

Candidate Marks Report

Series : B 2025

This candidate's script has been assessed using On-Screen Marking. The marks are therefore not shown on the script itself, but are summarised in the table below.

Centre No :	PK470	Assessment Code :	9701
Candidate No :	80	Component Code :	22
Candidate Name :	MUHAMMAD JARGEES,		

In the table below 'Total Mark' records the mark scored by this candidate.
'Max Mark' records the Maximum Mark available for the question.

Paper:	9701/22	
Paper	43 / 60	
Total:		
Question	Total / Max Mark Mark	
1ai	1 / 1	
1aai	1 / 1	
1aiii	1 / 2	
1bi	1 / 1	
1bii	0 / 1	
1ci	0 / 1	
1cii	1 / 1	
1ciii	2 / 2	
2ai	0 / 1	
2aai	1 / 1	
2b	1 / 2	
2c	2 / 4	
2di	1 / 1	
2dii	1 / 1	
2ei	1 / 1	
2eii	1 / 1	
2eiii	4 / 4	
2fi	2 / 2	
2fii	1 / 1	
2fiii	1 / 1	
3a	1 / 2	
3b	1 / 2	
3c	1 / 1	
3di	0 / 2	
3dii	1 / 3	
3ei	1 / 1	
3eii	1 / 2	
3eiii	1 / 1	
4ai	0 / 1	
4aai	3 / 3	
4aiii	1 / 1	
4aiv	1 / 1	

4av	1	/ 2
4b	1	/ 1
4ci	1	/ 1
4cii	1	/ 1
4di	1	/ 1
4dii	3	/ 3
4diii	0	/ 1

**Cambridge International AS & A Level** *fx-991 es plus*CANDIDATE
NAME

Muhammad Jargees

CENTRE
NUMBER

PK470

CANDIDATE
NUMBER

0080

CHEMISTRY

9701/22

Paper 2 AS Level Structured Questions

October/November 2025

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer all questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has 16 pages. Any blank pages are indicated.

1 Manganese, Mn, and its compounds are widely used in many chemical reactions.

(a) Mn is usually found as a single isotope, manganese-55.

(i) Determine the number of protons, neutrons and electrons in an atom of manganese-55.

number of protons 25 neutrons 30 electrons 25 [1]

(ii) Define isotopes.

~~The relative mass of an atom compared to $\frac{1}{12}$ th~~
~~of the mass of elements with same proton but different~~ nucleon no. [1]

(iii) A sample of manganese from the Moon is found to contain manganese-53 in addition to manganese-55.

State the two pieces of information needed to determine the relative atomic mass, A_r , of manganese in this sample.

1 Percentage abundance [1]
 2 relative mass of Mn [2]

(b) The shorthand electronic configuration of manganese is $[\text{Ar}] 3d^5 4s^2$.

(i) Complete the full electronic configuration of manganese.

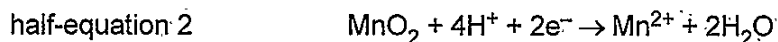
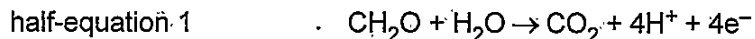
1s² 2s² 2p⁶ 3s² 3p⁶ 3d⁵ 4s² [1]

(ii) Deduce the total number of unpaired electrons in an atom of manganese.

..... 1 [1]



- (c) Manganese(IV) oxide reacts with methanal, CH_2O , in acidic conditions to produce carbon dioxide. The movement of electrons to or from relevant species is shown in the following half-equations.



- (i) Identify the species that is reduced in half-equation 2. Explain your answer.

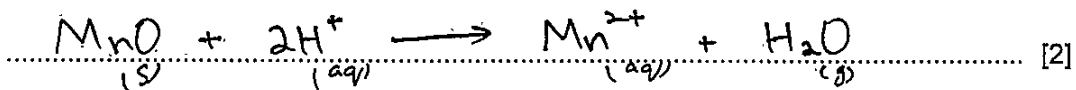
H^+ is reduced as its oxidation number decreased from +1 \rightarrow 0. [1]

- (ii) The oxidation state of carbon in methanal is 0.

Calculate the oxidation state of carbon in carbon dioxide.

+4 [1]

- (iii) Construct the ionic equation for the reaction of manganese(IV) oxide with methanal in acidic conditions.



[Total: 10]



2 The Period 3 elements show trends in physical and chemical properties across the period.

(a) (i) Explain why the elements Na to Al are good electrical conductors.

~~As~~ they all have delocalised electrons.



[1]

(ii) Explain why the elements P, S and Cl do not conduct electricity.

They do not have free moving electrons.



[1]

(b) Fig. 2.1 shows the variation in melting point of the Period 3 elements Si to Cl.

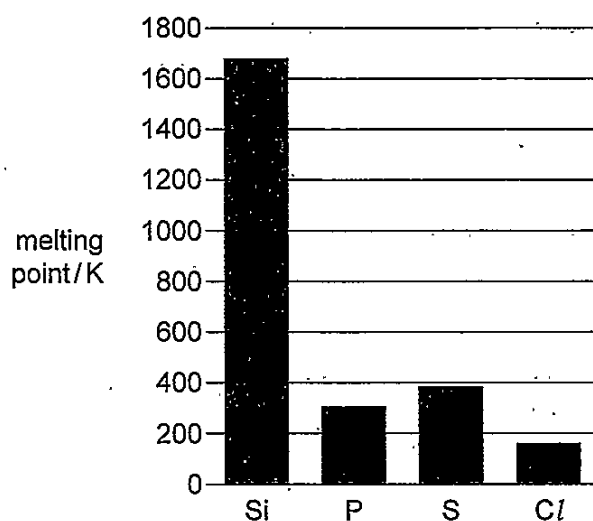


Fig. 2.1

The Period 3 elements Si to Cl are all non-metals.

Explain why there is a large difference between the melting point of Si and the melting points of P, S and Cl.

Si has a giant covalent structure while P, S and Cl have simple molecular structures so more energy needed to break bonds.



[2]



(c) Table 2.1 gives some information about some Period 3 chlorides.

Row B refers to the pH of the solution that forms when the Period 3 chloride is added to water.

Table 2.1

	formula of Period 3 chloride	NaCl	MgCl ₂	AlCl ₃	SiCl ₄	PCl ₅
A	oxidation number of element bonded to Cl	+1	+2	+3	+4	+5
B	pH of solution	7	6.5	6.5	2	2
C	bonding	I ionic	I ionic	ionic	C covalent	C covalent
D	structure	M	M	giant	S	S

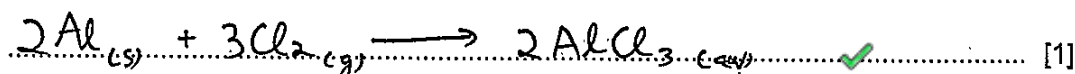
Complete Table 2.1.

You may use the following abbreviations.

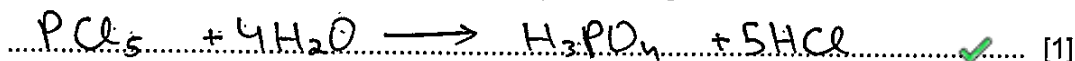
I = ionic, C = covalent, M = metallic
G = giant, S = simple

[4]

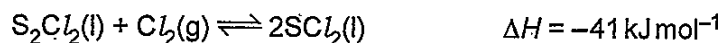
(d) (i) Write an equation for the formation of AlCl₃ from its elements.



(ii) Write an equation for the formation of H₃PO₄ from PCl₅.



(e) S₂Cl₂(l) reacts with Cl₂(g) in a reversible reaction to form SCl₂(l). Under certain conditions, a dynamic equilibrium is established.



(i) State what is meant by dynamic equilibrium.

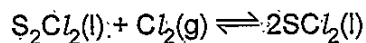
The rate of forward reaction is equal to the rate of backward reaction in a closed system. [1]

(ii) Identify the condition necessary to establish dynamic equilibrium.

Closed system. [1]



(iii) $\text{S}_2\text{Cl}_2(\text{l})$ is yellow and $\text{SCl}_2(\text{l})$ is red.



$$\Delta H = -41 \text{ kJ mol}^{-1}$$

State what is observed when the following changes are made to an equilibrium mixture of $\text{S}_2\text{Cl}_2(\text{l})$ and $\text{SCl}_2(\text{l})$.

Explain your answers.

- The equilibrium mixture is warmed gently.

observation ~~The container~~ ^{Yellow colour increases.} ~~The amount of green gas increases.~~

explanation The forward reaction is exothermic so increase in temperature would shift the equilibrium to the left. ✓

- The overall pressure of the equilibrium mixture is increased.

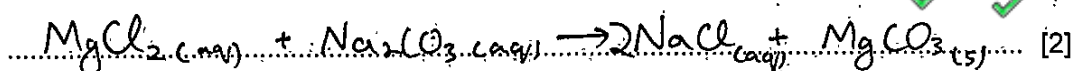
observation The red colour of solution increases. ✓

explanation There are less no. of moles on the ^{of gas} left side so increase in pressure would shift the equilibrium to the side with less moles of gas. ✓

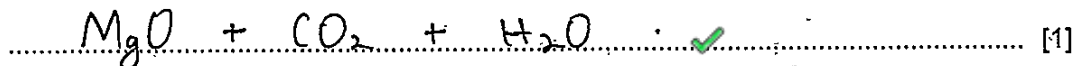
[4]

(f) Aqueous MgCl_2 reacts with aqueous Na_2CO_3 to form a white precipitate. Upon heating, the white precipitate undergoes thermal decomposition.

- (i) Construct an equation to show the reaction of aqueous MgCl_2 with aqueous Na_2CO_3 . Use state symbols in your equation.



- (ii) Identify the products of the thermal decomposition of the white precipitate.



- (iii) State the trend in thermal stability of the Group 2 carbonates down the group.

increases down the group. ✓ [1]

[Total: 20]





BLANK PAGE

SEEN



- 3 The alkanes are a homologous series of organic molecules. Alkanes are generally unreactive and are commonly used as fuels.

(a) Define homologous series.

a group
a series of organic molecules with same functional group. ✓ [2]

(b) Give two reasons to explain the general unreactivity of alkanes.

- 1 They are non-polar. ✓
- 2 Strong C-C bond (sigma bonds). [2]

(c) Alkanes with low relative molecular mass, M_r , are more useful than those found in heavier crude oil fractions.

Name the process that is used to obtain alkanes with low M_r from heavier crude oil fractions.

Cracking. ✓ [1]

(d) Hexane, C_6H_{14} , has four structural isomers.

Fig. 3.1 shows hexane and two of its structural isomers.

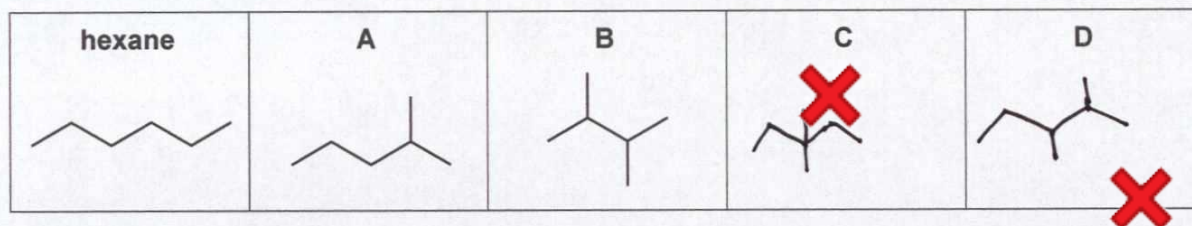


Fig. 3.1

(i) Complete Fig. 3.1 by drawing structures for C and D, the other two structural isomers of hexane. [2]

(ii) A, B and hexane have different boiling points.

Arrange A, B and hexane in order of increasing boiling point.

Explain your answer.

lowest B < A < hexane ✓ highest

[3]



- (e) Hexane can be converted into compounds E and F at high temperature and pressure. Fig. 3.2 shows the reaction scheme involving hexane, E and F.

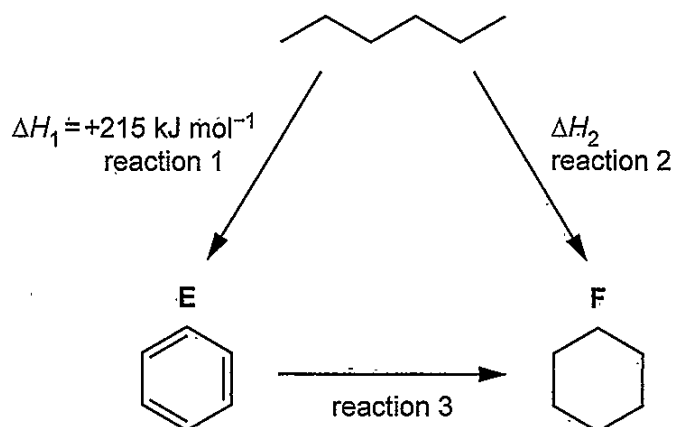


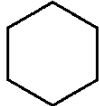
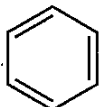
Fig. 3.2

- (i) Identify a suitable reagent for reaction 3.

$H_2(g)$ [1] ✓

- (ii) Use the data in Fig. 3.2 and in Table 3.1 to calculate the enthalpy change of reaction 2, ΔH_2 .

Table 3.1

compound	enthalpy change of formation, $\Delta H_f / \text{kJ mol}^{-1}$
	-156
	+48

$$\Delta H_3 = 48 - 156$$

$$\Rightarrow -108$$

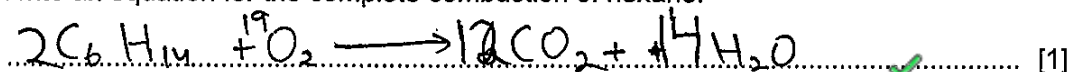
$$\Delta H_2 = \Delta H_3 + \Delta H_1$$

$$= -108 + 215$$

$$= 107$$

$\Delta H_2 =$ 107 kJ mol^{-1} [2] ✓

- (iii) Write an equation for the complete combustion of hexane.



- 4 Fig. 4.1 shows how propane, C_3H_8 , can be converted to propanoic acid, CH_3CH_2COOH .

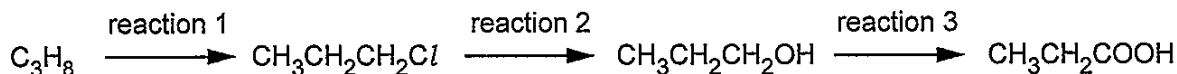
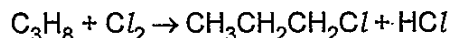


Fig. 4.1

- (a) Reaction 1 in Fig. 4.1 takes place in the presence of sunlight.



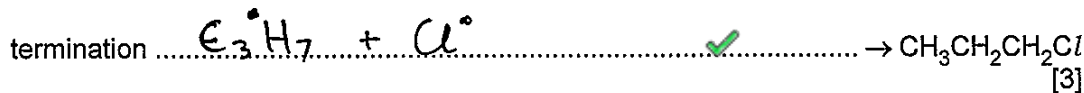
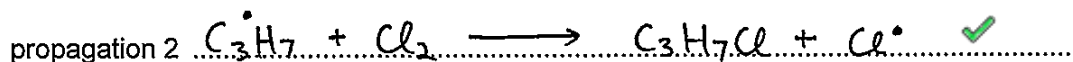
The reaction takes place via initiation, propagation and termination steps.

- (i) Name the mechanism shown by reaction 1.

Termination [1]

- (ii) Complete the mechanism for reaction 1.

Construct equations to describe the steps of the mechanism.

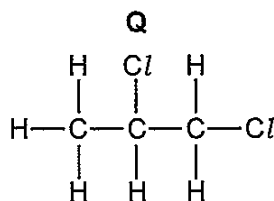


- (iii) Reaction 1 is initiated by the bond fission of Cl_2 .

State the type of bond fission shown in the initiation step.

homolytic [1]

- (iv) Compound Q is a by-product of reaction 1.



Name Q.

1,2-dichloropropane [1]



(v) The molecular formula of Q is $C_3H_6Cl_2$.

Identify the types of structural isomerism and stereoisomerism that a molecule with molecular formula $C_3H_6Cl_2$ can show.

type of structural isomerism positional isomerism ✓

type of stereoisomerism none

[2]

(b) State the reagent and solvent required for reaction 2.

aqueous NaOH / in water ✓

[1]

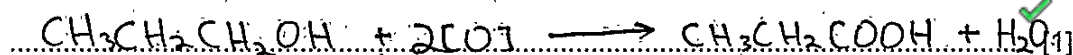
(c) Reaction 3 takes place when $CH_3CH_2CH_2OH$ is heated under reflux with acidified potassium dichromate(VI) solution.

(i) State the colour change that takes place in the reaction mixture.

orange to green ✓

[1]

(ii) Construct an equation to represent reaction 3. Use [O] to represent an atom of oxygen from the oxidising agent.



(d) $\text{CH}_3\text{CH}_2\text{COOH}$ reacts with an unsaturated alcohol **R** to form unsaturated ester **S**.

(i) State the **type** of reaction that forms **S**.

..... Condensation. ✓ [1]

(ii) The infrared spectrum of **S** is shown in Fig. 4.2.

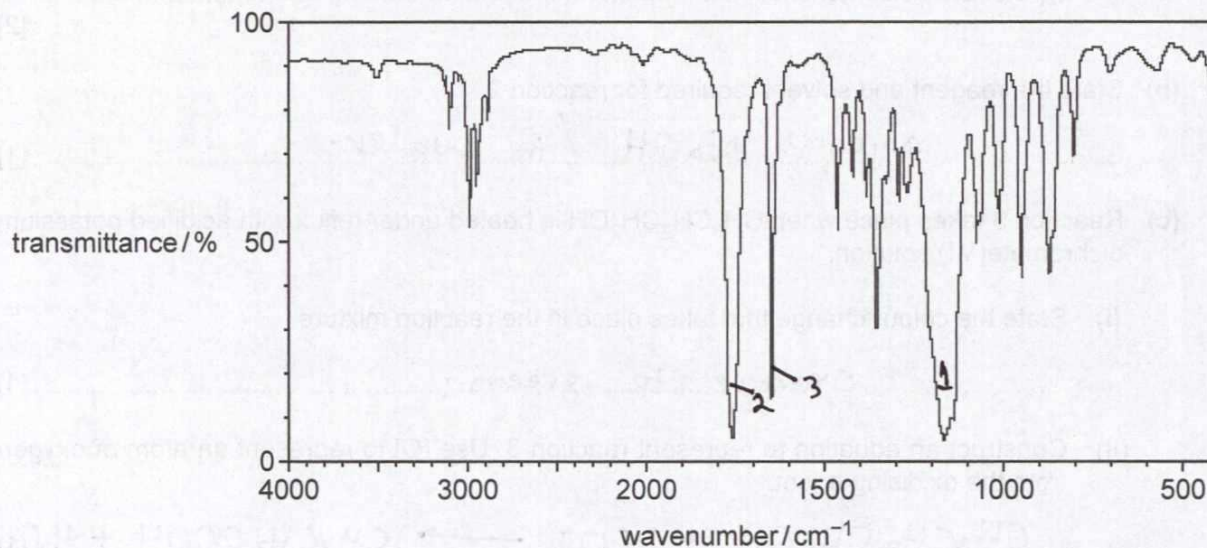


Fig. 4.2

Three absorptions in the infrared spectrum in Fig. 4.2 confirm that **S** is an ester and is unsaturated.

- Write **1**, **2** or **3** on Fig. 4.2 against each of these three absorptions.
- Complete Table 4.1 to show which bond is responsible for each absorption that you have identified in Fig. 4.2.

Table 4.1

absorption	1	2	3
bond responsible	<u>C-O</u>	<u>C=O</u>	<u>C=C</u>

[3]

✓

✓

✓



Table 4.2

bond	functional groups containing the bond	characteristic infrared absorption range (in wavenumbers) / cm^{-1}
C-O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C-H	alkane	2850–2950
N-H	amine, amide	3300–3500
O-H	carboxyl hydroxy	2500–3000 3200–3650

(iii) The mass spectrum of **S** shows the following peaks.

Table 4.3

peak	relative abundance
M^+	4.7
$[M+1]^+$	0.31

Use Table 4.3 to calculate the number of carbon atoms in **S**.

number of carbon atoms in **S** = 7 [1]

[Total: 16]

BLANK PAGE

SEEN



**Important values, constants and standards**

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25°C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ ($4.18 \text{ J g}^{-1} \text{ K}^{-1}$)

SEEN



The Periodic Table of Elements

Group																					
1	2	1												13	14	15	16	17	18		
<div>Key</div> <div>atomic number atomic symbol name relative atomic mass</div> <div>1 H hydrogen 1.0</div>																					
3	4													5	6	7	8	9	10	11	12
Li lithium 6.9	Be beryllium 9.0													B boron 10.8	C carbon 12.0	N nitrogen 14.0	O oxygen 16.0	F fluorine 19.0	Ne neon 20.2		
11	12													13	14	15	16	17	18		
Na sodium 23.0	Mg magnesium 24.3													Al aluminium 27.0	Si silicon 28.1	P phosphorus 31.0	S sulfur 32.1	Cl chlorine 35.5	Ar argon 39.9		
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36				
K potassium 39.1	Ca calcium 40.1	Sc scandium 45.0	Ti titanium 47.9	V vanadium 50.9	Cr chromium 52.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8				
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54				
Rb rubidium 85.5	Sr strontium 87.6	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3				
55	56	57–71 lanthanoids		72	73	74	75	76	77	78	79	80	81	82	83	84	85	86			
Cs cesium 132.9	Ba barium 137.3			Hf hafnium 178.5	Ta tantalum 180.9	W tungsten 183.8	Re rhenium 186.2	Os osmium 190.2	Ir iridium 192.2	Pt platinum 195.1	Au gold 197.0	Hg mercury 200.6	Tl thallium 204.4	Pb lead 207.2	Bi bismuth 209.0	Po polonium —	At astatine —	Rn radon —			
87	88	89–103 actinoids		104	105	106	107	108	109	110	111	112	113	114	115	116	117	118			
Fr francium —	Ra radium —			Rf rutherfordium —	Db dubnium —	Sg seaborgium —	Bh bohrium —	Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Nh nihonium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessine —	Og oganesson —			

lanthanoids	57	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
	lanthanum	cerium	praseodymium	neodymium	promethium	samarium	euroium	gadolinium	terbium	dysprosium	holmium	erbium	thulium	ytterbium	lutetium	
	138.9	140.1	140.9	144.2	—	150.4	152.0	157.3	158.9	162.5	164.9	167.3	168.9	173.1	175.0	
actinoids	89	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
	actinium	thorium	protactinium	uranium	neptunium	plutonium	americium	curium	berkelium	californium	einsteinium	fermium	mendelevium	nobelium	lawrencium	
	—	232.0	231.0	238.0	—	—	—	—	—	—	—	—	—	—	—	—

