Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **February/March 2023**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

9420182174

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 **20** pages. Any blank pages are indicated.

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[Turn over

1 Four equations representing reactions of nitrogen or one of its compounds are given.

Which equation represents a disproportionation reaction?

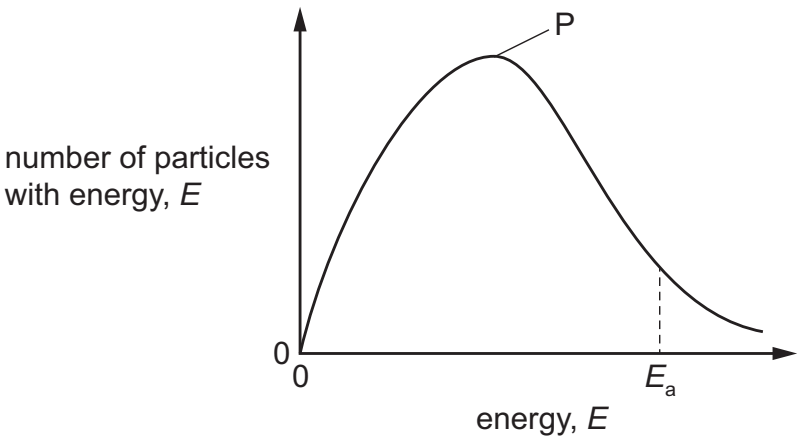
A $2HNO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$

B $N_2 + 3H_2 \rightarrow 2NH_3$

C $NH_4Cl + NaOH \rightarrow NH_3 + NaCl + H_2O$

D $2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$

2 The diagram shows the Boltzmann distribution for one mole of a gas. The gas takes part in a reaction with an activation energy, E_a.



Which statement correctly describes the effect of an increase in temperature?

A Peak P will be higher and fewer molecules will have energy > E_a.

B Peak P will be higher and more molecules will have energy > E_a.

C Peak P will be lower and fewer molecules will have energy > E_a.

D Peak P will be lower and more molecules will have energy > E_a.

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3 A student carries out four experiments to investigate the rate of reaction between 3.0 g of calcium carbonate and hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

experiment 1	$CaCO_3$ powder + 2.0 mol dm^{-3} HCl at 35 °C
experiment 2	$CaCO_3$ powder + 2.0 mol dm^{-3} HCl at 35 °C
experiment 3	large chips of $CaCO_3$ + 1.0 mol dm^{-3} HCl at room temperature
experiment 4	large chips of $CaCO_3$ + 1.0 mol dm^{-3} HCl at 35 °C

The student collects the $CO_2(g)$ and times how long it takes to produce the same volume of gas for each experiment.

What could be the correct times for the four experiments?

	experiment 1 / s	experiment 2 / s	experiment 3 / s	experiment 4 / s
A	5	10	30	95
B	5	10	95	30
C	5	30	95	10
D	95	30	10	5

4 The table shows the partial pressures in an equilibrium mixture formed by the Haber process.

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

substance	partial pressure / kPa
nitrogen	7000
hydrogen	8000
ammonia	4000

What is the numerical value of the equilibrium constant, K_p, for this reaction?

A 4.46×10^{-9} **B** 4.76×10^{-5} **C** 7.14×10^{-5} **D** 2.24×10^{8}

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5 A reversible reaction is shown.

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g) \qquad \Delta H = +77.0 \text{ kJ mol}^{-1}$$

Which change in conditions will move the position of equilibrium to the right and increase the value of the equilibrium constant?

A a decrease in pressure

B a decrease in temperature

C an increase in pressure

D an increase in temperature

6 The ore psilomelane may be considered to have the general formula $Ba(Mn^{x+})(Mn^{y+})_8O_{16}(OH)_4$.

In this general formula, *x*+ and *y*+ are the two different oxidation states of manganese in psilomelane.

What could be the values of *x* and *y*?

	x	*y*
A	2	4
B	6	4
C	6	3
D	7	3

7 Silicon reacts with a mixture of calcium oxide and magnesium oxide at 1200 °C.

$$2MgO + 2CaO + Si \rightarrow 2Mg + Ca_2SiO_4$$

Which statement about this reaction is correct?

A Calcium is reduced and silicon is neither oxidised nor reduced.

B Magnesium is reduced and calcium is neither oxidised nor reduced.

C Magnesium is reduced and silicon is neither oxidised nor reduced.

D Silicon is reduced and calcium is neither oxidised nor reduced.

8 In which species is there a lone pair of electrons?

A CH_3 **B** CH_3^+ **C** CH_3^- **D** CH_4

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9 Under which conditions will nitrogen behave most like an ideal gas?

	temperature	pressure
A	low	high
B	high	low
C	low	low
D	high	high

10 The equation for a chemical reaction is shown. All substances are in their standard states.

$$XeF_6 + 3H_2O \rightarrow XeO_3 + 6HF$$

Which statement describes the standard enthalpy change of reaction for this reaction?

A the enthalpy change when a total of one mole of products is produced

B the enthalpy change when a total of one mole of reactants is reacted

C the enthalpy change when one mole of water reacts

D the enthalpy change when six moles of hydrogen fluoride are produced

11 Molten aluminium chloride has a simple molecular structure. Each molecule consists of two aluminium atoms and six chlorine atoms.

Which statement is correct?

A All the chlorine atoms in 1 g of molten aluminium chloride have the same mass.

B One mole of molten aluminium chloride contains 6.02×10^{23} aluminium atoms.

C One mole of molten aluminium chloride contains 3.61×10^{24} chlorine atoms.

D The empirical formula of molten aluminium chloride is Al_2Cl_6.

12 Which atom contains four times as many neutrons as the $^{7}_{3}Li$ atom?

A $^{40}_{20}Ca$ **B** $^{24}_{12}Mg$ **C** $^{31}_{15}P$ **D** $^{26}_{14}Si$

13 Which statement about the first ionisation energies of magnesium and neon is correct?

A Magnesium has the greater numerical value and both are endothermic.

B Magnesium has the greater numerical value and both are exothermic.

C Neon has the greater numerical value and both are endothermic.

D Neon has the greater numerical value and both are exothermic.

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14 In a sample of pure water, what is the maximum number of hydrogen bonds that one molecule of water can be involved in?

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

15 Hydrated cobalt(II) sulfate loses water when heated to give anhydrous cobalt(II) sulfate. All the water of crystallisation is lost to the atmosphere as steam.

When 3.10 g of hydrated cobalt(II) sulfate, $CoSO_4 \cdot xH_2O$, is heated to constant mass the **loss** in mass is 1.39 g.

What is the value of *x*, to the nearest whole number?

A 4 **B** 6 **C** 7 **D** 11

16 The table shows bond energies for some diatomic molecules. Deuterium, D, is an isotope of hydrogen.

bond	energy / kJ mol^{-1}
F–F	158
C*l*–C*l*	242
Br–Br	193
I–I	151
H–H	436
D–D	442

Which statements are correct?

1 Diatomic molecules have exact values for their bond energies, which are always positive.

2 The trend in Group 7 bond energies can be explained by the variation in instantaneous dipole–induced dipole (id–id) forces.

3 A value for the enthalpy change for the reaction between deuterium and chlorine can be calculated using these data alone.

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

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17 Two procedures are described.

1 Sulfur is burned in an excess of oxygen and then NO is added to the product mixture.

2 Sulfur is burned in an excess of oxygen and then NO_2 is added to the product mixture.

Which procedures will produce some sulfur trioxide, SO_3?

A both 1 and 2 **B** 1 only **C** 2 only **D** neither 1 nor 2

18 Powder P is a mixture containing two of AgCl, AgBr or AgI.

P is shaken with dilute aqueous ammonia. A yellow solid, Q, remains.

The mixture is filtered and Q is washed and dried. The filtrate is collected and treated with aqueous nitric acid to produce a white precipitate, R, which is filtered off, washed and dried.

Q and R are warmed separately with concentrated sulfuric acid, H_2SO_4.

Which observations are made?

	Q + concentrated H_2SO_4	R + concentrated H_2SO_4
A	violet fumes	orange fumes
B	violet fumes	steamy fumes
C	steamy fumes	violet fumes
D	orange fumes	steamy fumes

19 Two Period 3 elements, X and Y, burn separately in oxygen to form solid oxides.

The oxide of X is insoluble in water.

The oxide of Y dissolves in water to form a solution which dissolves the oxide of X.

What could X and Y be?

	X	Y
A	aluminium	sodium
B	magnesium	sodium
C	silicon	phosphorus
D	silicon	sulfur

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20 Which row describes the structure and bonding of SiO_2 and $SiCl_4$?

	SiO_2		$SiCl_4$	
	structure	bonding	structure	bonding
A	giant	covalent	giant	covalent
B	giant	covalent	simple	covalent
C	giant	ionic	giant	covalent
D	giant	ionic	simple	covalent

21 A sample containing 0.010 mol of anhydrous calcium nitrate is heated strongly until it fully decomposes.

All the gas produced is collected and its volume measured at room conditions.

What is the volume of gas produced?

A 120 cm^3 **B** 600 cm^3 **C** 720 cm^3 **D** 840 cm^3

22 V and Z are both elements in Period 3 of the Periodic Table. Each element forms one stable ion that does not contain another element.

The atomic radius of each element and the ionic radius of the ion described above is shown.

element	atomic radius / nm	ionic radius / nm
V	0.186	0.095
Z	0.099	0.181

Which statement is correct?

A Ions of V and Z have the same number of full electron shells.

B Ions of Z are positively charged.

C Z has a greater electronegativity than V.

D V has more outer electrons than Z.

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23 In Group 2 of the Periodic Table, the properties of the elements and their compounds show regular change down the group.

Which property shows a **decrease** from magnesium to barium?

A the decomposition temperature of the carbonates

B the decomposition temperature of the nitrates

C the solubility of the hydroxides

D the solubility of the sulfates

24 Four properties of beryllium, Be, or a beryllium compound are listed.

Which property is different from the property of magnesium or the equivalent magnesium compound?

A Be reacts with O_2 when heated in air; Mg does not.

B Be reacts with aqueous H_2SO_4 to form a metal sulfate and H_2; Mg does not.

C $Be(NO_3)_2$ decomposes on heating to form a metal oxide, NO_2 and O_2; $Mg(NO_3)_2$ does not.

D $BeCl_2$ reacts with water to form fumes of HCl; $MgCl_2$ does not.

25 Which two formulae correctly represent a pair of structural isomers?

A $CH_3CH(CH_3)COOH$ and $(CH_3)_2CHCOOH$

B $CH_3CH(COOH)CH_3$ and $(CH_3)_2CHCOOH$

C $CH_3CHCOOH$ and $CH_3CH_2CH_2COOH$

D $CH_3CH_2CH_2COOH$ and $(CH_3)_2CHCOOH$

26 Which reagents and conditions would result in the formation of butanenitrile, $CH_3CH_2CH_2CN$?

A 1-bromobutane heated under pressure with ammonia in ethanol

B 1-bromopropane heated with potassium cyanide in ethanol

C propanal heated with hydrogen cyanide in the presence of potassium cyanide

D propanone heated with hydrogen cyanide in the presence of potassium cyanide

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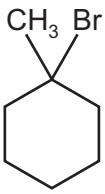
27 Compound X, $C_7H_{13}Br$, reacts with hot alcoholic NaOH to produce two compounds, Y and Z.

On reaction with Br_2, Y gives a product, $C_7H_{12}Br_2$, which exists as a mixture of four optical isomers.

On reaction with Br_2, Z gives a product, $C_7H_{12}Br_2$, which is non-chiral.

What could X be?

A



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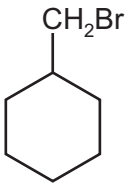

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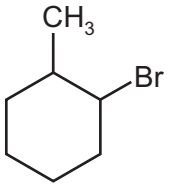

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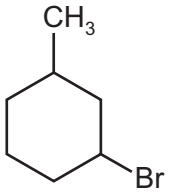
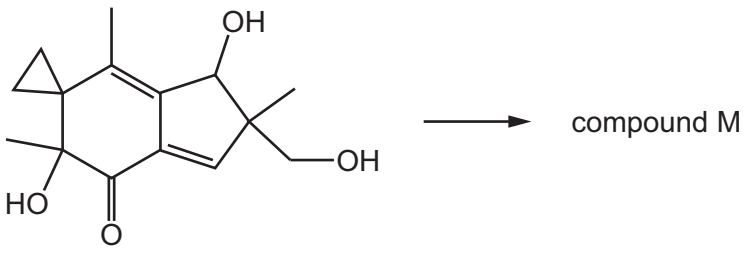


28 When illudin S is heated under reflux with an excess of acidified potassium dichromate(VI), compound M is formed.

illudin S



What is the molecular formula of compound M?

A $C_{15}H_{16}O_4$ **B** $C_{15}H_{16}O_5$ **C** $C_{15}H_{18}O_4$ **D** $C_{15}H_{18}O_5$

29 Cyclohexene, C_6H_{10}, is a hydrocarbon with a six-membered ring of carbon atoms.

It has several structural isomers that are straight-chain alkenes. The number of double bonds in each of these molecules is P.

What is the shape of the cyclohexene molecule and what is the value of P?

	shape	P
A	planar	1
B	planar	2
C	non-planar	1
D	non-planar	2

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30 Exhaust gases from an internal combustion engine are made less harmful by passing them through a catalytic converter. A number of reactions take place in the catalytic converter. Two such reactions are described in the table.

Which row is correct?

	the type of reaction that removes carbon monoxide	the type of reaction that removes unburned hydrocarbons
A	oxidation	oxidation
B	oxidation	reduction
C	reduction	reduction
D	reduction	oxidation

31 Which compound reacts most rapidly with aqueous silver nitrate by an S_N1 mechanism?

A 1-chloromethylpropane

B 2-chloromethylpropane

C 1-iodomethylpropane

D 2-iodomethylpropane

32 Tartaric acid, HOOCCH(OH)CH(OH)COOH, is found in many plants.

A sample of tartaric acid reacts with an excess of $LiAlH_4$ to form the organic product J.

What happens when NaOH(aq) is added to separate samples of tartaric acid and J?

A Both tartaric acid and J react.

B Only tartaric acid reacts.

C Only J reacts.

D Neither tartaric acid nor J react.

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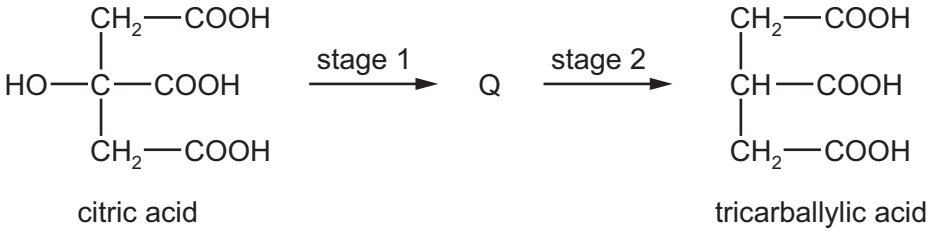
33 Citric acid can be converted into tricarballylic acid in two stages. An intermediate, Q, is formed.



citric acid tricarballylic acid

Which reagents are needed for each stage?

	stage 1	stage 2
A	concentrated H_2SO_4	H_2(g) and Ni
B	concentrated H_2SO_4	$LiAlH_4$
C	$LiAlH_4$	H_2SO_4(aq)
D	NaOH(aq)	H_2(g) and Ni

34 Structural and stereoisomerism should be considered when answering this question.

P has molecular formula $C_5H_{10}O$.

P produces an orange precipitate with 2,4-dinitrophenylhydrazine (2,4-DNPH reagent).

How many isomeric structures does P have?

A 5 **B** 6 **C** 7 **D** 8

35 Two isomeric alcohols, W and X, have molecular formula C_4H_9OH.

W is oxidised to carbonyl compound Y which gives a red precipitate with Fehling's solution.

X is oxidised to carbonyl compound Z which does **not** give a red precipitate with Fehling's solution.

Which of W and X gives a yellow precipitate with alkaline I_2(aq)?

A insufficient data is given to answer this question

B W only

C X only

D neither W nor X

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36 The ester ethyl butanoate can be hydrolysed using an excess of dilute sodium hydroxide solution.

Which substance is a product of this reaction?

A $CH_3CH_2CH_2CO_2Na$

B CH_3CO_2Na

C CH_3CH_2ONa

D H_2O

37 An aqueous solution contains 4.00 g of a carboxylic acid, Q. When this solution reacts with an excess of magnesium, 380 cm^3 of gas is produced, measured at s.t.p.

What is the relative formula mass of Q?

A 59 **B** 118 **C** 126 **D** 236

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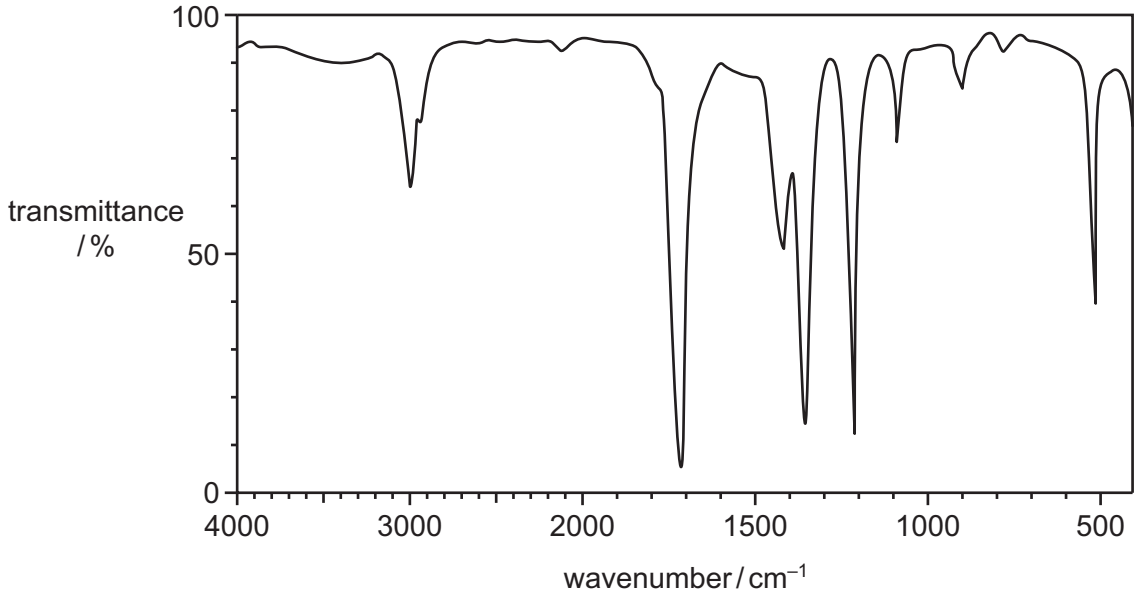
38 The infrared spectrum of an organic compound is shown.



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	2850–3100
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

Which compound could give this spectrum?

A $CH_3CH_2CO_2H$

B $CH_3CH(OH)CH_3$

C CH_3COCH_3

D CH_3COCH_2OH

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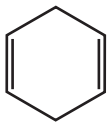
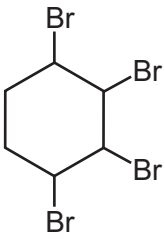
39 Cyclohexa-1,4-diene is treated with a solution of bromine in tetrachloromethane in the dark.



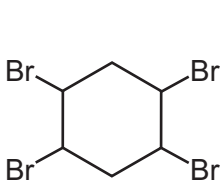
cyclohexa-1,4-diene

Which product is formed?

A



B



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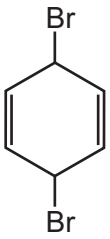

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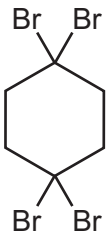

40 2-methylbut-2-ene is reacted with hot, concentrated, acidified potassium manganate(VII) solution.

What are the products of this reaction?

A ethanal and propanone

B ethanoic acid and propanone

C ethanoic acid and propan-2-ol

D ethanol and propan-2-ol

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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	$L = 6.022 \times 10^{23}\,\text{mol}^{-1}$
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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

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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											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 –

Key

atomic number
atomic symbol
name
relative atomic mass

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 –