Write your name here

Surname	Other names

Pearson Edexcel
Level 3 GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Paper 2: Core Organic and Physical Chemistry

Specimen paper for first teaching September 2015
Time: 1 hour 30 minutes

Paper Reference
8CH0/02

You must have:
Data Booklet
Scientific calculator, ruler

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.*
- You may use a scientific calculator.
- For questions marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- Show all your working in calculations and include units where appropriate.

Turn over ▶

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S 4 9 1 3 9 A 0 1 2 4

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Answer ALL questions.

Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒.
If you change your mind about an answer, put a line through the box ☒
and then mark your new answer with a cross ☒.

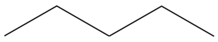
1 The compound 2,2-dimethylpropane can be represented using different types of formula. Its structural formula can be shown as $(CH_3)_4C$.

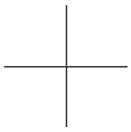
(a) (i) Give the empirical formula of 2,2-dimethylpropane.

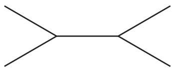
(1)

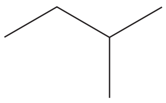
(ii) Which is the skeletal formula of 2,2-dimethylpropane?

(1)

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(b) Which is the correct name for an isomer of 2,2-dimethylpropane?

(1)

☒ **A** 1,2-dimethylpropane

☒ **B** 2,2-diethylmethane

☒ **C** 2-methylbutane

☒ **D** 2-methylbutene

S 4 9 1 3 9 A 0 2 2 4

(c) Give the displayed formulae of the two isomers of 2,2-dimethylpropane.

(2)

(Total for Question 1 = 5 marks)

2 In the manufacture of ammonia, the reaction between methane and steam is used to form the hydrogen needed. The equation for this reaction is

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta_r H = +210\ \text{kJ mol}^{-1}$$

Typical conditions used in this reaction are

- a temperature of 1000 K
- a pressure of 30 atm
- the presence of a catalyst

(a) A chemist recommends lowering the temperature to 800 K to save energy.

Explain two disadvantages of making this change.

(4)

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(b) The manufacturer decides to keep the temperature at 1000 K but to increase the pressure to 50 atm. This change causes only a slight increase in energy usage.

Explain the main disadvantage of making this change in pressure.

(2)

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S 4 9 1 3 9 A 0 4 2 4

(c) Which is the expression for the equilibrium constant for this reaction in the gas phase?

(1)

☒ **A** $K_c = \dfrac{[CO] + [3H_2]}{[CH_4] + [H_2O]}$

☒ **B** $K_c = \dfrac{[CO][3H_2]}{[CH_4][H_2O]}$

☒ **C** $K_c = \dfrac{[CO][H_2]^3}{[CH_4][H_2O]}$

☒ **D** $K_c = \dfrac{[CO] + [H_2]^3}{[CH_4] + [H_2O]}$

(Total for Question 2 = 7 marks)

3 Ethanethiol (CH_3CH_2SH) is a compound with a structure similar to that of ethanol.

Unlike ethanol, it has an unpleasant smell that can be detected in very low concentrations by humans.

For safety reasons it is added to gaseous, odourless fuels such as propane so that fuel leaks can be detected.

When the fuel is burned, the gaseous ethanethiol undergoes complete combustion to form the oxides $CO_2(g)$, $SO_2(g)$ and $H_2O(g)$.

(a) Table 1 shows some mean bond enthalpy data.

Bond	C–C	C–H	C–S	S–H	O=O	C=O	S=O	H–O
Mean bond enthalpy / kJ mol^{-1}	347	413	259	364	498	805	523	464

Table 1

(i) Write the equation for the complete combustion of ethanethiol.

State symbols are not required.

(1)

(ii) Use your equation and data from Table 1 to calculate the enthalpy change for the combustion of ethanethiol.

(3)

S 4 9 1 3 9 A 0 6 2 4

(b) Table 2 shows some enthalpy changes of formation.

Substance	$\Delta_f H$ / kJ mol^{-1}
$CH_3CH_2SH(g)$	–46
$O_2(g)$	0
$CO_2(g)$	–394
$SO_2(g)$	–297
$H_2O(g)$	–242

Table 2

(i) Why is the value for $\Delta_f H$ of $O_2(g)$ zero?

(1)

☒ **A** $O_2(g)$ is an element

☒ **B** $O_2(g)$ is a gas

☒ **C** $O_2(g)$ is a molecule

☒ **D** $O_2(g)$ is a non-metal

(ii) Use Hess's Law, and data from Table 2, to calculate another value for the enthalpy change for the combustion of ethanethiol.

(2)

(c) Give a reason why the values for the enthalpy change of combustion of ethanethiol in (a)(ii) and (b)(ii) are different.

(1)

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(Total for Question 3 = 8 marks)

4 This question is about some hydrocarbons.

(a) A student wrote these statements about cyclobutane (C_4H_8):

The -ane ending of the name means that cyclobutane is an alkane, so its general formula is C_nH_{2n+2}

The molecular formula means that its general formula is C_nH_{2n}, so it is an alkene

Criticise each statement.

(2)

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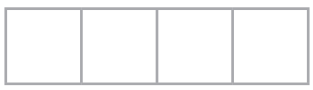
(b) Cyclobutane can be formed by an addition reaction, starting from cyclobutene.

Write the equation for this reaction.

State symbols are not required.

(1)

(c) An unusual type of hydrocarbon, known as a ladderane, can be described as consisting of cyclobutane rings joined together. The skeletal formula of one example of a ladderane is



What is the molecular formula of this ladderane?

(1)

S 4 9 1 3 9 A 0 8 2 4

(d) Which statement correctly describes a radical involved in reactions of alkanes?

(1)

- ☒ **A** an ion with a negative charge
- ☒ **B** an ion with a positive charge
- ☒ **C** a species with an even number of outer electrons
- ☒ **D** a species with an odd number of outer electrons

(e) The equation for a reaction of ethane with bromine is

$$C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$$

(i) Write the sequence of four equations showing the mechanism of this reaction, including the termination step that results in the formation of a halogenoalkane.

(4)

(ii) Which terms are used in a correct description of this reaction mechanism?

(1)

☒ **A** heterolytic fission and addition

☒ **B** heterolytic fission and radical substitution

☒ **C** homolytic fission and addition

☒ **D** homolytic fission and radical substitution

(iii) Explain why C_4H_{10}, but **not** C_3H_8, is also formed in this reaction.

(2)

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(Total for Question 4 = 12 marks)

5 Nichrome is an alloy used to make wires for electrical heating elements.

An investigation is carried out into the resistance to corrosion of two types of nichrome. The table shows their compositions by mass.

Nichrome A		**Nichrome B**	
Metal	**Percentage by mass**	**Metal**	**Percentage by mass**
nickel	80	nickel	72
chromium	20	chromium	18
		copper	10

Nickel and chromium both react with hydrochloric acid to form a salt and hydrogen. Both nichromes contain nickel and chromium in the ratio 4:1 by mass.

In one experiment, a sample of nichrome A was added to hydrochloric acid, and the hydrogen gas formed was collected. Its volume was measured over a period of time.

(a) Which is a correct equation for the reaction between nickel and hydrochloric acid to form nickel(II) chloride?

(1)

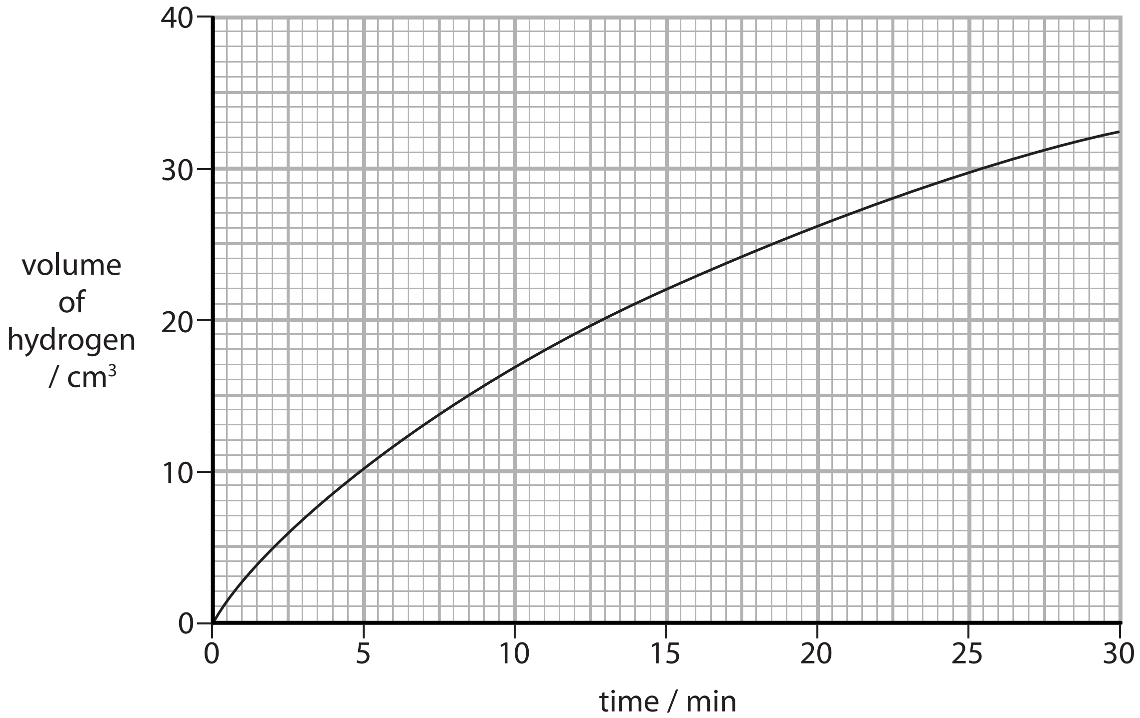
☒ **A** $2Ni(s) + 2HCl(aq) \rightarrow 2NiCl(aq) + H_2(g)$

☒ **B** $2Ni(s) + 2HCl(l) \rightarrow 2NiCl(aq) + H_2(g)$

☒ **C** $Ni(s) + 2HCl(aq) \rightarrow NiCl_2(aq) + H_2(g)$

☒ **D** $Ni(s) + 2HCl(l) \rightarrow NiCl_2(aq) + H_2(g)$

(b) The graph shows the results obtained when nichrome A reacts with hydrochloric acid.



(i) Draw a tangent to the curve on this graph, at t_1 = 6.5 min.

Calculate the rate of reaction at t_1. Include units in your answer.

(3)

(ii) The rate of reaction at t_2 = 24.5 min is lower.

Give reasons why the rates of reaction at t_1 and t_2 differ.

You should assume that the temperature of the reaction mixture does not change during the experiment.

(2)

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S 4 9 1 3 9 A 0 1 2 2 4

*(c) It was suggested that nichrome B has a lower resistance to corrosion because the copper in it might act as a catalyst in the reactions of nickel and chromium with hydrochloric acid.

Devise a method a scientist could use to find out whether copper acts as a catalyst or a reactant in these reactions of nichrome B.

(6)

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(Total for Question 5 = 12 marks)

6 **Y** is an organic compound that contains only carbon, hydrogen and oxygen. **Y** is a volatile liquid at room temperature. Samples of **Y** were analysed by two different experimental methods.

(a) In method 1, a known mass of **Y** was burned and the masses of carbon dioxide and water were measured.

The results of method 1 are shown.

Mass of **Y** = 0.815 g

Mass of carbon dioxide = 2.086 g

Mass of water = 0.851 g

Use this information to calculate the masses of carbon, hydrogen and oxygen in 0.815 g of **Y** and hence determine the empirical formula of **Y**.

(5)

(b) In method 2, a known mass of **Y** was injected into a heated gas syringe and the volume of vapour was measured.

The results of method 2 are shown.

Mass of **Y**	= 0.250 g
Volume of vapour	= 92 cm^3
Temperature of vapour	= 110 °C
Atmospheric pressure	= 1.01×10^5 Pa

Use this information to determine the molar mass of **Y**.

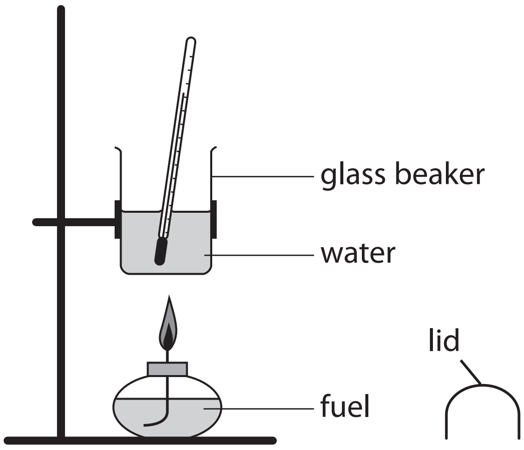
(4)

(c) Use your answers to parts (a) and (b) to suggest a structural formula for **Y**.

(1)

(Total for Question 6 = 10 marks)

7 The diagram shows apparatus that can be used, with appropriate safety precautions, to find the enthalpy change of combustion, $\Delta_c H$, of a liquid fuel.



The fuels used in an investigation are

- two alkanes – pentane and octane
- two alcohols – methanol and ethanol

The lid should be removed from the spirit burner just before igniting the fuel, and replaced after the flame is extinguished.

(a) These are the results of the experiment using pentane.

Mass of water in glass beaker	= 150.0 g
Initial temperature of water	= 18.6 °C
Final temperature of water	= 54.8 °C
Initial mass of burner, lid and pentane	= 152.25 g
Final mass of burner, lid and pentane	= 151.38 g

(i) Calculate the heat energy, in kJ, transferred to the water.

Give your answer to 3 significant figures.

(3)

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(ii) State the reason why using the lid increases the accuracy of this experiment.

(1)

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(b) In the experiment using octane, a black solid formed on the underside of the glass beaker.

Write an equation for the combustion of octane that shows the formation of this black solid.

State symbols are not required.

(2)

(c) In the experiment using methanol, the heat energy transferred to the water was 8960 J, and the mass of methanol burned was 0.717 g.

Calculate the enthalpy change of combustion of methanol, in kJ mol^{-1}, using these data, giving your answer to an appropriate number of significant figures.

(3)

(d) In the experiment involving ethanol, a value of $-747\,kJ\,mol^{-1}$ was calculated for $\Delta_c H$.

Justify how, if at all, using a copper can in place of the glass beaker would affect the calculated value of $\Delta_c H$.

(2)

(e) Data book values for the enthalpy changes of combustion, in $kJ\,mol^{-1}$, of the compounds in the investigation are

pentane	–3509
octane	–5512
methanol	–715
ethanol	–1371

Give two reasons why the combustion of 1 mol of each of the alcohols releases less energy than the combustion of 1 mol of each of the alkanes.

(2)

(Total for Question 7 = 13 marks)

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8 This question is about halogenoalkanes and their reactions.

(a) Which formula represents a tertiary halogenoalkane?

(1)

☒ **A** $CH_3CH_2CH_2CH_2Cl$

☒ **B** $CH_3CH_2CH(CH_3)Cl$

☒ **C** $(CH_3)_3CCl$

☒ **D** $(CH_3)_2CHCH_2Cl$

(b) The table shows some mean bond enthalpy data.

Bond	Mean bond enthalpy / kJ mol^{-1}
C–Cl	346
C–Br	290
C–I	228

A general equation for the reaction of halogenoalkanes with aqueous potassium hydroxide, using **X** to represent a halogen, is

$$CH_3CH_2CH_2\mathbf{X} + OH^- \rightarrow CH_3CH_2CH_2OH + \mathbf{X}^-$$

(i) Use data from the table to explain the trend in reactivity of the primary halogenopropanes in this reaction.

(2)

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(ii) Draw the mechanism for the reaction between $CH_3CH_2CH_2Br$ and aqueous potassium hydroxide. Show relevant dipole and lone pairs of electrons.

(3)

(c) The compound $CH_3CH_2CH_2Br$ was heated under reflux with potassium hydroxide dissolved in a mixture of water and ethanol. There were two organic products, **P** and **Q**, formed in this reaction. **P** and **Q** belong to different homologous series. After separating **P** and **Q**, their spectra were obtained.

(i) The mass spectrum of **P** shows peaks at $m/z = 29$ and at $m/z = 60$.

Use this information to identify **P**. Justify your answer.

(3)

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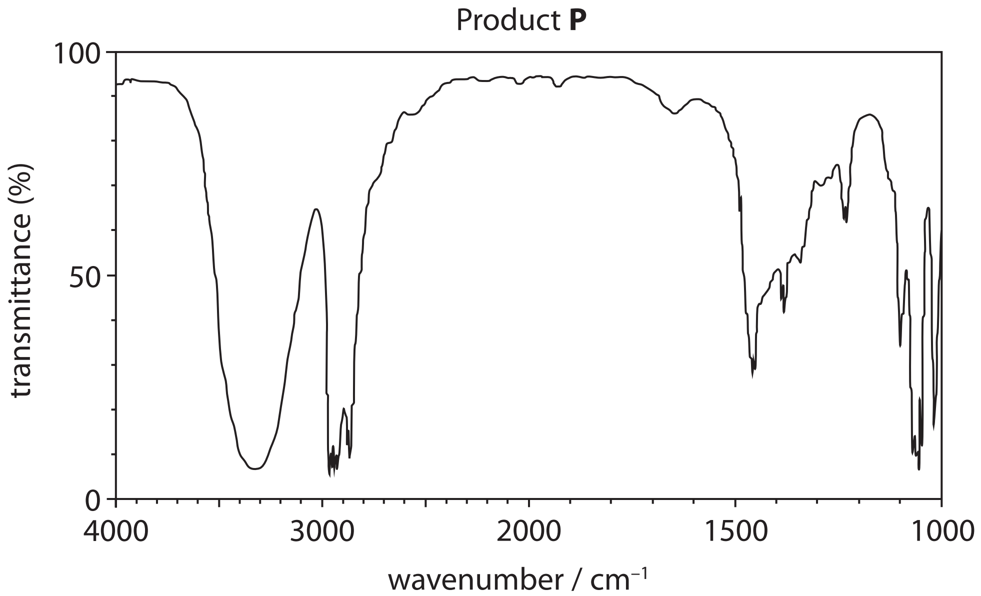
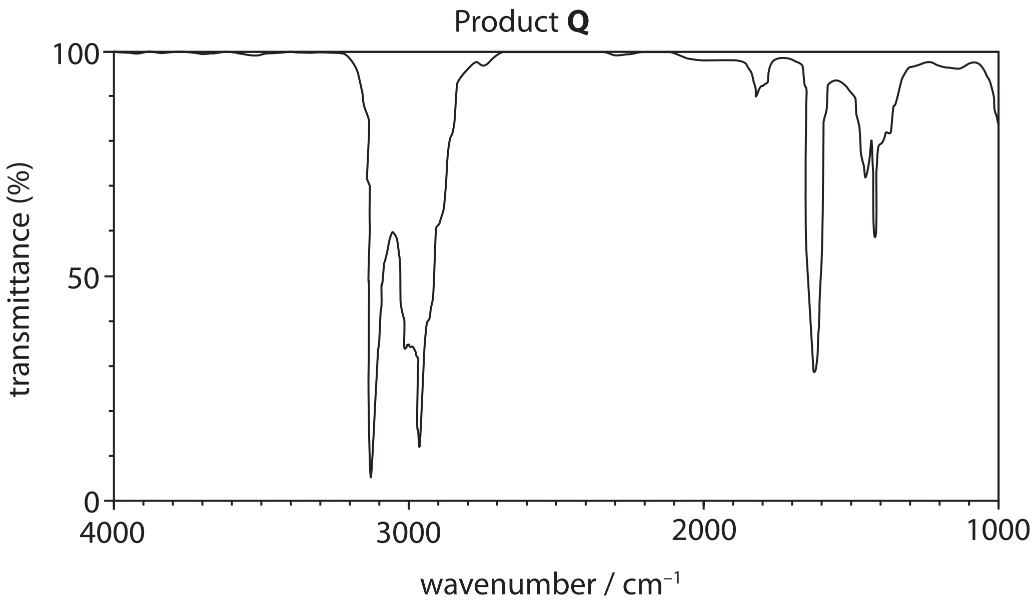
(ii) The infrared spectra of **P** and **Q** are shown.





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Explain how each spectrum shows the homologous series to which each product belongs.

(4)

(Total for Question 8 = 13 marks)

TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0 (8)
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	*(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											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

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