Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/12**

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

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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1 Equations involving four enthalpy changes are shown.

$Na(g) \rightarrow Na^+(g) + e^-$ $\Delta H = W$

$Na(g) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = X$

$Na(s) \rightarrow Na(g)$ $\Delta H = Y$

$Na(s) \rightarrow Na^{2+}(g) + 2e^-$ $\Delta H = Z$

Which equation represents the second ionisation energy of sodium?

A X **B** X + Y – W **C** X – W **D** Z – W

2 This question refers to isolated gaseous atoms in the ground state.

In which atom are all electrons paired?

A Ba **B** Br **C** S **D** Si

3 Which sample contains the most iodine?

A 1 g of CaI_2 **B** 1 g of KI **C** 1 g of NaI **D** 1 g of NH_4I

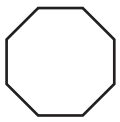
4 When a small sample of hydrocarbon Q is completely combusted, it produces 3.52 g of carbon dioxide and 1.44 g of water.

What could be the structure of hydrocarbon Q?

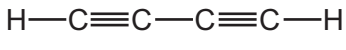
A



B



C



D



5 Ethane and ethene are both hydrocarbon molecules.

What is a feature of **both** molecules?

A a planar structure

B bond angles of 109°

C σ covalent bonds

D π covalent bonds

6 Elements J and L are both in Group 15.

J and L each form a gaseous covalent hydride in which their oxidation number is –3.

In the liquefied forms of these hydrides, significant hydrogen bonding occurs only in the hydride of L.

Which row about J and L could be correct?

	identity of J	identity of L	outer shell electron configuration
A	As	N	p^5
B	As	N	s^2p^3
C	N	As	p^5
D	N	As	s^2p^3

7 Which gas will behave **least** like an ideal gas at 150 °C and 101 kPa?

A ammonia

B fluorine

C krypton

D steam

8 When an evacuated glass bulb of volume 200 cm^3 is filled with a gas at 300 K and 101 kPa, the mass of the bulb increases by 0.68 g. The gas obeys the ideal gas equation.

What is the identity of the gas?

A argon

B krypton

C neon

D nitrogen

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9 The standard enthalpy of formation of $NO_2(g)$ is $+33.2\,kJ\,mol^{-1}$.

The standard enthalpy of formation of $N_2O_4(g)$ is $+9.2\,kJ\,mol^{-1}$.

What is the standard enthalpy change for the reaction $2NO_2(g) \rightarrow N_2O_4(g)$?

A $-57.2\,kJ\,mol^{-1}$

B $-24.0\,kJ\,mol^{-1}$

C $+42.4\,kJ\,mol^{-1}$

D $+75.6\,kJ\,mol^{-1}$

10 Separate samples of $25.0\,cm^3$ of $0.1\,mol\,dm^{-3}$ NaOH(aq) are added to each of three different acid solutions, as described. The temperature of each of the solutions was 298 K before mixing.

sample	acid	type of acid	concentration / $mol\,dm^{-3}$	volume / cm^3
1	H_2SO_4	strong	0.05	25.0
2	HC*l*	strong	0.05	25.0
3	CH_3CO_2H	weak	0.05	25.0

Which statement describes the temperature rises that occur on mixing each of these three acids separately with NaOH?

A The temperature rise in all three mixtures is the same.

B The temperature rise using H_2SO_4 and HC*l* is the same.

C The temperature rise using CH_3CO_2H is greater than using HC*l*.

D The greatest temperature rise occurs using H_2SO_4.

11 NCl_3 reacts with H_2O.

$$NCl_3 + 3H_2O \rightarrow NH_3 + 3HClO$$

The oxidation state of nitrogen does not change in this reaction.

Which statement is correct?

A Chlorine is reduced.

B Chlorine is oxidised.

C Hydrogen is both oxidised and reduced.

D This is not a redox reaction.

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12 In which row do the oxidation numbers of vanadium increase?

	smallest ⟶		largest
A	VO_4^{3-}	VO_3^-	VO_2^+
B	VO^{2+}	V_2O_3	VO_4^{3-}
C	V_2O_3	VO^{2+}	VO_3^-
D	VO_4^{3-}	VO_2^+	VO^{2+}

13 A synthesis for methanol is shown.

$$CO_2 + 3H_2 \rightleftharpoons CH_3OH + H_2O \qquad \Delta H = -49\,kJ\,mol^{-1}$$

Which conditions would produce the greatest yield of methanol at equilibrium?

	pressure	temperature / °C
A	high	80
B	high	20
C	low	80
D	low	20

14 Hydrogen and iodine can react reversibly to produce hydrogen iodide. The equation is shown.

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

4.00 mol of hydrogen gas and X mol of iodine vapour are mixed in a sealed container of volume 1.00 dm^3 at a temperature of 460 K. The system is allowed to reach equilibrium.

The equilibrium mixture contains 2.00 mol of hydrogen iodide. The equilibrium constant, K_c, for the reaction at 460 K is 4.0.

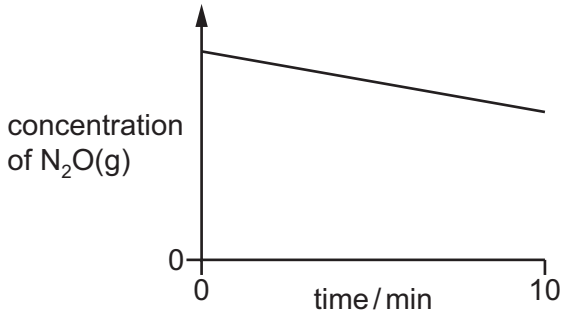
What is the value of X?

A 0.50 mol **B** 1.17 mol **C** 1.33 mol **D** 2.50 mol

15 A large amount of $N_2O(g)$ decomposes into nitrogen gas and oxygen gas in the presence of a tiny amount of a gold foil catalyst.

The gold foil provides a solid surface on which the catalysed reaction takes place.

The graph shows the concentration of $N_2O(g)$ against time as it decomposes. The graph is a straight line.



Which row describes:

- the change in rate of reaction as $N_2O(g)$ decomposes from 0 to 10 minutes
- the effect of adding more gold foil catalyst on the rate of decomposition of the same amount and concentration of $N_2O(g)$?

	change in rate of reaction as $N_2O(g)$ decomposes	effect of adding more gold foil on the rate of decomposition
A	none	increases
B	none	none
C	decreases	increases
D	decreases	none

16 The Haber process for the manufacture of ammonia is represented by the equation shown.

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

Which statement is correct about this reaction when the temperature is increased?

A Both forward and backward rates increase.

B The backward rate only increases.

C The forward rate only increases.

D There is no effect on the backward or forward rates.

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17 $NH_3(aq)$ is added to separate samples of $NaCl(aq)$, $MgCl_2(aq)$, $BaCl_2(aq)$ and $SiCl_4(l)$. Under the conditions of this experiment, only two samples will produce a white precipitate when $NH_3(aq)$ is added.

What are these two samples?

A $MgCl_2(aq)$ and $BaCl_2(aq)$

B $MgCl_2(aq)$ and $SiCl_4(l)$

C $NaCl(aq)$ and $BaCl_2(aq)$

D $NaCl(aq)$ and $SiCl_4(l)$

18 Why is the ionic radius of a sulfide ion larger than the ionic radius of a potassium ion?

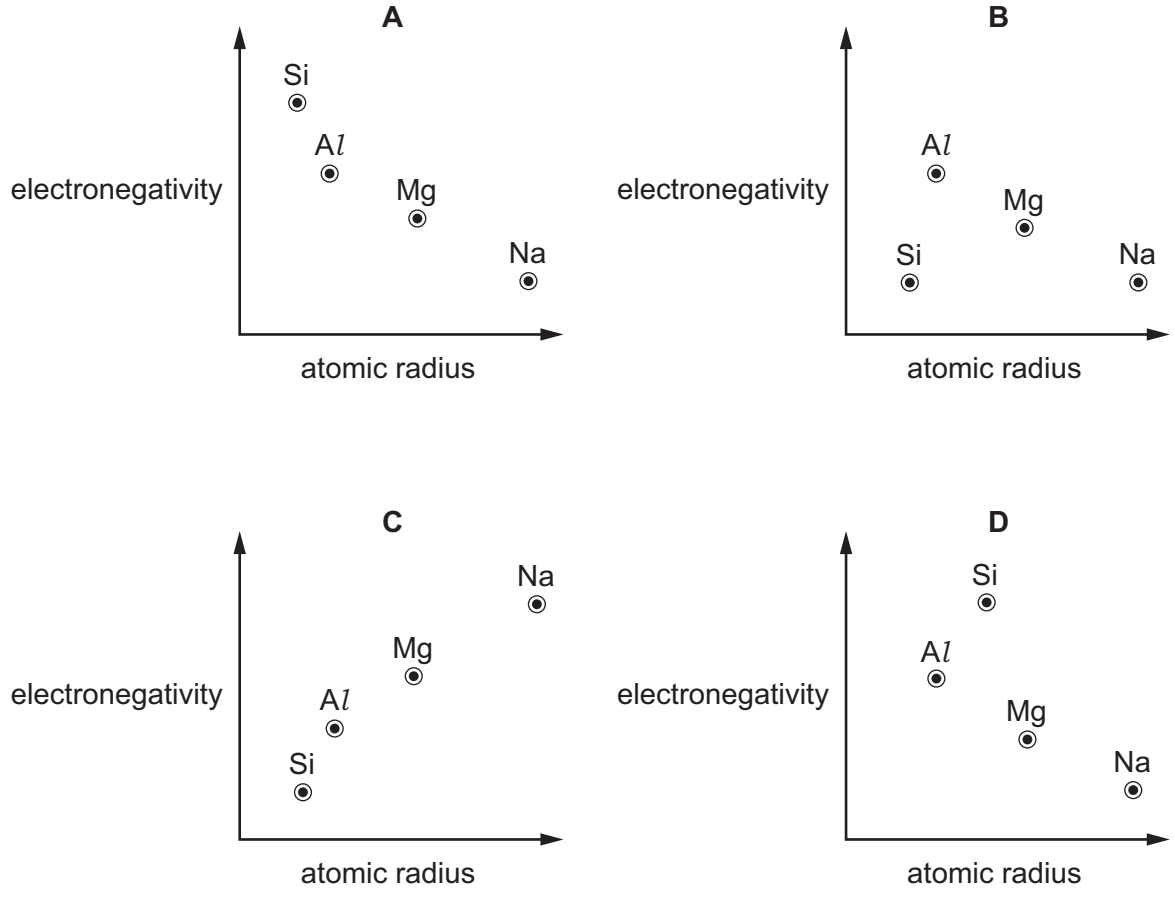
A Ionic radius always decreases with increasing atomic number.

B Positive ions always have smaller radii than negative ions.

C The potassium ion has more protons in its nucleus than the sulfide ion.

D The sulfide ion is doubly charged; the potassium ion is singly charged.

19 Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?



20 The table gives information about calcium carbonate and calcium hydroxide.

Which row is correct?

	calcium carbonate is more soluble in water than calcium hydroxide	calcium hydroxide can be manufactured using calcium carbonate as a starting material
A	no	no
B	no	yes
C	yes	no
D	yes	yes

21 Q is a Group 2 metal.

An excess of $QCO_3(s)$ is added to $H_2SO_4(aq)$ followed by filtration. A sample of QSO_4 is then obtained by evaporation of the filtrate.

What could be the identity of Q?

A barium, calcium or magnesium

B barium or calcium only

C calcium only

D calcium or magnesium only

22 X, Y and Z are three elements in Group 17.

X_2 has weaker covalent bonds than Y_2.

X_2 has stronger instantaneous dipole–induced dipole forces between its molecules than Z_2.

Y_2 is a stronger oxidising agent than Z_2.

What could be X, Y and Z?

	X	Y	Z
A	Br	C*l*	I
B	C*l*	Br	I
C	I	Br	C*l*
D	I	C*l*	Br

23 Chlorine reacts with aqueous sodium hydroxide forming two chlorine-containing products.

Which row shows the oxidation states of chlorine in the products under the conditions stated?

	conditions	oxidation state of Cl in products
A	cold NaOH(aq)	–1 and +3
B	cold NaOH(aq)	–1 and +5
C	hot NaOH(aq)	–1 and +3
D	hot NaOH(aq)	–1 and +5

24 A catalytic converter reduces the amount of pollutants in the fumes from a car exhaust.

Which row identifies a pollutant and shows how it is removed by the action of the catalyst?

	pollutant	chemical removal
A	carbon dioxide	reduced to carbon
B	carbon monoxide	oxidised to carbon dioxide
C	oxides of nitrogen	oxidised to nitric acid
D	unburnt hydrocarbons	oxidised to carbon dioxide and hydrogen

25 Solid R is added to a solution of ammonium nitrate and the mixture is heated. A gas is given off which turns red litmus to blue.

What could be R?

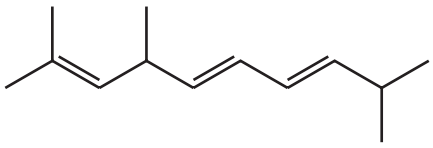
A aluminium chloride

B magnesium chloride

C sodium oxide

D phosphorus oxide

26 A skeletal formula is shown.



What is the total number of stereoisomers including the one shown?

A 4 **B** 6 **C** 8 **D** 16

27 The molecular formula CH_3 can represent an anion, a cation or a free radical. Species with the molecular formula CH_3 can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons on the central carbon atom must be present for CH_3 to act in these different ways?

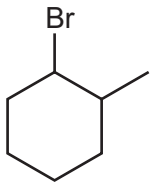
	CH_3 as an electrophile	CH_3 as a free radical	CH_3 as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

28 Compound Z, $C_7H_{13}Br$, has two chiral centres. A sample of Z contains all four possible optical isomers.

This sample of Z reacts with hot ethanolic NaOH to produce a mixture of **only** three isomers. Two of these isomers are optical isomers of each other.

What could be the formula of Z?

A



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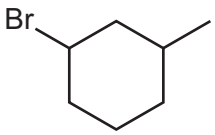

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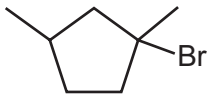

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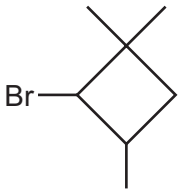

29 The free-radical substitution reaction between methane and chlorine involves initiation, propagation and termination stages.

Which row is correct?

	involved in initiation stage	radical produced in a propagation stage
A	homolytic fission	H•
B	homolytic fission	CH_3•
C	heterolytic fission	H•
D	heterolytic fission	CH_3•

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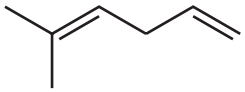
30 The alkene shown reacts with an excess of HBr via an electrophilic addition reaction.



What is the **major** product formed?

A 3,5-dibromo-2-methylhexane

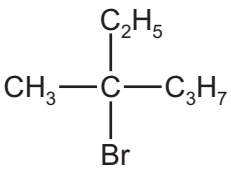
B 2,5-dibromo-2-methylhexane

C 2,6-dibromo-2-methylhexane

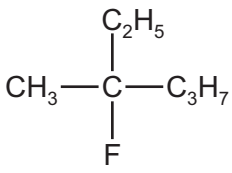
D 3,6-dibromo-2-methylhexane

31 The diagram shows the structures of two halogenoalkanes, P and Q.

P



Q



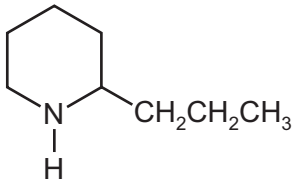
Both compounds can be hydrolysed.

Which row is correct?

	compound more readily hydrolysed	reaction mechanism
A	P	S_N1
B	P	S_N2
C	Q	S_N1
D	Q	S_N2

32 The structure of coniine is shown.

coniine



Coniine can be synthesised by reacting ammonia with a dibromo compound, X.

X

$$NH_3 + C_8H_{16}Br_2 \rightarrow \text{coniine} + 2HBr$$

What is compound X?

A 1,1-dibromo-2-propylcyclopentane

B 1,2-dibromo-2-propylcyclopentane

C $Br(CH_2)_3CHBr(CH_2)_3CH_3$

D $Br(CH_2)_4CHBr(CH_2)_2CH_3$

33 Primary alcohols can be oxidised to aldehydes using either acidified potassium dichromate(VI) or acidified potassium manganate(VII). The reaction mixtures change colour as the oxidising agent is reduced.

What are the colour changes seen?

	acidified potassium dichromate(VI)		acidified potassium manganate(VII)	
	before	after	before	after
A	green	orange	purple	colourless
B	orange	green	colourless	purple
C	orange	green	purple	colourless
D	purple	colourless	orange	green

34 Which reaction has a product that gives a yellow precipitate when treated with alkaline I_2(aq)?

A 2-chloropropane is warmed with a dilute aqueous solution of sodium hydroxide.

B Ethanal is heated under reflux with acidified potassium dichromate(VI).

C Methyl ethanoate is heated under reflux with dilute sulfuric acid.

D Propanal is reacted with $NaBH_4$, followed by dilute sulfuric acid.

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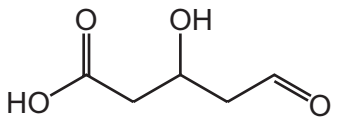
35 The skeletal formula of M is shown.

M



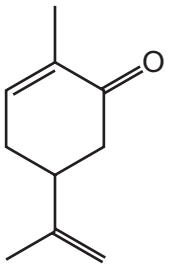
M is reacted with an excess of $LiAlH_4$. Dilute acid is then added.

What is the molecular formula of the final organic product?

A $C_5H_6O_5$ **B** $C_5H_{10}O_4$ **C** $C_5H_{10}O_3$ **D** $C_5H_{12}O_3$

36 Which compound forms a precipitate when mixed with 2,4-DNPH reagent and also forms a precipitate when mixed with Fehling's reagent?

A



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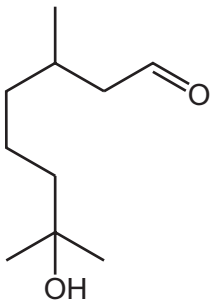

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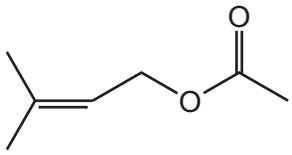

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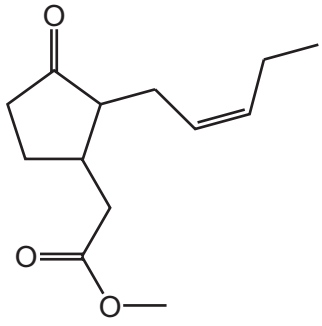

37 Which reaction is a redox reaction?

A ethanenitrile heated under reflux with dilute hydrochloric acid

B ethanoic acid reacted with aqueous sodium hydroxide

C ethanoic acid reacted with sodium

D ethyl ethanoate heated under reflux with dilute hydrochloric acid

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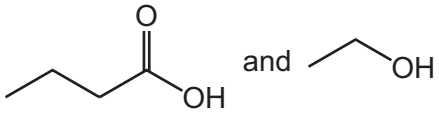
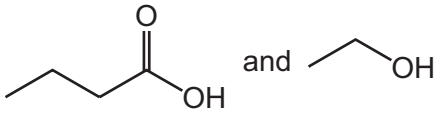
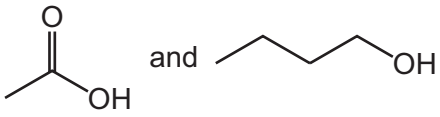
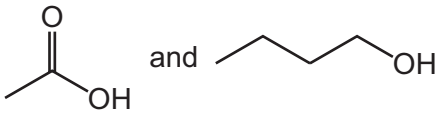
[Turn over

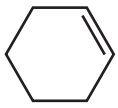
38 Ethyl butanoate is a flavouring, with a fruity flavour.

Which row is correct?

	alcohol and acid that react to form ethyl butanoate	the mass of water formed when 2.32 g of ester is formed
A		0.36 g
B		0.40 g
C		0.36 g
D		0.40 g

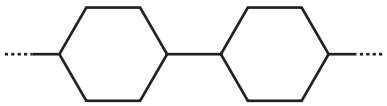
39 Cyclohexene, as shown in the diagram, can form an addition polymer.

cyclohexene



Which structure represents a section of the polymer?

A



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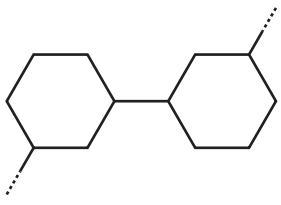

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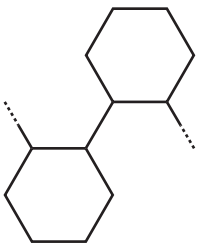

D



40 Three organic compounds are listed.

1 ethanal

2 propan-1-ol

3 propan-2-ol

Which compounds will have a mass spectrum that contains a fragment peak at $m/e = 43$?

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

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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	$L = 6.02 \times 10^{23}\,\text{mol}^{-1}$
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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

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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		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 –