Write your name here

Surname	Other names

Edexcel GCE

Centre Number | Candidate Number

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Wednesday 23 May 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.

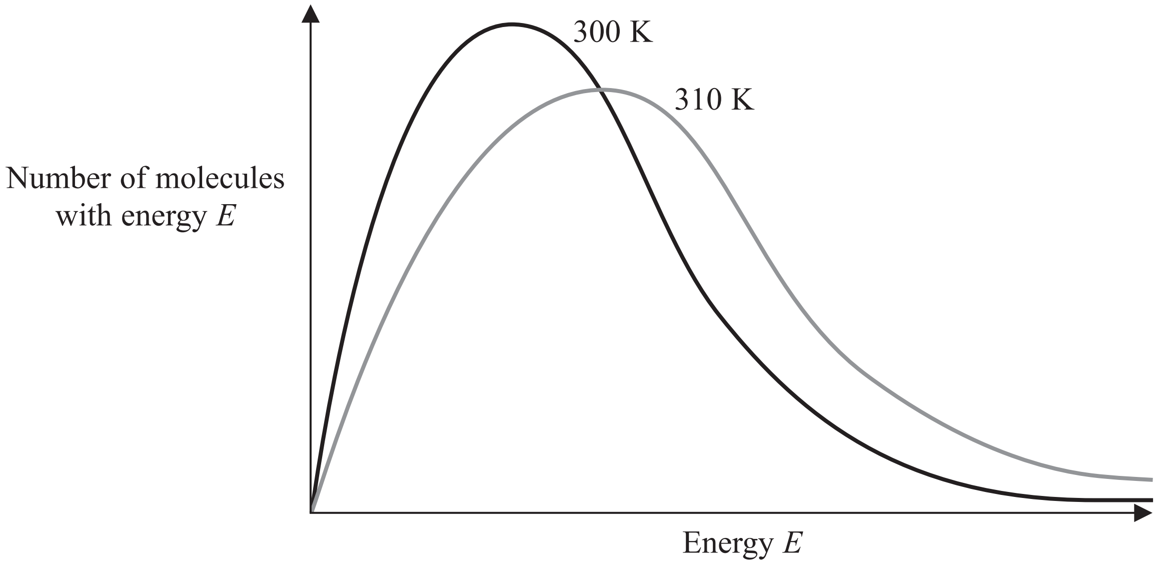
Turn over ▶

7/7/5/5/
P 3 9 3 0 7 A 0 1 2 0
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 diagram below shows the Maxwell-Boltzmann distribution of molecular energies for a gaseous system at two temperatures.



(a) The energy plotted on the horizontal axis is **mainly**

(1)

☒ **A** activation.

☒ **B** kinetic.

☒ **C** rotation.

☒ **D** vibration.

(b) The rate of a chemical reaction increases with temperature **mainly** because

(1)

☒ **A** the activation energy increases.

☒ **B** the activation energy decreases.

☒ **C** more collisions occur with energy greater than the activation energy.

☒ **D** the molecules collide more frequently.

(c) The total area under each curve

(1)

☒ **A** decreases with increasing temperature.

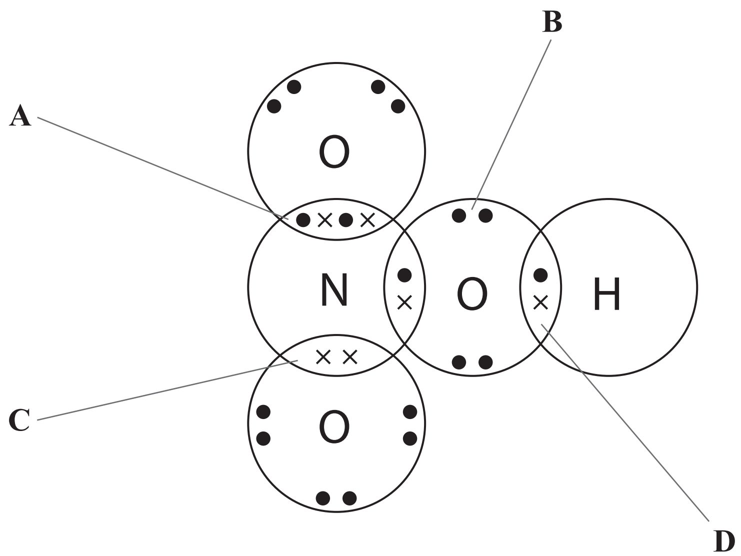
☒ **B** increases with increasing temperature.

☒ **C** increases or decreases with increasing temperature, depending on the size of the molecules.

☒ **D** does not change with temperature.

(Total for Question 1 = 3 marks)

2 The diagram below shows a dot and cross diagram of nitric acid.



(a) Identify which of the labelled sets of electrons represents a dative covalent bond.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) In terms of orbital overlap, the double bond is

(1)

☒ **A** a π bond.

☒ **B** two σ bonds.

☒ **C** two π bonds.

☒ **D** a σ bond and a π bond.

(Total for Question 2 = 2 marks)

3 The colour observed in a flame test is due to

☒ **A** electrons jumping to a higher energy level, absorbing energy.

☒ **B** electrons jumping to a higher energy level, emitting energy.

☒ **C** electrons dropping from a higher energy level, absorbing energy.

☒ **D** electrons dropping from a higher energy level, emitting energy.

(Total for Question 3 = 1 mark)

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4 The best way to confirm the presence of **iodine** in an aqueous solution is

☒ **A** adding hexane to form a purple layer.

☒ **B** adding hexane to form an orange layer.

☒ **C** adding acidified silver nitrate solution to form a yellow precipitate which is soluble in concentrated ammonia.

☒ **D** adding acidified silver nitrate solution to form a yellow precipitate which is insoluble in concentrated ammonia.

(Total for Question 4 = 1 mark)

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5 The oxidation number of sulfur in sodium hydrogensulfide, NaHS, is

☒ **A** –2

☒ **B** –1

☒ **C** +1

☒ **D** +2

(Total for Question 5 = 1 mark)

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6 Which of the following is **not** a disproportionation reaction?

☒ **A** $Cl_2 + 2OH^- \rightarrow Cl^- + ClO^- + H_2O$

☒ **B** $Cu_2O + H_2SO_4 \rightarrow CuSO_4 + Cu + H_2O$

☒ **C** $3IO^- \rightarrow 2I^- + IO_3^-$

☒ **D** $Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$

(Total for Question 6 = 1 mark)

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

7 Hydrogen iodide has a higher boiling temperature than hydrogen bromide. This is because

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

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

☒ **C** hydrogen iodide has a larger permanent dipole than hydrogen bromide.

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

(Total for Question 7 = 1 mark)

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8 Butane has a higher boiling temperature than 2-methylpropane. This is because butane has

☒ **A** stronger C—H bonds.

☒ **B** more electrons.

☒ **C** a larger surface area.

☒ **D** hydrogen bonds.

(Total for Question 8 = 1 mark)

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9 The oxygen atom in a molecule of water has two bonding pairs and two lone pairs of electrons. Based on the electron-pair repulsion theory, the H—O—H bond angle is most likely to be

☒ **A** 180°

☒ **B** 109.5°

☒ **C** 107°

☒ **D** 104.5°

(Total for Question 9 = 1 mark)

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10 The shape of a molecule of boron trifluoride, BF_3, is

☒ **A** trigonal planar.

☒ **B** pyramidal.

☒ **C** tetrahedral.

☒ **D** T-shaped.

(Total for Question 10 = 1 mark)

11 When solid samples of sodium carbonate and magnesium carbonate are strongly heated

☒ **A** both compounds decompose.

☒ **B** sodium carbonate decomposes but magnesium carbonate does not.

☒ **C** magnesium carbonate decomposes but sodium carbonate does not.

☒ **D** neither compound decomposes.

(Total for Question 11 = 1 mark)

12 As Group 2 is **descended**

☒ **A** the solubility of hydroxides and of sulfates increases.

☒ **B** the solubility of hydroxides increases and of sulfates decreases.

☒ **C** the solubility of hydroxides decreases and of sulfates increases.

☒ **D** the solubility of hydroxides and of sulfates decreases.

(Total for Question 12 = 1 mark)

13 These questions concern the use of infrared (IR) spectra to identify organic compounds. The IR absorption ranges associated with some organic functional groups are given below.

A O—H stretching in alcohols at 3750 – 3200 cm^{-1}

B C═O stretching in aldehydes at 1740 – 1720 cm^{-1}

C C═O stretching in ketones at 1700 – 1680 cm^{-1}

D C═O stretching in carboxylic acids at 1725 – 1700 cm^{-1}

(a) When propan-2-ol is refluxed with potassium dichromate(VI) and sulfuric acid, the **product** will show a peak due to

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) When propan-1-ol is heated with potassium dichromate(VI) and sulfuric acid, the **product**, that is distilled off as it is formed, will show a peak due to

(1)

☒ **A**

☒ **B**

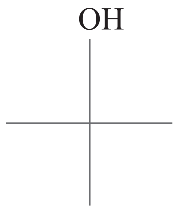
☒ **C**

☒ **D**

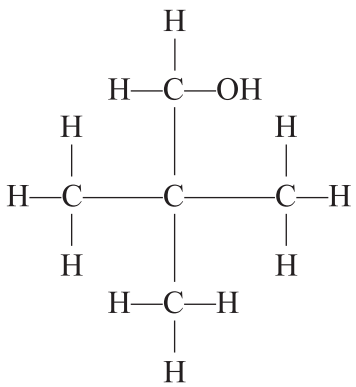
(Total for Question 13 = 2 marks)

14 Which of the following formulae does **not** represent 2,2-dimethylpropan-1-ol?

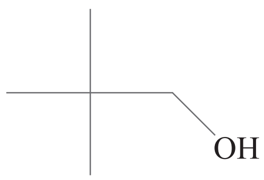
☒ **A**



☒ **B**



☒ **C**



☒ **D** $(CH_3)_3CCH_2OH$

(Total for Question 14 = 1 mark)

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15 Nucleophiles are

☒ **A** electron pair donors that attack regions of high electron density.

☒ **B** electron pair donors that attack regions of low electron density.

☒ **C** electron pair acceptors that attack regions of high electron density.

☒ **D** electron pair acceptors that attack regions of low electron density.

(Total for Question 15 = 1 mark)

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16 Which of the following is **not** true? Chlorofluorocarbons, CFCs,

☒ **A** are flammable.

☒ **B** are greenhouse gases.

☒ **C** damage the ozone layer.

☒ **D** are excellent refrigerants.

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

17 (a) Ozone, O_3, is formed when oxygen is exposed to ultraviolet (UV) radiation or to an electric discharge. Ozone is a blue gas whereas oxygen is colourless. When the two gases are mixed, an equilibrium is established as shown in the following equation.

$$3O_2(g) \rightleftharpoons 2O_3(g) \qquad \Delta H = +143 \text{ kJ mol}^{-1}$$

(i) When the temperature of the pale blue equilibrium mixture is increased at constant volume, the colour darkens. Explain this observation in terms of the changes to the equilibrium.

(2)

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(ii) State and explain what you would **see** if the pressure of the system at equilibrium were increased.

(2)

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(iii) A small amount of oxygen gas containing the isotope ^{18}O is added to the equilibrium mixture. After a few hours, ozone containing ^{18}O is detected. Given that the equilibrium position is **not** affected, explain this observation.

(1)

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(b) The concentration of ozone in the atmosphere may be determined by bubbling air through a solution of acidified potassium iodide. Iodine is formed in solution, the concentration of which may be determined by titration with a solution of sodium thiosulfate of known concentration. The equations for the reactions are

$$O_3 + 2I^- + 2H^+ \rightarrow O_2 + H_2O + I_2 \qquad \text{Equation 1}$$

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

In an experiment to determine the concentration of ozone in a sample of air, 100 m^3 of air was bubbled through 100 cm^3 of a solution containing an excess of acidified potassium iodide.

The resulting solution was titrated against a solution of sodium thiosulfate of concentration 0.0155 mol dm^{-3}. The volume of sodium thiosulfate solution required for complete reaction was 25.50 cm^3.

(i) Calculate the number of moles of sodium thiosulfate that react.

(1)

(ii) Calculate the number of moles of iodine that reacted with the sodium thiosulfate.

(2)

(iii) Use equation 1 to deduce the number of moles of ozone that reacted with the acidified potassium iodide.

(1)

(iv) Calculate the volume of ozone, measured in m^3, present in the original sample of air. Assume that all gas volumes were measured at room temperature and pressure and that the molar volume of any gas under these conditions is $0.024\ m^3\ mol^{-1}$.

(1)

(v) Calculate the concentration of ozone in the sample of air in units of parts per million (ppm) by volume.

(1)

(vi) A student suggested that the 100 cm^3 of acidified potassium iodide should be divided into four portions before the titration. Explain how this change increases the reliability and decreases the accuracy of the experiment.

(3)

Increases reliability ....

....

....

Decreases accuracy ....

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(c) Give the oxidation numbers of oxygen in equation 1, shown below. Hence state the role of ozone in this reaction.

(3)

$$O_3 + 2I^- + 2H^+ \rightarrow O_2 + H_2O + I_2$$

Oxidation number of O ....

Role of ozone ....

(d) Ozone is used as an alternative to chlorine to disinfect flood damaged buildings, to remove residual smoke odours from fires and in the treatment of drinking water. Suggest one advantage of using ozone rather than chlorine, given that chlorine and ozone are both toxic.

(1)

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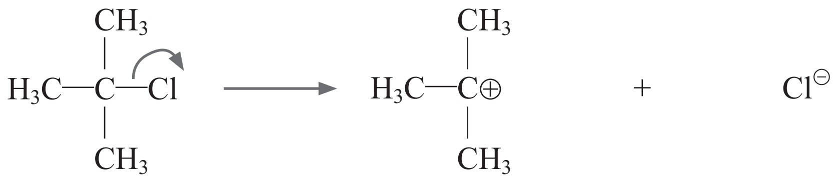
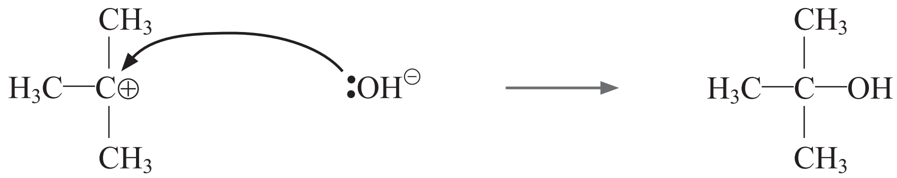
(Total for Question 17 = 18 marks)

18 The steps below show the reaction mechanism for the reaction of a halogenoalkane with sodium hydroxide in aqueous solution to form an alcohol.



X **Y**



Z

(a) (i) Name **X** and **Z**.

(2)

X ....

Z ....

(ii) Draw the **skeletal** formula of **X**.

(1)

(iii) What type of alcohol is **Z**?

(1)

....

(b) (i) Name the mechanism and type of reaction shown above.

(2)

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(ii) Explain what the curly arrows shown in the mechanism represent.

(1)

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*(iii) Suggest the shape of the intermediate **Y**. Explain your answer.

(3)

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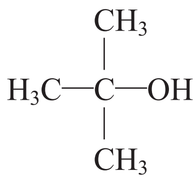
(iv) If the reaction is carried out in alcoholic (ethanolic) rather than aqueous solution, a different type of reaction occurs and a different product is formed. Name the type of reaction that occurs in alcoholic (ethanolic) solution and identify the product by name or formula.

(2)

Type of reaction..

Product

(c) The alcohol **Z** (shown below) resists oxidation. However, **Z** has three structural isomers which are readily oxidized. On complete oxidation, one isomer forms a ketone and the other two isomers form carboxylic acids.



Z

(i) Draw the structural formula of the isomer of **Z** that forms a ketone.

(1)

(ii) Draw the structural formulae of the isomers of **Z** that form carboxylic acids.

(2)

(Total for Question 18 = 15 marks)

19 Metal nitrates decompose on heating. Potassium nitrate, KNO_3, decomposes to form potassium nitrite and oxygen, whereas calcium nitrate, $Ca(NO_3)_2$, decomposes to form calcium oxide, nitrogen dioxide and oxygen.

(a) Write equations for the decomposition of each of these metal nitrates. State symbols are **not** required.

(2)

(i) Potassium nitrate

(ii) Calcium nitrate

(b) State **two** things that you would **see** when anhydrous calcium nitrate is heated.

(2)

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*(c) Explain why potassium nitrate and calcium nitrate decompose to form different products.

(3)

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(Total for Question 19 = 7 marks)

TOTAL FOR SECTION B = 40 MARKS

SECTION C

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

20

Fuels of the Future

Concerns about the future availability of fossil fuels, and the fact that their combustion produces greenhouse gases, have led to a search for alternative sources of energy. A great deal of attention has been directed at developing the use of hydrogen as a fuel. Since the only product of its combustion is water, hydrogen is considered to be a clean fuel.

However, the use of hydrogen has major drawbacks. The small size of the hydrogen molecule means that it is difficult to prevent leaks and, to store enough to provide a reasonable amount of fuel for a car, hydrogen must be compressed to around 700 atmospheres. Furthermore, the main source of hydrogen is currently fossil fuels such as methane, which is combined with steam in a series of reactions to form carbon dioxide and hydrogen.

One suggested alternative to hydrogen is ammonia. Ammonia, which is obtained by combining nitrogen and hydrogen at temperatures around 450 °C and pressures of about 150 atmospheres, also has serious disadvantages: it is a toxic, corrosive and pungent gas which is difficult to ignite.

However, burning ammonia produces only nitrogen and water and it is relatively easy to liquefy, having a boiling temperature of just –33 °C. Furthermore, the technology works: ammonia was used as a fuel for Belgian buses in the Second World War and, in 2007, the 'NH3 Car' project based in Ann Arbor, Michigan, used a mixture of ammonia and petrol to fuel a 2500 mile journey, from Detroit to San Francisco, in a modified pickup truck.

(a) (i) Explain the term **greenhouse gas**.

(2)

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....

....

*(ii) State and explain whether or not water (in the gaseous state) is a greenhouse gas. **(2)**

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....

(iii) Write the equation for the formation of hydrogen from methane and steam. State symbols are **not** required. **(2)**

(iv) Suggest why using methane to form hydrogen in this way is preferable to burning methane directly. **(1)**

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....

(v) Storing hydrogen at a pressure of 700 atmospheres is a disadvantage to its use as a fuel because of the costs involved. Suggest why using such high pressures is so expensive. **(1)**

....

....

....

(b) (i) Draw a dot and cross diagram for ammonia, showing the outer electrons only. **(1)**

*(ii) By considering the intermolecular forces involved, explain why methane has a boiling temperature of 109 K while ammonia has a boiling temperature of 240 K, although these two compounds have very similar molar masses.

(4)

(c) (i) Write the equation for the combustion of ammonia. State symbols are **not** required.

(2)

(ii) The enthalpy change of combustion of methane is –890.3 kJ mol^{-1} and that of ammonia is –510.1 kJ mol^{-1}. Suggest **two** additional items of information, **not** connected with environmental factors or the fact that methane is non-renewable, which would be useful in comparing methane and ammonia as fuels.

(2)

(iii) The fact that ammonia has a pungent smell is listed as a disadvantage of its use as a fuel. Suggest why this might also be an advantage.

(1)

(iv) Suggest why ammonia was mixed with petrol in the 'NH3 Car' project.

(1)

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....

(v) State, with a reason, whether hydrogen or ammonia can currently be considered to be long term replacements for fossil fuels.

(1)

....

....

....

(Total for Question 20 = 20 marks)

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

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)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	*(18)*
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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											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