Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 2: Application of Core Principles of Chemistry

Friday 20 October 2017 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH02/01

Candidates must have: Scientific calculator

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.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care on these questions 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.
- Try to answer every question.
- Check your answers if you have time at the end.
- Show all your working in calculations and include units where appropriate.

Turn over ▶

P 5 0 7 8 6 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 Which compound is likely to show the **most** ionic character?

☒ **A** PH_3

☒ **B** BH_3

☒ **C** NaI

☒ **D** KCl

(Total for Question 1 = 1 mark)

2 Which species has a similar shape to that of an ammonia molecule?

☒ **A** BH_3

☒ **B** CH_3^+

☒ **C** CH_3^-

☒ **D** CO_3^{2-}

(Total for Question 2 = 1 mark)

3 Which compound contains a dative covalent bond?

☒ **A** NH_3

☒ **B** NCl_3

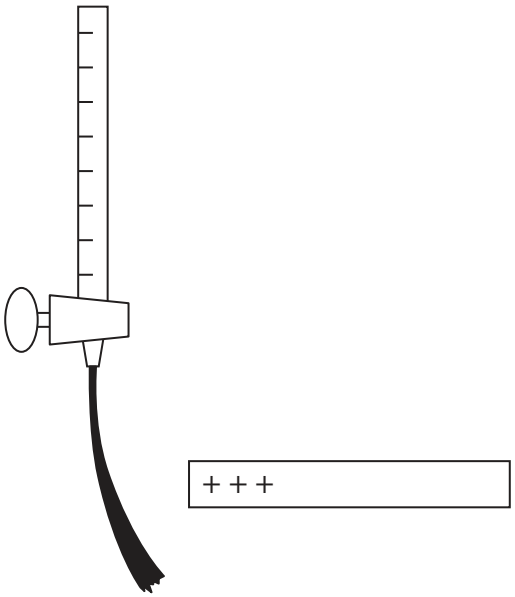
☒ **C** NH_4Cl

☒ **D** CH_3NH_2

(Total for Question 3 = 1 mark)

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

4 The diagram shows a liquid leaving a burette and passing a charged rod.



Which of the following liquids will be **most** attracted to the charged rod?

☒ **A** CCl_4

☒ **B** C_5H_{12}

☒ **C** CS_2

☒ **D** $CHCl_3$

(Total for Question 4 = 1 mark)

5 Which substance has more than one type of intermolecular force between its molecules in the liquid state?

☒ **A** Br_2

☒ **B** P_4

☒ **C** NH_3

☒ **D** CH_4

(Total for Question 5 = 1 mark)

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

6 Which is a pure form of carbon that has **both** hexagonal and pentagonal rings in its structure?

☒ **A** Graphite

☒ **B** Diamond

☒ **C** Cyclohexane

☒ **D** Buckminsterfullerene

(Total for Question 6 = 1 mark)

7 Which species contains bond angles equal to 90°?

☒ **A** $BeCl_2$

☒ **B** NH_4^+

☒ **C** $SiCl_4$

☒ **D** SF_6

(Total for Question 7 = 1 mark)

8 A white solid gives a lilac flame-test colour. It reacts with water, forming a strongly alkaline solution.

The solid could be

☒ **A** calcium oxide

☒ **B** potassium oxide

☒ **C** calcium chloride

☒ **D** potassium chloride

(Total for Question 8 = 1 mark)

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

9 As the atomic number of the Group 2 metals increases, the

- ☒ **A** first ionisation energy decreases.
- ☒ **B** atomic radius decreases.
- ☒ **C** electronegativity increases.
- ☒ **D** number of outer shell electrons increases.

(Total for Question 9 = 1 mark)

10 Which Group 2 hydroxide is the most soluble in water?

- ☒ **A** Barium hydroxide
- ☒ **B** Calcium hydroxide
- ☒ **C** Magnesium hydroxide
- ☒ **D** Strontium hydroxide

(Total for Question 10 = 1 mark)

11 What is the trend in bond energies for the sequence of molecules chlorine to bromine to iodine?

- ☒ **A** Decreases
- ☒ **B** Decreases to bromine then increases
- ☒ **C** Increases
- ☒ **D** Increases to bromine then decreases

(Total for Question 11 = 1 mark)

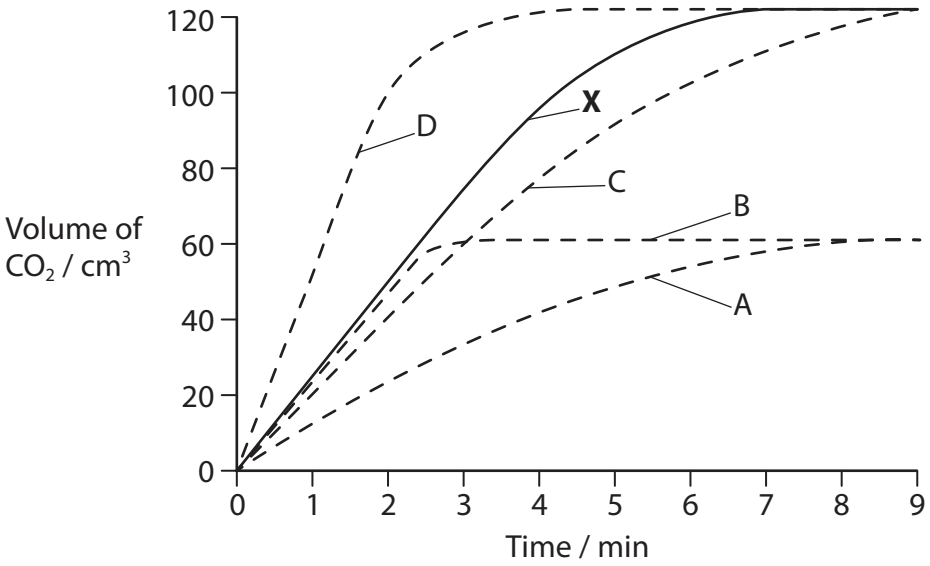
12 What is seen when concentrated sulfuric acid is added to solid sodium chloride at room temperature?

- ☒ **A** Green gas
- ☒ **B** Steamy fumes
- ☒ **C** White smoke
- ☒ **D** Yellow solid

(Total for Question 12 = 1 mark)

13 Curve **X** was obtained when 0.50 g of calcium carbonate **powder** reacted with excess dilute hydrochloric acid at 20 °C.

Which curve best represents the reaction of a single 0.25 g **chip** of calcium carbonate with excess of the same dilute hydrochloric acid at the same temperature?



☒ **A**

☒ **B**

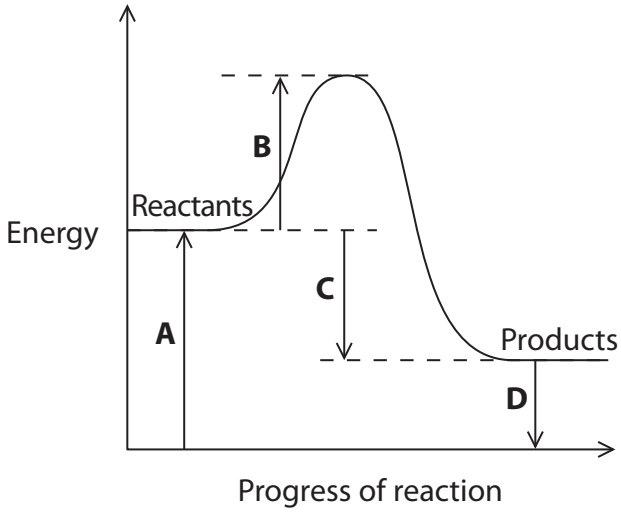
☒ **C**

☒ **D**

(Total for Question 13 = 1 mark)

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

14 Consider the following reaction profile.



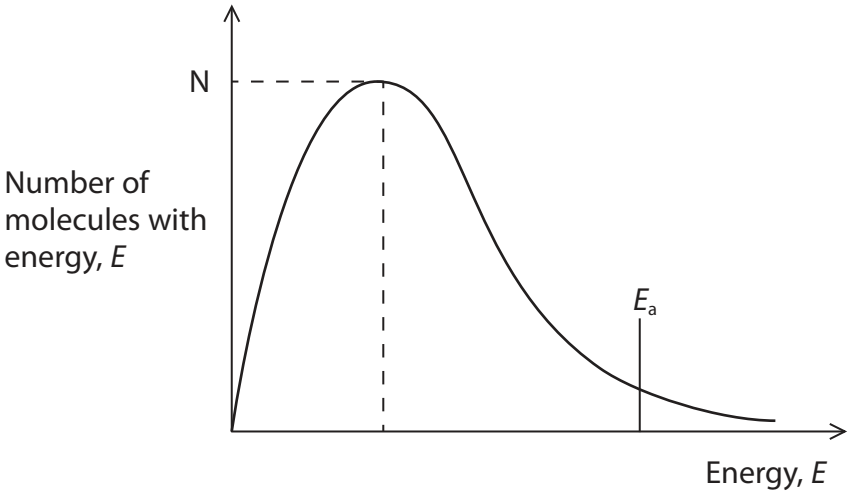
Which energy change would alter if a catalyst were added to the reaction?

- ☒ **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 The Maxwell–Boltzmann distribution for a reaction mixture is shown below.
E_a is the activation energy and N is the number of molecules with the most probable energy.



What is the effect of **increasing** the temperature on E_a and on N?

	Effect on E_a	Effect on N
☒ **A**	increases	decreases
☒ **B**	increases	increases
☒ **C**	constant	decreases
☒ **D**	constant	increases

(Total for Question 15 = 1 mark)

16 Which statement regarding a chemical reaction at equilibrium is **always** true?

☒ **A** The rates of the forward and backward reactions are equal.

☒ **B** The concentrations of reactants and products are equal.

☒ **C** The forward and backward reactions have stopped.

☒ **D** The addition of a catalyst changes the position of equilibrium.

(Total for Question 16 = 1 mark)

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

17 In which system will a change in pressure have **no** effect on the position of equilibrium?

☒ **A** $2NO_2(g) \rightleftharpoons N_2O_4(g)$

☒ **B** $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

☒ **C** $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$

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

(Total for Question 17 = 1 mark)

18 1.00 dm^3 of a solution with a **sodium** ion concentration of 0.100 mol dm^{-3} is required. What volume of 0.200 mol dm^{-3} sodium sulfate solution is needed to make this solution by dilution with water?

☒ **A** 100 cm^3

☒ **B** 250 cm^3

☒ **C** 500 cm^3

☒ **D** 1000 cm^3

(Total for Question 18 = 1 mark)

19 Propan-2-ol is produced from the reaction of propene and steam.
Assuming a 65% yield, what is the mass of propene required to produce 390 g of propan-2-ol?

[Molar masses / g mol^{-1} propene = 42.0 propan-2-ol = 60.0]

☒ **A** 254 g

☒ **B** 273 g

☒ **C** 420 g

☒ **D** 600 g

(Total for Question 19 = 1 mark)

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

20 Propene can be formed by heating 1-bromopropane with alcoholic potassium hydroxide solution.

This reaction is an example of

☒ **A** reduction.

☒ **B** hydrolysis.

☒ **C** elimination.

☒ **D** condensation.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

21 There are **four** isomeric alcohols with the molecular formula $C_4H_{10}O$.

(a) Two of these alcohols are butan-1-ol ($CH_3CH_2CH_2CH_2OH$) and butan-2-ol. The other two isomers are alcohol **X** and alcohol **Y**.

(i) Draw the **displayed** formula for butan-2-ol, showing all the bonds.

(1)

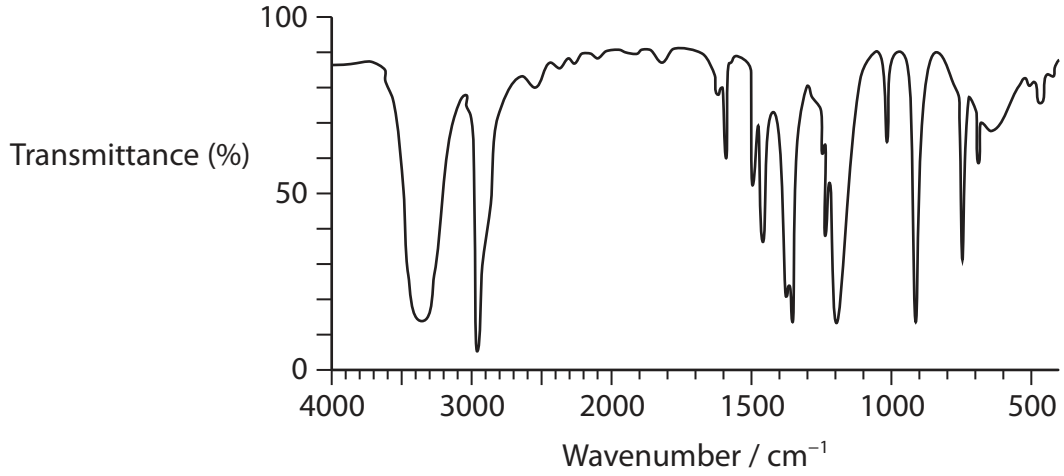
(ii) Alcohol **X** does not react with acidified potassium dichromate(VI) solution. Give the structure of alcohol **X**.

(1)

(iii) **Name** the fourth isomer, alcohol **Y**.

(1)

(b) The infrared spectrum of one of the four alcohols with the formula $C_4H_{10}O$ is shown.



Some infrared data is given in the table below.

Bond	Wavenumber / cm^{-1}
C—H stretch, alkane	2962 — 2853
C—H stretch, alkene	3100 — 3010
O—H stretch (weak), carboxylic acids	3300 — 2500
O—H stretch (broad), alcohols	3750 — 3200

(i) Circle the relevant part of the infrared spectrum which confirms that this isomer is an alcohol.

(1)

(ii) State how the infrared spectrum can be used to identify which one of the four alcohols with the formula $C_4H_{10}O$ is present.

(1)

.....

.....

.....

.....

(c) Butan-1-ol reacts with acidified potassium dichromate(VI) solution to form two different organic products, depending on the reaction conditions.

(i) Classify the alcohol butan-1-ol.

(1)

.....

(ii) Draw the **displayed** formula of the organic product formed when butan-1-ol is heated under reflux with acidified potassium dichromate(VI) solution.

(1)

(iii) Draw the **displayed** formula of the organic product formed when butan-1-ol is gently heated with acidified potassium dichromate(VI) solution and the product distilled off as it is formed.

(1)

(iv) State the type of reaction butan-1-ol undergoes in both (c)(ii) and (c)(iii).

(1)

Type of reaction: .....

(Total for Question 21 = 9 marks)

22 This question is about halogenoalkanes.

(a) A student investigates the relative rate of hydrolysis of three halogenoalkanes.

The student mixes 5 cm^3 of ethanol with five drops of halogenoalkane. This mixture is warmed to 50 °C in a water bath. The student adds 5 cm^3 of aqueous silver nitrate, also heated to 50 °C, to the halogenoalkane. The time taken for a precipitate to form is recorded in a table.

Halogenoalkane	Time taken for a precipitate to form /s
$CH_3CH_2CH_2CH_2Cl$	120
$CH_3CH_2CH_2CH_2Br$	62
$CH_3CH_2CH_2CH_2I$	20

(i) Explain why ethanol is added to each halogenoalkane.

(1)

.....

.....

(ii) Complete the equation for the hydrolysis of 1-iodobutane, $CH_3CH_2CH_2CH_2I$.

(1)

$CH_3CH_2CH_2CH_2I + H_2O \rightarrow$

(iii) Give the **name** of the organic product which forms in each of these hydrolysis reactions.

(1)

.....

(iv) Classify the type and mechanism of the reaction occurring when halogenoalkanes undergo hydrolysis, under the conditions described in this investigation.

(2)

.....

*(v) Describe and explain the trend in the rates of hydrolysis of the three halogenoalkanes.

(3)

(b) Chlorofluorocarbons (CFCs) are halogenoalkanes which have been shown to play a role in ozone depletion. Halogenoalkanes, which contain fluorine as the only halogen (HFCs), do not harm the ozone layer.

Following the Montreal Protocol of September 1987, CFCs have been replaced in many applications by HFCs.

*(i) Explain why CFCs deplete the ozone layer, whereas HFCs do not.

(2)

(ii) Suggest a reason why ozone depletion still occurs.

(1)

(Total for Question 22 = 11 marks)

23 A student was asked to find the identity of a Group 1 metal hydroxide by titration.

The student was given the following outline method.

- Fill a burette with dilute hydrochloric acid
- Accurately weigh about 1.14 g of the metal hydroxide
- **Carefully** dissolve all the metal hydroxide in water, transfer the solution and washings to a volumetric flask and then add more water to make 250.0 cm^3 of solution
- Thoroughly mix the contents of the volumetric flask
- Accurately transfer 25.0 cm^3 of this solution to a conical flask
- Add two or three drops of a suitable indicator to the solution in the flask
- Carry out a rough titration of the solution in the flask with the dilute hydrochloric acid
- Accurately repeat the titration several times and calculate a mean titre.

The student's results and relevant data are shown.

Mass of metal hydroxide = 1.14 g

Concentration of the hydrochloric acid = 0.730 g in 100 cm^3 of solution

Mean titre = 23.80 cm^3

(a) Give a reason why the student does not simply add 1.14 g of the metal hydroxide to 250 cm^3 of water.

(1)

.....

.....

(b) Name the most suitable piece of apparatus for transferring 25.0 cm^3 of the metal hydroxide solution to the conical flask.

(1)

.....

(c) Name a suitable indicator to add to the solution in the conical flask and give the colour change at the end-point.

(3)

.....

Colour change from ..... to .....

(d) The equation for the reaction between the metal hydroxide and hydrochloric acid is shown. The letter **M** represents the unknown Group 1 metal.

$$\mathbf{M}OH + HCl \rightarrow \mathbf{M}Cl + H_2O$$

(i) Calculate the concentration, in mol dm^{-3}, of the hydrochloric acid in the burette.

(2)

(ii) Calculate the number of moles of hydrochloric acid used in the titration.

(1)

(iii) Deduce the number of moles of **M**OH in 25.0 cm^3 of solution.

(1)

(iv) Calculate the total number of moles of **M**OH in the original solution.

(1)

(v) Calculate the molar mass of **M**OH, in g mol^{-1}.

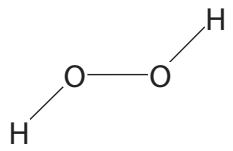
(1)

(vi) Deduce the Group 1 metal present in the compound **M**OH.

(1)

(Total for Question 23 = 12 marks)

24 A hydrogen peroxide molecule can be represented by the structure shown.



(a) Suggest a value for the H—O—O bond angle.

(1)

.....

(b) Hydrogen peroxide dissolves in water.

(i) State the strongest type of interaction that occurs between molecules of hydrogen peroxide and water.

(1)

.....

(ii) Draw a diagram to show the interaction named in (b)(i) between one molecule of hydrogen peroxide and one molecule of water.
Show any relevant lone pairs and dipoles in your diagram.

(3)

*(c) Explain, in terms of electronegativity, why the boiling temperature of H_2S_2 is lower than that of H_2O_2.

(2)

.....

.....

.....

.....

(Total for Question 24 = 7 marks)

TOTAL FOR SECTION B = 39 MARKS

SECTION C

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

25 This question is about some aspects of the chemistry of Group 7 elements.
The elements in this group can also be described as p-block elements.
The elements chlorine, bromine and iodine can all be extracted from sea water.

The bromine in sea water is present as bromide ions, Br^-.
The extraction of bromine from sea water occurs in four main stages.

Stage **1**: Formation of bromine when gaseous chlorine molecules are bubbled into an aqueous solution of bromide ions

Stage **2**: Removal of bromine vapour

Stage **3**: Production of hydrobromic acid solution from bromine

Stage **4**: Oxidation of hydrobromic acid to bromine.

(a) State why the halogens are described as p-block elements.

(1)

.....

.....

(b) Give the physical states of bromine and iodine at room temperature.

(2)

Bromine .....

Iodine .....

(c) (i) Give an **ionic** equation for the reaction occurring in Stage **1**.
Include state symbols in your answer.

(2)

(ii) Describe what you would **see** when the reaction in (c)(i) is carried out.

(1)

(iii) State the role of the chlorine during the reaction in (c)(i).
Justify your answer in terms of electron transfer.

(2)

*(d) If Stage **1** is carried out under conditions of high acidity, this prevents the disproportionation of chlorine molecules.

$$Cl_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + Cl^-(aq) + HClO(aq)$$

Explain, in terms of the above equilibrium, why this is so.

(2)

(e) In Stage **3**, bromine vapour is converted into hydrobromic acid by the reaction of bromine with a mixture of sulfur dioxide and water vapour.

(i) Give the half-equation for the formation of bromide ions from bromine molecules.
State symbols are not required.

(1)

(ii) Give the half-equation for the reaction between sulfur dioxide and water molecules to form hydrogen ions and sulfate(VI) ions.
State symbols are not required.

(1)

(iii) Hence write the ionic equation for the reaction between bromine and sulfur dioxide, in the presence of water, to form hydrogen ions, bromide ions and sulfate(VI) ions.
State symbols are not required.

(2)

(f) (i) Identify, by name or formula, a **compound** that can be used to distinguish between separate aqueous solutions of potassium bromide and potassium iodide.

(1)

.....

(ii) State what would be observed when a solution of the compound in (f)(i) is added to each of the separate aqueous solutions of potassium bromide and potassium iodide.

(2)

Observation with potassium bromide: .....

Observation with potassium iodide: .....

(iii) Identify, by name, a further reagent that could be added to the mixtures resulting from the test in (f)(ii) to confirm the identity of the halide ions.

(2)

.....

(iv) Compare the observations that would be made when the reagent identified in (f)(iii) is added to the mixtures formed in (f)(ii).

(2)

.....

.....

.....

.....

(Total for Question 25 = 21 marks)

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

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
(1)	(2)											(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	(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	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