Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

Paper 1 Multiple Choice **May/June 2024**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

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.

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[Turn over

1 Which pair of formulae is correct?

A Ag_2CO_3 and $(NH_4)_3NO_3$

B K_2HCO_3 and $Zn_3(PO_4)_2$

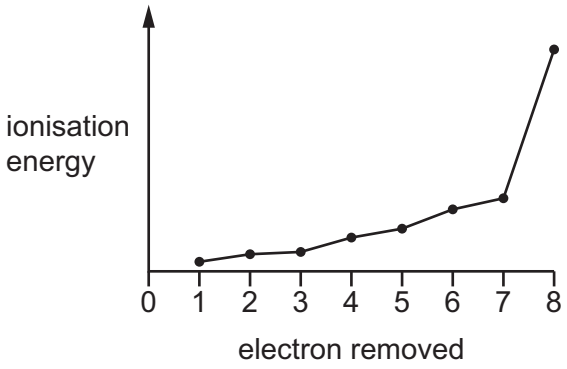
C $AgHCO_3$ and K_3PO_4

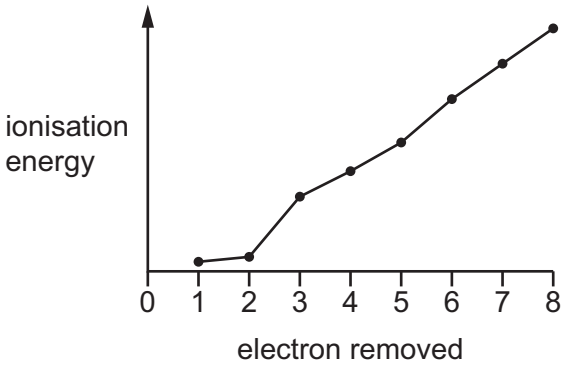
D $ZnCO_3$ and $(NH_4)_2PO_4$

2 How many molecules are present in 62 g of solid white phosphorus, P_4?

A L **B** $2L$ **C** $\frac{L}{2}$ **D** $\frac{L}{4}$

3 The first eight successive ionisation energies for two elements of Period 3 of the Periodic Table are shown in the graphs.





What is the formula of the ionic compound formed from these elements?

A $MgCl_2$ **B** $CaBr_2$ **C** Na_2S **D** K_2Se

4 In which pairs are **both** species free radicals?

1 Cl and O

2 Cl^- and O^{2-}

3 Cl and O^-

4 Cl^+ and O^{2+}

A 1, 3 and 4 **B** 1 and 3 only **C** 1 only **D** 2 only

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5 Which shape is correctly predicted by VSEPR theory?

	number of bonded electron pairs	number of lone pairs	shape
A	2	2	linear
B	2	2	tetrahedral
C	3	1	pyramidal
D	3	1	trigonal planar

6 In which species does the underlined atom have an incomplete outer shell?

A $\underline{B}F_3$ **B** $\underline{C}H_3^-$ **C** $F_2\underline{O}$ **D** $H_3\underline{O}^+$

7 In this question it should be assumed that nitrogen behaves as an ideal gas under the conditions stated.

Which volume is occupied by 1.00 g of nitrogen at 50.0 °C and at a pressure of 120 kPa?

A 0.124 dm^3 **B** 0.799 dm^3 **C** 1.60 dm^3 **D** 22.4 dm^3

8 Consider the following four compounds.

1 $(CH_3)_3CH$

2 $CH_3CH_2CH_2OH$

3 $CH_3CH_2CH_2SH$

4 $CH_3CH_2CH_2CH_3$

What is the order of increasing boiling point of the compounds (lowest first)?

A $1 \rightarrow 4 \rightarrow 2 \rightarrow 3$

B $1 \rightarrow 4 \rightarrow 3 \rightarrow 2$

C $4 \rightarrow 1 \rightarrow 2 \rightarrow 3$

D $4 \rightarrow 1 \rightarrow 3 \rightarrow 2$

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9 Ethane can react with fluorine to produce 1,2-difluoroethane, $C_2H_4F_2$.

$$C_2H_6 + 2F_2 \rightarrow C_2H_4F_2 + 2HF \qquad \Delta H = -960\,kJ\,mol^{-1}$$

bond	energy / kJ mol^{-1}
C–H	410
C–C	350
F–F	158
H–F	562

What is the bond energy of the C–F bond in 1,2-difluoroethane?

A 407 kJ mol^{-1} **B** 474 kJ mol^{-1} **C** 486 kJ mol^{-1} **D** 972 kJ mol^{-1}

10 Which equation has an enthalpy change equal to the standard enthalpy of formation of sodium oxide?

A $Na(s) + \frac{1}{4}O_2(g) \rightarrow \frac{1}{2}Na_2O(s)$

B $Na(s) + O_2(g) \rightarrow Na_2O(s)$

C $2Na(s) + \frac{1}{2}O_2(g) \rightarrow Na_2O(s)$

D $4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$

11 Nitrogen dioxide reacts with water.

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

Which statement about this reaction is correct?

A Both products are formed because oxygen atoms gain electrons.

B Nitrogen atoms undergo disproportionation.

C The oxidation number of hydrogen is increased.

D Water acts as an oxidising agent.

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12 Phosphorus reacts with concentrated sulfuric acid to produce phosphoric acid, sulfur dioxide and water.

$$a H_2SO_4 + bP \rightarrow cH_3PO_4 + dSO_2 + eH_2O$$

a, *b*, *c*, *d* and *e* are all whole numbers.

The equation can be balanced by using oxidation numbers.

What is the value of the sum $a + b + c + d + e$?

A 10 **B** 14 **C** 15 **D** 16

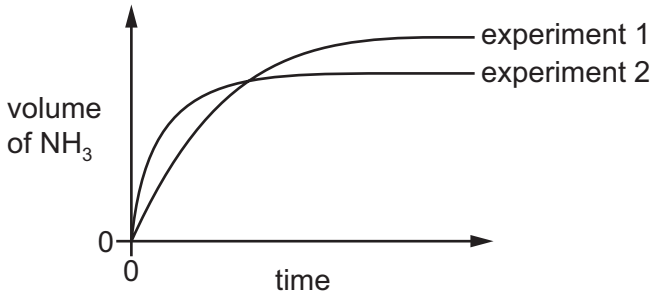
13 The volume of ammonia produced against time is measured in two experiments.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

In experiment 1, 3 mol of $H_2(g)$ and 1 mol of $N_2(g)$ react together at 45 °C and a pressure of 200 atm.

A graph showing the volume of ammonia produced against time is plotted.

Experiment 2 is then performed. Experiment 2 differs from experiment 1 in **one** condition only.



How does experiment 2 differ from experiment 1?

A An iron catalyst is present in experiment 2.

B 2 mol of helium gas is present in the reaction mixture in experiment 2.

C A pressure of 250 atm is used in experiment 2.

D A temperature of 600 °C is used in experiment 2.

14 Which reaction has an equilibrium constant, K_p, that has no units?

A $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

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

C $2NO_2(g) \rightleftharpoons N_2O_4(g)$

D $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

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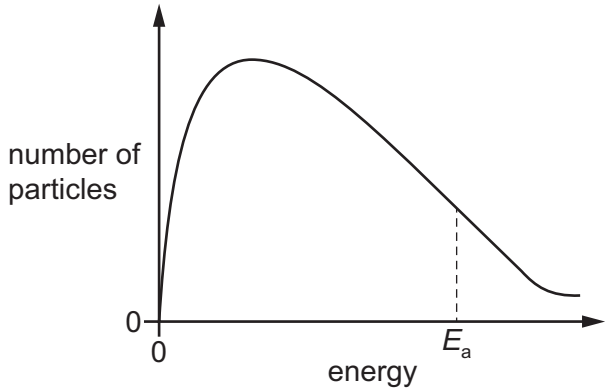
15 Gas Q decomposes slowly at room temperature.

$$Q(g) \rightarrow X(g) + Z(g)$$

The Boltzmann distribution curve for gas Q at room temperature is shown.



Which change occurs when a catalyst is added to gas Q?

A The peak of the curve moves to the right on the diagram.

B The number of particles with enough energy to decompose increases.

C The kinetic energy of the unreacted particles increases.

D The value of E_a decreases, moving the vertical dotted line to the right on the diagram.

16 Which statement is correct?

A Aluminium chloride has a giant ionic lattice of Al^{3+} and Cl^- ions.

B Sodium chloride dissolves in water, forming hydrogen chloride and sodium hydroxide.

C The strong covalent bonds in silicon chloride prevent it from reacting with water.

D When phosphorus(V) chloride is added to water, the resulting solution conducts electricity.

17 A mixture of calcium carbonate, calcium nitrate, strontium carbonate and strontium nitrate is thermally decomposed. The decomposition reaction of each substance goes to completion. Each substance is anhydrous.

How many different products are formed?

A 4 **B** 5 **C** 7 **D** 8

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18 W is a solid that reacts with water to produce an alkaline solution.

The addition of two drops of dilute H_2SO_4 to this alkaline solution produces a white precipitate.

What could be the identity of solid W?

A magnesium hydroxide

B magnesium oxide

C barium oxide

D phosphorus oxide

19 Chlorine gas is reacted with cold aqueous sodium hydroxide.

Which statement is correct for this reaction?

A Chlorine is both oxidised and reduced.

B Chlorine is neither oxidised nor reduced.

C Chlorine is oxidised but not reduced.

D Chlorine is reduced but not oxidised.

20 Sodium is added to water to form solution Y. The pH of solution Y is measured.

When powdered substance X is added to solution Y, the pH falls.

Which **two** compounds could each be substance X?

A $MgCl_2$ and $Al(OH)_3$

B $MgCl_2$ and K_2O

C $NaCl$ and $Al(OH)_3$

D $NaCl$ and K_2O

21 The table shows statements about some of the properties of halogens and their compounds and explanations for these properties.

Which row shows a correct statement about the property and a correct explanation for the statement?

	statement	explanation
A	iodine is a solid at room temperature	the I–I bond strength is high
B	the decomposition of hydrogen iodide is more endothermic than the decomposition of hydrogen chloride	chlorine is more reactive than iodine
C	when chlorine is bubbled into aqueous potassium iodide, a purple solution is seen	chlorine is a stronger oxidising agent than iodine
D	when concentrated sulfuric acid is added to solid potassium iodide, a purple vapour is seen	iodide ions are being oxidised to iodine by the sulfuric acid

22 Which statement describes a property of an ammonium ion?

A An aqueous ammonium ion is a weak Brønsted–Lowry base.

B Aqueous ammonium sulfate reacts with dilute hydrochloric acid to make ammonia gas.

C An ammonium ion has a pyramidal shape with an H–N–H bond angle of 107°.

D The four N–H covalent bonds in an ammonium ion are identical to each other.

23 Catalytic converters are fitted in the exhaust systems of many cars.

Gas X:

- causes acid rain if it is released into the air
- is removed from car exhaust fumes by a catalytic converter.

What is gas X?

A carbon dioxide

B carbon monoxide

C hydrocarbon vapour

D nitrogen dioxide

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24 In the general formula of which class of compound is the ratio of hydrogen atoms to carbon atoms the highest?

A alcohols

B aldehydes

C carboxylic acids

D halogenoalkanes

25 Which statement is correct?

A Adding sodium oxide to water gives a lower pH solution than adding silicon oxide to water.

B The oxidation state of sodium in its chloride is higher than the oxidation state of silicon in its chloride.

C The atomic radius of sodium is larger than that of silicon.

D The melting point of the chloride of sodium is lower than the melting point of the chloride of silicon.

26 Z is a gaseous hydrocarbon which has a density of $3.50 \times 10^{-3}\,g\,cm^{-3}$ under room conditions.

Z reacts with an excess of hot concentrated acidified $KMnO_4$. Only **one** type of carboxylic acid is formed in this reaction.

What is Z?

A but-2-ene

B 2,3-dimethylbut-2-ene

C hex-2-ene

D hex-3-ene

27 Compound X can be oxidised to compound Y.

Compound Y gives a yellow precipitate with alkaline I_2(aq).

What is compound X?

A butan-1-ol

B butan-2-ol

C methylpropan-1-ol

D methylpropan-2-ol

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28 Aqueous NaOH reacts with 1-bromopropane to give propan-1-ol.

What should be included in a diagram of the first step in the mechanism?

A a curly arrow from a lone pair on the OH^- ion to the $C^{\delta+}$ atom of 1-bromopropane

B a curly arrow from the $C^{\delta+}$ atom of 1-bromopropane to the OH^- ion

C a curly arrow from the C–Br bond to the C atom

D the homolytic fission of the C–Br bond

29 In which reaction is the organic compound oxidised?

A $CH_3CH_2CH_2CHO$ + Tollens' reagent

B $CH_3CH_2CH_2CHO$ + $LiAlH_4$

C $CH_3CH_2CH_2OH$ + concentrated H_3PO_4

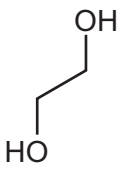
D $CH_3CO_2C_2H_5$ + dilute H_2SO_4

30 1 mole of each of the following four compounds is reacted separately with:

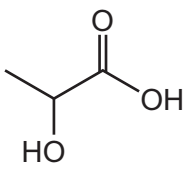
- an excess of sodium
- an excess of sodium carbonate.

Which compound produces the same volume of gas with each of the **two** reagents?

A



B



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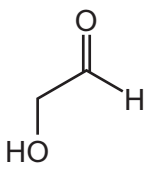
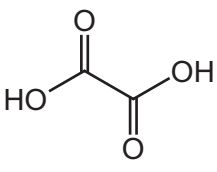


D



31 Which reaction will distinguish between propan-1-ol and propan-2-ol?

A warming with acidified $KMnO_4$

B warming with acidified $K_2Cr_2O_7$

C dehydration, followed by reaction with $Br_2(aq)$

D mild oxidation, followed by reaction with Fehling's reagent

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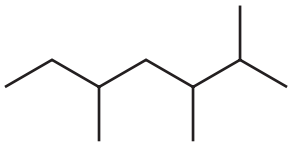
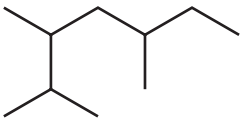
32 Compound T has the skeletal formula shown.

compound T

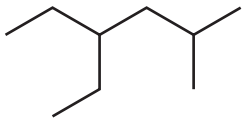


Which structure is a structural isomer of compound T?

A



B



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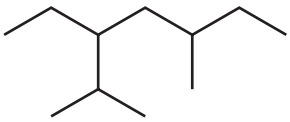

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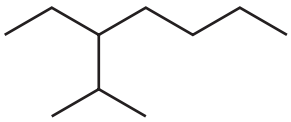
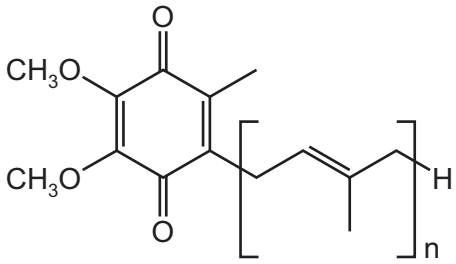


33 The diagram shows a simplified structure of coenzyme Q_{10}.

coenzyme Q_{10}



Which row describes the structure of coenzyme Q_{10} correctly?

	the coenzyme is	number of π bonds in one molecule
A	an aldehyde	$n + 2$
B	an aldehyde	$n + 4$
C	a ketone	$n + 2$
D	a ketone	$n + 4$

34 The molecule of limonene, $C_{10}H_{16}$, contains a 6-membered ring. This is the only cyclic component in its structure.

Which volume of hydrogen, at room conditions, is required to react completely with the C=C double bonds in **one** mole of limonene?

A $12\,dm^3$ **B** $24\,dm^3$ **C** $48\,dm^3$ **D** $72\,dm^3$

35 1-bromopropane reacts with hot ethanolic NaOH.

What is the molecular formula of the product in this reaction?

A C_3H_6 **B** C_3H_8 **C** C_3H_7O **D** C_3H_8O

36 A sample of pent-2-en-4-ol, $C_5H_{10}O$, contains all the possible stereoisomers of this compound.

How many stereoisomers are there in the sample?

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

37 Which pair of reagents reacts to form a product with a chiral carbon atom?

A $CH_3CH{=}CH_2$ + HBr

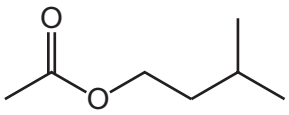
B $(CH_3)_2C{=}O$ + $NaBH_4$

C CH_3CH_2CHO + HCN

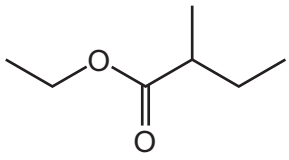
D CH_3COOH + CH_3CH_2OH

38 The diagrams show the structures of two esters, X and Y, that are formed in ripening apples.

ester X



ester Y



Which carboxylic acids are formed when these esters are hydrolysed by $H_2SO_4(aq)$?

	ester X	ester Y
A	CH_3COOH	CH_3CH_2COOH
B	CH_3COOH	$CH_3CH_2CH(CH_3)COOH$
C	$CH_3CH(CH_3)CH_2COOH$	CH_3CH_2COOH
D	$CH_3CH(CH_3)CH_2COOH$	$CH_3CH_2CH(CH_3)COOH$

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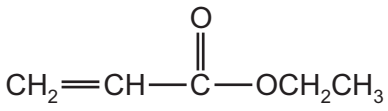
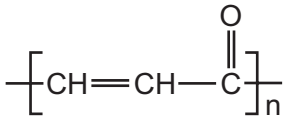
39 An addition polymer is made from monomer Z.

monomer Z

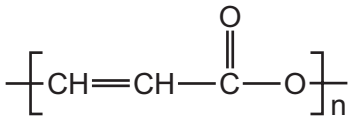


What is the structure of the polymer made from this monomer?

A



B



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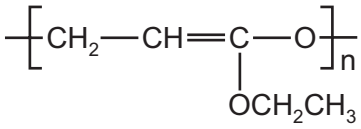

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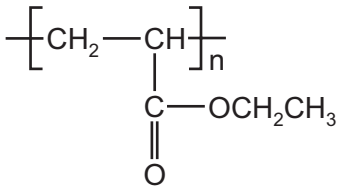
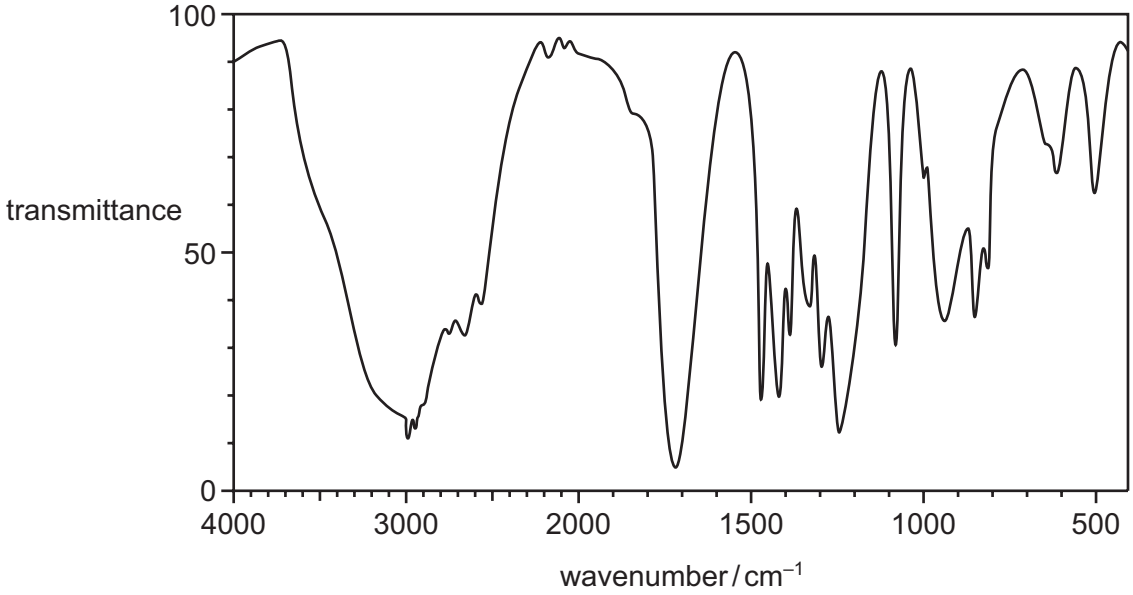


40 Compound X reacts with acidified $K_2Cr_2O_7$ to form compound Y.

The infrared spectrum of compound Y 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	2850–2950
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3600

What is the identity of compound X?

A propan-1-ol

B propan-2-ol

C propanone

D propanoic acid

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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 –