)

(b) The skeletal formula of cycloalkane **D** is shown.



(i) Give the name of **D**.

(1)

(ii) Give the molecular formula of **D**.

(1)

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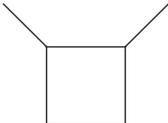
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(c) There are four structural isomers of  $C_6H_{12}$  with a ring of four carbon atoms.

One of these isomers is shown, in the first box.

Complete the **skeletal** formulae of the other three isomers.

(2)

			
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(d) A cycloalkane, **E**, has a molar mass of  $126 \text{ g mol}^{-1}$ .

Deduce the molecular formula of **E**.

(1)

.....



- (e) A sample of gaseous cyclopentane with a volume of  $25 \text{ cm}^3$  was mixed with  $250 \text{ cm}^3$  of oxygen (an excess) and the mixture was ignited. Only gaseous products were formed.



Calculate the volume of each gas remaining after the reaction.  
All the gas volumes were measured at the same temperature and pressure.

(3)



(f) Cyclobutane,  $C_4H_8$ , reacts with chlorine in sunlight.

(i) Name the mechanism and type of reaction that is occurring.

Subs

(2)

(ii) Complete the equation for the initiation step of this reaction mechanism. Include appropriate curly arrows.

(2)



(iii) Write the equations for the **two** propagation steps to form chlorocyclobutane.

Use  $C_4H_8$  as the formula for cyclobutane.

Curly arrows and state symbols are not required.

(2)

(iv) A small amount of a hydrocarbon forms in this reaction.

Deduce the **skeletal** formula of this hydrocarbon. Justify your answer.

(2)

Skeletal formula of product

Justification

(Total for Question 21 = 18 marks)



22 This question is about atomic structure and gases.

(a) Chlorine exists as two isotopes with mass numbers 35 and 37.

(i) State the number and type of each of the particles in the **nucleus** of a chlorine-35 atom.

(2)

(ii) Complete the electronic configuration of a chloride **ion**,  $\text{Cl}^-$ , using the s, p, d notation.

(1)

$1s^2$

(iii) A sample of chlorine contains 75.53 % of chlorine-35 atoms.

Calculate the relative atomic mass of this sample of chlorine.  
Give your answer to **two** decimal places.

(2)



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(b) Fluorine has one naturally occurring isotope with mass number 19.

Chlorine and fluorine react to form chlorine trifluoride,  $\text{ClF}_3$ .

- (i) Draw a dot-and-cross diagram to show the bonding in a molecule of chlorine trifluoride.  
Show the outer shell electrons only.

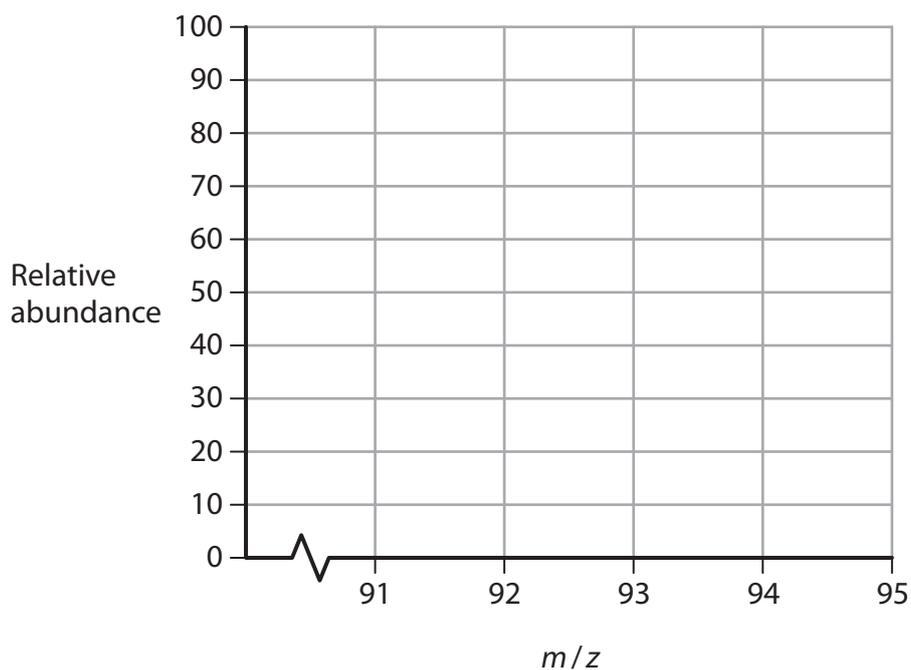
(2)

- (ii) State, in terms of electrons, what is unusual about the dot-and-cross diagram you have drawn.

(1)

- (iii) Complete the mass spectrum to show the peaks you would expect for the molecular ion  $\text{ClF}_3^+$ .

(3)



- (iv) Calculate, using the ideal gas equation, the volume in  $\text{cm}^3$  occupied by 0.0200 mol of  $\text{ClF}_3$  gas at a temperature of  $60^\circ\text{C}$  and a pressure of  $1.28 \times 10^5 \text{ Pa}$ . Give your answer to an appropriate number of significant figures.

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

(4)

(Total for Question 22 = 15 marks)

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**23** This question is mainly about alkenes.

- (a) A few drops of bromine water are added to separate test tubes of propane and propene and the mixtures are shaken.

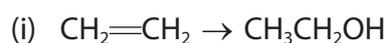
Describe what is seen at the end of each experiment.

(2)

Propane .....

Propene .....

- (b) Give the reagents and conditions for each of these conversions.



(1)

.....

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(1)

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- (c) Draw the structure of Z-3-methylpent-2-ene.

(1)



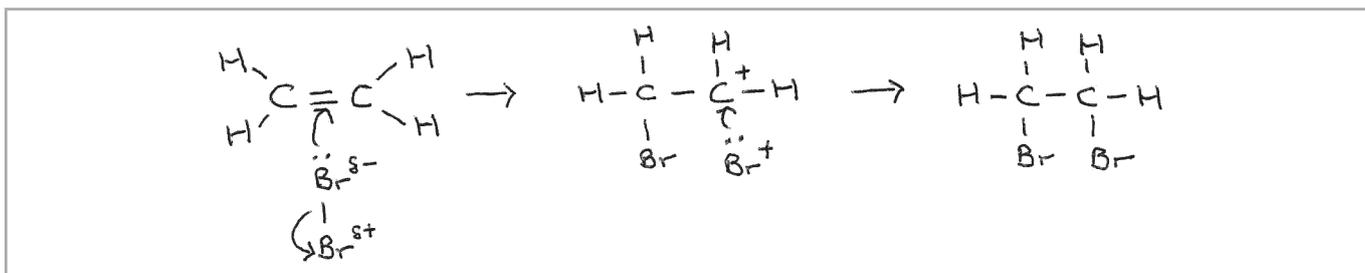
- (d) Exactly  $720 \text{ cm}^3$  of hydrogen gas, measured at room temperature and pressure (r.t.p.), reacted with  $0.010 \text{ mol}$  of an alkene to form an alkane.

Deduce the number of double bonds in one molecule of the alkene.  
You **must** show your working.

[Molar volume of gas at r.t.p. =  $24\,000 \text{ cm}^3 \text{ mol}^{-1}$ ]

(2)

- (e) A student drew a mechanism for the addition of bromine to ethene.



Describe the three changes needed to correct this student's mechanism.

(3)

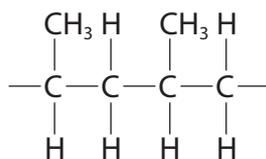
Change 1.....

Change 2.....

Change 3.....



(f) Part of the structure of a polymer is shown.



Draw the structure of the monomer used to make this polymer.

(1)

(Total for Question 23 = 11 marks)

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24 This question is about phosphorus and some of its compounds.

(a) The atomic number of phosphorus is 15.

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

(1)



(ii) Explain why the first ionisation energy of phosphorus is greater than that of sulfur.

(2)

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(b) Phosphorus has a melting temperature of 44°C.

Silicon has a melting temperature of 1410°C.

Explain why the melting temperature of phosphorus is much lower than that of silicon.

(3)

Si : giant lattice structure

break covalent bond

P : simple molecular structure

weak I.M.F

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(c) Phosphorus(V) chloride,  $\text{PCl}_5$ , exists as covalent molecules in the gaseous state.

(i) Complete the table for a  $\text{PCl}_5$  molecule.

(3)

Number of bonding pairs of electrons on phosphorus	
Number of lone pairs of electrons on phosphorus	
Shape of molecule	
Cl—P—Cl bond <b>angles</b>	

(ii) In the solid state, phosphorus(V) chloride is ionic.

The cation and anion each have one phosphorus atom but a different number of chlorine atoms.

The cation is tetrahedral and the anion is octahedral.

Predict the formula of each ion. Include the charge on each ion.

(2)

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(d) In an experiment,  $8.00 \text{ cm}^3$  of  $0.250 \text{ mol dm}^{-3}$  sodium hydroxide, NaOH, reacted completely with  $10.0 \text{ cm}^3$  of  $0.100 \text{ mol dm}^{-3}$  phosphoric acid,  $\text{H}_3\text{PO}_4$ .

Use these data to deduce the balanced equation for this reaction.  
You **must** show your working.

(3)



(e) Hydrated magnesium phosphate has the formula  $\text{Mg}_3(\text{PO}_4)_2 \cdot y\text{H}_2\text{O}$ .

A sample of this compound contains 78.5% by mass of anhydrous magnesium phosphate.

Deduce the value of  $y$ .

You **must** show your working.

[Molar mass of anhydrous magnesium phosphate,  $\text{Mg}_3(\text{PO}_4)_2 = 262.9 \text{ g mol}^{-1}$ ]

(2)

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(Total for Question 24 = 16 marks)

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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

## Key

relative atomic mass  
**atomic symbol**  
name  
atomic (proton) number

(1) (2)

6.9  
**Li**  
lithium  
3

9.0  
**Be**  
beryllium  
4

23.0  
**Na**  
sodium  
11

24.3  
**Mg**  
magnesium  
12

(13)

10.8  
**B**  
boron  
5

12.0  
**C**  
carbon  
6

27.0  
**Al**  
aluminium  
13

28.1  
**Si**  
silicon  
14

(14)

14.0  
**N**  
nitrogen  
7

14.0  
**P**  
phosphorus  
15

31.0  
**S**  
sulfur  
16

32.1  
**Cl**  
chlorine  
17

(15)

16.0  
**O**  
oxygen  
8

16.0  
**Se**  
selenium  
34

17.0  
**Br**  
bromine  
35

(16)

19.0  
**F**  
fluorine  
9

35.5  
**Ar**  
argon  
18

(17)

20.2  
**Ne**  
neon  
10

(12)

65.4  
**Zn**  
zinc  
30

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(11)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(10)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(9)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(8)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(7)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(6)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(5)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(4)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(3)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(2)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

(1)

63.5  
**Cu**  
copper  
29

58.7  
**Ni**  
nickel  
28

58.9  
**Co**  
cobalt  
27

101.1  
**Ru**  
ruthenium  
44

102.9  
**Rh**  
rhodium  
45

106.4  
**Pd**  
palladium  
46

112.4  
**Cd**  
cadmium  
48

107.9  
**Ag**  
silver  
47

114.8  
**In**  
indium  
49

118.7  
**Sn**  
tin  
50

121.8  
**Sb**  
antimony  
51

127.6  
**Te**  
tellurium  
52

200.6  
**Hg**  
mercury  
80

204.4  
**Tl**  
thallium  
81

207.2  
**Pb**  
lead  
82

197.0  
**Au**  
gold  
79

195.1  
**Pt**  
platinum  
78

192.2  
**Ir**  
iridium  
77

186.2  
**Re**  
rhenium  
75

183.8  
**W**  
tungsten  
74

180.9  
**Ta**  
tantalum  
73

178.5  
**Hf**  
hafnium  
72

173.0  
**La\***  
lanthanum  
57

138.9  
**Ac\***  
actinium  
89

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140	141	144	150	152	157	159	163	165	167	169	173	175
<b>Ce</b> cerium 58	<b>Pr</b> praseodymium 59	<b>Nd</b> neodymium 60	<b>Sm</b> samarium 62	<b>Eu</b> europium 63	<b>Gd</b> gadolinium 64	<b>Tb</b> terbium 65	<b>Dy</b> dysprosium 66	<b>Ho</b> holmium 67	<b>Er</b> erbium 68	<b>Tm</b> thulium 69	<b>Yb</b> ytterbium 70	<b>Lu</b> lutetium 71
232	[231]	238	[242]	[243]	[247]	[245]	[251]	[254]	[253]	[256]	[254]	[257]
<b>Th</b> thorium 90	<b>Pa</b> protactinium 91	<b>U</b> uranium 92	<b>Pu</b> plutonium 94	<b>Am</b> americium 95	<b>Cm</b> curium 96	<b>Bk</b> berkelium 97	<b>Cf</b> californium 98	<b>Es</b> einsteinium 99	<b>Fm</b> fermium 100	<b>Md</b> mendelevium 101	<b>No</b> nobelium 102	<b>Lr</b> lawrencium 103

\* Lanthanide series

\* Actinide series

DO NOT WRITE IN THIS AREA

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