Write your name here

Surname	Other names

Pearson
Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Tuesday 2 June 2015 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

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 ▶

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 The bond angle in beryllium chloride, $BeCl_2$, is most likely to be

☒ **A** 90°

☒ **B** 104.5°

☒ **C** 120°

☒ **D** 180°

(Total for Question 1 = 1 mark)

2 Graphite and buckminsterfullerene are forms of carbon. Buckminsterfullerene dissolves in octane but graphite does not. This is because

☒ **A** the bonds between carbon atoms in buckminsterfullerene are weaker than those in graphite.

☒ **B** buckminsterfullerene is molecular whereas graphite is a giant structure.

☒ **C** graphite has delocalised electrons but buckminsterfullerene does not.

☒ **D** graphite has covalent bonds and London forces but buckminsterfullerene has just London forces.

(Total for Question 2 = 1 mark)

3 Which of the following molecules is polar?

☒ **A** Carbon dioxide, CO_2

☒ **B** Silicon tetrachloride, $SiCl_4$

☒ **C** Ammonia, NH_3

☒ **D** Boron trifluoride, BF_3

(Total for Question 3 = 1 mark)

4 In which series of compounds does covalent character **increase** when going from left to right?

☒ **A** KI, KBr, KCl

☒ **B** NaI, KI, RbI

☒ **C** NaCl, $MgCl_2$, $AlCl_3$

☒ **D** SO_2, P_4O_{10}, SiO_2

(Total for Question 4 = 1 mark)

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5 Hydrogen bromide has a lower boiling temperature than hydrogen iodide. This is because

☒ **A** hydrogen bromide has a smaller permanent dipole than hydrogen iodide.

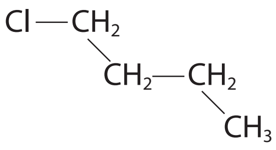
☒ **B** hydrogen bromide has weaker London forces than hydrogen iodide.

☒ **C** hydrogen iodide forms hydrogen bonds but hydrogen bromide does not.

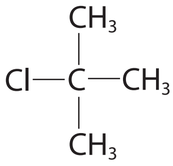
☒ **D** the H—I bond is stronger than the H—Br bond.

(Total for Question 5 = 1 mark)

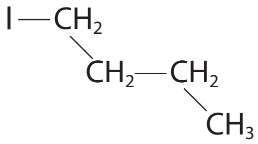
6 Consider the following compounds, **E**, **F**, **G** and **H**.



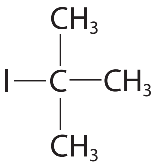
E



F



G



H

The boiling temperature of these compounds **increases** in the order

☒ **A** **H G F E**

☒ **B** **G H E F**

☒ **C** **E F G H**

☒ **D** **F E H G**

(Total for Question 6 = 1 mark)

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7 In which of the following reactions is sulfuric(IV) acid, H_2SO_3, acting as an oxidizing agent?

☒ **A** $H_2SO_3 + H_2O \rightarrow H_3O^+ + HSO_3^-$

☒ **B** $H_2SO_3 \rightarrow SO_2 + H_2O$

☒ **C** $H_2SO_3 + 2FeCl_3 + H_2O \rightarrow 2FeCl_2 + H_2SO_4 + 2HCl$

☒ **D** $H_2SO_3 + 2H_2S \rightarrow 3H_2O + 3S$

(Total for Question 7 = 1 mark)

8 Which of the following properties **decreases** on descending Group 2 of the Periodic Table?

☒ **A** Solubility of the sulfates.

☒ **B** Solubility of the hydroxides.

☒ **C** Reactivity of the elements.

☒ **D** Ionic character of the oxides.

(Total for Question 8 = 1 mark)

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9 Compound **X** is an anhydrous, white solid which decomposes on heating to form a white solid residue, a colourless gas, and a colourless vapour which condenses to a colourless liquid.

Compound **X** is

☒ **A** sodium carbonate.

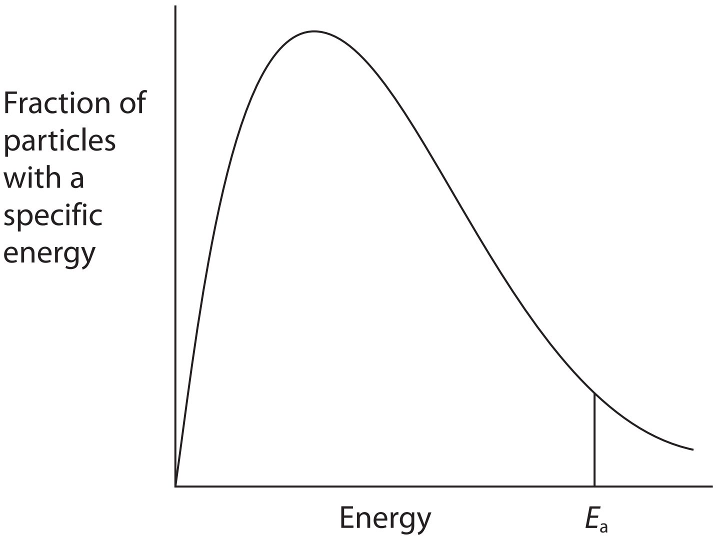
☒ **B** sodium hydrogencarbonate.

☒ **C** sodium nitrate.

☒ **D** sodium sulfate.

(Total for Question 9 = 1 mark)

10 These questions concern the Maxwell-Boltzmann energy distribution shown below.



(a) What is the best way to describe the activation energy, E_a, of a reaction?

(1)

☒ **A** The average energy of the particles that react.

☒ **B** The minimum energy required for a reaction to occur.

☒ **C** The energy difference between the reactants and products.

☒ **D** The energy produced by the particles that react.

(b) How does the curve above change when the temperature is **increased**?

(1)

☒ **A** The peak increases in height and moves to the left.

☒ **B** The peak increases in height and moves to the right.

☒ **C** The peak decreases in height and moves to the left.

☒ **D** The peak decreases in height and moves to the right.

(c) What would be the effect on the diagram if the reactant concentrations were **increased**?

(1)

☒ **A** There would be no change.

☒ **B** The E_a line would move to the right.

☒ **C** The E_a line would move to the left.

☒ **D** The peak decreases in height and moves to the right.

(d) What would be the effect on the diagram if a catalyst was added?
The activation energy would

(1)

☒ **A** be unchanged and the peak would move to the right.

☒ **B** move to the left and the peak would move to the right.

☒ **C** move to the left and the peak would move to the left.

☒ **D** move to the left and the peak would be unchanged.

(Total for Question 10 = 4 marks)

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11 Propanal, CH_3CH_2CHO, and propanone, CH_3COCH_3, are carbonyl compounds. When these compounds are compared using physical methods of analysis, which of the following statements is **not** correct?

☒ **A** The compounds produce different patterns in the fingerprint region of the IR spectrum.

☒ **B** The carbonyl groups absorb at frequencies in the same region of the IR spectrum.

☒ **C** The compounds produce different fragmentation patterns in a mass spectrum.

☒ **D** The compounds have molecular ion peaks at different mass to charge ratios in a mass spectrum.

(Total for Question 11 = 1 mark)

12 A sample of propanone, CH_3COCH_3, was heated under reflux with potassium dichromate(VI) acidified with sulfuric acid, and then the mixture was distilled. Apart from the peaks due to the C—C and C—H bonds, what peak(s) would be present in the IR spectrum of the distillate?

☒ **A** A peak due to the C═O only.

☒ **B** A peak due to the O—H only.

☒ **C** Peaks due to C═O and O—H.

☒ **D** Peaks due to C—O, C═O and O—H.

(Total for Question 12 = 1 mark)

13 Which of the following describes the appearance of iodine under the stated conditions?

	Solid	Dissolved in aqueous potassium iodide	Dissolved in a liquid hydrocarbon
☒ **A**	purple	brown	purple
☒ **B**	brown	blue-black	yellow
☒ **C**	shiny grey	brown	purple
☒ **D**	shiny grey	brown	brown

(Total for Question 13 = 1 mark)

14 Why do calculations of global warming exclude the effect of water vapour in the atmosphere?

☒ **A** Water vapour is not a greenhouse gas.

☒ **B** Water vapour is a much less potent greenhouse gas than carbon dioxide.

☒ **C** The average concentration of water vapour in the atmosphere is fairly constant.

☒ **D** The concentration of water vapour in the atmosphere is much lower than that of carbon dioxide.

(Total for Question 14 = 1 mark)

15 A compound of nitrogen and hydrogen only is analyzed and found to contain 97.7% by mass of nitrogen. What is the empirical formula of the compound?

Molar masses /g mol^{-1}: H = 1; N = 14

☒ **A** NH_3

☒ **B** NH_2

☒ **C** N_3H_5

☒ **D** N_3H

(Total for Question 15 = 1 mark)

16 Chlorofluorocarbons, CFCs, damage the ozone layer. The mechanism of the process involves

☒ **A** homolytic fission.

☒ **B** heterolytic fission.

☒ **C** electrophilic addition.

☒ **D** nucleophilic substitution.

(Total for Question 16 = 1 mark)

17 Electrophiles are

☒ **A** electron pair donors that are attracted to regions of high electron density.

☒ **B** electron pair donors that are attracted to regions of low electron density.

☒ **C** electron pair acceptors that are attracted to regions of high electron density.

☒ **D** electron pair acceptors that are attracted to regions of low electron density.

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

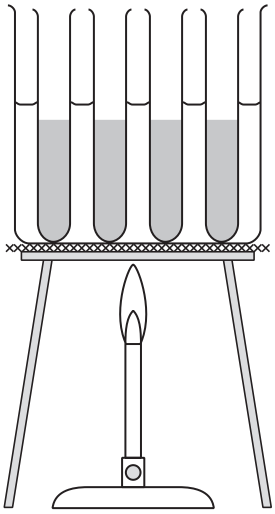
SECTION B

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

18 Halogenoalkanes react slowly with water to form alcohols. The equation for the reaction is

$$RX + H_2O \rightarrow ROH + H^+ + X^-$$

(a) The rate of this reaction for different halogenoalkanes was investigated using the apparatus below.



In one experiment, equal amounts of 1-chlorobutane, 1-bromobutane and 1-iodobutane were placed in separate test tubes with 5 cm^3 of ethanol. These test tubes were placed in the water bath together with a test tube containing aqueous silver nitrate. After about 5 minutes, 1 cm^3 of the silver nitrate solution was added to each test tube containing a halogenoalkane and the time taken for a precipitate to form in each test tube was noted. The temperature of the water bath was maintained at 50 °C.

(i) Why is ethanol used as a solvent in this experiment?

(1)

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....

(ii) Explain why the apparatus was left for 5 minutes before the silver nitrate was added.

(1)

....

....

(iii) **Name** the precipitate formed in the test tube containing 1-bromobutane and write an **ionic** equation for the formation of this precipitate. State symbols are not required.

(2)

Precipitate ....

Ionic equation

(iv) Predict the order (fastest first) in which the halogenoalkanes form precipitates. Explain your answer.

(2)

Order ....

....

Explanation ....

....

....

....

(b) Alcohols are usually prepared from halogenoalkanes using aqueous alkali, rather than water, as the reaction is faster.

(i) Name the mechanism and type of reaction occurring when 1-bromobutane reacts with aqueous alkali.

(2)

....

(ii) Explain why the formation of alcohols is faster with aqueous alkali than with water.

(1)

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....

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(iii) Give the mechanism for the reaction of 1-bromobutane with aqueous alkali.

Show the lone pair involved in the mechanism and any relevant dipoles and curly arrows.

(3)

(iv) One student suggested that the final reaction mixture could be tested for the presence of an alcohol using phosphorus(V) chloride while another suggested using potassium dichromate(VI) with sulfuric acid.

Describe the result of a positive test for alcohols using each of these reagents.

Explain which test is better for the final reaction mixture.

(3)

Observation with PCl_5 ....

Observation with acidified $K_2Cr_2O_7$ ....

Explanation ....

....

....

(c) 1-bromobutane is classified as a **primary** halogenoalkane and is one of the four structural isomers with a molecular formula C_4H_9Br.

Give the **skeletal** formula of the three isomers, other than 1-bromobutane, classifying the halogenoalkane in each case.

(3)

Skeletal formula	Classification

(Total for Question 18 = 18 marks)

19 Two white powders, **A** and **B**, known to be Group 2 carbonates, are investigated.

(a) (i) The presence of the carbonate ion is usually confirmed using a simple test carried out in two stages at room temperature. Describe this test and its results.

(2)

Test ....

....

Results ....

....

....

(ii) Using barium carbonate as your example, write the equation for each of the stages of the carbonate test. Include state symbols in both equations.

(3)

First equation (test)

Second equation (result)

(b) When a flame test is carried out on the two powders, **A** gives no colour and **B** gives a yellow-red flame.

(i) Describe how a flame test is carried out.

(3)

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(ii) Give the **formulae** of the metal ions in **A** and **B**.

(2)

A .... **B**..

*(iii) Explain the origin of the flame colour.

(3)

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(iv) Suggest why compound **A** produces no flame colour.

(1)

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*(c) When Group 2 metal carbonates are heated strongly, they decompose forming the metal oxide and carbon dioxide.

Explain why the thermal stability of the metal carbonates increases as the group is descended.

(3)

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(Total for Question 19 = 17 marks)

20 Induced hydraulic fracturing, commonly known as fracking, which was developed in 1947, is a technique for extracting natural gas (mainly methane) from shale deposits. While natural gas is a much cleaner fuel than coal, it is difficult to carry out fracking without leakage. Because methane is a far more potent greenhouse gas than carbon dioxide, it has been calculated that leakage rates of around 2% are sufficient to increase global warming.

(a) Suggest what is meant by 'natural gas is a much cleaner fuel than coal'.

(1)

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(b) Explain how greenhouse gases cause global warming.

(2)

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(c) Suggest why methane is a far more potent greenhouse gas than carbon dioxide.

(1)

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(Total for Question 20 = 4 marks)

TOTAL FOR SECTION B = 39 MARKS

SECTION C

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

21

Swimming Pool Chemistry

The circulation of water in swimming pools is much slower than that in most natural water courses, but the number of people using a given volume of water is often far greater. If steps are not taken to keep microorganisms and other contaminants under control, the water will become hazardous. Filters are used to remove solid material and chemicals are added to disinfect the water.

The most common method of disinfection involves the use of chlorine compounds, but systems using bromine have advantages. These systems depend on their oxidizing properties. With chlorine systems, the key species is the chlorate(I) ion (OCl^-) which kills bacteria by damaging the structure of their cell walls and disrupting enzyme activity.

A simple way of adding chlorate(I) ions to water is by using chlorine. The weak acid, chloric(I) acid (HOCl), is formed and this dissociates producing the chlorate(I) ion.

(a) The equation for the reaction of chlorine with water is:

$$Cl_2(aq) + H_2O(l) \rightleftharpoons HOCl(aq) + HCl(aq)$$

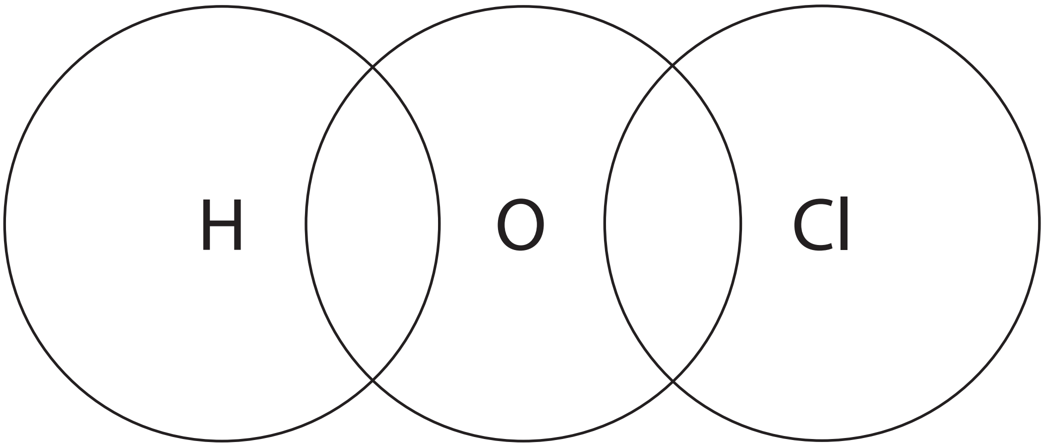
By referring to the relevant oxidation numbers, explain why this is a disproportionation reaction.

(3)

(b) (i) Complete the dot and cross diagram for chloric(I) acid (HOCl). Use a dot (•) to represent the hydrogen electron, circles (o) to represent the oxygen electrons and crosses (×) to represent the chlorine electrons.

Show the outer electrons only, but include non-bonding electrons.

(2)



*(ii) Predict the bond angle in chloric(I) acid. Explain your answer fully.

(5)

Bond angle = ...

....

....

....

....

....

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....

(c) If the concentration of chlorate(I) ions in a swimming pool is too low, bacteria will flourish. If it is too high, swimmers will be harmed. In the United Kingdom, it is recommended that the concentration of chlorine be in the range 1–2 mg dm^{-3}. The total amount of chlorine, Cl_2, present can be measured by titration.

In such a determination, excess sulfuric acid and potassium iodide were added to a 1.00 dm^3 sample of swimming pool water and the resulting solution required 9.65 cm^3 of 0.00550 mol dm^{-3} sodium thiosulfate for complete reaction.

The equations for the reactions are:

$$Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$$

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

(i) Show that the concentration of chlorine, Cl_2, in this sample meets the UK recommended requirements.
All steps in your calculation must be shown.

(3)

(ii) Analysing a single sample of swimming pool water in this way is likely to give unreliable results because it is not possible to repeat the titration.
Suggest another way in which this method is unreliable.

(1)

(d) One advantage of the bromine disinfection system is that, while chloric(I) acid decomposes in sunlight forming hydrogen chloride and oxygen, bromic(I) acid (HOBr) is stable. Another advantage is that bromine is less volatile than chlorine.

(i) Write an equation for the decomposition of chloric(I) acid in sunlight.
State symbols are not required.

(1)

(ii) Explain why bromine is less volatile than chlorine.

(2)

(e) The pH of the swimming pool affects the performance of the disinfectant. The data below show how the concentrations of bromine species vary with pH.

pH	% bromine as HOBr	% bromine as OBr^-
6.0	100	0.0
7.0	98.0	2.0
8.0	83.0	17.0
8.5	57.0	43.0

The equation for the reaction of bromic(I) acid in water is

$$HOBr(aq) \rightleftharpoons H^+(aq) + OBr^-(aq)$$

(i) Assume the pH of the swimming pool is neutral. Explain how any changes in the pH of the swimming pool affect the concentration of the bromine species.

(3)

(ii) The higher the concentration of bromate(I) ions, the more effective the disinfectant.

Suggest a disadvantage of too high a pH.

(1)

(Total for Question 21 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
(1)	*(2)*											*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	
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	*(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

* 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