Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | Candidate Number

Thursday 23 May 2019

Morning (Time: 1 hour 30 minutes) | Paper Reference **WCH12/01**

Chemistry

International Advanced Subsidiary / Advanced Level

Unit 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols

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 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.*
- In the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how 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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1/1/1/1/1/1/1/1/1/

P 6 1 4 7 5 A 0 1 2 8

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 Calcium carbonate reacts with hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

Which factor does **not** affect the rate of this reaction?

☒ **A** concentration

☒ **B** pressure

☒ **C** surface area

☒ **D** temperature

(Total for Question 1 = 1 mark)

2 The rate of a reaction doubles for each 10 K increase in temperature.
If the temperature of this reaction is increased from 298 K to 358 K the rate of the reaction increases by a factor of

☒ **A** 6

☒ **B** 12

☒ **C** 36

☒ **D** 64

(Total for Question 2 = 1 mark)

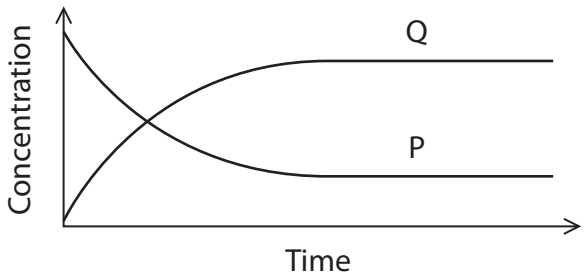
Use this space for any rough working. Anything you write in this space will gain no credit.

3 A large amount of P is added to a small amount of Q. A reversible reaction occurs in which P reacts to form Q.

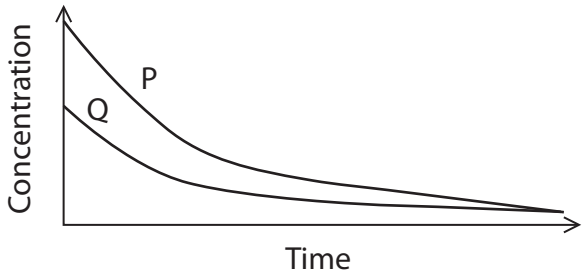
$$P \rightleftharpoons Q$$

Which graph shows how the concentrations of P and Q change as the reaction reaches equilibrium?

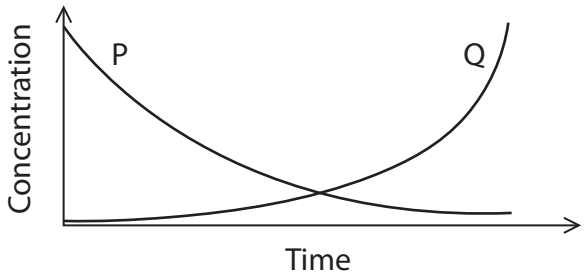
☒ **A**



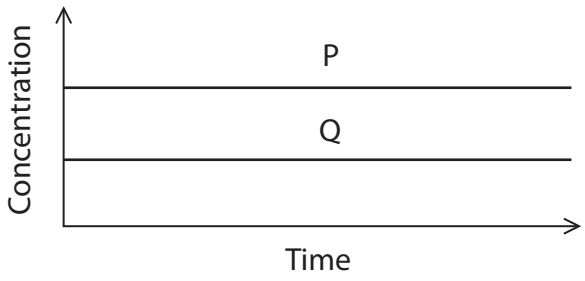
☒ **B**



☒ **C**



☒ **D**



(Total for Question 3 = 1 mark)

4 Which equilibrium shifts to the right-hand side when the pressure in the system **decreases** at constant temperature?

☒ **A** $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

☒ **B** $F_2(g) + H_2(g) \rightleftharpoons 2HF(g)$

☒ **C** $C_6H_6(g) + 3H_2(g) \rightleftharpoons C_6H_{12}(g)$

☒ **D** $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$

(Total for Question 4 = 1 mark)

5 Potassium chloride reacts with concentrated sulfuric acid, producing misty fumes. It can be deduced that

☒ **A** sulfuric acid is acting as an oxidising agent

☒ **B** chloride ions are acting as an oxidising agent

☒ **C** hydrogen chloride is formed in the reaction

☒ **D** chlorine is formed in the reaction

(Total for Question 5 = 1 mark)

6 The oxidation number of sulfur in the sulfate ion, SO_4^{2-}, is

☒ **A** −2

☒ **B** +4

☒ **C** +6

☒ **D** +8

(Total for Question 6 = 1 mark)

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

7 Which of these is a disproportionation reaction?

☒ **A** $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

☒ **B** $6NaOH + 3Br_2 \rightarrow 5NaBr + NaBrO_3 + 3H_2O$

☒ **C** $2NaOH + 2Al + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$

☒ **D** $NaOH + CO_2 \rightarrow NaHCO_3$

(Total for Question 7 = 1 mark)

8 Which of these sulfates is the **least** soluble in water?

☒ **A** $CaSO_4$

☒ **B** $BaSO_4$

☒ **C** K_2SO_4

☒ **D** Rb_2SO_4

(Total for Question 8 = 1 mark)

9 Use the data shown.

$CH_4(g) + 2F_2(g) \rightarrow CF_4(g) + 2H_2(g)$ $\quad \Delta H^{\ominus} = -858\,kJ\,mol^{-1}$

$C(s) + 2F_2(g) \rightarrow CF_4(g)$ $\quad \Delta H^{\ominus} = -933\,kJ\,mol^{-1}$

What is the standard enthalpy change of formation of methane (CH_4) in $kJ\,mol^{-1}$?

☒ **A** −1791

☒ **B** −75

☒ **C** +75

☒ **D** +1791

(Total for Question 9 = 1 mark)

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

10 Chlorine reacts with ethane to form chloroethane and hydrogen chloride.

$$Cl_2 + C_2H_6 \rightarrow C_2H_5Cl + HCl$$

Bond	Bond enthalpy / kJ mol^{-1}
C—Cl	346
C—H	413
Cl—Cl	243
H—Cl	432
C—C	347

What is the enthalpy change for the reaction, in kJ mol^{-1}?

☒ **A** −1434

☒ **B** −122

☒ **C** +122

☒ **D** +1434

(Total for Question 10 = 1 mark)

11 Which equation represents the standard enthalpy change of atomisation of bromine?

☒ **A** $Br_2(g) \rightarrow 2Br(g)$

☒ **B** $Br_2(l) \rightarrow 2Br(g)$

☒ **C** $\frac{1}{2}Br_2(l) \rightarrow Br(g)$

☒ **D** $\frac{1}{2}Br_2(g) \rightarrow Br(g)$

(Total for Question 11 = 1 mark)

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

12 In an experiment, 50.0 cm^3 of 1.0 mol dm^{-3} HCl(aq) reacts with 50.0 cm^3 of 1.0 mol dm^{-3} NaOH(aq).

The energy released = 2500 J.

The specific heat capacity of the mixture is 4.18 J g^{-1} $°C^{-1}$

What temperature change occurs in the reaction?

☒ **A** an increase of 6.0°C

☒ **B** a decrease of 6.0°C

☒ **C** an increase of 12.0°C

☒ **D** a decrease of 12.0°C

(Total for Question 12 = 1 mark)

13 Which of these species is **not** a nucleophile?

☒ **A** NH_4^+

☒ **B** CN^-

☒ **C** H_2O

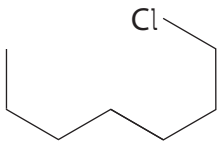
☒ **D** CH_3NH_2

(Total for Question 13 = 1 mark)

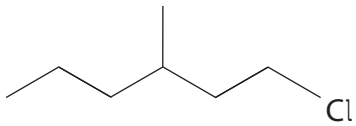
Use this space for any rough working. Anything you write in this space will gain no credit.

14 Which of these isomers has the **highest** boiling temperature?

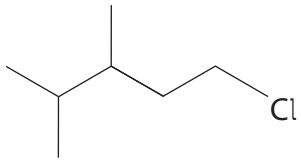
☒ **A**



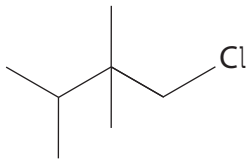
☒ **B**



☒ **C**



☒ **D**



(Total for Question 14 = 1 mark)

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

15 A white solid, **X**, gives a red colour in the flame test and a cream precipitate forms when acidified silver nitrate solution is added to a solution of **X**.

(a) What is the white solid, **X**?

(1)

☒ **A** lithium chloride

☒ **B** calcium chloride

☒ **C** strontium bromide

☒ **D** barium bromide

(b) What causes the flame colour to be red?

(1)

☒ **A** electrons absorb blue and green light as they are promoted

☒ **B** electrons emit red light as they are promoted

☒ **C** blue and green light is absorbed as electrons return to lower energy levels

☒ **D** red light is emitted as electrons return to lower energy levels

(Total for Question 15 = 2 marks)

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

16 This question is about hydrogen bonding.

(a) Which property is **not** due to hydrogen bonding?

(1)

☒ **A** ice has a lower density than water at 0°C

☒ **B** hydrogen fluoride has a higher boiling temperature than hydrogen chloride

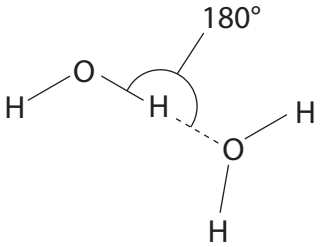
☒ **C** H—H bond enthalpy is greater than Si—H bond enthalpy

☒ **D** alcohols are less volatile than alkanes with a similar molar mass

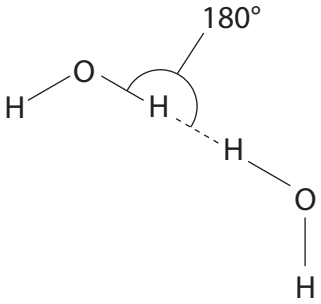
(b) Which diagram best represents a hydrogen bond between two water molecules?

(1)

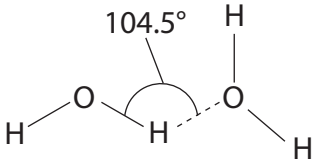
☒ **A**



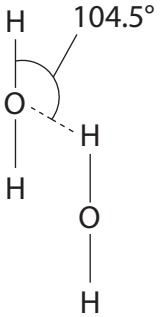
☒ **B**



☒ **C**

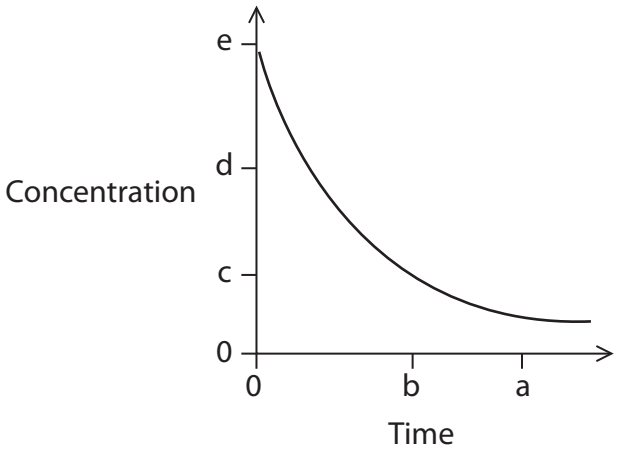


☒ **D**



(Total for Question 16 = 2 marks)

17 The graph shows how the concentration of a reactant changes with time.



Which expression gives the best estimate for the value of the rate of this reaction at time b?

☒ **A** b ÷ c

☒ **B** d ÷ a

☒ **C** e ÷ a

☒ **D** e ÷ b

(Total for Question 17 = 1 mark)

18 Which of these carboxylic acids would be expected to have a major peak at $m/z = 57$ in its mass spectrum?

☒ **A** $CH_3CH_2CH_2COOH$

☒ **B** CH_3COOH

☒ **C** $(CH_3)_2CHCOOH$

☒ **D** CH_3CH_2COOH

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions.

Write your answers in the spaces provided.

19 Iodine can be extracted from seaweed. The seaweed is heated strongly to burn off the organic matter. The resultant ash is boiled in water to dissolve the iodide ions, and the mixture is filtered.

(a) Acidified hydrogen peroxide (H_2O_2) is added to the filtrate.
A redox reaction takes place with iodine and water as the only products.

(i) Write half-equations for the oxidation and reduction reactions that take place.
State symbols are not required.

(2)

(ii) Use your answers to (a)(i) to write the overall equation for this redox reaction.
State symbols are not required.

(1)

(b) The iodine is separated from the aqueous solution using solvent extraction. The aqueous solution is mixed with cyclohexane in a separating funnel, forming two layers.

The mixture is then shaken gently and left until the layers separate.

Most of the iodine dissolves in the cyclohexane layer.

(i) State the colour of each layer **after** separation.

(2)

Aqueous layer .....

Cyclohexane layer .....

(ii) Explain why iodine is very soluble in cyclohexane but only slightly soluble in water.

(2)

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(c) The cyclohexane layer is then removed from the separating funnel and dried.

Identify, by name or formula, a suitable drying agent.

(1)

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(Total for Question 19 = 8 marks)

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20 This question is about compounds containing Group 2 elements.

(a) Hydrated magnesium nitrate has the formula $Mg(NO_3)_2.xH_2O$.
A student devised an experiment to determine the value of **x** by leaving 5.12 g of hydrated magnesium nitrate for several hours in a warm oven. After this time, the solid remaining had a mass of 2.97 g.

(i) State why the student used a warm oven to remove the water from the hydrated salt, rather than direct heating with a Bunsen burner.

(1)

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.....

(ii) Use the data obtained by the student to calculate the value of **x**.

You **must** show your working.

(4)

(b) Magnesium carbonate, $MgCO_3$, is a white solid used as an additive in foods.

(i) Explain, in terms of energy changes, why magnesium carbonate is insoluble in water.

(2)

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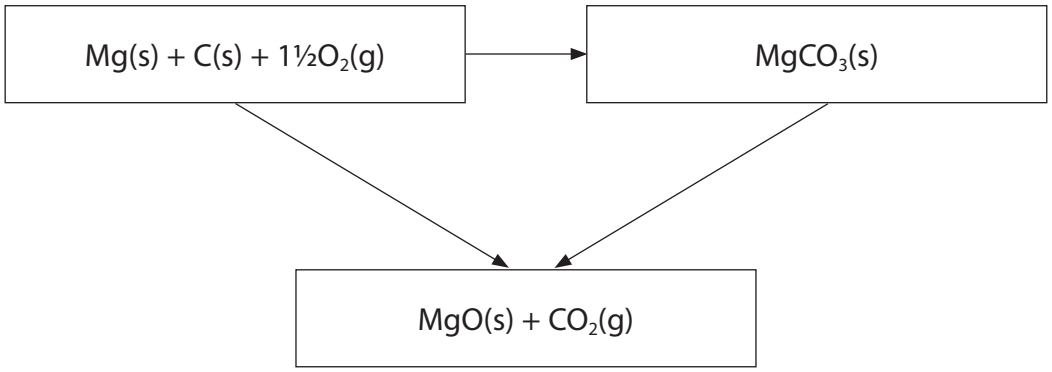
(ii) The Hess cycle and data to calculate the enthalpy change for the thermal decomposition of $MgCO_3$ are shown.



Compound	$\Delta_f H^{\ominus}$ / kJ mol^{-1}
$CO_2(g)$	−394
MgO(s)	−602
$MgCO_3(s)$	−1096

Calculate the enthalpy change for the thermal decomposition of $MgCO_3$.

(2)

(iii) Explain the trend in thermal stability of Group 2 carbonates.

(4)

(Total for Question 20 = 13 marks)

21 The halogenoalkane 1-chlorobutane reacts under suitable conditions with potassium hydroxide to form the alcohol butan-1-ol.

(a) (i) Name a suitable solvent for the potassium hydroxide in this reaction.

(1)

.....

(ii) State the type and mechanism of this reaction.

(1)

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(iii) Draw the mechanism for this reaction.

Use curly arrows, and show relevant dipoles and lone pairs.

(3)

(b) A student carried out the reaction.
After separation and purification, the mass of butan-1-ol formed was 12.1 g.

The yield of the reaction was 64.0 %.

Calculate the volume of 1-chlorobutane used in the reaction.

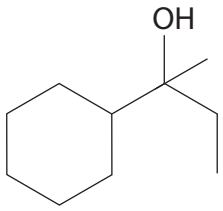
Give your answer to an appropriate number of significant figures.

[Density of 1-chlorobutane = 0.886 g cm^{-3}]

(4)

(Total for Question 21 = 9 marks)

22 An alcohol **Y** has the structure shown.



(a) Describe a **chemical** test and its positive result for the alcohol functional group in **Y**.

(2)

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(b) **Y** reacts with concentrated phosphoric(V) acid, H_3PO_4, to form four isomers with the molecular formula $C_{10}H_{18}$.

(i) Draw the skeletal formulae of the **four** isomers formed in this reaction.

(4)

(ii) Describe, by referring to wavenumbers and bonds, how the infrared spectra of the isomers differ from the infrared spectrum of alcohol **Y**.

(2)

(c) An isomer of **Y**, citronellol, has the systematic name 3,7-dimethyloct-6-en-1-ol.

Draw the structure of citronellol.

(2)

(Total for Question 22 = 10 marks)

TOTAL FOR SECTION B = 40 MARKS

SECTION C

Answer ALL the questions.

Write your answers in the spaces provided.

23 Propanoic acid, CH_3CH_2COOH, is a colourless liquid used as a preservative in animal feed. Propanoic acid can be formed by oxidising the alcohol propan-1-ol.

(a) Write the balanced equation for the oxidation of propan-1-ol to form propanoic acid. Use [O] to represent the oxygen from the oxidising agent. State symbols are not required.

(1)

*(b) Propan-1-ol is heated with a concentrated solution of acidified potassium dichromate(VI).

Explain how the conditions used affect the rate of the reaction **and** ensure that propanoic acid is the only organic product.

(6)

(c) A student suggested using universal indicator to check for the presence of propanoic acid formed in the reaction mixture.

Give a reason why the result of this test is **not** likely to be conclusive.

(1)

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(d) The permitted mass of propanoic acid used in animal feed is in the range 1000–3000 mg kg^{-1}. A titration method may be used to check the concentration of propanoic acid in animal feed.

A 50.0 cm^3 sample of propanoic acid solution was extracted from 50 g of an animal feed.
The sample was added to a volumetric flask and the volume made up to 250.0 cm^3 and mixed thoroughly. A pipette was used to transfer 25.0 cm^3 of the diluted acid into a conical flask containing an indicator.

The contents of the conical flask were titrated with a solution of sodium hydroxide, NaOH(aq), with concentration 0.00668 mol dm^{-3}.

The procedure was repeated twice and the results obtained are shown.

	Run 1	Run 2	Run 3
Titre / cm^3	23.20	22.10	22.20

(i) Phenolphthalein is a suitable indicator for this titration.

State the colour **change** at the end-point.

(2)

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(ii) Suggest **two** possible reasons why the titre for Run 1 is greater than the other two titres.

(2)

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(iii) The equation for the reaction of propanoic acid with sodium hydroxide is

$$CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$$

Calculate the mass in grams of propanoic acid extracted from the animal feed.

Give your answer to an appropriate number of significant figures.

(5)

(iv) Use your answer to (d)(iii) to determine whether the acid in this sample lies within the permitted range for use in animal feed.

(2)

(v) Suggest how the animal feed would be affected if the amount of propanoic acid was outside the permitted range.

(1)

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(Total for Question 23 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									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	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(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

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

* Lanthanide series

* Actinide series