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

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

Paper Reference
WCH02/01

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 ▶

P44882A

6/6/6/5/3/

P 4 4 8 8 2 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 A flame test was carried out on a mixture of magnesium chloride and potassium chloride. The flame colour observed was

☒ **A** white and lilac.

☒ **B** orange.

☒ **C** lilac.

☒ **D** bright white, which masks any other colour.

(Total for Question 1 = 1 mark)

2 The equation for the reaction of lithium with excess water is

☒ **A** $2Li(s) + 2H_2O(l) \rightarrow Li_2O_2(s) + 2H_2(g)$

☒ **B** $2Li(s) + H_2O(l) \rightarrow Li_2O(s) + H_2(g)$

☒ **C** $Li(s) + H_2O(l) \rightarrow LiOH(s) + \frac{1}{2}H_2(g)$

☒ **D** $2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$

(Total for Question 2 = 1 mark)

3 Solid sodium is reacted with chlorine gas and the product of this reaction is added to water. This gives

☒ **A** an insoluble white crystalline solid.

☒ **B** a colourless solution.

☒ **C** a pale green solution.

☒ **D** a cloudy white mixture.

(Total for Question 3 = 1 mark)

4 The solids barium hydroxide and barium sulfate are similar in

☒ **A** their colours.

☒ **B** the pH of their solutions.

☒ **C** their reactions with hydrochloric acid.

☒ **D** their solubility in water.

(Total for Question 4 = 1 mark)

5 The solids magnesium carbonate and magnesium nitrate are identical in

☒ **A** the gas released on heating the solids.

☒ **B** their reaction with hydrochloric acid.

☒ **C** the solid product of their thermal decomposition.

☒ **D** their solubility in water.

(Total for Question 5 = 1 mark)

6 The oxidation number of sulfur in potassium aluminium sulfate (potash alum), $KAl(SO_4)_2.12H_2O$, is

☒ **A** –2

☒ **B** +2

☒ **C** +6

☒ **D** +8

(Total for Question 6 = 1 mark)

7 Which one of the following equations represents a halogen displacement reaction that can occur?

☒ **A** $2KBr(aq) + I_2(aq) \rightarrow 2KI(aq) + Br_2(aq)$

☒ **B** $2KCl(aq) + Br_2(aq) \rightarrow 2KBr(aq) + Cl_2(aq)$

☒ **C** $2KF(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + F_2(aq)$

☒ **D** $2KBr(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + Br_2(aq)$

(Total for Question 7 = 1 mark)

8 The silver halide which is insoluble in water but soluble in dilute aqueous ammonia is

☒ **A** AgCl

☒ **B** AgBr

☒ **C** AgI

☒ **D** AgAt

(Total for Question 8 = 1 mark)

9 Consider the following equilibrium.

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g) \qquad \Delta H = -92.5 \text{ kJ mol}^{-1}$$

In which of the following would **both** the stated changes increase the amount of the product, PCl_5, present at equilibrium?

☒ **A** Decreasing temperature and decreasing pressure.

☒ **B** Decreasing temperature and increasing pressure.

☒ **C** Increasing temperature and increasing pressure.

☒ **D** Increasing temperature and decreasing pressure.

(Total for Question 9 = 1 mark)

10 Consider the following simplified equilibrium for an indicator, HIn.

$$\underset{\text{yellow}}{HIn(aq)} \rightleftharpoons H^+(aq) + \underset{\text{purple}}{In^-(aq)}$$

Addition of a few drops of sodium carbonate solution would

☒ **A** make the colour of the equilibrium mixture turn purple and then yellow.

☒ **B** make the colour of the equilibrium mixture paler.

☒ **C** make the equilibrium mixture more yellow.

☒ **D** make the equilibrium mixture more purple.

(Total for Question 10 = 1 mark)

11 Which of the following species has the smallest bond angle?

☒ **A** CO_2

☒ **B** H_2O

☒ **C** SO_3

☒ **D** H_3O^+

(Total for Question 11 = 1 mark)

12 Which of the following bonds is likely to be the most polar?

☒ **A** H—F

☒ **B** P—O

☒ **C** N—Cl

☒ **D** C—S

(Total for Question 12 = 1 mark)

13 A lump of malachite, $CuCO_3.Cu(OH)_2$, reacts with 40 cm^3 of 0.50 mol dm^{-3} hydrochloric acid. The rate of reaction can be increased significantly by

☒ **A** increasing the pressure.

☒ **B** crushing the malachite lump.

☒ **C** replacing the acid with 80 cm^3 of 0.25 mol dm^{-3} hydrochloric acid.

☒ **D** using a magnetic stirrer to agitate the mixture.

(Total for Question 13 = 1 mark)

14 Consider the following reaction carried out with 0.10 g of magnesium ribbon and excess hydrochloric acid.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Which method should be used to follow the rate of this reaction?

☒ **A** Measure the pH of the solution, using a pH meter.

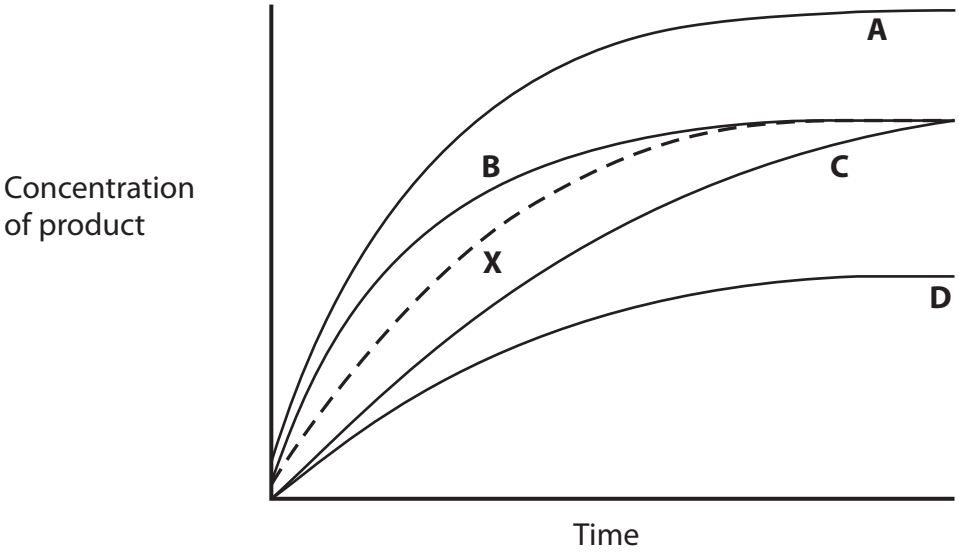
☒ **B** Measure the colour of the solution, using a colorimeter.

☒ **C** Measure the volume of gas being formed, using a gas syringe.

☒ **D** Measure the mass of the mixture, using a balance which weighs to two decimal places.

(Total for Question 14 = 1 mark)

15 In a reaction, the change in concentration of a product with time is shown by the dashed line **X** on the graph below.



Which of the lines, **A** to **D**, shows the effect of adding a catalyst to this reaction?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 15 = 1 mark)

16 Bromoethane reacts with concentrated alcoholic ammonia to produce ethylamine. However, in this reaction mixture, the ethylamine formed further reacts with the bromoethane to produce diethylamine.

This further reaction of ethylamine can best be limited by carrying out the reaction with

- ☒ **A** iodoethane instead of bromoethane.
- ☒ **B** less concentrated ammonia.
- ☒ **C** excess bromoethane.
- ☒ **D** excess ammonia.

(Total for Question 16 = 1 mark)

17 In the preparation of 1-bromobutane from butan-1-ol, it is preferable to react the sodium bromide with 50% sulfuric acid, rather than concentrated sulfuric acid.

The main reason for **not** using concentrated sulfuric acid is because it

☒ **A** makes the reaction too exothermic.

☒ **B** oxidizes HBr to Br_2.

☒ **C** is a dehydrating agent.

☒ **D** is more hazardous.

(Total for Question 17 = 1 mark)

18 The reaction between aqueous hydroxide ions and a halogenoalkane to produce an alcohol is classified as

☒ **A** electrophilic substitution with heterolytic bond fission.

☒ **B** electrophilic substitution with homolytic bond fission.

☒ **C** nucleophilic substitution with heterolytic bond fission.

☒ **D** nucleophilic substitution with homolytic bond fission.

(Total for Question 18 = 1 mark)

19 Which of the following has the longest bond length?

☒ **A** Cl—Cl

☒ **B** H—Cl

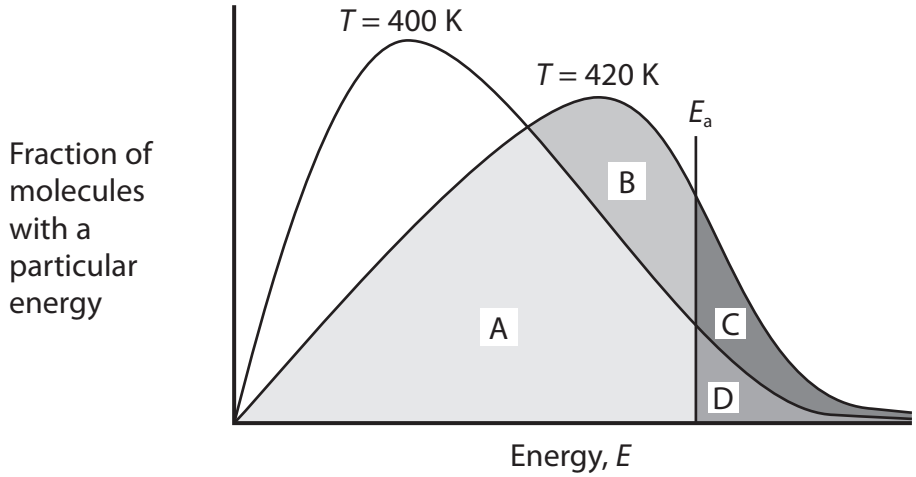
☒ **C** O═O

☒ **D** N≡N

(Total for Question 19 = 1 mark)

20 A Maxwell-Boltzmann distribution graph can be used to illustrate the effect of increasing temperature on the rate of a chemical reaction.

Which area on the graph below indicates the **increase** in the number of molecules that have sufficient energy to react, when the temperature changes from 400 K to 420 K?



☒ **A** Area B + C

☒ **B** Area C + D

☒ **C** Area C

☒ **D** Area D

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

21 This is a question about an acid-base titration.

Potassium hydroxide, KOH, is used to assist in the removal of hair. For example, it is present in some pre-shave products and used in solutions for soaking animal skins prior to the removal of the animal hair.

The skin of a red-brown cow was soaked in a solution of potassium hydroxide containing 226.8 g of potassium hydroxide in 45.0 dm^3 of solution. After several hours, the skin was removed.

The residual solution, **R**, contained unreacted potassium hydroxide. In order to determine the potassium hydroxide concentration in **R**, 25.00 cm^3 samples of the solution were titrated with 0.0500 mol dm^{-3} sulfuric acid.

Titration	Trial	1	2	3
Final volume / cm^3	5.00	9.50	14.10	18.55
Initial volume / cm^3	0.00	5.00	9.55	14.10
Volume added / cm^3	5.00	4.50	4.55	4.45

Mean titre = 4.50 cm^3

The equation for the reaction is:

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

(a) (i) Calculate the number of moles of sulfuric acid that react with 25.00 cm^3 of the potassium hydroxide solution **R**.

(1)

(ii) From your answer to (a)(i), deduce the number of moles of potassium hydroxide in the 25.00 cm^3 of solution **R**.

(1)

(iii) Calculate the concentration, in mol dm^{-3}, of potassium hydroxide in the solution **R**.

(1)

(iv) Calculate the **difference** between the initial concentration of the potassium hydroxide used to soak the animal skin and the concentration of solution **R**, which you have calculated in (a)(iii).

Relative Atomic Masses: K = 39.1; O = 16; H = 1

(3)

Initial KOH Concentration .....

KOH concentration in solution **R** .....

Difference .....

(v) Calculate the total mass of potassium hydroxide used up in the soaking process. Give your answer to **three** significant figures.

(2)

(b) The indicator phenolphthalein could have been used for this titration.

(i) State the colour change you would expect at the end-point of a titration when sulfuric acid is added to potassium hydroxide using phenolphthalein.

(2)

From ..... to .....

(ii) Suggest why the particular skin used might make it difficult to accurately judge the end-point of the titration.

(1)

.....

.....

(iii) Phenolphthalein is used as a solution in ethanol which is highly flammable. A student suggested that for safety reasons there should be no naked flames present during this titration.

Is this an appropriate suggestion? Justify your answer.

(1)

.....

.....

.....

(c) Titration experiments use equipment with a measurement uncertainty. For a pipette, the uncertainty is ±0.06 cm^3 on the volume measured. For each burette reading, the uncertainty is ±0.05 cm^3.

(i) By calculating the percentage error for the burette titre value of 4.50 cm^3, and for the pipette volume of 25.00 cm^3, show that in this case the burette error is greater than the pipette error.

(2)

Burette titre % error .....

Pipette volume % error .....

(ii) Suggest **two** ways by which the percentage error for the burette titre could be reduced, without changing the apparatus.

(2)

1 .....

.....

2 .....

.....

(iii) The trial titre value was not included in the calculation of the mean.

In what circumstances could the trial value be used in the calculation of the mean?

(1)

.....

.....

(Total for Question 21 = 17 marks)

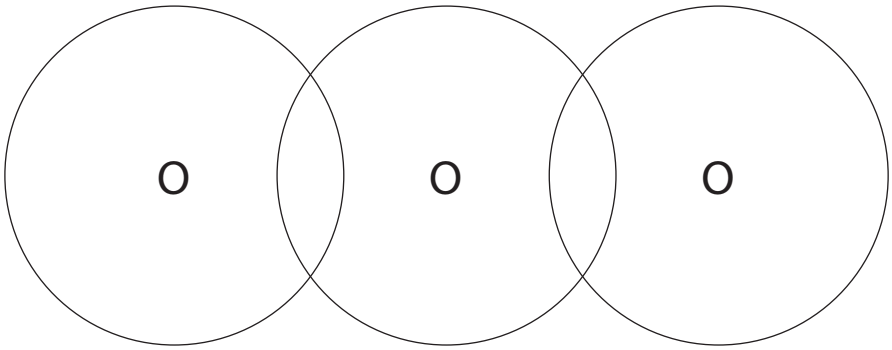
22 This is a question about environmental chemistry.

(a) Ozone, O_3, is a non-linear molecule present in the Earth's upper atmosphere. It absorbs ultraviolet radiation from the Sun and so protects living organisms from this type of radiation.

(i) Complete the dot and cross diagram for the ozone molecule. Show the outer electrons only.

Use dots (●) for the electrons of the left-hand oxygen atom, crosses (**x**) for the central oxygen atom and triangles (△) for the right-hand oxygen atom.

(2)



(ii) Explain why ozone is a non-linear molecule.

(1)

.....

.....

(iii) State **one** harmful consequence to a person of increased exposure to ultraviolet radiation.

(1)

.....

.....

(iv) What property of ultraviolet radiation makes it more harmful than infrared radiation to living organisms? Justify your answer.

(1)

.....

.....

(v) Nitrogen oxides in aircraft emissions are involved in the depletion of the ozone layer. One of these oxides is the free radical nitrogen monoxide.

Define the term **free radical**.

(1)

.....

.....

(vi) Complete the equations below for the reaction of the nitrogen monoxide with ozone.

(3)

Reaction 1 $NO^{\bullet}$ + O_3 → ..... + ...

Reaction 2 ..... + O_3 → ..... + ...

Overall Reaction →

(vii) Based on your answer in (a)(vi), what is the role of the nitrogen monoxide in the depletion of the ozone layer?

(1)

.....

.....

(viii) Suggest why the release of free radical nitrogen oxides by vehicles, such as buses and lorries, does not affect the ozone layer.

(1)

.....

.....

(b) Environmentalists are concerned by the increase in concentration in the atmosphere of gases that absorb infrared radiation because of the effect on climate change.

(i) Carbon dioxide is a molecule in the atmosphere that absorbs infrared radiation.

Explain why this molecule absorbs infrared radiation and what effect this absorption has on the molecule.

(2)

.....

.....

.....

.....

(ii) Suggest a gas, of which there is a significant concentration in the atmosphere, which does **not** absorb infrared radiation.

(1)

(iii) CFCs make a significant contribution to global warming, despite being present in only very small concentrations in the atmosphere. Suggest a reason for this.

(1)

(iv) Suggest why there is now little concern over the contribution of CFCs to global warming compared with that of carbon dioxide.

(1)

(v) Water vapour is another molecule in the atmosphere that absorbs infrared radiation, but it is not considered to be responsible for anthropogenic climate change. Justify this statement.

(2)

(vi) The term 'carbon neutrality' has become widely used with reference to biofuels. Use of biofuels is one of the measures employed in an attempt to stabilise the level of carbon dioxide in the atmosphere and hence to reduce climate change.

Explain the term 'carbon neutrality' and suggest why biofuels are unlikely to be completely carbon neutral.

(2)

(vii) Suggest **two** measures, other than the use of biofuels, by which the chemical industry could reduce its carbon footprint.

(2)

1 .....

.....

2 .....

.....

(Total for Question 22 = 22 marks)

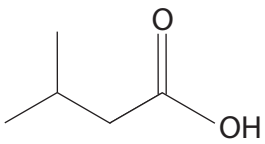
TOTAL FOR SECTION B = 39 MARKS

SECTION C

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

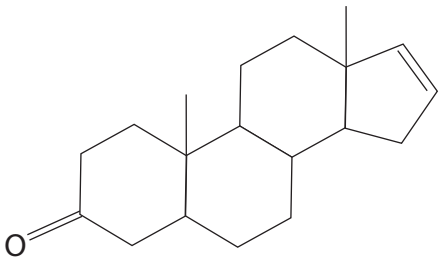
23 Some organic molecules, either on their own or as part of a mixture, contribute to some very unpleasant odours.

The molecule shown below, commonly called isovaleric acid, is responsible for the smell of sweaty feet.



Isovaleric acid can be used to produce esters that have important industrial uses in the pharmaceutical industry, as sedatives and tranquilizers, and in the food industry, as flavouring and fragrance additives.

The molecule with the systematic name (5α)-androst-16-en-3-one, labelled **X** in this question, is found in human sweat and urine.



X

However, in other situations, these molecules can induce a very different effect. For example, **X** is present in commercial products used by pig farmers to determine when sows are ready for mating.

(a) What is the systematic name for isovaleric acid?

(1)

.....

(b) What is the molecular formula of isovaleric acid?

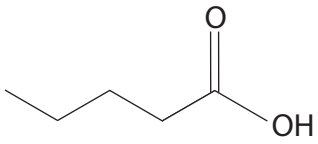
(1)

.....

(c) Isovaleric acid has three structural isomers which are also carboxylic acids. One of these acids is drawn in the first box below.

In the empty boxes below, draw the structures, using **skeletal** formulae, of the other two carboxylic acid structural isomers of isovaleric acid.

(2)

 valeric acid		

*(d) At room temperature, valeric acid is a liquid. It is sparingly soluble in water and very soluble in ethanol.

Describe simple experiments you could carry out to show the different solubilities of valeric acid in these two solvents. No measurements are required, but you should state how you would make your experiments valid.

State the expected observations from your experiments.

(3)

(e) Isoamyl alcohol is the alcohol from which isovaleric acid can be produced directly. This alcohol forms intermolecular hydrogen bonding.

Using the simplified representation R—O—H, draw a hydrogen bond between two alcohol molecules and clearly indicate the bond angle about the hydrogen involved in the hydrogen bond.

(2)

(f) There are also London forces between molecules of isoamyl alcohol.

*(i) Describe how London forces are formed.

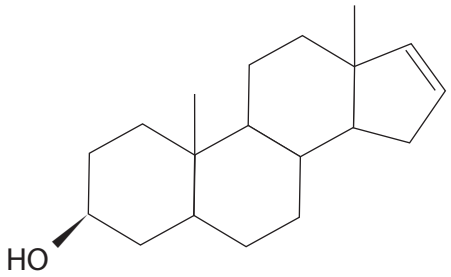
(2)

(ii) The straight-chain structural isomer of isoamyl alcohol has a boiling temperature of 138 °C.

Suggest whether the boiling temperature for isoamyl alcohol will be higher than, lower than or the same as the straight-chain isomer. Justify your choice.

(3)

(g) The molecule identified as **X** in the introduction to question 23, can be formed from the alcohol **Y** shown below.



Y

(i) The oxidation of an alcohol of this type with acidified sodium dichromate(VI) could involve either reflux or distillation.

Explain why either could be used in this case.

(1)

.....

.....

.....

(ii) An alternative reagent for the oxidation of an alcohol is acidified potassium manganate(VII), $KMnO_4$. However, this is likely to produce other products because **X** contains another functional group that could react with this reagent.

Name this other functional group in **X** and suggest the type of molecule formed in its reaction with acidified potassium manganate(VII), $KMnO_4$.

(2)

Functional group that reacts .....

Type of molecule formed .....

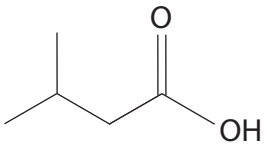
*(h) Isovaleric acid and alcohol **Y** could react together to produce a compound with a pleasant aroma, but this can be masked by even a small residue of the starting molecules.

Generally, spectroscopic methods are much more reliable than sense of smell in detecting the presence of molecules.

The infrared absorption ranges associated with some functional groups are given below.

O—H stretching in alcohols	3750 – 3200 cm^{-1}
O—H stretching in carboxylic acids	3300 – 2500 cm^{-1}
C=O stretching in aldehydes	1740 – 1720 cm^{-1}
C=O stretching in ketones	1700 – 1680 cm^{-1}
C=O stretching in carboxylic acids, alkyl	1725 – 1700 cm^{-1}
C—H stretching in alkane	2962 – 2853 cm^{-1}
C—H stretching in alkene	3095 – 3010 cm^{-1}

By quoting appropriate data, describe how both infrared spectroscopy and mass spectrometry could be used to determine the presence of **isovaleric acid**. The skeletal formula of isovaleric acid is shown below.



(4)

(Total for Question 23 = 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)
							1.0 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 damstadtium 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