Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Thursday 19 January 2012 – 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 ▶

P39303A

7/7/5/3/

P 3 9 3 0 3 A 0 1 2 4

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 This question concerns the shapes of molecules and ions:

A linear

B trigonal planar

C pyramidal

D tetrahedral

Select from **A to D** the shape of

(a) boron trichloride, BCl_3

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) the ammonium ion, NH_4^+

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) carbon dioxide, CO_2

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 3 marks)

2 Tetrachloromethane, CCl_4, is a

☒ **A** polar molecule with polar bonds.

☒ **B** polar molecule with non-polar bonds.

☒ **C** non-polar molecule with polar bonds.

☒ **D** non-polar molecule with non-polar bonds.

(Total for Question 2 = 1 mark)

3 The difference in boiling temperature between methane (T_b = 109 K) and ethane (T_b = 185 K) is best explained by the different numbers of

☒ **A** protons.

☒ **B** electrons.

☒ **C** covalent bonds.

☒ **D** hydrogen bonds.

(Total for Question 3 = 1 mark)

4 What is the oxidation number of oxygen in OF_2?

☒ **A** −2

☒ **B** −1

☒ **C** +1

☒ **D** +2

(Total for Question 4 = 1 mark)

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

☒ **A** $2NaOH + H_2SO_3 \rightarrow Na_2SO_3 + 2H_2O$

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

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

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

(Total for Question 5 = 1 mark)

6 Ethanol is soluble in water. The **best** explanation for this is

☒ **A** ethanol molecules form hydrogen bonds with water molecules.

☒ **B** ethanol molecules form London (dispersion) forces with water molecules.

☒ **C** ethanol molecules form permanent dipole interactions with water molecules.

☒ **D** ethanol and water are miscible liquids.

(Total for Question 6 = 1 mark)

7 During a titration, when the solution in a pipette is transferred to a conical flask, a small amount of liquid remains in the tip of the pipette. This situation should be dealt with by

☒ **A** leaving the liquid in the pipette which is calibrated to allow for it.

☒ **B** slightly over-filling the pipette to compensate for the additional volume.

☒ **C** carefully blowing the liquid out of the pipette to ensure that it is empty.

☒ **D** repeating the titration.

(Total for Question 7 = 1 mark)

8 The tolerance of a 25 cm^3 pipette is ±0.06 cm^3. The percentage error in the measurement of 25 cm^3 using this pipette is

☒ **A** ±0.06%

☒ **B** ±0.12%

☒ **C** ±0.24%

☒ **D** ±0.48%

(Total for Question 8 = 1 mark)

9 A series of titrations is carried out using the same conical flask. Before carrying out each titration, the conical flask **must** be

☒ **A** rinsed with ethanol.

☒ **B** rinsed with distilled or deionised water.

☒ **C** rinsed with the solution that it will contain.

☒ **D** dried to remove all traces of liquid.

(Total for Question 9 = 1 mark)

10 When excess calcium is added to water, effervescence occurs and

☒ **A** a clear colourless solution is formed.

☒ **B** a cloudy suspension is formed.

☒ **C** an orange-red flame is seen.

☒ **D** a yellow flame is seen.

(Total for Question 10 = 1 mark)

11 When samples of magnesium nitrate, $Mg(NO_3)_2$, and calcium nitrate, $Ca(NO_3)_2$, are heated

☒ **A** both compounds decompose to form the corresponding nitrite and oxygen.

☒ **B** both compounds decompose to form the corresponding oxide, nitrogen dioxide and oxygen.

☒ **C** magnesium nitrate decomposes to form magnesium nitrite and oxygen whereas calcium nitrate decomposes to form calcium oxide, nitrogen dioxide and oxygen.

☒ **D** magnesium nitrate decomposes to form magnesium oxide, nitrogen dioxide and oxygen whereas calcium nitrate decomposes to form calcium nitrite and oxygen.

(Total for Question 11 = 1 mark)

12 Which of the following properties of the elements chlorine, bromine and iodine **increases** with increasing atomic number?

☒ **A** Boiling temperature

☒ **B** Bond enthalpy

☒ **C** Electronegativity

☒ **D** First ionization energy

(Total for Question 12 = 1 mark)

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

13 Which of the following is a secondary alcohol?

☒ **A** butan-1-ol

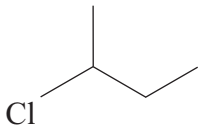
☒ **B** butan-2-ol

☒ **C** 2-methylpropan-1-ol

☒ **D** 2-methylpropan-2-ol

(Total for Question 13 = 1 mark)

14 The compound



has the systematic name

☒ **A** 2-chlorobutane

☒ **B** 3-chlorobutane

☒ **C** 1-chloro-1-methylpropane

☒ **D** 1-chloro-2-methylbutane

(Total for Question 14 = 1 mark)

15 When a chloroalkane is heated with aqueous sodium hydroxide

☒ **A** no reaction occurs with primary, secondary or tertiary chloroalkanes.

☒ **B** a reaction occurs with primary and secondary chloroalkanes but not with tertiary chloroalkanes.

☒ **C** a reaction occurs with tertiary chloroalkanes but not with primary and secondary chloroalkanes.

☒ **D** a reaction occurs with primary, secondary and tertiary chloroalkanes.

(Total for Question 15 = 1 mark)

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

16 Brown nitrogen dioxide, NO_2, exists in equilibrium with colourless dinitrogen tetroxide, N_2O_4.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \quad \Delta H = -57.2 \text{ kJ mol}^{-1}$$
brown colourless

(a) The **pressure** is increased. When equilibrium is restored, the appearance of the mixture of gases will be

(1)

☒ **A** colourless.

☒ **B** unchanged.

☒ **C** paler brown.

☒ **D** darker brown.

(b) The **temperature** is increased. When equilibrium is restored, the appearance of the mixture of gases will be

(1)

☒ **A** colourless.

☒ **B** unchanged.

☒ **C** paler brown.

☒ **D** darker brown.

(Total for Question 16 = 2 marks)

17 When propanal, CH_3CH_2CHO, and propanone, CH_3COCH_3, are compared using physical methods of analysis, which of the following is **not** correct?

☒ **A** The carbonyl groups absorb at very similar frequencies of the IR spectrum.

☒ **B** The compounds will have different patterns in the fingerprint region of the IR spectrum.

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

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

(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 The boiling temperatures of some hydrides are given below.

Compound	Boiling temperature / K
HF	293
HCl	188
HBr	206
HI	238
H_2O	373

*(a) Explain, by comparing the forces involved, why HI has a higher boiling temperature than HBr.

(3)

*(b) Explain, by comparing the types of forces involved, why HF has a higher boiling temperature than HCl.

(3)

(c) Suggest why H_2O has a higher boiling temperature than HF.

(1)

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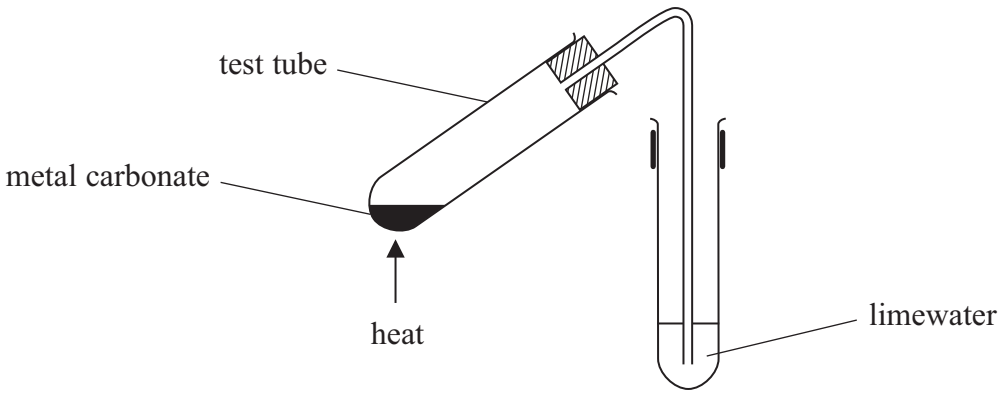
(Total for Question 18 = 7 marks)

19 The carbonates of Group 2 in the Periodic Table decompose on heating to form the corresponding metal oxide and carbon dioxide. A general equation for the reaction is

$$MCO_3(s) \rightarrow MO(s) + CO_2(g)$$

The thermal stability of these carbonates can be compared in the laboratory using the apparatus in the diagram below. The test tube on the left contains a sample of a metal carbonate and the tube on the right contains limewater.



(a) (i) State the measurement that you would make in this experiment.

(1)

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.....

(ii) Suggest **three** ways to make sure that, when carrying out this experiment, the thermal stabilities of the different carbonates are compared fairly.

(3)

1 .....

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2 .....

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3 .....

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(b) (i) State the trend in the thermal stability of the metal carbonates as the group is descended.

(1)

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*(ii) Explain this trend in stability.

(3)

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(Total for Question 19 = 8 marks)

20 Chlorine disinfectants are essentially solutions containing chlorine molecules and chlorate(I) ions in an equilibrium summarised by the equation

$$Cl_2(aq) + H_2O(l) \rightleftharpoons 2H^+(aq) + ClO^-(aq) + Cl^-(aq) \qquad \textbf{Equation 1}$$

The chlorine content of a disinfectant was determined using the following procedure.

1. 10.0 cm^3 of the disinfectant was transferred to a 250 cm^3 volumetric flask.

2. Approximately 20 cm^3 of nitric acid and 20 cm^3 potassium iodide solution (both in excess) were added to the volumetric flask.

3. The solution in the volumetric flask was made up to the mark with distilled water and then mixed thoroughly.

4. 10.0 cm^3 portions of the solution in the volumetric flask were titrated against a solution of sodium thiosulfate, concentration 0.109 mol dm^{-3}. Starch solution was added near the end-point of the titration and the mean (average) titre was 27.35 cm^3.

The equations for the reactions involved in this procedure are

$$Cl_2(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Cl^-(aq) \qquad \textbf{Equation 2}$$

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq) \qquad \textbf{Equation 3}$$

(a) (i) Calculate the number of moles of sodium thiosulfate used in the titration.

(2)

(ii) Calculate the number of moles of iodine, I_2, that reacted in the titration (step 4).

(1)

(iii) Hence state the number of moles of chlorine, Cl_2, in 10.0 cm^3 of the solution in the volumetric flask.

(1)

(iv) Calculate the concentration of chlorine, in mol dm^{-3}, in the **original** disinfectant.

(2)

(b) **Equation 1** is an example of a disproportionation reaction. Define the term 'disproportionation' and explain, by considering the relevant oxidation numbers, why this reaction is a disproportionation.

(3)

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(c) State the colours of the titration solution just before the starch solution is added, after the starch solution is added and the colour change at the end-point of the reaction.

(2)

Colour just before adding the starch .....

Colour after adding the starch .....

Colour at the end-point .....

(Total for Question 20 = 11 marks)

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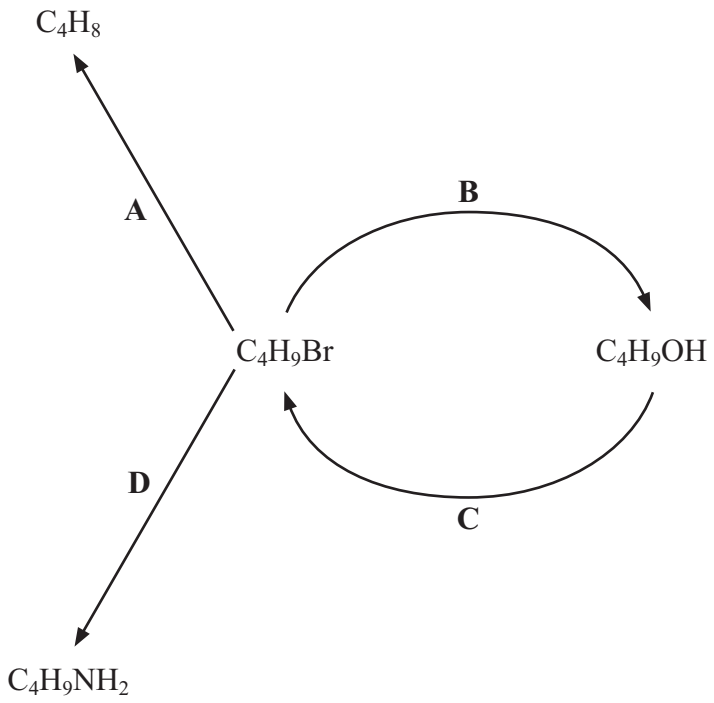
21 Halogenoalkanes are important intermediates in organic chemistry. The scheme below summarises some important reactions of a halogenoalkane.



(a) Identify the reagents and any specific conditions required for the reactions in the diagram. (You may assume that a suitable temperature is maintained in each reaction.)

(4)

A .....

B .....

C .....

D .....

(b) (i) Classify the type of reaction in each of **A** and **D**.

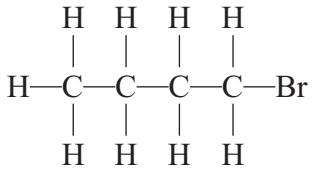
(2)

A .....

D .....

*(ii) Reaction **B** can proceed via two possible reaction mechanisms, depending on the structure of the original compound. For each of the two isomers of C_4H_9Br shown below, draw the structure of the intermediate or transition state which is formed during the reaction. Explain in each case why the specified structure is more favourable.

(4)



Intermediate or transition state

Explanation .....

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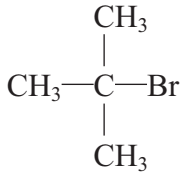

Intermediate or transition state

Explanation .....

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(iii) If C_4H_9I is used instead of C_4H_9Br in reaction **D**, the rate of formation of $C_4H_9NH_2$ increases. Explain why the rate of reaction increases.

(1)

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.....

.....

(c) Halogenoalkanes are widely used as refrigerants and belong to the class of refrigerants that cool by change of state (typically by boiling).

(i) Suggest how halogenoalkanes cool by change of state.

(1)

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.....

.....

(ii) Suggest **two** characteristics or properties desirable in a refrigerant.

(2)

1 .....

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2 .....

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(Total for Question 21 = 14 marks)

TOTAL FOR SECTION B = 40 MARKS

SECTION C

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

22 Nitrogen monoxide is an unusual molecule both in its chemical structure (shown below) and in its impact on our lives.

Nitrogen monoxide is an important chemical messenger in all mammals and, at appropriate concentrations, it is vital to life; however, at high concentrations in the body, it is extremely toxic.

Nitrogen monoxide is considered a dangerous atmospheric pollutant; it is involved in the formation of a range of toxic substances, including ozone, at low altitudes, and in the depletion of the ozone layer at high altitudes.

Nitrogen monoxide is formed by the direct combination of nitrogen and oxygen at high temperatures, a reaction that occurs naturally in lightning discharges, and as a by-product of the reactions in internal combustion and jet engines. Catalytic converters reduce nitrogen monoxide emissions from car engines by catalysing the reaction between nitrogen monoxide and carbon monoxide to form nitrogen and carbon dioxide.

The reactions of nitrogen monoxide which involve ozone in the atmosphere are summarised below.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

$$NO_2(g) \xrightarrow{\text{UV radiation}} NO(g) + O(g)$$

$$O_2(g) + O(g) \longrightarrow O_3(g)$$

$$NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g)$$

When the ratio of nitrogen dioxide to nitrogen monoxide is high (> 3), the rate of formation of ozone is faster than its rate of removal. When the ratio is low (< 0.3), the reverse is true.

Ozone causes breathing difficulties, headaches, fatigue and can aggravate respiratory problems. The reaction of nitrogen monoxide with hydrocarbons can also produce other toxic compounds, such as aldehydes.

(a) Write the equation for the formation of nitrogen monoxide from nitrogen and oxygen. State symbols are **not** required.

(1)

(b) The electronic structure of nitrogen monoxide is unusual in that it has an unpaired electron.

(i) What name is given to a chemical species such as nitrogen monoxide that has an unpaired electron?

(1)

.....

(ii) Chemical species with unpaired electrons occur as intermediates in some chemical reactions. What type of bond breaking produces these species?

(1)

.....

(c) (i) Suggest the most likely source of the hydrocarbons that react with nitrogen monoxide to form toxic compounds.

(1)

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(ii) Suggest the type of reaction that is involved when a hydrocarbon is converted into an aldehyde.

(1)

.....

(iii) Draw the **skeletal** formula of the aldehyde with three carbon atoms.

(1)

(iv) By considering the equation

$$NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g)$$

explain the effect of the reaction of hydrocarbons with nitrogen monoxide on the breakdown of ozone.

(1)

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(d) Suggest why the proportion of nitrogen dioxide might be reduced at high altitudes.

(2)

(e) Explain why it is important to maintain the concentration of ozone in the upper atmosphere.

(2)

(f) (i) Write an equation for the reaction on a catalytic converter described in the passage. State symbols are **not** required.

(1)

(ii) Draw an energy profile for the exothermic reaction in (f)(i). Label the axes, the reactants and products, the enthalpy change and the activation energy.

(3)

*(iii) By referring to your energy profile, explain how a catalyst speeds up a chemical reaction.

(3)

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(g) Jet aircraft are considered a greater threat to the ozone layer than road vehicles. Suggest an explanation for this.

(2)

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(Total for Question 22 = 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)											(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							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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