Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/11**

Paper 1 Multiple Choice **May/June 2022**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

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You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

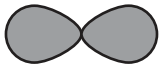
INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- 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.

[Turn over

1 Which atom has its outermost electron in an orbital of the shape shown, with principal quantum number 3?



A sodium

B chlorine

C calcium

D bromine

2 Which atom has the same number of electrons as the hydroxide ion, OH^-?

A F **B** Ne **C** Na **D** Mg

3 In separate experiments, 5.0 g samples of each of four s-block metals are added to an excess of water. The gas evolved is collected and its volume measured under the same conditions of temperature and pressure for each sample.

Which metal produces the largest volume of gas?

A calcium

B potassium

C rubidium

D strontium

4 A student reacts 1 mol of copper with concentrated nitric acid to produce 1 mol of copper(II) nitrate, 2 mol of water and substance X. No other product is formed.

Substance X does not contain copper or hydrogen.

What could be substance X?

A N_2 **B** N_2O **C** NO **D** NO_2

5 In which structure are three atoms bonded together in a straight line?

A poly(ethene), $-(CH_2CH_2)_n-$

B propane, C_3H_8

C silicon tetrachloride, $SiCl_4$

D sulfur hexafluoride, SF_6

6 Which statement about aluminium chloride is correct?

A Aluminium chloride has a much higher melting point than magnesium chloride due to the small size of the aluminium ion.

B Anhydrous aluminium chloride reacts vigorously with water to form a solution with a pH greater than 7.

C Each Al_2Cl_6 molecule found in aluminium chloride vapour contains two coordinate bonds.

D The bonding between aluminium and chlorine is strongly ionic due to the large difference in electronegativity.

7 'Black powder' is a mixture of potassium nitrate, carbon and sulfur. The mixture reacts as shown.

$$4KNO_3(s) + 7C(s) + S(s) \rightarrow 3CO_2(g) + 3CO(g) + 2N_2(g) + K_2S(s) + K_2CO_3(s)$$

A sealed tube containing black powder has a volume of 10.0 cm^3. When all of the black powder reacts, the reaction causes a pressure of 2×10^6 Pa and a temperature of 2500 K.

The volume of the K_2CO_3 and K_2S produced can be ignored.

How many moles of KNO_3 are contained in the sealed tube?

A 4.81×10^{-4} **B** 9.63×10^{-4} **C** 1.93×10^{-3} **D** 9.63×10^{-1}

8 For which pair is the boiling point of the first compound **higher** than the boiling point of the second compound?

A CH_3CH_2OH and CH_3CH_2SH

B $CH_3CO_2CH_3$ and $CH_3CH_2CO_2H$

C CH_3OCH_3 and CH_3CH_2OH

D CH_3CH_2CHO and $CH_3CH_2CO_2H$

9 The equation for an enthalpy change is shown. The enthalpy change is Q.

$$2C(s) + 3H_2(g) + 3.5O_2(g) \xrightarrow{Q} 2CO_2(g) + 3H_2O(l)$$

What is the correct expression to calculate Q?

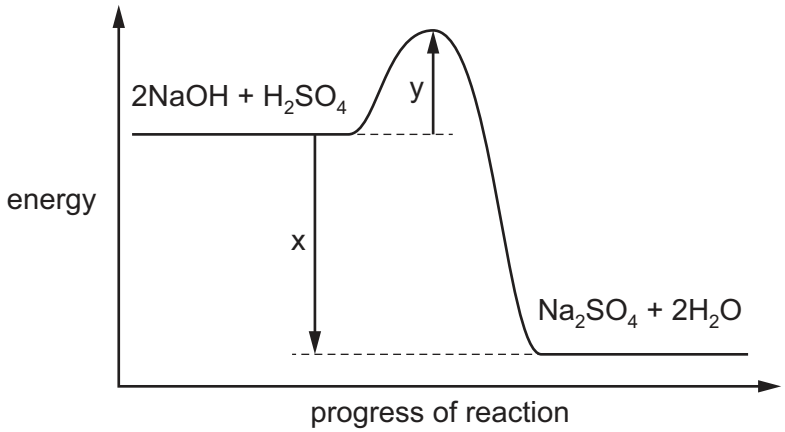
A $2 \times \Delta H_c^{\ominus}[CO_2(g)] - 3 \times \Delta H_f^{\ominus}[H_2(g)]$

B $3 \times \Delta H_f^{\ominus}[H_2O(g)] + 2 \times \Delta H_c^{\ominus}[CO_2(g)]$

C $2 \times \Delta H_f^{\ominus}[CO_2(g)] - 3 \times \Delta H_f^{\ominus}[H_2(g)]$

D $3 \times \Delta H_f^{\ominus}[H_2O(l)] + 2 \times \Delta H_f^{\ominus}[CO_2(g)]$

10 A reaction pathway diagram for the reaction of aqueous sodium hydroxide and dilute sulfuric acid is shown.



What is the value of the enthalpy change of neutralisation, ΔH_{neut}?

A x **B** x – y **C** $\frac{x}{2}$ **D** $\frac{(x-y)}{2}$

11 A student reacts 4 mol of ammonia with oxygen to produce an oxide of nitrogen and water only. Each nitrogen atom increases its oxidation state by 5 in the reaction.

How many moles of oxygen gas react with 4 mol of ammonia in this reaction?

A 4 mol **B** 5 mol **C** 7 mol **D** 10 mol

12 In the treatment of domestic water supplies, chlorine is added to water to kill bacteria. Some $Cl O^-$ ions are formed.

What is the change in oxidation number of chlorine when forming the $Cl O^-$ ion from aqueous chlorine?

A –1 **B** 0 **C** +1 **D** +2

13 Ethanoic acid is mixed with ethanol.

The ethanol is contaminated with a small amount of methanol.

The following equilibria are established.

$$CH_3CO_2H(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3CO_2CH_2CH_3(l) + H_2O(l) \qquad K_c = K_1$$

$$CH_3CO_2H(l) + CH_3OH(l) \rightleftharpoons CH_3CO_2CH_3(l) + H_2O(l) \qquad K_c = K_2$$

Which statement about the equilibrium mixture is correct?

A Only ethyl ethanoate will be formed because there is much more ethanol present than methanol.

B In this mixture $\frac{[CH_3CO_2CH_2CH_3]}{[CH_3CO_2CH_3]} = \frac{K_1}{K_2}$.

C Adding water to the mixture will alter the mole ratio of the two esters.

D Adding methyl ethanoate to the mixture will increase the number of moles of ethyl ethanoate.

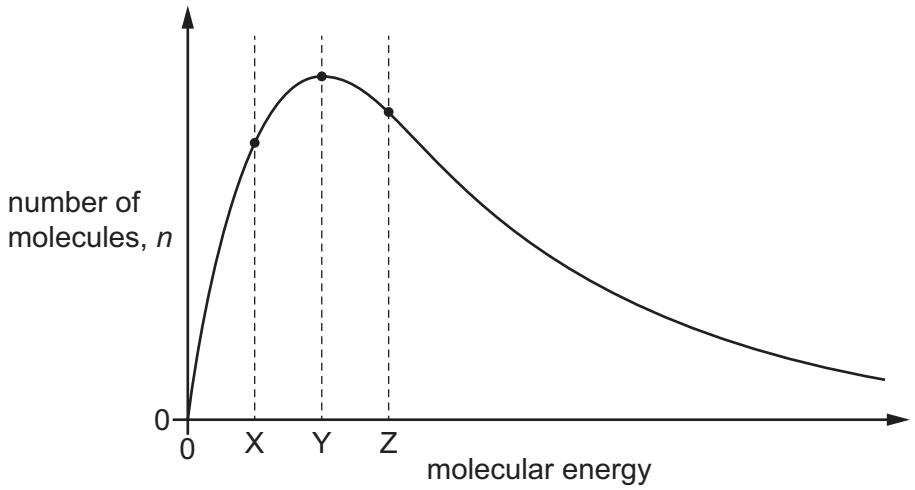
14 SO_3 is manufactured from SO_2 and O_2 in the Contact process.

The reaction is exothermic.

Which row shows the effect on the equilibrium yield obtained in the Contact process of increasing the temperature and of adding a vanadium(V) oxide catalyst?

	increasing the temperature	adding vanadium(V) oxide as catalyst
A	equilibrium yield decreases	equilibrium yield increases
B	equilibrium yield decreases	equilibrium yield unchanged
C	equilibrium yield increases	equilibrium yield unchanged
D	equilibrium yield increases	equilibrium yield increases

15 The Boltzmann distribution for a gas at a constant temperature of 50 °C is shown.



If the temperature of the gas is **reduced** by 10 °C, the graph changes shape.

What happens to the values of *n* for the molecular energies X, Y and Z?

	X	Y	Z
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

16 A 3.0 g sample of Na_2CO_3 powder is stirred into 50 cm^3 of 1.0 mol dm^{-3} HC*l*. The volume of CO_2 produced is 600 cm^3.

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

[M_r: Na_2CO_3, 106.0]

Which volume of CO_2 is produced if 1.0 g of Na_2CO_3 powder is stirred into 50 cm^3 of 1.0 mol dm^{-3} HC*l* under the same conditions?

A 600 cm^3 **B** 452 cm^3 **C** 226 cm^3 **D** 200 cm^3

17 Solid sodium iodide reacts with concentrated sulfuric acid to form more than one product that contains sulfur.

What is the lowest oxidation number of sulfur in these products?

A –2 **B** 0 **C** +4 **D** +6

18 Which statement for the element in Period 3 and Group 13 of the Periodic Table is correct?

A It has the highest melting point of the elements in its period.

B It has exactly one electron in its shell with principal quantum number 3.

C It forms an oxide that reacts with aqueous sodium hydroxide.

D It forms a chloride that dissolves in water to give a neutral solution.

19 A student reacts 0.100 mol of each of sodium, magnesium and phosphorus atoms separately with an excess of oxygen.

Which rows are correct?

	oxide	mass of oxide formed / g
1	sodium	3.10
2	magnesium	4.03
3	phosphorus	7.10

A 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

20 A mixture contains magnesium carbonate and barium carbonate only. A sample of the mixture is dissolved in nitric acid to produce a solution.

How could this solution be processed into a magnesium compound and a separate barium compound?

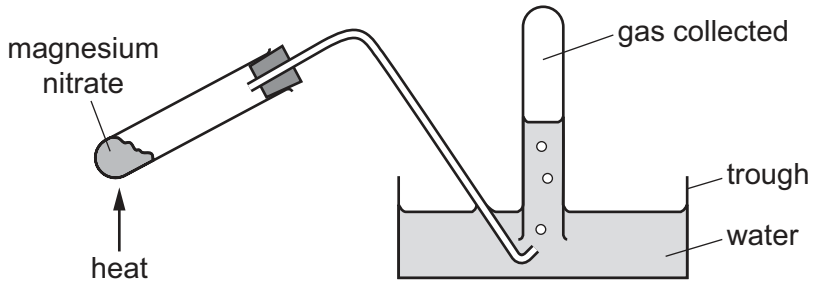
A Add HCl(aq), filter off the solid barium chloride.

B Add HCl(aq), filter off the solid magnesium chloride.

C Add H_2SO_4(aq), filter off the solid barium sulfate.

D Add H_2SO_4(aq), filter off the solid magnesium sulfate.

21 A sample of magnesium nitrate is heated in the apparatus shown.



The pH of the solution in the trough is measured.

The gas collected is tested with a glowing splint.

What are the results?

	pH of solution in trough	splint test
A	8	relights
B	2	relights
C	8	extinguished
D	2	extinguished

22 The results of tests performed on a white crystalline solid, X, are given in the table.

reagent and conditions	observation
X is gently heated	X sublimes
X is shaken with H_2O	a colourless solution, Y, forms
Y is warmed with NaOH(aq)	a gas is given off
$AgNO_3$(aq) is added to Y	a white precipitate, Z, forms
Z is shaken with NH_3(aq)	a colourless solution forms

What is the identity of X?

A aluminium bromide

B aluminium chloride

C ammonium bromide

D ammonium chloride

23 Silicon is heated in an excess of chlorine, producing compound J.

An excess of water is added to the sample of J produced.

Which row is correct?

	structure of J	Is HCl produced when water is added to J?
A	giant molecular	no
B	giant molecular	yes
C	simple molecular	no
D	simple molecular	yes

24 In a catalytic converter, 5.6 g of carbon monoxide react with an excess of nitrogen monoxide.

What is produced in this reaction?

A 2.4 g of C and 6.0 g of NO_2

B 2.4 g of C and 9.2 g of NO_2

C 8.8 g of CO_2 and 1.4 g of N_2

D 8.8 g of CO_2 and 2.8 g of N_2

25 Which reaction mixture produces an acidic gas?

A aqueous ammonium nitrate and solid calcium oxide

B calcium and aqueous hydrochloric acid

C potassium chloride and concentrated sulfuric acid

D sodium oxide and water

26 Ethanol can be used to make propanenitrile in two steps.

$$CH_3CH_2OH \xrightarrow{X} CH_3CH_2Br \xrightarrow{Y} CH_3CH_2CN$$

What types of reaction are X and Y?

	X	Y
A	free-radical substitution	electrophilic substitution
B	free-radical substitution	nucleophilic substitution
C	nucleophilic substitution	nucleophilic substitution
D	nucleophilic substitution	electrophilic substitution

27 Which compound will react with $LiAlH_4$ to form two optical isomers?

A $CH_3CH_2COCH_3$

B $CH_3CH_2CH_2CHO$

C $CH_3CH_2COCH_2CH_3$

D $CH_3CH(CH_3)CH_2CO_2H$

28 How many esters have the molecular formula $C_4H_8O_2$?

A 2 **B** 3 **C** 4 **D** 5

29 Carbon monoxide, CO, nitrogen dioxide, NO_2, and sulfur dioxide, SO_2, are all atmospheric pollutants.

Which reaction occurs in the atmosphere?

A CO is spontaneously oxidised to CO_2.

B NO_2 is reduced to NO by SO_2.

C NO_2 is reduced to NO by CO.

D SO_2 is oxidised to SO_3 by CO_2.

30 Oct-1-ene, $CH_3(CH_2)_5CH=CH_2$, can be thermally cracked.

Which of the compounds W, X, Y and Z can be obtained by thermally cracking oct-1-ene?

W	X	Y	Z
$CH_2=CH_2$	$CH_3CH=CH_2$	$CH_3CH_2CH_3$	$CH_2=CHCH=CH_2$

A W, X, Y and Z

B W, X and Y only

C W, X and Z only

D W and X only

31 Structural isomerism and stereoisomerism should be taken into account when answering this question.

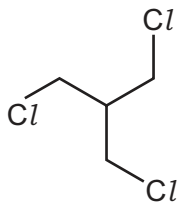
How many isomeric alkenes with formula C_5H_8 are present in the mixture produced when 1,4-dibromopentane is reacted with NaOH in ethanol?

A 1 **B** 2 **C** 3 **D** 4

32 The presence of a halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

Which compound would be the quickest to produce a precipitate?

A



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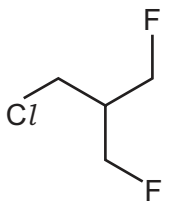

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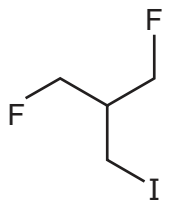

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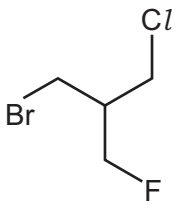


33 17.6 g of pentan-1-ol is completely combusted.

Which volume of gaseous products is formed when measured at s.t.p.?

A 22.4 dm^3 **B** 24.0 dm^3 **C** 49.3 dm^3 **D** 52.8 dm^3

34 Crotyl alcohol, $CH_3CH=CHCH_2OH$, is a colourless liquid which is used as a solvent.

Crotyl alcohol will react separately with Br_2, $K_2Cr_2O_7/H^+$, conc. $KMnO_4/H^+$ and PCl_5 under suitable conditions.

Which row is correct?

	reactant	conditions	main product
A	Br_2	room temperature	$CH_3CH=CHCH_2Br$
B	$K_2Cr_2O_7/H^+$	heat under reflux	$CH_3CH=CHCHO$
C	conc. $KMnO_4/H^+$	heat under reflux	$CH_3CH=CHCO_2H$
D	PCl_5	room temperature	$CH_3CH=CHCH_2Cl$

35 The skeletal formulae of two organic compounds are shown.

Which reagents can be used to distinguish these two compounds?

1 alkaline I_2(aq)

2 acidified $K_2Cr_2O_7$

3 2,4-dinitrophenylhydrazine (2,4-DNPH reagent)

A 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 2 only

36 A carbonyl compound, X, reacts with HCN in the presence of NaCN to make a compound with M_r 85. Compound X does **not** react with Fehling's reagent.

What is compound X?

A butanal

B butanone

C propanal

D propanone

37 Which compound produces butan-2-ol and ethanoic acid on hydrolysis?

A $CH_3CO_2CH(CH_3)_2$

B $CH_3CO_2CH(CH_3)CH_2CH_3$

C $CH_3CH(CH_3)CO_2CH_2CH_3$

D $CH_3CH_2CO_2CH(CH_3)CH_2CH_3$

38 Two 1 g samples of Y are reacted separately and completely with sodium and with sodium carbonate. The volumes of the gases produced are collected and measured.

	relative volumes of gases	
	with Na	with Na_2CO_3
Y	2	1

What could Y be?

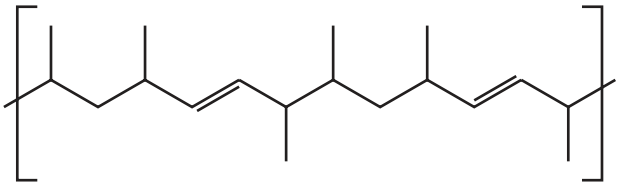
A $CH_3CH(OH)CH_2OH$

B $CH_3CH(OH)CO_2H$

C CH_3COCH_2OH

D CH_3COCO_2H

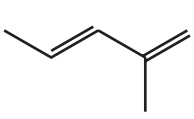
39 The diagram shows a section of an addition polymer formed from two different monomers.



One of the monomers is propene.

What is the other monomer?

A



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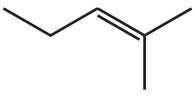
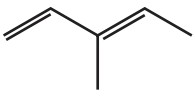


C



D

40 A scientist chooses either infrared spectroscopy or mass spectrometry to find a particular piece of information.

In which row has the **best** choice been made?

	target information	analytic method used
A	identities of functional groups in an organic compound	infrared spectroscopy
B	identities of functional groups in an organic compound	mass spectrometry
C	values of successive ionisation energies of Na	infrared spectroscopy
D	values of successive ionisation energies of Na	mass spectrometry

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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0		Key atomic number atomic symbol name relative atomic mass									5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –