

Please check the examination details below before entering your candidate information

Candidate surname

Other names

Pearson Edexcel
Level 3 GCE

Centre Number

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Candidate Number

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Tuesday 11 June 2019

Afternoon (Time: 1 hour 45 minutes)

Paper Reference **9CH0/02**

Chemistry

Advanced

Paper 2: Advanced Organic and Physical Chemistry

Candidates must have: Scientific calculator
Data Booklet
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 90.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- For the question 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.
- 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

Answer ALL questions.

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

1 This question is about some reactions of alcohols.

(a) (i) Which alcohol **cannot** be oxidised by acidified potassium dichromate(VI)?

(1)

- A hexan-2-ol
- B 2-methylpentan-2-ol
- C hexan-3-ol
- D 2-methylpentan-3-ol

(ii) Which alcohol reacts with iodine in the presence of alkali to form a yellow solid?

(1)

- A hexan-2-ol
- B 2-methylpentan-2-ol
- C hexan-3-ol
- D 2-methylpentan-3-ol

(b) Which reagent is used with iodine to prepare iodoalkanes from alcohols?

(1)

- A red phosphorus
- B concentrated phosphoric acid
- C sulfur
- D concentrated sulfuric acid

(Total for Question 1 = 3 marks)

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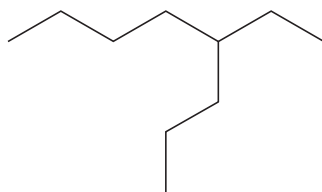
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2 This question is about alkanes and their reactions.

(a) What is the IUPAC name for this alkane?



(1)

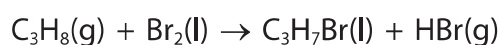
- A 4-ethyloctane
- B 5-ethyloctane
- C 3-propylheptane
- D 5-propylheptane

(b) What is the name of the process that could be used to produce propane, C_3H_8 , from decane, $C_{10}H_{22}$?

(1)

- A substitution
- B reforming
- C fractional distillation
- D cracking

(c) A student researched the reaction of propane with bromine and found that the reaction could be used to make 1-bromopropane.



(i) The first step of the reaction involves

(1)

- A heterolytic bond fission to form free radicals
- B heterolytic bond fission to form ions
- C homolytic bond fission to form free radicals
- D homolytic bond fission to form ions



(ii) Calculate the atom economy by mass for the formation of 1-bromopropane in the reaction in (c).

(2)

(iii) A source from the internet gave the percentage yield for this reaction as 31.0%. The best explanation for the low percentage yield of 1-bromopropane in this reaction is

(1)

- A bromine is very unreactive
- B a gaseous reactant always gives a low yield
- C the reaction is very slow
- D the reaction produces a mixture of organic products

(iv) Calculate the volume of propane, in dm^3 , measured at room temperature and pressure, that is needed to produce 14.7 g of 1-bromopropane, assuming a percentage yield of 31.0%.

Give your answer to an appropriate number of significant figures.

[Molar gas volume at r.t.p. = $24.0 \text{ dm}^3 \text{ mol}^{-1}$]

(3)

(Total for Question 2 = 9 marks)



3 This question is about compounds of Group 5 elements.

(a) Phosphorus forms two chlorides with the formulae PCl_3 and PCl_5 .

(i) Explain the shape of the PCl_3 molecule. The bond angle is not required.

(3)

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(ii) Draw a diagram to show the three-dimensional shape of the PCl_5 molecule in the gas phase.

Include bond angles and the name of the shape.

(3)

(iii) Explain why phosphorus forms PCl_5 but nitrogen does not form NCl_5 .

(2)

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(b) Nitrogen trichloride, NCl_3 , has a boiling temperature of 344 K, and nitrogen trifluoride, NF_3 , has a boiling temperature of 144 K.

Explain this difference in boiling temperatures, by referring to all the intermolecular forces present.

(5)

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(c) Which of these compounds produces hydrogen chloride when it reacts with PCl_5 ?

(1)

- A propanal
- B propan-1-ol
- C propanone
- D propyl propanoate

(Total for Question 3 = 14 marks)

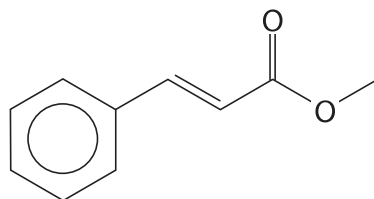


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4 Methyl cinnamate, $C_{10}H_{10}O_2$, is a white crystalline solid used in the perfume industry.



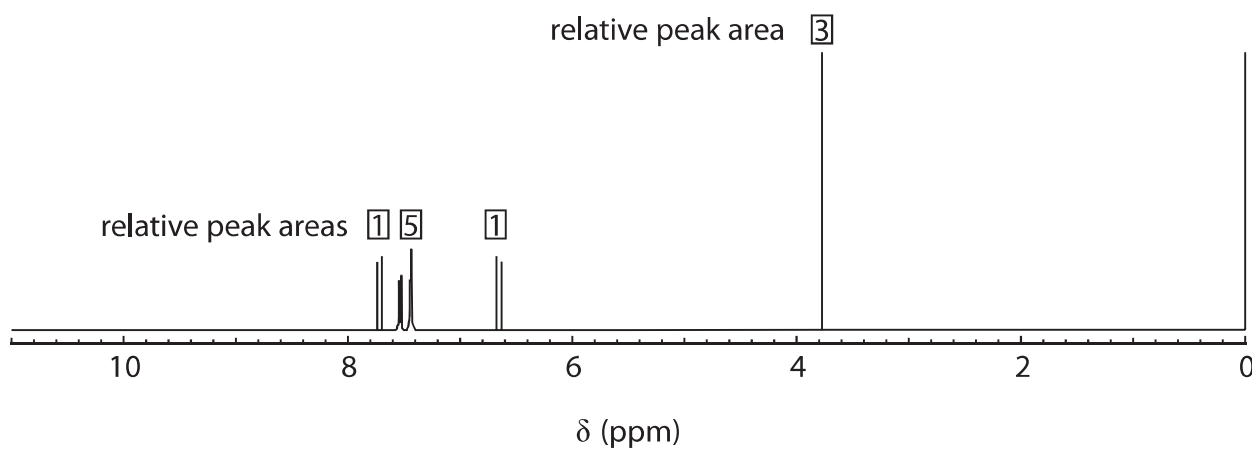
methyl cinnamate

(a) Calculate the mass of carbon in 2.34 g of methyl cinnamate.

(2)

(b) A sample of methyl cinnamate was analysed by high resolution proton NMR spectroscopy.

A simplified spectrum is shown.



(i) Name the compound responsible for the peak at a chemical shift of 0 ppm, stating its purpose.

(2)

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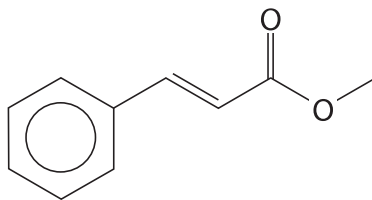
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- (ii) Identify the proton environment that causes the peak at a chemical shift of 3.8 ppm by circling it on the diagram shown. Fully justify your answer.

(3)



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- (c) Methyl cinnamate undergoes an addition reaction in the dark with bromine.

- (i) Draw the mechanism for the reaction between methyl cinnamate and bromine, Br₂.
Include curly arrows, and relevant lone pairs and dipoles.

(4)

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(ii) Deduce the number of optical isomers of the addition product that can exist.

(1)

- A 2
- B 3
- C 4
- D 8

(iii) When plane-polarised light is passed through an optical isomer, the plane of polarisation is

(1)

- A diffracted
- B reflected
- C refracted
- D rotated

(Total for Question 4 = 13 marks)

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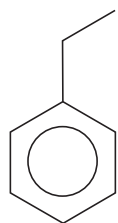
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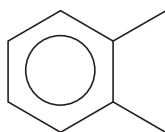
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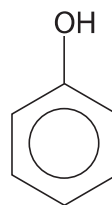
- 5 This question is about the arenes, ethylbenzene, xylene, and phenol, which can be identified in wine samples using gas chromatography.



ethylbenzene



xylene



phenol

- (a) Ethylbenzene can be formed by the reaction of a chloroalkane with benzene, catalysed by aluminium chloride, AlCl_3 .
- (i) Draw the **displayed** formula of the chloroalkane required for this reaction. (1)
- (ii) Draw the mechanism for this reaction. Include equations showing the role of the catalyst and how it is regenerated. (5)



(iii) Explain whether phenol is likely to be less or more reactive than benzene with the chloroalkane from (a)(i).

(3)

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(b) A student carried out an experiment to determine the molar mass of xylene.

The student's sample of xylene vapour had a mass of 0.271 g.

At a temperature of 165 °C and a pressure of 118 kPa, this sample had a volume of 70.5 cm³.

Use the Ideal Gas Equation to calculate the molar mass, in g mol⁻¹, of this sample.

Give your answer to an appropriate number of significant figures.

You **must** show your working.

(4)



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(c) The time taken for a compound to pass through the column in gas chromatography is called the retention time.

Explain why different compounds will have different retention times in the same column, under the same conditions.

(2)

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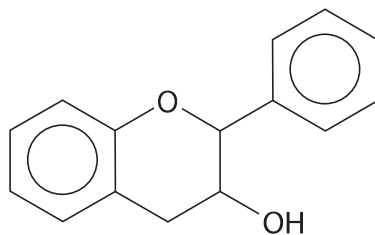
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(Total for Question 5 = 15 marks)



6 The compound flavan-3-ol is found in tea, fruit and wine.



(a) Clearly label all the chiral carbon atoms in flavan-3-ol. (1)

(b) Give the molecular formula for flavan-3-ol. (1)

*(c) A sample of flavan-3-ol extracted from wine contained some ethanol. The sample was left in a flask, open to the air for several days. The contents were then analysed to identify any new compounds formed. Several new compounds were found to be present, including some with a distinctive fruity smell.

Identify **four** new organic compounds that could form under these conditions by considering the chemistry of alcohols. Justify your answers. Include the structure of two compounds formed from flavan-3-ol, one of which has a fruity smell. (6)



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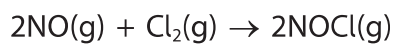
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Handwriting practice area with 20 horizontal dotted lines.

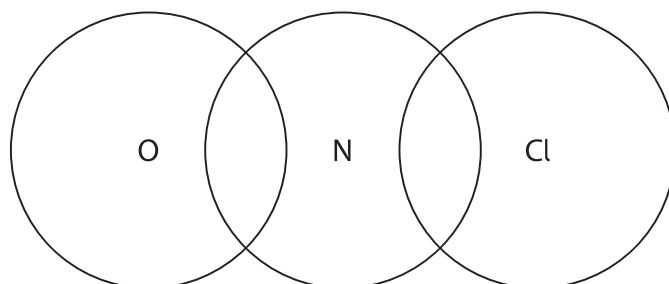
(Total for Question 6 = 8 marks)



7 Nitrogen monoxide and chlorine react together to form nitrosyl chloride.



(a) Draw a dot-and-cross diagram for nitrosyl chloride, showing only the outer shell electrons.



(2)

(b) The rate equation for the formation of nitrosyl chloride is

$$\text{Rate} = k[\text{NO}]^2[\text{Cl}_2]$$

(i) Complete the table by adding the missing values.

Experiment	$[\text{NO}] / \text{mol dm}^{-3}$	$[\text{Cl}_2] / \text{mol dm}^{-3}$	Rate / $\text{mol dm}^{-3} \text{ s}^{-1}$
1	0.122	0.241	1.09×10^{-2}
2		0.482	8.72×10^{-2}
3	0.366		4.91×10^{-2}

(2)



(ii) Calculate the rate constant, k , using data from Experiment 1.
Include units with your answer.

(3)

(iii) Explain how using a catalyst increases the rate constant, k .

(2)

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(iv) The heterogeneous catalyst palladium was suggested for use in this reaction. Explain how impurities in the gaseous reactants could make the catalyst less effective.

(3)

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(Total for Question 7 = 12 marks)

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8 Gentian violet is a purple crystalline solid used as an antifungal treatment.

It can be synthesised from dimethylphenylamine, $C_6H_5N(CH_3)_2$.

(a) The dimethylphenylamine used in the synthesis can be made by the stepwise reaction of phenylamine with chloromethane.



The reaction mechanism for Step 1 between phenylamine and chloromethane is the same as that in the reaction between ammonia and chloromethane.

(i) What is the reaction type and mechanism in Step 1?

(1)

- A electrophilic addition
- B electrophilic substitution
- C nucleophilic addition
- D nucleophilic substitution

(ii) Draw the mechanism for the reaction in Step 1.
Include curly arrows, and relevant lone pairs and dipoles.

(4)



(iii) Describe, in outline, how a sample of a solid, such as gentian violet, is purified by recrystallisation.

Specific details of the solvent used are not required.

(4)

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(b) The rate constant for the reaction between a solution of gentian violet and aqueous sodium hydroxide was determined at different temperatures.

Temperature (T) / K	1 / Temperature ($1/T$) / K^{-1}	Rate constant, k / $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$	$\ln k$
283.5	3.53×10^{-3}	2.71×10^{-3}	-5.91
287.5	3.48×10^{-3}	3.55×10^{-3}	
291.5		4.75×10^{-3}	-5.35
295.0	3.39×10^{-3}	6.10×10^{-3}	-5.10
298.5	3.35×10^{-3}	7.60×10^{-3}	-4.88

(i) Complete the data in the table.

(1)

(ii) Plot a graph and use it to determine the activation energy for the reaction in kJ mol^{-1} .

You should include the value and units of the gradient of the line.

The Arrhenius equation can be shown as

$$\ln k = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant}$$

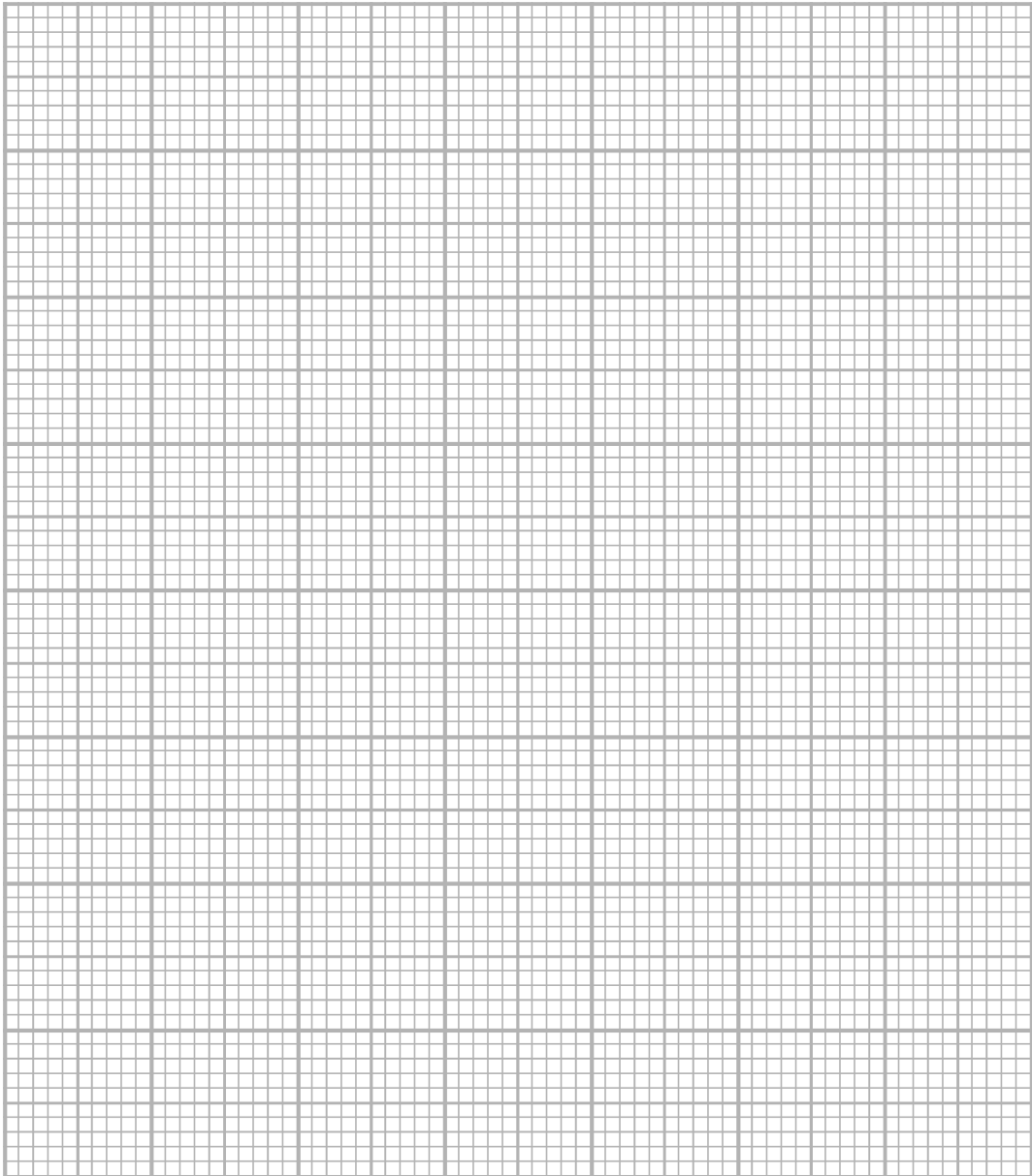
(6)



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Gradient

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Activation energy

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(Total for Question 8 = 16 marks)

TOTAL FOR PAPER = 90 MARKS



The Periodic Table of Elements

	1	2											3	4	5	6	7	0 (8)		
	(1)	(2)											(13)	(14)	(15)	(16)	(17)	(18)		
													Key							
													relative atomic mass							
													atomic symbol							
													name							
													atomic (proton) number							
	6.9	9.0											10.8	12.0	14.0	16.0	19.0	4.0		
	Li	Be											B	C	N	O	F	He		
	lithium	beryllium											boron	carbon	nitrogen	oxygen	fluorine	helium		
	3	4											5	6	7	8	9	2		
	23.0	24.3											27.0	28.1	31.0	32.1	35.5	20.2		
	Na	Mg											Al	Si	P	S	Cl	Ne		
	sodium	magnesium											aluminium	silicon	phosphorus	sulfur	chlorine	neon		
	11	12											13	14	15	16	17	10		
	39.1	40.1											69.7	72.6	74.9	79.0	79.9	83.8		
	K	Ca											Ga	Ge	As	Se	Br	Kr		
	potassium	calcium											gallium	germanium	arsenic	selenium	bromine	krypton		
	19	20											31	32	33	34	35	36		
	85.5	87.6											114.8	118.7	121.8	127.6	126.9	131.3		
	Rb	Sr											In	Sn	Sb	Te	I	Xe		
	rubidium	strontium											indium	tin	antimony	tellurium	iodine	xenon		
	37	38											49	50	51	52	53	54		
	132.9	137.3											204.4	207.2	209.0	[209]	[210]	[222]		
	Cs	Ba											Tl	Pb	Bi	Po	At	Rn		
	caesium	barium											thallium	lead	bismuth	polonium	astatine	radon		
	55	56											81	82	83	84	85	86		
	[223]	[226]											200.6	200.6	209.0	209.0	[210]	[222]		
	Fr	Ra											Hg	Tl	Pb	Bi	Po	At		
	francium	radium											mercury	thallium	lead	bismuth	polonium	astatine		
	87	88											80	81	82	83	84	85		
													197.0	197.0	197.0	197.0	[272]	[272]		
													Au	Au	Au	Au	Rg	Rg		
													gold	gold	gold	gold	roentgenium	roentgenium		
													79	79	79	79	111	111		
													[277]	[277]	[277]	[277]	[271]	[271]		
													Hs	Hs	Hs	Hs	Ds	Ds		
													hassium	hassium	hassium	hassium	darmstadtium	darmstadtium		
													108	108	109	109	110	110		
													[264]	[264]	[264]	[264]	[268]	[268]		
													Bh	Bh	Bh	Bh	Mt	Mt		
													bohrium	bohrium	bohrium	bohrium	meitnerium	meitnerium		
													107	107	107	107	109	109		
													[147]	[147]	[147]	[147]	[152]	[152]		
													Pm	Pm	Pm	Pm	Eu	Eu		
													promethium	promethium	promethium	promethium	europium	europium		
													61	61	63	63	64	65		
													Gd	Gd	Gd	Gd	Gd	Gd		
													gadolinium	gadolinium	gadolinium	gadolinium	gadolinium	gadolinium		
													96	96	95	95	96	96		
													[242]	[242]	[242]	[242]	[247]	[247]		
													Pu	Pu	Pu	Pu	Am	Am		
													plutonium	plutonium	plutonium	plutonium	americium	americium		
													94	94	95	95	96	96		
													[237]	[237]	[237]	[237]	[243]	[243]		
													Np	Np	Np	Np	Am	Am		
													neptunium	neptunium	neptunium	neptunium	americium	americium		
													93	93	94	95	96	96		
													[231]	[231]	[231]	[231]	[243]	[243]		
													Pa	Pa	Pa	Pa	U	U		
													protactinium	protactinium	protactinium	protactinium	uranium	uranium		
													91	91	92	92	92	92		
													140	141	144	144	150	150		
													Ce	Pr	Nd	Nd	Sm	Sm		
													cerium	praseodymium	neodymium	neodymium	samarium	samarium		
													58	59	60	61	62	62		
													[232]	[231]	[238]	[237]	[242]	[242]		
													Th	Pa	U	Np	Pu	Pu		
													thorium	protactinium	uranium	neptunium	plutonium	plutonium		
													90	91	92	93	94	94		
													163	165	167	169	173	175		
													Dy	Ho	Er	Tm	Yb	Lu		
													dysprosium	holmium	erbium	thulium	ytterbium	lutetium		
													66	67	68	69	70	71		
													[251]	[254]	[253]	[256]	[254]	[257]		
													Cf	Es	Fm	Md	No	Lr		
													californium	einsteinium	fermium	mendeleevium	nobelium	lawrencium		
													98	99	100	101	102	103		

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

* Lanthanide series

* Actinide series

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