A' Level Chemistry

Year 1

Unit 2: Amount Of Substance

Summer Examination Revision Pack

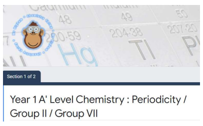
The questions in this pack should be attempted **AFTER** completing all other revision.

Grade Accelerator
Recall Definitions
Drawing Diagrams
Using Equations
Drawing Graphs

Quizlet

Quizlet Classes
Flashcard Based
Games
Tests & Quizzes
Keyword Spell Checker

Condensed Notes
Keywords & Definitions
Key Concepts
Application
Key Skills



Online Forms
Take Time to Answer
Use Paper & Calculator
Work It Out
Review Missed Marks

Use the 3 Wave Process when completing these revision packs.

1. Complete the questions without assistance
(Can't answer a question? Leave it and move on)
2. Use your notes to fill any gaps after step 1
3. Use the mark scheme to fill in any remaining gaps.

1. Having gaps after step 1 is normal, that's why we are doing revision!
2. If your notes don't help during step 2, they are not good enough!
(Change your note taking method and try to understand the problem)
3. If you don't understand why the mark scheme answer is correct, **see Andy.**

STOP If you struggle with the questions in the pack, **STOP!** and complete some more revision.

STOP If you come to a complete dead-end, **STOP!** and speak to **Andy** asap.

Do not write outside the box

0 6 A student does an experiment to determine the percentage of copper in an alloy.

The student

- reacts 985 mg of the alloy with concentrated nitric acid to form a solution (all of the copper in the alloy reacts to form aqueous copper(II) ions)
- pours the solution into a volumetric flask and makes the volume up to 250 cm^3 with distilled water
- shakes the flask thoroughly
- transfers 25.0 cm^3 of the solution into a conical flask and adds an excess of potassium iodide
- uses exactly 9.00 cm^3 of 0.0800 mol dm^{-3} sodium thiosulfate ($Na_2S_2O_3$) solution to react with all the iodine produced.

The equations for the reactions are

$$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$$

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

0 6 . 1 Calculate the percentage of copper by mass in the alloy.

Give your answer to the appropriate number of significant figures.

[6 marks]

% copper ________________________

Do not write outside the box

0 6 . 2 Suggest **two** ways that the student could reduce the percentage uncertainty in the measurement of the volume of sodium thiosulfate solution, using the same apparatus as this experiment.

[2 marks]

1 ____

____

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2 ____

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____

0 6 . 3 State the role of iodine in the reaction with sodium thiosulfate.

[1 mark]

____

0 6 . 4 Give the full electron configuration of a copper(II) ion.

[1 mark]

____

0 6 . 5 Copper(I) iodide is a white solid.

Explain why copper(I) iodide is white.

[2 marks]

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____

____

____

Question 6 continues on the next page

Turn over ►

Question	Answers	Additional Comments/Guidelines	Mark
06.1	M1 Amount of $S_2O_3^{2-}$ = $\frac{9.00 \times 0.0800}{1000}$ = 7.20×10^{-4} mol		1
	(From equations mol $S_2O_3^{2-}$ = mol Cu^{2+}) M2 Amount of Cu^{2+} in 25 cm^3 = 7.20×10^{-4} mol	M2 = answer to M1 (1:1 ratio)	1
	M3 Amount of Cu^{2+} in 250 cm^3 = 7.20×10^{-4} **<u>x10</u>** = 7.20×10^{-3} mol	M3 = M2 x 10	1
	M4 Mass of copper = 7.20×10^{-3} mol **<u>x 63.5</u>** = 0.457 g	M4 = M3 x 63.5	1
	M5 mass = 0.985 g	M5 converting 985mg to g	1
	M6 % Cu = 0.457 x $\frac{100}{0.985}$ = 46.4 %	M6 is for the answer to **3 sf** Allow % Cu = 457 x $\frac{100}{985}$ = 46.4 % for M5 and M6 Allow (M4 x1000)/985 x 100 for M5 and M6	1
06.2	Use more of the alloy Use a lower concentration of the thiosulfate solution/lower mass of $Na_2S_2O_3$ to make solution		1 1
06.3	Oxidizing agent	Allow electron acceptor	1
06.4	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$	Do not allow $[Ar]3d^9$	1
06.5	Full (3)d (sub)shell or $(3)d^{10}$ No (d-d) transitions possible/ cannot absorb visible/white light	M2 is dependent on M1 Ignore reflects visible/white light	1 1

0 8 A student does an experiment to determine the percentage by mass of sodium chlorate(I), NaClO, in a sample of bleach solution.

Method:

- Dilute a 10.0 cm^3 sample of bleach solution to 100 cm^3 with distilled water.
- Transfer 25.0 cm^3 of the diluted bleach solution to a conical flask and acidify using sulfuric acid.
- Add excess potassium iodide to the conical flask to form a brown solution containing $I_2(aq)$.
- Add 0.100 mol dm^{-3} sodium thiosulfate solution ($Na_2S_2O_3$) to the conical flask from a burette until the brown solution containing $I_2(aq)$ becomes a colourless solution containing $I^-(aq)$.

The student uses 33.50 cm^3 of sodium thiosulfate solution.

The density of the original bleach solution is 1.20 g cm^{-3}

The equations for the reactions in this experiment are

$$ClO^-(aq) + 2\,H^+(aq) + 2\,I^-(aq) \rightarrow Cl^-(aq) + H_2O(l) + I_2(aq)$$

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

0 8 . 1 Use all the information given to calculate the percentage by mass of NaClO in the original bleach solution.

Give your answer to 3 significant figures.

[7 marks]

Percentage by mass ________________________

Do not write outside the box

0 8 . 2 The total uncertainty from two readings and an end point error in using a burette is ± 0.15 cm^3

What is the total percentage uncertainty in using the burette in this experiment?

[1 mark]

Tick (✓) **one** box.

0.45% ☐

0.90% ☐

1.34% ☐

8

Turn over for the next question

Question	Answers	Additional comments/Guidelines	Mark
08.1	M1 n($S_2O_3^{2-}$) = 33.50 x 0.100 ÷1000 = <u>0.00335</u> M2 n(I_2) = 0.00335 **÷ 2** = 0.001675 (from eqn 2) M3 n(ClO^-) in 25 cm^3 pipette = 0.001675 (from eqn 1) M4 n(ClO^-) in 100 cm^3 flask = 0.001675 **<u>x 4</u>** = 0.00670 = n(NaClO) in original 10cm^3 sample M5 mass (NaClO) = 0.00670 <u>x 74.5</u> = 0.499 g M6 mass (bleach) = 10.0 x 1.20 = <u>12</u> g M7 % by mass of NaClO = $\frac{0.499}{12}$ x 100 = 4.16 %	M2 = M1÷2 M3 = M2 M4 = M3 x 4 M5 = M4 <u>x 74.5</u> M6 = mass of bleach M7 = (M5÷M6) x 100 to 3 significant figures Allow 4.15% to 4.17%	1 1 1 1 1 1 1
08.2	0.45%		1

Do not write outside the box

0 3 The outer layers of some golf balls are made from a polymer called polyisoprene.
The isoprene monomer is a non-cyclic branched hydrocarbon that contains 88.2 % carbon by mass.
The empirical formula of isoprene is the same as its molecular formula.

0 3 . 1 Deduce the molecular formula of isoprene and suggest a possible structure.
[4 marks]

Molecular formula ____________________

Structure

Question 3 continues on the next page

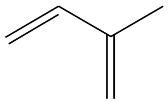
<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td rowspan="4">03.1</td><td rowspan="3">

	C	H
%mass	88.2	11.8
mol	$\frac{88.2}{12}$	$\frac{11.8}{1}$
	=7.35	=11.8
÷ smaller	$\frac{7.35}{7.35}$	$\frac{11.8}{7.35}$
	= 1	1.61
x5	=5	=8

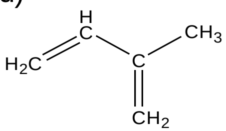
Empirical formula = molecular formula C_5H_8

</td><td>M1 for amounts 7.35 and 11.8</td><td>1</td></tr>
<tr><td>M2 for process dividing M1 by smaller</td><td>1</td></tr>
<tr><td>M3 for answer C_5H_8 only</td><td>1</td></tr>
<tr><td>

M4 (must be branched)

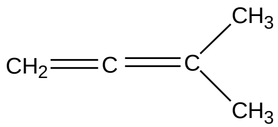


OR



</td><td>

Allow alternatives



HC≡CCH$(CH_3)_2$

</td><td>1</td></tr>
</table>

Do not write outside the box

1 0 Some compounds with different molecular formulas have the same relative molecular mass to the nearest whole number.

1 0 . 1 A dicarboxylic acid has a relative molecular mass of 118, to the nearest whole number.

Deduce the molecular formula of the acid.

[3 marks]

Molecular formula ______________________________

1 0 . 2 A student dissolved some of the dicarboxylic acid from Question **10.1** in water and made up the solution to 250 cm^3 in a volumetric flask.
In a titration, a 25.0 cm^3 sample of the acid solution needed 21.60 cm^3 of 0.109 mol dm^{-3} sodium hydroxide solution for neutralisation.

Calculate the mass, in g, of the dicarboxylic acid used.
Give your answer to the appropriate number of significant figures.

[4 marks]

Mass ______________________ g

Question	Answers	Additional Comments/Guidelines	Mark
10.1	$(COOH)_2$ = $C_2H_2O_4$= 90 118 - 90 = 28 OR C_2H_4 $C_4H_6O_4$	Must be molecular formula Structural formula can score M1 & M2	M1 M2 M3
10.2	Amount NaOH = $(21.60 \times 10^{-3}) \times 0.109$ $= 2.3544 \times 10^{-3}$ mol Amount H_2A in 25cm^3 = 1.177×10^{-3} mol Amount H_2A in 250 cm^3 = 1.177×10^{-2} mol Mass = 1.39 g (Must be 3sf)	M1 for answer (to 3sfs min) M2 = 0.5 × M1 M3 = M2 × 10 M4 = answer to (M3 × 118) and must be 3sf	M1 M2 M3 M4

0 8 This question is about citric acid, a hydrated tricarboxylic acid. Its formula can be represented as $H_3Y.xH_2O$

0 8 . 1 A 1.50 g sample of $H_3Y.xH_2O$ contains 0.913 g of oxygen by mass.
The sample burns completely in air to form 1.89 g of CO_2 and 0.643 g of H_2O

Show that the empirical formula of citric acid is $C_3H_5O_4$

[5 marks]

0 8 . 2 A 3.00 g sample of $H_3Y.xH_2O$ (M_r = 210.0) is heated to constant mass.
The anhydrous H_3Y that remains has a mass of 2.74 g

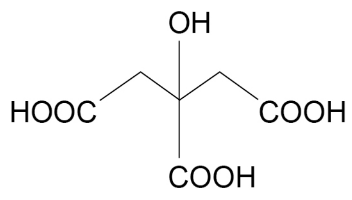
Show, using these data, that the value of x = 1

[2 marks]

Do not write outside the box

Figure 5 shows the structure of H_3Y

Figure 5



0 8 . 3 Complete this IUPAC name for H_3Y

[1 mark]

____________________________ propane-1, 2, 3-tricarboxylic acid

0 8 . 4 State the number of peaks you would expect in the ^{13}C NMR spectrum for H_3Y

[1 mark]

____

9

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th></tr>
<tr><td>08.1</td><td>
M1 Amount CO_2 = $^{1.89}/_{44}$ = 0.043 = mol C
M2 Amount H_2O = $^{0.643}/_{18}$ = 0.0357 mol
M3 Amount H = 0.036 x 2 = 0.0714 mol
M4 Amount O = $^{0.913}/_{16}$ = 0.057 mol
<table>
<tr><td></td><td>C</td><td>H</td><td>O</td></tr>
<tr><td></td><td>0.043</td><td>0.0714</td><td>0.057</td></tr>
<tr><td rowspan="2">M5</td><td>1</td><td>1.66</td><td>1.33</td></tr>
<tr><td>3</td><td>5</td><td>4</td></tr>
</table>
</td><td>
Alternate method
M1 mass C = 1.89 – (1.89 x $\frac{32}{44}$) = 0.515 g
M2 mass H = 1.5 – (0.515 + 0.913)
M3 = 0.0715 g
OR mass M2 H = 0.643 – (0.643 x $\frac{16}{18}$)
M3 = 0.0714 g
<table>
<tr><td></td><td>C</td><td>H</td><td>O</td></tr>
<tr><td>M4</td><td>$\frac{0.515}{12}$ = 0.043</td><td>$\frac{0.0715}{1}$ = 0.0715</td><td>$\frac{0.913}{16}$ = 0.057</td></tr>
<tr><td rowspan="2">M5</td><td>1</td><td>1.66</td><td>1.33</td></tr>
<tr><td>3</td><td>5</td><td>4</td></tr>
</table>
</td><td>1
1
1
1

1</td></tr>
</table>

08.2	**M1** Amount H_2O = $^{0.26}/_{18}$ = 0.014 mol **M2** Amount $H_3Y.xH_2O$ = $^{3}/_{210}$ = 0.014 mol or Amount of H_3Y = 2.74/192 = 0.014 mol (hence ratio 1:1)	Common alternate method **M1** Amount $H_3Y.xH_2O$ = $^{3}/_{210}$ = 0.0143 mol **M2** M_r H_3Y = $\frac{2.74}{0.0143}$ = 192 M_r xH_2O = 210 -192 = 18 (hence x= 1)	1 1
08.3	2(-) Hydroxy		1
08.4	Number of peaks = 4	Allow Four	1

Do not write outside the box

0 3 This question is about hydrogen peroxide, H_2O_2

The half-equation for the oxidation of hydrogen peroxide is

$$H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$$

Hair bleach solution contains hydrogen peroxide.

A sample of hair bleach solution is diluted with water.
The concentration of hydrogen peroxide in the diluted solution is 5.00% of that in the original solution.
A 25.0 cm^3 sample of the diluted hair bleach solution is acidified with dilute sulfuric acid.
This acidified sample is titrated with 0.0200 mol dm^{-3} potassium manganate(VII) solution.
The reaction is complete when 35.85 cm^3 of the potassium manganate(VII) solution are added.

0 3 . 1 Give an ionic equation for the reaction between potassium manganate(VII) and acidified hydrogen peroxide.

Calculate the concentration, in mol dm^{-3}, of hydrogen peroxide in the original hair bleach solution.

(If you were unable to write an equation for the reaction you may assume that the mole ratio of potassium manganate(VII) to hydrogen peroxide is 3:4
This is **not** the correct mole ratio.)

[5 marks]

Concentration ____________________________ mol dm^{-3}

Do not write outside the box

0 3 . 2 State why an indicator is **not** added in this titration.

[1 mark]

0 3 . 3 Give the oxidation state of oxygen in hydrogen peroxide.

[1 mark]

0 3 . 4 Hydrogen peroxide decomposes to form water and oxygen.

Give an equation for this reaction.

Calculate the amount, in moles, of hydrogen peroxide that would be needed to produce 185 cm^3 of oxygen gas at 100 kPa and 298 K

The gas constant, R = 8.31 J K^{-1} mol^{-1}

[5 marks]

Equation

Amount ______________________ mol

Question	Answers	Additional Comments/Guidelines	Mark
03.1	M1 $2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$	ignore state symbols	1
	M2 $n(MnO_4^-) = \frac{0.020 \times 35.85}{1000} = \underline{7.17 \times 10^{-4}}$ (mol)		1
	M3 $n(H_2O_2) = 7.17 \times 10^{-4} \times 5/2 = 1.793 \times 10^{-3}$ (mol)	M3 = M2 × 5/2	1
	M4 conc (H_2O_2 in sample) $= \frac{1.793 \times 10^{-3}}{25 \times 10^{-3}} = 0.0717$ (mol dm^{-3})	M4 = $\frac{M3 \times 1000}{25}$	1
	M5 original conc of H_2O_2 (= 0.0717 × $\underline{20}$) = 1.43 (mol dm^{-3})	M5 = $\frac{M4 \times 100}{5}$ allow 1.43–1.44	1 AO2
		alternative answer using 3:4 ratio given on question paper M3 = $7.17 \times 10^{-4} \times 4/3 = 9.56 \times 10^{-4}$ M4 = 0.0382 (mol dm^{-3}) M5 = 0.765 (mol dm^{-3})	

Question	Answers	Additional Comments/Guidelines	Mark
03.2	$KMnO_4$ is self-indicating **or** $KMnO_4$ is no longer decolourised at end point **or** (solution) changes (from colourless) to (pale) pink/purple at end point		1 AO1

Question	Answers	Additional Comments/Guidelines	Mark
03.3	–1		1 AO2

Question	Answers	Additional Comments/Guidelines	Mark
03.4	M1 $2H_2O_2 \rightarrow 2H_2O + O_2$	allow multiples ignore state symbols	1
	M2 V = 185 × 10^{-6} (m^3) <u>and</u> P = 100 000(Pa)	unit conversions	1
	M3 $n = \frac{PV}{RT} = \frac{100\,000 \times 185 \times 10^{-6}}{8.31 \times 298}$	rearrangement of ideal gas equation	1
	M4 $n(O_2)$ = 7.47 × 10^{-3} (mol)	calculation	1
	M5 $n(H_2O_2)$ = (7.47 × 10^{-3} × 2) = 0.0149 (mol)	allow M4 × 2 to 2 sig fig or more	1
		if incorrect rearrangement in M3 can score M1, M2 and M5	AO1 AO2

Do not write outside the box

0 1 . 3 Sodium ethanedioate is used to find the concentration of solutions of potassium manganate(VII) by titration. The equation for this reaction is

$$2\,MnO_4^- + 16\,H^+ + 5\,C_2O_4^{2-} \rightarrow 2\,Mn^{2+} + 8\,H_2O + 10\,CO_2$$

A standard solution is made by dissolving 162 mg of $Na_2C_2O_4$ (M_r = 134.0) in water and making up to 250 cm^3 in a volumetric flask.

25.0 cm^3 of this solution and an excess of sulfuric acid are added to a conical flask.
The mixture is warmed and titrated with potassium manganate(VII) solution.
The titration is repeated until concordant results are obtained.
The mean titre is 23.85 cm^3

Calculate the concentration, in mol dm^{-3}, of the potassium manganate(VII) solution.

[4 marks]

Concentration ______________________ mol dm^{-3}

Turn over ►

Question	Answers	Additional comments/Guidelines	Mark
1.3	**M1** amount of $Na_2C_2O_4$ = $\frac{0.162}{134.0} = 0.00121$ mol **M2** stoichiometry $(\frac{2}{5})$ (4.84×10^{-4}) **M3** scaling (÷10) = $0.00121 \times \frac{2}{5} \div 10 = 4.84 \times 10^{-5}$ mol **M4** concentration of MnO_4^- = $\frac{4.84 \times 10^{-5}}{\frac{23.85}{1000}} = 0.00203$ mol dm^{-3}	 M1 x $\frac{2}{5}$ M2 ÷ 10 (conc/40) M3 x $\frac{1000}{23.85}$ Min 2 sig figs	1 1 1 1

Do not write outside the box

0 2 Tschermigite is a hydrated, water-soluble mineral, with relative formula mass of 453.2

The formula of tschermigite can be represented as $M.xH_2O$, where M represents all the ions present.

Table 4 shows its composition by mass.

Table 4

Element	% by mass
N	3.09
H	6.18
Al	5.96
S	14.16
O	70.61

In an analysis, it is found that the mineral contains the ions NH_4^+, Al^{3+} and SO_4^{2-}

Calculate the empirical formula of tschermigite and the value of x in $M.xH_2O$

Describe the tests, with their results, including ionic equations, that would confirm the identities of the ions present.

[6 marks]

Do not write outside the box

6

Turn over ►

<table>
<tr><th>Question</th><th colspan="2">Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td rowspan="5">02</td><td colspan="2">This question is marked using levels of response. Refer to the Mark Scheme Instructions for examiners for guidance on how to mark it.</td><td rowspan="5">Indicative Chemistry content

Stage 1 Formula
(1a) divides % masses by A_r for each element
(N = 0.221; H = 6.18; Al = 0.221; S = 0.441; O =4.41)
(1b) divides throughout by smallest and confirms <u>formula</u> as $NH_{28}AlS_2O_{20}$
Correct formula ticks 1a and 1b irrespective of method
(1c) $x = 12$

Stage 2 Ion ID
(2a) addition of NaOH/OH^- and warming gives gas that turns (damp) red litmus blue (= ammonia) showing NH_4^+ (water bath = warm)

(2b) white ppt with acidified $BaCl_2$/Ba^{2+} = SO_4^{2-}

(2c) addition of NaOH/OH^- until in excess gives white ppt that redissolves = Al^{3+}
OR addition of carbonate giving white ppt and effervescence/fizzing/bubbles/gas formed

Stage 3 Equations (Ignore state symbols)
(3a) $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$
(3b) $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$

(3c) $Al(H_2O)_6^{3+} + 3\ OH^- \rightarrow Al(H_2O)_3(OH)_3 + 3\ H_2O$
Allow $Al^{3+} + 3\ OH^- \rightarrow Al(OH)_3$

(3d) $Al(H_2O)_3(OH)_3 + OH^- \rightarrow Al(H_2O)_2(OH)_4^- + H_2O$
Allow $Al(OH)_3 + OH^- \rightarrow Al(OH)_4^-$ etc.
OR $2Al(H_2O)_6^{3+} + 3CO_3^{2-} \rightarrow 2Al(H_2O)_3(OH)_3 + 3CO_2 + 3H_2O$
Equation with CO_3^{2-} ‘ticks’ 3c AND 3d</td><td rowspan="5">6

(2 x AO2, 4 x AO3)</td></tr>
<tr><td>Level 3

5-6 marks</td><td>All stages are covered and the explanation of each stage is correct and virtually complete

Answer communicates the whole explanation, including equations, coherently and shows a logical progression through all three stages</td></tr>
<tr><td>Level 2

3-4 marks</td><td>All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies
OR two stages covered and the explanations are generally correct and virtually complete

Answer is coherent and shows some progression through all three stages. Some steps in each stage may be incomplete</td></tr>
<tr><td>Level 1

1-2 marks</td><td>Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies
OR only one stage is covered but the explanation is generally correct and virtually complete

Answer shows some progression between two stages</td></tr>
<tr><td>Level 0

0 marks</td><td>Insufficient correct Chemistry to warrant a mark</td></tr>
</table>

The Periodic Table of the Elements

Key

relative atomic mass
symbol
name
atomic (proton) number

1	2											3	4	5	6	7	0
(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	96.0 **Mo** molybdenum 42	[97] **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	[267] **Rf** rutherfordium 104	[270] **Db** dubnium 105	[269] **Sg** seaborgium 106	[270] **Bh** bohrium 107	[270] **Hs** hassium 108	[278] **Mt** meitnerium 109	[281] **Ds** darmstadtium 110	[281] **Rg** roentgenium 111	[285] **Cn** copernicium 112	[286] **Nh** nihonium 113	[289] **Fl** flerovium 114	[289] **Mc** moscovium 115	[293] **Lv** livermorium 116	[294] **Ts** tennessine 117	[294] **Og** oganesson 118

* **58 – 71** Lanthanides	140.1 **Ce** cerium 58	140.9 **Pr** praseodymium 59	144.2 **Nd** neodymium 60	[145] **Pm** promethium 61	150.4 **Sm** samarium 62	152.0 **Eu** europium 63	157.3 **Gd** gadolinium 64	158.9 **Tb** terbium 65	162.5 **Dy** dysprosium 66	164.9 **Ho** holmium 67	167.3 **Er** erbium 68	168.9 **Tm** thulium 69	173.0 **Yb** ytterbium 70	175.0 **Lu** lutetium 71
† **90 – 103** Actinides	232.0 **Th** thorium 90	231.0 **Pa** protactinium 91	238.0 **U** uranium 92	[237] **Np** neptunium 93	[244] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[247] **Bk** berkelium 97	[251] **Cf** californium 98	[252] **Es** einsteinium 99	[257] **Fm** fermium 100	[258] **Md** mendelevium 101	[259] **No** nobelium 102	[262] **Lr** lawrencium 103