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Pearson Edexcel
International
Advanced Level

Centre Number

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Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Thursday 14 January 2016 – 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 ►

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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 Which row in the table shows the number of protons, neutrons and electrons in a fluoride ion, F⁻?

Use the Periodic Table as a source of data.

| | Protons | Neutrons | Electrons |
|----------------------------|---------|----------|-----------|
| <input type="checkbox"/> A | 8 | 9 | 9 |
| <input type="checkbox"/> B | 9 | 9 | 10 |
| <input type="checkbox"/> C | 9 | 10 | 9 |
| <input type="checkbox"/> D | 9 | 10 | 10 |

(Total for Question 1 = 1 mark)

- 2 A sample of oxygen contains the isotopes ¹⁶O, ¹⁷O, ¹⁸O.

How many peaks would there be for the O₂⁺ ions in the mass spectrum of this sample of oxygen?

- A 3
 B 5
 C 6
 D 9

(Total for Question 2 = 1 mark)

- 3 2000 g of a solution contains 0.015 g of solute.

In the solution, the concentration of the solute in parts per million (ppm) is

- A 3.0
 B 7.5
 C 30
 D 75

(Total for Question 3 = 1 mark)

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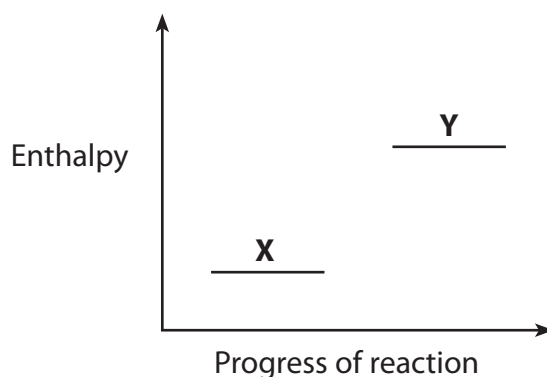


4 What is the concentration, in mol dm^{-3} , of a solution of 10.6 g of sodium carbonate, Na_2CO_3 , in 250 cm^3 of solution?

- A 0.40
 B 0.25
 C 0.10
 D 0.025

(Total for Question 4 = 1 mark)

5 An enthalpy level diagram for a reaction is



Which row in the table shows the correct terms for X and Y and the enthalpy change for this reaction?

| | X | Y | Enthalpy change |
|----------------------------|-----------|-----------|-----------------|
| <input type="checkbox"/> A | products | reactants | endothermic |
| <input type="checkbox"/> B | products | reactants | exothermic |
| <input type="checkbox"/> C | reactants | products | endothermic |
| <input type="checkbox"/> D | reactants | products | exothermic |

(Total for Question 5 = 1 mark)

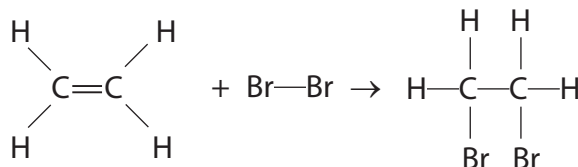
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6 The table shows the mean bond enthalpies for some covalent bonds.

| Covalent bond | C—C | C=C | Br—Br | C—Br | C—H |
|-------------------------------------------|-----|-----|-------|------|-----|
| Mean bond enthalpy / kJ mol ⁻¹ | 347 | 612 | 193 | 290 | 413 |

What is the approximate enthalpy change, in kJ mol⁻¹, for the reaction shown?



- A -225
- B -122
- C +122
- D +225

(Total for Question 6 = 1 mark)

7 The first six ionization energies, in kJ mol⁻¹, of an element are

1086, 2353, 4621, 6223, 37832, 47278

In which group of the Periodic Table is this element?

- A 2
- B 3
- C 4
- D 5

(Total for Question 7 = 1 mark)

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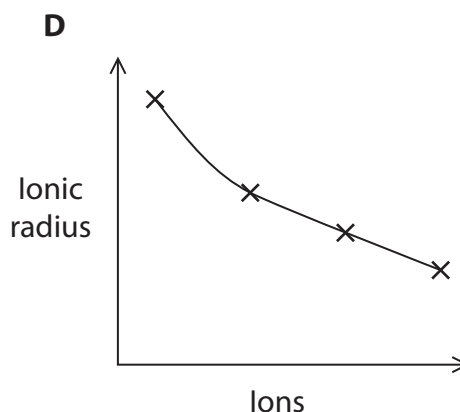
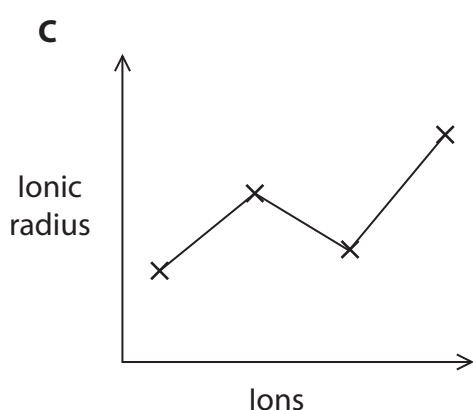
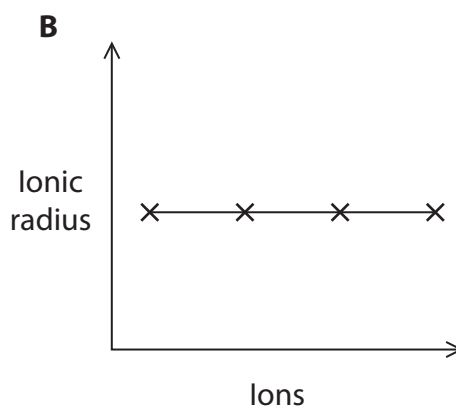
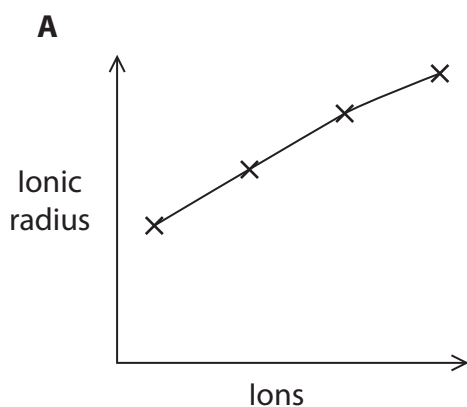
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- 8 Each diagram shows the trend in the ionic radius for four sequences of ions. The diagrams are not to scale.



- (a) Which diagram shows the trend in the ionic radius for the sequence Li^+ , Na^+ , K^+ , Rb^+ ?

(1)

- A
- B
- C
- D

- (b) Which diagram shows the trend in the ionic radius for the sequence Na^+ , Mg^{2+} , Al^{3+} , Si^{4+} ?

(1)

- A
- B
- C
- D

(Total for Question 8 = 2 marks)



9 Some energy changes involved in a Born-Haber cycle are

- A electron affinity
- B lattice energy
- C standard enthalpy change of atomization
- D standard enthalpy change of formation

(a) Which enthalpy or energy change is represented by **p**?



- A
- B
- C
- D

(b) Which enthalpy or energy change is represented by **q**?



- A
- B
- C
- D

(c) Which enthalpy or energy change is represented by **r**?



- A
- B
- C
- D

(Total for Question 9 = 3 marks)

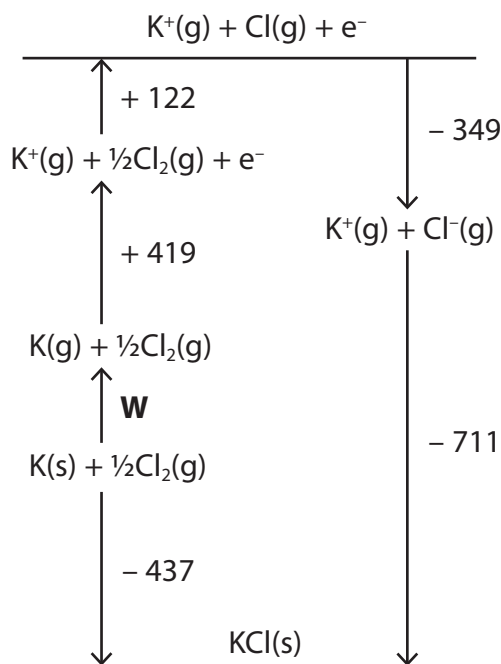
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- 10 The diagram, which is not drawn to scale, shows the Born-Haber cycle for potassium chloride. The energy changes given are in kJ mol^{-1} .



What is the value for **W**, in kJ mol^{-1} ?

- A -956
- B -82
- C +82
- D +956

(Total for Question 10 = 1 mark)

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



- 11 Which row in the table shows the lattice energies, in kJ mol^{-1} , of calcium fluoride, potassium fluoride and potassium iodide?

| | Calcium fluoride | Potassium fluoride | Potassium iodide |
|----------------------------|------------------|--------------------|------------------|
| <input type="checkbox"/> A | -2630 | -817 | -651 |
| <input type="checkbox"/> B | -2630 | -651 | -817 |
| <input type="checkbox"/> C | -651 | -817 | -2630 |
| <input type="checkbox"/> D | -817 | -2630 | -651 |

(Total for Question 11 = 1 mark)

- 12 The experimental value for the lattice energy of beryllium iodide is $-2800 \text{ kJ mol}^{-1}$ and the theoretical value is $-2653 \text{ kJ mol}^{-1}$.

The best explanation for the difference is that the

- A beryllium ion is large and polarizes the iodide ion.
 B beryllium ion is small and polarizes the iodide ion.
 C iodide ion is large and polarizes the beryllium ion.
 D iodide ion is small and polarizes the beryllium ion.

(Total for Question 12 = 1 mark)

- 13 Carbon (diamond) and oxygen both form covalent bonds between their atoms in the element.

What is the **best** reason for the fact that diamond has a much higher melting temperature than oxygen?

- A Diamond is a solid but oxygen is a gas at room temperature.
 B Diamond has a giant atomic structure but oxygen has a simple molecular structure.
 C The covalent bonds between carbon atoms in diamond are stronger than those between oxygen atoms.
 D There is a single covalent bond between carbon atoms in diamond but a double covalent bond between oxygen atoms.

(Total for Question 13 = 1 mark)

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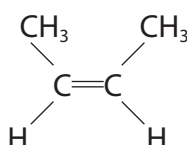


14 The bonding in solid ammonium chloride is

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

(Total for Question 14 = 1 mark)

15 One of the isomers with the formula C_4H_8 is



Possible names for this isomer are

- A *cis*-but-2-ene and *E*-but-2-ene.
- B *cis*-but-2-ene and *Z*-but-2-ene.
- C *trans*-but-2-ene and *E*-but-2-ene.
- D *trans*-but-2-ene and *Z*-but-2-ene.

(Total for Question 15 = 1 mark)

16 An electrophile is a species that

- A can accept a pair of electrons to form a covalent bond.
- B can donate a pair of electrons to form a covalent bond.
- C always has a negative charge.
- D always has a positive charge.

(Total for Question 16 = 1 mark)

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



17 Alkenes react with hydrogen gas in the presence of a nickel catalyst.

0.2 mol of an alkene reacted completely with 19.2 dm³ of hydrogen gas at room temperature and pressure.

How many C=C bonds are there in a molecule of this alkene?

[The molar volume of a gas is 24.0 dm³ mol⁻¹ at room temperature and pressure]

- A 4
- B 3
- C 2
- D 1

(Total for Question 17 = 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.

18 (a) The relative atomic masses of elements can be determined using a mass spectrometer.

(i) Define the term **relative atomic mass**.

(3)

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(ii) Describe fully how positive ions are formed from gaseous atoms in a mass spectrometer.

(2)

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(iii) The following data were obtained from the mass spectrum of a sample of strontium.

| Mass / charge ratio | % abundance |
|---------------------|-------------|
| 84.0 | 0.56 |
| 86.0 | 9.86 |
| 87.0 | 7.02 |
| 88.0 | 82.56 |

Calculate the relative atomic mass of strontium in this sample.

Give your answer to **three** significant figures.

(2)

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(b) In which block of the Periodic Table is strontium found?

(1)



(c) Draw the dot and cross diagram for strontium chloride.

Show **outer** electrons only.

(2)

(d) A solution of strontium nitrate was prepared from strontium oxide and dilute nitric acid.

Write the equation for this reaction, including state symbols.

(2)

(e) A compound of strontium contains 49.9% strontium, 13.7% carbon and 36.4% oxygen, by mass.

Calculate the empirical formula for this compound.

[Use relative atomic masses: Sr = 87.6, C = 12.0, O = 16.0]

(3)

(Total for Question 18 = 15 marks)



19 The first ionization energies for the elements in Period 3 of the Periodic Table are

| Element | Na | Mg | Al | Si | P | S | Cl | Ar |
|------------------------------------------------|-----|-----|-----|-----|------|------|------|------|
| First ionization energy / kJ mol^{-1} | 496 | 738 | 578 | 789 | 1012 | 1000 | 1251 | 1521 |

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

Write the symbols for the sub-shells on the dotted lines.

(2)



1s

- *(ii) The first ionization energies generally increase from left to right across the period.

Explain why the first ionization energy of sulfur is **lower** than that of phosphorus.

(2)

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- (iii) Write an equation, with state symbols, to show the **third** ionization energy of phosphorus.

(2)

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* (b) (i) Explain why the first ionization energy of nitrogen is greater than the first ionization energy of phosphorus.

(3)

(ii) Draw a dot and cross diagram to show the bonding in a molecule of nitrogen.
Show **outer** electrons only.

(2)

(c) Solid white phosphorus exists as P_4 molecules.

Calculate the number of molecules in 24.8 g of white phosphorus.

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

(2)

(Total for Question 19 = 13 marks)

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20 Compound **X** has the molecular formula C_5H_{12} .

(a) Draw the **displayed** formulae of the **three** structural isomers of C_5H_{12} .

(2)

(b) C_5H_{12} reacts with chlorine to form a mixture of products.

(i) Classify the type and mechanism of this reaction.

(2)

(ii) Write the equations for the two propagation steps for this mechanism. Use the molecular formula, C_5H_{12} , in your first equation. Curly arrows are not required.

(2)

(iii) Write the equation for **one** termination step for this mechanism. Curly arrows are not required.

(1)

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- (c) An experiment was carried out to determine the enthalpy change of combustion of compound **X**, C_5H_{12} .

100.0 g of water was heated by burning 0.144 g of compound **X**.

The temperature rise of the water was 14.5°C .

- (i) Calculate the energy transferred, in **kJ**, in this experiment.

Use the equation

$$\text{heat energy produced (J)} = \text{mass of water} \times 4.18 \times \text{temperature change} \quad (1)$$

energy transferred = kJ

- (ii) Calculate the number of moles of compound **X** used in this experiment. (1)

moles of **X** =

- (iii) Calculate the enthalpy change of combustion of compound **X**. Include a sign and units in your answer. (2)

enthalpy change of combustion =

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(iv) The Data Book values for the enthalpy changes of combustion of the three structural isomers with the formula C_5H_{12} are:

$-3509.1 \text{ kJ mol}^{-1}$

$-3503.4 \text{ kJ mol}^{-1}$

$-3492.5 \text{ kJ mol}^{-1}$

The experimental value calculated in (c)(iii) is very different from these values. Give **two** reasons, other than heat loss, for this large difference.

(2)

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(v) Explain why it is **not** possible to deduce which of the isomers is compound **X** by comparing this experimental value and the Data Book values.

(1)

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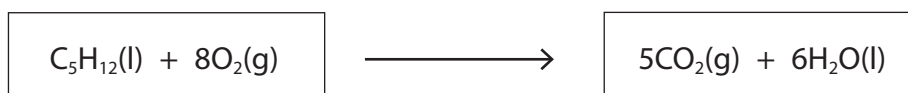


*(d) Complete the Hess cycle and use it to calculate the enthalpy change of combustion of C_5H_{12} from the following data.

Show all of your working.

| | |
|---------------------------------------------------------------|------------------------------|
| Standard enthalpy change of formation of $C_5H_{12}(l)$ | $-173.2 \text{ kJ mol}^{-1}$ |
| Standard enthalpy change of combustion of $H_2(g)$ | $-285.8 \text{ kJ mol}^{-1}$ |
| Standard enthalpy change of combustion of carbon(s, graphite) | $-393.5 \text{ kJ mol}^{-1}$ |

(4)



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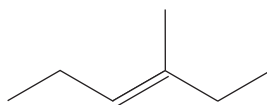
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21 This question is about alkenes.

(a) (i) Give the molecular formula of this alkene.

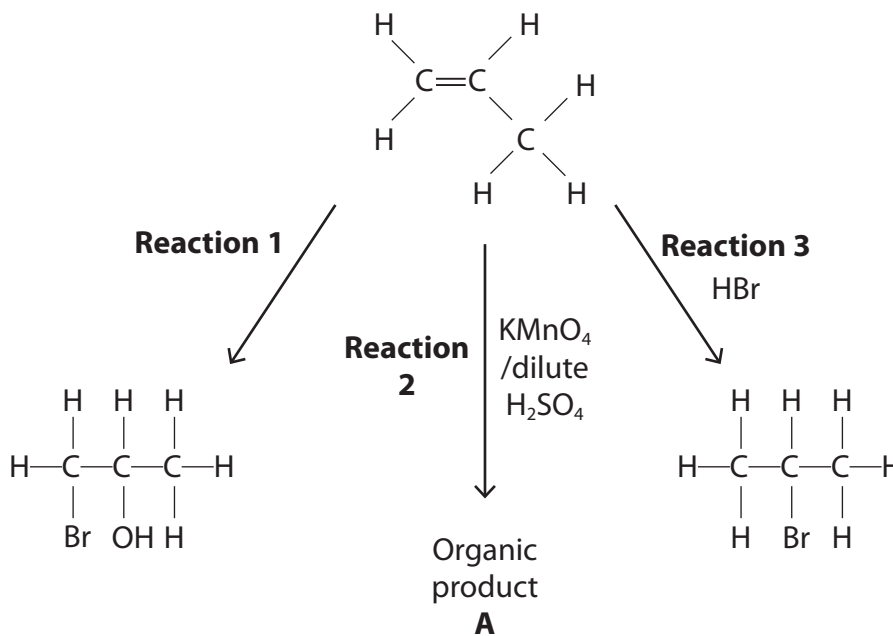
(1)



(ii) Explain why the alkene in (a)(i) exhibits geometric isomerism.

(2)

(b) Propene reacts with three different reagents.



(i) Give the reagent needed for **Reaction 1**.

(1)



(ii) Identify, by name or formula, the organic product **A** formed in **Reaction 2**. (1)

(iii) State the colour change that you would see when **Reaction 2** is carried out. (1)

From to

(iv) Give the mechanism for **Reaction 3**. Use curly arrows and show any relevant dipoles and lone pairs. (4)

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(c) But-2-ene polymerizes to form poly(but-2-ene).

Draw a section of this polymer, showing **two** repeat units.

(1)

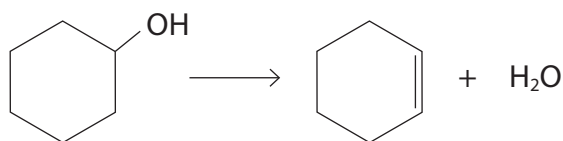
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(d) Cyclohexanol forms cyclohexene in the following reaction.



(i) Calculate the percentage atom economy by mass for the production of cyclohexene.

(1)

(ii) Calculate the percentage yield if 10.20 g of cyclohexanol produced 6.15 g of cyclohexene.

(2)

(Total for Question 21 = 14 marks)

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



The Periodic Table of Elements

| | 1 | 2 | Key | | | | | | | | | | 0 (8) | | | | | | | | | | | | | | | | | | | | |
|---------------------|----------------------|-------|--------------------------|--------------------|------------------------|--------------------------|----------------------------|-----------------------|-----------------------|------------------------|-------------------------|----------------------|------------------------|----------------------|-------------------------|------------------------|-------------------------|---------------------|---------------------------|------------------------|--------------------------|-------------------------------------------------------------------------------------|-----------------------|--------------------|-------------------------|---------------------|-----------------------|-----------------------|----------------------|----------------------|----------------------|-------|---------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | | | | | | | | | | | | | | | |
| | relative atomic mass | | atomic symbol name | | atomic (proton) number | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.9 | Li lithium 3 | 9.0 | Be beryllium 4 | | | | | | | | | | | 4.0 | He helium 2 | | | | | | | | | | | | | | | | | | |
| 23.0 | Na sodium 11 | 24.3 | Mg magnesium 12 | | | | | | | | | | | 20.2 | Ne neon 10 | | | | | | | | | | | | | | | | | | |
| 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 | 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 | 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 | [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 | [245] | Bk berkelium 97 | [251] | Cf californium 98 | [254] | Es einsteinium 99 | [253] | Fm fermium 100 | [256] | Md mendelevium 101 | [255] | No nobelium 102 | [257] | Lr lawrencium 103 | | | | | | | | |

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