

Write your name here

Surname

Other names

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

Centre Number

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Candidate Number

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# Chemistry

**Advanced Subsidiary**

**Unit 1: The Core Principles of Chemistry**

Friday 27 May 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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**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 Cold water fish require a minimum of 8 parts per million by mass (ppm) of oxygen dissolved in water.

The minimum mass of oxygen required in 1 kg of water is

- A  $8 \times 10^{-6}$  g  
 B  $8 \times 10^{-3}$  g  
 C  $8 \times 10^{-2}$  g  
 D  $8 \times 10^{-1}$  g

(Total for Question 1 = 1 mark)

- 2 Calculate the total number of **atoms** in 8.5 g of  $\text{CH}_2\text{Cl}_2$ .

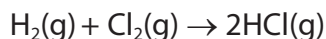
DATA: Molar mass of  $\text{CH}_2\text{Cl}_2 = 85 \text{ g mol}^{-1}$ .

Avogadro constant =  $6.0 \times 10^{23} \text{ mol}^{-1}$

- A  $1.8 \times 10^{23}$   
 B  $2.4 \times 10^{23}$   
 C  $3.0 \times 10^{23}$   
 D  $3.0 \times 10^{24}$

(Total for Question 2 = 1 mark)

- 3  $50 \text{ cm}^3$  of hydrogen is mixed with  $25 \text{ cm}^3$  of chlorine. The gases react as shown in the equation below.



What is the total volume of gas present at the end of the reaction?

[All gas volumes are measured at the same temperature and pressure.]

- A  $75 \text{ cm}^3$   
 B  $100 \text{ cm}^3$   
 C  $125 \text{ cm}^3$   
 D  $150 \text{ cm}^3$

(Total for Question 3 = 1 mark)

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- 4 Sodium hydrogencarbonate decomposes on heating.



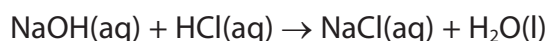
What is the maximum volume of carbon dioxide, in  $\text{dm}^3$ , which could be obtained by heating 0.25 mol sodium hydrogencarbonate?

The gas volume is measured at room temperature and pressure when the molar volume of a gas =  $24 \text{ dm}^3 \text{ mol}^{-1}$ .

- A 3  
 B 6  
 C 12  
 D 24

(Total for Question 4 = 1 mark)

- 5 An experiment was carried out to measure the enthalpy change of the following reaction.



$50 \text{ cm}^3$  of hydrochloric acid was mixed with  $50 \text{ cm}^3$  of sodium hydroxide solution. Each solution contained 0.10 mol solute. The temperature rise was  $12^\circ\text{C}$ .

Energy transferred (J) = mass of solution  $\times$  4.2  $\times$  change in temperature

Assume the density of all solutions is  $1.0 \text{ g cm}^{-3}$ .

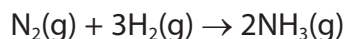
What is the enthalpy change of the reaction in  $\text{kJ mol}^{-1}$ ?

- A  $-\frac{50 \times 4.2 \times 12}{0.1 \times 1000}$   
 B  $-\frac{50 \times 4.2 \times 12}{0.2 \times 1000}$   
 C  $-\frac{100 \times 4.2 \times 12}{0.1 \times 1000}$   
 D  $-\frac{100 \times 4.2 \times 12}{0.05 \times 1000}$

(Total for Question 5 = 1 mark)



- 6 In the synthesis of ammonia, 56.0 g nitrogen was reacted with excess hydrogen.



The mass of ammonia produced was 6.00 g.

What is the percentage yield of ammonia?

- A 5.66  
 B 8.82  
 C 9.10  
 D 10.7

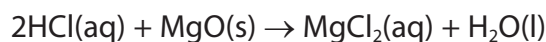
(Total for Question 6 = 1 mark)

- 7 Which of the following has the smallest ionic radius?

- A  $\text{O}^{2-}$   
 B  $\text{F}^-$   
 C  $\text{Na}^+$   
 D  $\text{Mg}^{2+}$

(Total for Question 7 = 1 mark)

- 8 Magnesium chloride crystals were prepared using the following reaction.



(a) The ionic equation for this reaction is

(1)

- A  $2\text{Cl}^-(\text{aq}) + \text{Mg}^{2+}(\text{s}) \rightarrow \text{MgCl}_2(\text{aq})$   
 B  $2\text{Cl}^-(\text{aq}) + \text{MgO}(\text{s}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{O}^{2-}(\text{l})$   
 C  $2\text{H}^+(\text{aq}) + 2\text{Cl}^-(\text{aq}) + \text{MgO}(\text{s}) \rightarrow \text{Mg}^{2+}(\text{Cl}^-)_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$   
 D  $2\text{H}^+(\text{aq}) + \text{MgO}(\text{s}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$

(b) The amount of hydrochloric acid used was 0.10 mol. Which of the following solutions of hydrochloric acid contains this amount of HCl?

(1)

- A 100 cm<sup>3</sup> of 0.10 mol dm<sup>-3</sup>  
 B 40 cm<sup>3</sup> of 0.25 mol dm<sup>-3</sup>  
 C 25 cm<sup>3</sup> of 0.40 mol dm<sup>-3</sup>  
 D 20 cm<sup>3</sup> of 5.00 mol dm<sup>-3</sup>



(c) An **excess** of magnesium oxide was reacted with the 0.10 mol of hydrochloric acid.

Which of the following is the **smallest** mass which would provide an excess of magnesium oxide?

Molar mass of MgO = 40.3 g mol<sup>-1</sup>

(1)

- A 1.50 g
- B 2.50 g
- C 3.00 g
- D 5.00 g

(d) What is the first step in obtaining pure hydrated crystals of magnesium chloride from the resulting reaction mixture?

(1)

- A Heating the mixture to concentrate it.
- B Allowing the mixture to evaporate slowly.
- C Filtering the mixture.
- D Distilling the mixture.

(e) Use the data below to calculate the number of moles of water of crystallization in each mole of hydrated magnesium chloride.

Substance	Molar mass / g mol <sup>-1</sup>
Magnesium chloride	95.1
Hydrated magnesium chloride	203.1

(1)

- A 2
- B 4
- C 6
- D 8

(Total for Question 8 = 5 marks)



9 What is the equation for the lattice energy of magnesium chloride?

- A  $\text{Mg(s)} + \text{Cl}_2(\text{g}) \rightarrow \text{MgCl}_2(\text{s})$
- B  $\text{Mg}^{2+}(\text{s}) + 2\text{Cl}^-(\text{g}) \rightarrow \text{MgCl}_2(\text{s})$
- C  $\text{Mg}^{2+}(\text{g}) + 2\text{Cl}^-(\text{g}) \rightarrow \text{MgCl}_2(\text{s})$
- D  $\text{Mg}^{2+}(\text{g}) + 2\text{Cl}^-(\text{g}) \rightarrow \text{MgCl}_2(\text{g})$

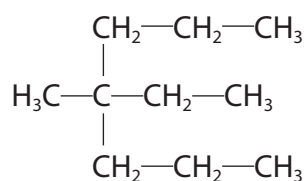
(Total for Question 9 = 1 mark)

10 A compound has the composition by mass of 54.5% C, 9.1% H and 36.4% O.  
What is its empirical formula?

- A  $\text{C}_2\text{H}_2\text{O}$
- B  $\text{C}_2\text{H}_4\text{O}$
- C  $\text{C}_4\text{H}_9\text{O}$
- D  $\text{C}_6\text{HO}_4$

(Total for Question 10 = 1 mark)

11 What is the IUPAC name of the following hydrocarbon?



- A 2,2-dipropylbutane
- B 4-methyl-4-propylhexane
- C 2-ethyl-2-propylpentane
- D 4-ethyl-4-methylheptane

(Total for Question 11 = 1 mark)

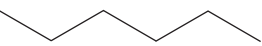
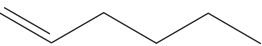
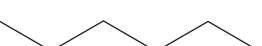


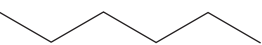


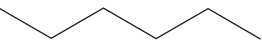
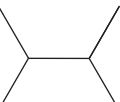
12 Which of the following shows geometric isomerism?

- A propene
- B but-1-ene
- C but-2-ene
- D 2,3-dimethylbut-2-ene

(Total for Question 12 = 1 mark)



13 Which of the following is a reforming reaction?

- A  →  + H<sub>2</sub>
- B  →  +  + H<sub>2</sub>
- C  →  + 
- D  → 

(Total for Question 13 = 1 mark)

14 In the reaction of methane with chlorine, ultraviolet light causes

- A homolytic fission of the Cl—Cl bond in chlorine molecules.
- B heterolytic fission of the Cl—Cl bond in chlorine molecules.
- C homolytic fission of the C—H bond in methane molecules.
- D heterolytic fission of the C—H bond in methane molecules.

(Total for Question 14 = 1 mark)

15 In the mechanism of the reaction of methane with chlorine to form chloromethane, which of the following is a propagation step?

- A  $\cdot\text{CH}_3 + \cdot\text{Cl} \rightarrow \text{CH}_3\text{Cl}$
- B  $\cdot\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \cdot\text{Cl}$
- C  $\text{CH}_4 + \cdot\text{Cl} \rightarrow \text{CH}_3\text{Cl} + \cdot\text{H}$
- D  $\cdot\text{CH}_3 + \text{Cl}_2 \rightarrow \cdot\text{CH}_2\text{Cl} + \text{HCl}$

(Total for Question 15 = 1 mark)

16 The empirical formula of poly(ethene) is

- A CH
- B CH<sub>2</sub>
- C C<sub>2</sub>H<sub>4</sub>
- D C<sub>n</sub>H<sub>2n</sub>

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

17 A mass spectrometer can be used to measure relative isotopic masses.

(a) State the meaning of the term **isotopes**.

(1)

(b) (i) In a mass spectrometer, a sample of the vapour of an element is ionized.  
State how this ionization is carried out.

(1)

(ii) Complete the equation showing the simplest ionization of a vaporised element **M**.

(1)

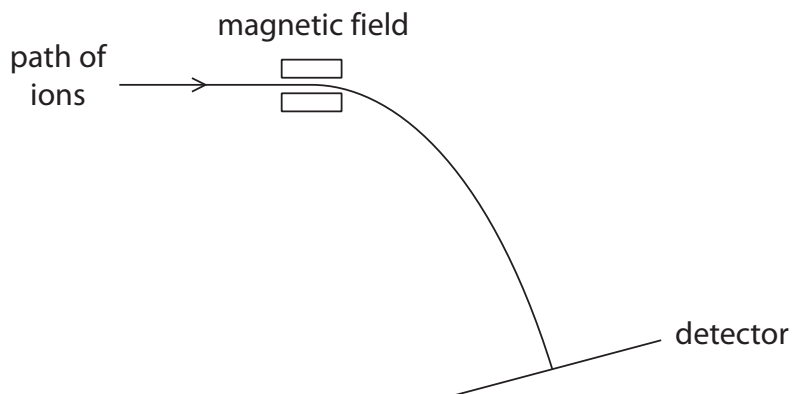


(iii) How are the ions accelerated in the mass spectrometer?

(1)

(iv) Ions with the same charge and travelling with the same velocity are then passed through a magnetic field.

(1)



The path of one ion is shown.

Add a line to the diagram to show the path of a **lighter** ion as it passes through the magnetic field and travels to the detector.

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(c) A sample of silicon is analysed in a mass spectrometer.

Relative isotopic mass	Relative abundance
28	92.17
29	4.71
30	3.12

Calculate the relative atomic mass of silicon, showing your working.  
Give your answer to **four** significant figures.

(2)

(d) A high resolution mass spectrometer measures masses to **four** decimal places.  
The relative molecular mass of a compound is found to be 84.0581.

The relative atomic mass of an oxygen atom,  $^{16}\text{O}$ , is 15.9949

The relative atomic mass of a hydrogen atom,  $^1\text{H}$ , is 1.0079

Use these data to deduce whether the compound is  $\text{C}_6\text{H}_{12}$  or  $\text{C}_5\text{H}_8\text{O}$ . Show your working, and state the assumption you make.

(3)

Assumption

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(e) A helium mass spectrometer is an instrument used to detect leaks in containers.

A sealed container filled with helium is placed in a vacuum chamber. Any helium leaking out of the container is detected by the mass spectrometer.

Suggest **one** reason that makes helium suitable for this purpose, other than its lack of reactivity.

(1)

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**(Total for Question 17 = 11 marks)**



18 This question is about the elements aluminium and magnesium.

(a) Complete the electronic configuration for an **atom** of aluminium.

(1)

1s<sup>2</sup>.....

(b) Complete the table to show the composition of an aluminium ion, Al<sup>3+</sup>.

(1)

Subatomic particle	Number of particles in Al <sup>3+</sup>
proton	
neutron	
electron	

(c) The table below shows the first four ionization energies of aluminium.

(i) Complete the table by identifying the orbital from which each electron is removed.

(2)

	First ionization energy	Second ionization energy	Third ionization energy	Fourth ionization energy
Ionization energy / kJ mol <sup>-1</sup>	578	1817	2745	11 578
Orbital				

(ii) Write the equation, including state symbols, which represents the second ionization energy of aluminium.

(2)



\*(iii) Explain why the second ionization energy of an element is always greater than the first ionization energy.

(2)

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\*(iv) Explain why the difference between the third and fourth ionization energies of aluminium is much larger than the difference between the first and second ionization energies.

(2)

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(d) Aluminium is a silvery metal with a melting temperature of 933 K.

(i) Draw a labelled diagram of the bonding in aluminium.

(2)

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(ii) The atomic number of magnesium is one less than aluminium. Would you expect magnesium to have a higher or lower melting temperature than aluminium? Justify your answer.

(2)

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(iii) Draw the dot and cross diagram for magnesium chloride,  $MgCl_2$ .

Show the outer electrons only.

(2)

\*(iv) Aluminium chloride has more covalent character than magnesium chloride.

Explain what this statement means. By considering the physical properties of these two chlorides, suggest **one** piece of evidence showing that aluminium chloride has more covalent character than magnesium chloride.

(3)

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(Total for Question 18 = 19 marks)

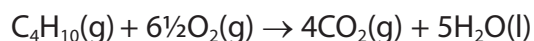
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- 19 Cordless hair-stylers use 2-methylpropane as a fuel. The 2-methylpropane reacts with oxygen on the surface of a heated catalyst.



- (a) Draw the **skeletal** formula of 2-methylpropane.

(1)

- (b) When the hair-styler is switched on, the catalyst is heated using a battery. Suggest why the battery is not needed after the catalyst has been heated initially.

(2)

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- (c) The standard enthalpy changes of formation for the three compounds are:

Compound	Standard enthalpy of formation / $\text{kJ mol}^{-1}$
$\text{C}_4\text{H}_{10}(\text{g})$	-134.5
$\text{CO}_2(\text{g})$	-393.5
$\text{H}_2\text{O}(\text{l})$	-285.8

- (i) The standard enthalpy change of formation of  $\text{H}_2\text{O}(\text{g})$  is  $-241.8 \text{ kJ mol}^{-1}$ . Explain why this is less negative than the standard enthalpy change of formation of  $\text{H}_2\text{O}(\text{l})$ .

(1)

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(ii) Use the data in the table to calculate the standard enthalpy change of combustion of 2-methylpropane in  $\text{kJ mol}^{-1}$ .

Show your method, which may involve the use of a Hess cycle.

Include a sign and units in your answer.

(3)

(iii) A refill canister for the cordless hair-styler holds 15 g of 2-methylpropane.

Calculate the energy in kJ which can be obtained from one canister.

(2)

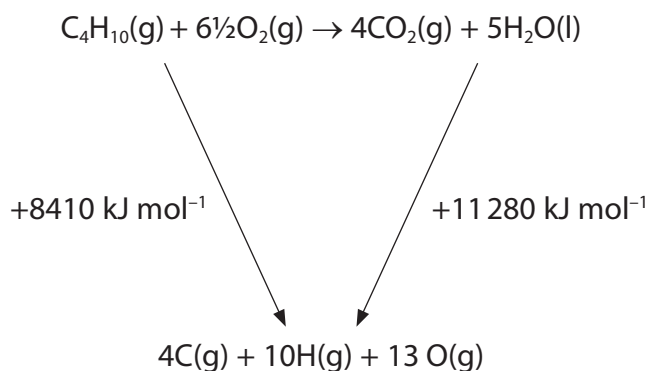
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(d) The enthalpy change of the reaction can also be calculated using the cycle below.



- (i) Calculate the enthalpy change of the reaction using this cycle. (1)
- (ii) The enthalpy change of vaporization of water was one piece of data used to calculate the enthalpy changes shown beside the arrows in the cycle. What other information was needed? (1)

(Total for Question 19 = 11 marks)





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20 Propene is an alkene which can be produced by cracking some of the hydrocarbons in crude oil.

- (a) Draw a dot and cross diagram showing the bonding in propene. Show outer electrons only.

(2)

- (b) (i) Propene is one product of the cracking of decane,  $C_{10}H_{22}$ .

Write the equation for the reaction in which one mole of decane is cracked to produce one mole of ethene, one mole of propene and one other product. State symbols are not required.

(1)

- (ii) A synthetic rubber can be made by polymerizing a mixture of ethene and propene.

Draw the structural formula of the repeat unit of this polymer which forms from one molecule of each alkene.

(2)

- (c) Propene is also used to make propane-1,2-diol. Give the reagents and colour change when this product is made at room temperature.

(3)

Reagents .....

Colour change from ..... to .....



(d) The reaction of propene with bromine **water** is used as a test for the carbon-carbon double bond.

State the colour change in this test.

Draw the displayed formula of the organic product and give its name.

(3)

Colour change from ..... to .....

Displayed formula of product

Name .....

(e) Write the mechanism for the reaction of propene with **hydrogen bromide** to give the major product. Include relevant dipoles.

(4)



\***(f)** Molecules of the element bromine, Br<sub>2</sub>, are not polar. Explain how **bromine** acts as an electrophile when it reacts with propene.

(2)

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**(g)** In the United States of America, large deposits of shale gas have been discovered. This gas is trapped in rocks and can be extracted by “fracking” which involves breaking up the rock with water under pressure.

Shale gas typically contains about 90% methane, mixed with about 3% ethane, 0.6% propane, 0.2% butane and 0.2% pentane. The rest is hydrogen, nitrogen and carbon dioxide.

Suggest how the use of shale gas may affect the relative amounts of poly(ethene) and poly(propene) which are produced in the USA and justify your answer.

(2)

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**(Total for Question 20 = 19 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)																																	
										<table border="1"> <tr> <td>1.0 H hydrogen 1</td> <td colspan="17"></td> </tr> </table>										1.0 H hydrogen 1																												4.0 He helium 2		
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23.0 Na sodium 11	24.3 Mg magnesium 12																32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18																															
										<table border="1"> <tr> <td>39.1 K potassium 19</td> <td>40.1 Ca calcium 20</td> <td>47.9 Ti titanium 22</td> <td>50.9 V vanadium 23</td> <td>52.0 Cr chromium 24</td> <td>54.9 Mn manganese 25</td> <td>55.8 Fe iron 26</td> <td>58.9 Co cobalt 27</td> <td>58.9 Ni nickel 28</td> <td>63.5 Cu copper 29</td> <td>65.4 Zn zinc 30</td> <td>72.6 Ge germanium 32</td> <td>74.9 As arsenic 33</td> <td>79.0 Br bromine 35</td> <td>79.9 Kr krypton 36</td> </tr> </table>										39.1 K potassium 19	40.1 Ca calcium 20	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	58.9 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Br bromine 35	79.9 Kr krypton 36											114.8 Sn tin 50					
39.1 K potassium 19	40.1 Ca calcium 20	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	58.9 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Br bromine 35	79.9 Kr krypton 36																																				
										<table border="1"> <tr> <td>85.5 Rb rubidium 37</td> <td>87.6 Sr strontium 38</td> <td>91.2 Zr zirconium 40</td> <td>92.9 Nb niobium 41</td> <td>95.9 Mo molybdenum 42</td> <td>[98] Tc technetium 43</td> <td>101.1 Ru ruthenium 44</td> <td>102.9 Rh rhodium 45</td> <td>106.4 Pd palladium 46</td> <td>107.9 Ag silver 47</td> <td>112.4 Cd cadmium 48</td> <td>118.7 In indium 49</td> <td>121.8 Sb antimony 51</td> <td>127.6 Te tellurium 52</td> <td>126.9 I iodine 53</td> <td>131.3 Xe xenon 54</td> </tr> </table>										85.5 Rb rubidium 37	87.6 Sr strontium 38	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	118.7 In indium 49	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54											204.4 Pb lead 82				
85.5 Rb rubidium 37	87.6 Sr strontium 38	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	118.7 In indium 49	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54																																			
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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																																			

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