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 21 January 2010 – 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 ▶

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7/7/5/3/

N 3 5 6 9 2 A 0 1 2 4

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 Which of the following bond angles occur in a molecule of ethanol, C_2H_5OH?

☐ **A** 90° and 180°

☐ **B** 104.5° and 180°

☐ **C** 104.5° and 109.5°

☐ **D** 109.5° and 120°

(Total for Question 1 = 1 mark)

2 Which of the following molecules is linear?

☐ **A** Carbon dioxide, CO_2

☐ **B** Sulfur dioxide, SO_2

☐ **C** Water, H_2O

☐ **D** Methanal, HCHO

(Total for Question 2 = 1 mark)

3 Which of the following molecules contains polar bonds but is **not** a polar molecule?

☐ **A** Chlorine, Cl_2

☐ **B** Hydrogen chloride, HCl

☐ **C** Trichloromethane, $CHCl_3$

☐ **D** Tetrachloromethane, CCl_4

(Total for Question 3 = 1 mark)

4 Which of the following has dipole-dipole interactions between its molecules, but no hydrogen bonding?

☐ **A** Methane, CH_4

☐ **B** Methanol, CH_3OH

☐ **C** Ammonia, NH_3

☐ **D** Hydrogen iodide, HI

(Total for Question 4 = 1 mark)

5 Which list below shows the compounds in order of **increasing** boiling temperature?

- ☒ **A** CH_4, HCl, HF
- ☒ **B** HF, CH_4, HCl
- ☒ **C** HCl, HF, CH_4
- ☒ **D** HF, HCl, CH_4

(Total for Question 5 = 1 mark)

6 Which of the following has the highest boiling temperature?

- ☒ **A** Pentane, $CH_3CH_2CH_2CH_2CH_3$
- ☒ **B** Hexane, $CH_3CH_2CH_2CH_2CH_2CH_3$
- ☒ **C** 2-methylbutane, $CH_3CH(CH_3)CH_2CH_3$
- ☒ **D** 2-methylpentane, $CH_3CH(CH_3)CH_2CH_2CH_3$

(Total for Question 6 = 1 mark)

7 Which of the following could **not** be an element in Group 2?

- ☒ **A** An element with an oxide which forms a solution of pH 10.
- ☒ **B** An element with an insoluble sulfate.
- ☒ **C** An element with a chloride which is liquid at room temperature.
- ☒ **D** An element with a carbonate which decomposes on heating.

(Total for Question 7 = 1 mark)

8 Chlorides of Group 1 elements produce coloured flames when

- ☒ **A** electrons become excited to a higher energy level.
- ☒ **B** excited electrons move from a higher to a lower energy level.
- ☒ **C** an outer electron leaves the atom.
- ☒ **D** electrons move between the negative and positive ions.

(Total for Question 8 = 1 mark)

9 This question is about the following compounds.

A Barium carbonate

B Lithium nitrate

C Potassium bromide

D Potassium nitrate

(a) Which compound gives a green colour in a flame test?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(b) Which compound gives a lilac colour in a flame test and does **not** decompose on heating?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for Question 9 = 2 marks)

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

10 20 cm^3 of sulfuric acid, concentration 0.25 mol dm^{-3}, was neutralized in a titration with barium hydroxide, concentration 0.50 mol dm^{-3}. The equation for the reaction is

$$Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$$

(a) The volume of barium hydroxide required was

(1)

- ☒ **A** 10 cm^3
- ☒ **B** 20 cm^3
- ☒ **C** 25 cm^3
- ☒ **D** 40 cm^3

(b) During the titration, the barium hydroxide was added until it was present in excess. The electrical conductivity of the titration mixture

(1)

- ☒ **A** increased steadily.
- ☒ **B** decreased steadily.
- ☒ **C** increased and then decreased.
- ☒ **D** decreased and then increased.

(Total for Question 10 = 2 marks)

11 Which of the following trends occurs going down the elements in Group 2?

- ☒ **A** The solubility of the hydroxides increases.
- ☒ **B** The first ionization energy increases.
- ☒ **C** The solubility of the sulfates increases.
- ☒ **D** The stability of the carbonates to heat decreases.

(Total for Question 11 = 1 mark)

12 Which of the following is **not** a true statement about hydrogen iodide?

- ☒ **A** It forms steamy fumes in moist air.
- ☒ **B** It dissolves in water to form an acidic solution.
- ☒ **C** It forms a cream precipitate with silver nitrate solution.
- ☒ **D** It forms dense white smoke with ammonia.

(Total for Question 12 = 1 mark)

13 Chemical reactions may involve

A oxidation

B reduction

C no change in oxidation number

D disproportionation

Which of the terms above best describes what happens to the **chlorine** in the following reactions?

(a) $Cl_2(g) + H_2O(l) \rightarrow HCl(aq) + HOCl(aq)$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) $Cl_2(g) + 2Na(s) \rightarrow 2NaCl(s)$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) $NaCl(s) + H_2SO_4(l) \rightarrow HCl(g) + NaHSO_4(s)$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 13 = 3 marks)

14 When chloroethane is heated with a concentrated solution of potassium hydroxide in **ethanol**, the reaction which occurs is

☒ **A** substitution.

☒ **B** elimination.

☒ **C** hydrolysis.

☒ **D** redox.

(Total for Question 14 = 1 mark)

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

15 Chloroethane reacts with **aqueous** potassium hydroxide solution, producing ethanol as the organic product.

(a) The hydroxide ion is acting as

(1)

☒ **A** an electrophile.

☒ **B** a nucleophile.

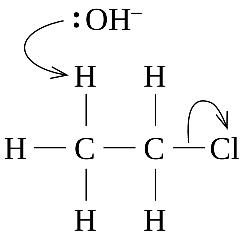
☒ **C** an oxidizing agent.

☒ **D** a reducing agent.

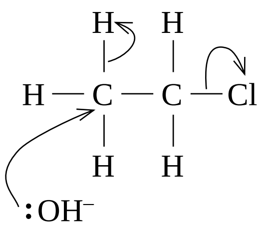
(b) Which of the following shows the correct electron-pair movements in this reaction?

(1)

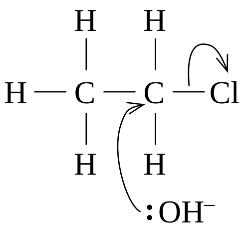
☒ **A**



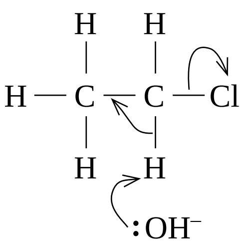
☒ **B**



☒ **C**



☒ **D**



(Total for Question 15 = 2 marks)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

16 Magnesium nitrate, $Mg(NO_3)_2$, decomposes when it is heated. One product is the brown gas, nitrogen dioxide.

(a) (i) Write an equation for this reaction. State symbols are **not** required.

(2)

(ii) Calcium nitrate decomposes in a similar way to magnesium nitrate, but at a higher temperature.

Explain why the two nitrates have different stability to heat.

(2)

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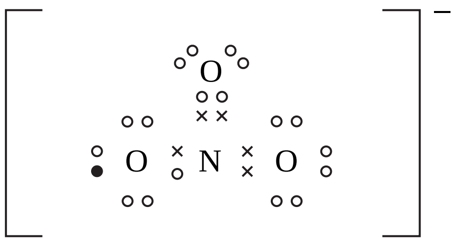
(b) Sodium nitrate decomposes to give different products to magnesium nitrate. Write an equation for the decomposition of sodium nitrate. State symbols are **not** required.

(1)

(c) A student suggested that the structure of the nitrate ion, NO_3^-, is



Scientists have found that the bonds between nitrogen and oxygen in the nitrate ion are all the same length. Is the student's suggestion supported by this evidence? Explain your answer.

(1)

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(d) Nitrogen dioxide gas can dimerize to dinitrogen tetroxide, N_2O_4, a very pale yellow gas, as shown in the equation below.

$$2NO_2(g) \rightleftharpoons N_2O_4(g) \qquad \Delta H = -58 \text{ kJ mol}^{-1}$$

(i) What would you see when an equilibrium mixture of these gases is warmed gently? Explain your answer.

(2)

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(ii) Explain why an equilibrium mixture of these gases eventually becomes paler in colour when the pressure on it is increased.

(2)

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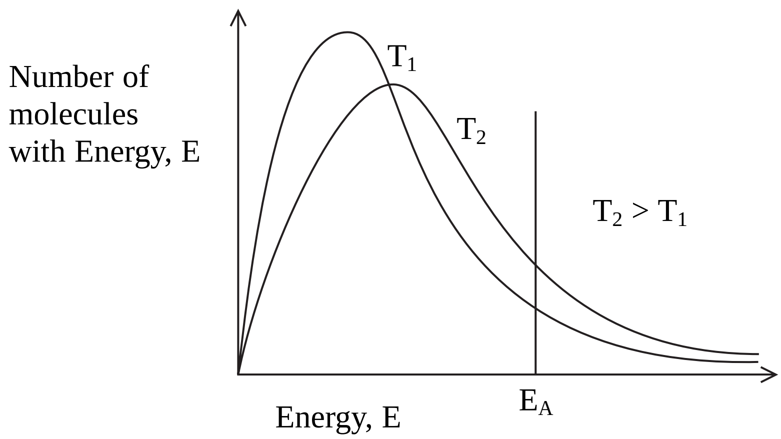
(e) Two Maxwell-Boltzmann distributions showing the energy of particles in a gas at different temperatures, T_1 and T_2, are shown below. The activation energy for the reaction is labelled E_A.



Use the distributions to explain why gases react faster when the temperature is increased.

(2)

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(Total for Question 16 = 12 marks)

17 This question is about some reactions of halogens and halide ions.

(a) (i) When chlorine is added to a solution containing bromide or iodide ions, a colour change occurs. What solvent would you add to the mixture to confirm the identity of the halogen produced?

(1)

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(ii) Give the result for the test with this solvent in a reaction in which bromine is produced.

(1)

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(b) (i) Solid potassium bromide and potassium iodide can be distinguished by their reactions with concentrated sulfuric acid.

Potassium bromide reacts with concentrated sulfuric acid initially to produce hydrogen bromide. This reacts further, as shown below, to produce a sharp smelling gas and a brown fuming liquid.

$$2HBr(g) + H_2SO_4(l) \rightarrow SO_2(g) + Br_2(l) + 2H_2O(l)$$

Show, by use of oxidation numbers for sulfur, that the sulfuric acid has been reduced.

(2)

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(ii) State TWO observations, which would differ from those with potassium bromide, when potassium iodide reacts with concentrated sulfuric acid.

(2)

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(iii) One product of the reaction with potassium iodide is hydrogen sulfide, H_2S. How does this show that iodide ions are more powerful reducing agents than bromide ions?

(1)

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(c) In areas where the natural concentration of fluoride ions in rocks is low, some water authorities add fluoride to the water supply to improve the dental health of children. An alternative would be to supply free fluoride tablets.

Give ONE reason why it could be considered more ethical to supply free fluoride tablets rather than to add fluoride compounds to the water supply.

(1)

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(Total for Question 17 = 8 marks)

18 Butan-1-ol and three other alcohols, **X**, **Y** and **Z**, are isomers.

(a) (i) Give TWO observations you would make when any one of the alcohols reacts with sodium.

(2)

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(ii) Give the molecular formula of the organic product of the reaction.

(1)

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(b) Isomer **X** does **not** react with a mixture of potassium dichromate(VI) and sulfuric acid.

Draw the displayed formula of **X** and name it.

(2)

Name ....

(c) When isomer **Y** is heated under reflux with a mixture of potassium dichromate(VI) and sulfuric acid, it forms 2-methylpropanoic acid.

Deduce the structural formula of the alcohol **Y**.

(1)

(d) (i) Isomer **Z** reacts with a mixture of potassium dichromate(VI) and sulfuric acid to form a compound **Q**, which does **not** react with Fehling's or Benedict's solution.

Deduce the structural formula of the alcohol **Z**.

(1)

(ii) What would be the principal difference between the infrared spectrum of **Q** and the infrared spectrum of 2-methylpropanoic acid?

You are **not** expected to quote absorption values.

(1)

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(e) One of the isomers, **X**, **Y** or **Z** can be converted to 2-chlorobutane.

What reagent would you use to carry out this conversion?

(1)

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(f) (i) 2-chlorobutane reacts with silver nitrate in a mixture of ethanol and water as a solvent. What would you see when the reaction occurred?

(1)

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*(ii) Both ethanol and water contain hydrogen bonds. By considering the hydrogen bonding on these two solvents, suggest why 2-chlorobutane is more soluble in ethanol than in water.

(2)

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(Total for Question 18 = 12 marks)

19 The concentration of iodine in solution can be measured by titration with sodium thiosulfate solution.

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

(a) Name a suitable indicator which could be used for this titration.

(1)

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(b) The amount of sulfur dioxide in the atmosphere can be measured by passing a known volume of air through iodine solution. Sulfur dioxide converts iodine to iodide ions.

$$SO_2(g) + I_2(aq) + 2H_2O(l) \rightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2I^-(aq)$$

In an experiment, 100 m^3 of air were passed through 100 cm^3 of iodine, concentration 0.0100 mol dm^{-3}. The remaining iodine was titrated with sodium thiosulfate solution and reacted with 12.60 cm^3 of sodium thiosulfate, concentration 0.100 mol dm^{-3}.

(i) How many moles of iodine were present in the solution of the iodine at the start of the experiment?

(1)

(ii) How many moles of iodine remained in the solution at the end of the experiment?

(2)

(iii) Calculate the number of moles of iodine which **reacted** with the sulfur dioxide, and hence the number of moles of sulfur dioxide in 100 m^3 of air.

(2)

(iv) The European Commission recommend exposure to sulfur dioxide in air should be less than 350 micrograms (350×10^{-6} g) per cubic metre.

Calculate whether the sulfur dioxide in this sample of air was within this limit. One mole of sulfur dioxide has mass 64.1 g.

(2)

(c) Explain whether the changes below would or would not improve the experimental procedure for measuring the concentration of sulfur dioxide in air used in (b).

(i) The 100 cm^3 of iodine was divided into 25 cm^3 samples before titration.

(1)

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(ii) The concentration of sodium thiosulfate used to titrate the iodine was changed from 0.100 mol dm^{-3} to 0.050 mol dm^{-3}.

(2)

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(iii) 150 m^3 of air was passed through the iodine. The solutions used were of the same concentrations as in the original experiment.

(2)

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(Total for Question 19 = 13 marks)

TOTAL FOR SECTION B = 45 MARKS

SECTION C

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

20

Fuel from the air?

A new catalyst that can break down carbon dioxide gas could allow us to use carbon from the atmosphere as a fuel source in a similar way to plants.

Plants break the stable bonds in carbon dioxide during photosynthesis. In the natural process, the carbon dioxide molecule is initially bonded to nitrogen atoms, making reactive compounds called carbamates. Carbamates are derivatives of carbamic acid, NH_2CO_2H. These compounds can then be broken down, allowing the carbon to be used in the synthesis of other plant products such as sugars and proteins.

A new catalyst produced by scientists is a graphite-like compound made from flat layers of carbon and nitrogen atoms arranged in hexagons. Carbon dioxide binds to the catalyst and takes part in the following reaction, which occurs at 150 °C and at about three times atmospheric pressure.

$$\underset{\text{benzene}}{C_6H_6} + CO_2 \rightarrow \underset{\text{phenol}}{C_6H_5OH} + CO$$

Carbon monoxide can then be used to make liquid fuels such as methanol.

The energy required for photosynthesis comes from light, and experiments are now going on to develop a light activated catalyst which could break down carbon dioxide in a new process.

(Source: adapted from an article from the *NewScientist.com* by Tom Simonite, March 2007)

*(a) Why are the bonds **within** a layer of carbon atoms in graphite stronger than the bonds **between** the layers of carbon atoms?

(2)

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(b) The data below gives the relative electrical conductivity of a pure graphite crystal.

Relative conductivity in plane of carbon hexagons	Relative conductivity perpendicular to plane of carbon hexagons
3.7	0.0017

Explain why the relative electrical conductivity of graphite differs with direction.

(2)

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(c) Suggest why the strength of the bond between the layers in graphite would increase if some carbon atoms were replaced with nitrogen atoms.

(2)

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(d) Suggest ONE benefit of using a light activated catalyst for the new process.

(1)

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....

(e) The liquid fuel, methanol, is made by reacting carbon monoxide with hydrogen.

Write an equation for this reaction. State symbols are **not** required.

(1)

*(f) Benzene, which is needed for the new process of breaking down carbon dioxide, can be made from coal. It is now usually made by catalytic treatment of one fraction of crude oil at temperatures of around 500 °C and 20 atmospheres pressure.

Suggest the benefits and disadvantages of breaking down carbon dioxide using benzene and the catalyst as described in the passage. You should consider

- the energy and resources needed
- the effects on the atmosphere
- whether it is a beneficial method for producing energy compared to direct use of fossil fuels.

(6)

(g) Carbon exists in forms other than graphite. Nanotubes are rolls of graphite layers, and fullerenes are cages of carbon atoms. Both nanotubes and fullerenes can trap other substances in their structures, and fullerenes can be coated with other substances.

Give ONE application of carbon nanotubes or fullerenes which exploits this behaviour.

(1)

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(Total for Question 20 = 15 marks)

TOTAL FOR SECTION C = 15 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)
							1.0 **H** hydrogen 1										*(18)* 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

	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
* Lanthanide series														
* 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