GradeMax

Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/14**

Paper 1 Multiple Choice **October/November 2025**

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 Helium forms an ion $^{3}_{2}He^{+}$.

Three statements about this ion are listed.

1 It contains two protons.

2 It contains three neutrons.

3 It contains one electron.

Which statements are correct?

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

2 The table shows the first five ionisation energies of element X.

element	ionisation energy / kJ mol^{-1}				
	1st	2nd	3rd	4th	5th
X	736	1450	7740	10 500	13 600

Element X is in Period 3 of the Periodic Table.

What is element X?

A sodium

B magnesium

C silicon

D argon

3 Methanethiol, CH_3SH, burns as shown.

$$CH_3SH + 3O_2 \rightarrow CO_2 + SO_2 + 2H_2O$$

A sample of 10 cm^3 of methanethiol gas was reacted with 60 cm^3 of oxygen. Both samples were measured at room conditions.

What would be the final volume of the resultant mixture of gases measured at room temperature?

A 20 cm^3 **B** 30 cm^3 **C** 50 cm^3 **D** 70 cm^3

4 A solution containing 4.4 g of an organic acid is exactly neutralised by 25.0 cm^3 of 2.0 mol dm^{-3} sodium hydroxide. The acid has one COOH group in each molecule.

What is the empirical formula of the acid?

A CH_2O **B** C_2H_4O **C** $C_3H_6O_3$ **D** $C_4H_8O_2$

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5 In which set do all the molecules have all their atoms arranged in one plane?

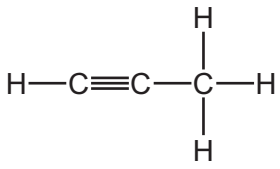
A $AlCl_3$, BF_3, PH_3

B $AlCl_3$, CO_2, NH_3

C BF_3, C_2H_4, C_3H_6

D C_2H_4, CO_2, H_2O

6 The diagram shows the bonding in a molecule of propyne.



Which types of hybridisation are shown by the carbon atoms in propyne?

A sp, sp^2 and sp^3

B sp and sp^3 only

C sp^2 and sp^3 only

D sp^2 only

7 The boiling point of water, H_2O, is higher than that of hydrogen sulfide, H_2S.

Which statement explains this difference in boiling points?

A The bond energy of O–H is greater than the bond energy of S–H.

B The intermolecular forces in H_2O are weaker than the intermolecular forces in H_2S.

C The S–H bond in H_2S is longer than the O–H bond in H_2O.

D There is significant intermolecular hydrogen bonding in H_2O but **not** in H_2S.

8 Which row describes silicon dioxide?

	electrical conductivity in liquid state	solubility in water
A	non-conductor	insoluble
B	non-conductor	soluble
C	conductor	insoluble
D	conductor	soluble

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9 The data shown are needed for this question.

$\Delta H_f^\ominus(P_4O_{10}(s)) = -3012\,kJ\,mol^{-1}$

$\Delta H_f^\ominus(H_2O(l)) = -286\,kJ\,mol^{-1}$

$\Delta H_f^\ominus(H_3PO_4(s)) = -1279\,kJ\,mol^{-1}$

What is $\Delta H^\ominus$ for the reaction shown?

$$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(s)$$

A $-9844\,kJ\,mol^{-1}$

B $-388\,kJ\,mol^{-1}$

C $-97\,kJ\,mol^{-1}$

D $+2019\,kJ\,mol^{-1}$

10 In an experiment to measure the enthalpy change of neutralisation of hydrochloric acid, $20\,cm^3$ of solution containing 0.04 mol of HC*l* is placed in a plastic cup of negligible heat capacity.

A $20\,cm^3$ sample of aqueous sodium hydroxide containing 0.04 mol of NaOH, at the same initial temperature, is added and the temperature rises by 15 K.

If the heat capacity per unit volume of the final solution is $4.2\,J\,K^{-1}\,cm^{-3}$, what is the enthalpy change of neutralisation of hydrochloric acid?

A $\frac{20 \times 4.2 \times 15}{0.04}\,J\,mol^{-1}$

B $40 \times 4.2 \times 15 \times 0.08\,J\,mol^{-1}$

C $\frac{40 \times 4.2 \times 15}{0.04}\,J\,mol^{-1}$

D $\frac{20 \times 4.2 \times 15}{0.08}\,J\,mol^{-1}$

11 Acidified potassium manganate(VII) reacts with iron(II) ethanedioate, FeC_2O_4.

The reactions taking place are shown.

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$

$$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$$

How many moles of iron(II) ethanedioate react with **one** mole of potassium manganate(VII)?

A 0.60 **B** 1.67 **C** 2.50 **D** 5.00

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12 Nitrogen dioxide decomposes on heating according to the equation shown.

$$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$$

When 4 mol of nitrogen dioxide were put into a 1 dm^3 container and heated to a constant temperature, the equilibrium mixture contained 0.8 mol of oxygen.

What is the value of the equilibrium constant, K_c, at the temperature of the experiment?

A $\frac{0.8^2 \times 0.8}{4^2}$ **B** $\frac{1.6 \times 0.8}{2.4^2}$ **C** $\frac{1.6^2 \times 0.8}{4^2}$ **D** $\frac{1.6^2 \times 0.8}{2.4^2}$

13 One particle of X reacts with one particle of Y in a single-step reaction to produce two particles of Z.

This reaction is exothermic and reversible.

$$X + Y \rightleftharpoons 2Z$$

Three statements about the forward and reverse reactions are listed.

1 The activation energy of the forward reaction is equal to the activation energy of the reverse reaction.

2 At equilibrium, the frequency of collisions between one particle of X and one particle of Y is equal to the frequency of collisions between two particles of Z.

3 At equilibrium, the frequency of effective collisions between one particle of X and one particle of Y is equal to the frequency of effective collisions between two particles of Z.

Which statements are correct?

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

14 When two aqueous solutions are mixed, the reaction between them is very slow.

An effective catalyst is added to the mixture without any change in temperature.

Which statement about this catalyst is correct?

A It increases the average energy of the reactant particles.

B It changes the distribution of energies of the reactant particles.

C It allows a greater number of reactant particles to react per unit time.

D It increases the number of reactant particles with the most probable energy.

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15 A mixture of gases reacts faster as its temperature increases.

Which row explains this?

	the activation energy remains unchanged	more particles have energy equal to or above the activation energy	there is an increase in the rate of successful collisions
A	false	false	false
B	true	true	true
C	false	true	true
D	true	false	false

16 A student investigated the chloride of a Period 3 element. This is what the student wrote down as their observations.

> The compound was a white crystalline solid. It dissolved easily in water to give a solution of pH 12. When placed in a test-tube and heated in a roaring Bunsen flame, the compound melted after several minutes' heating.

What can be deduced from these observations?

A At least one of the recorded observations is **not** correct.

B The compound was magnesium chloride, $MgCl_2$.

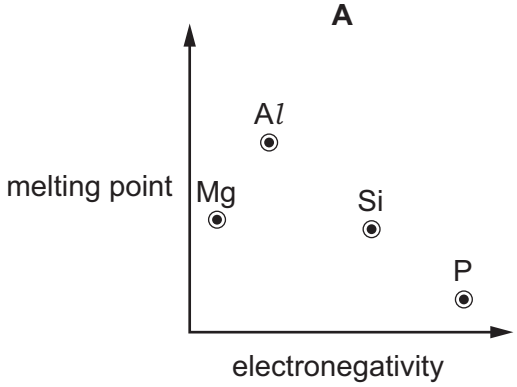
C The compound was phosphorus pentachloride, PCl_5.

D The compound was sodium chloride, $NaCl$.

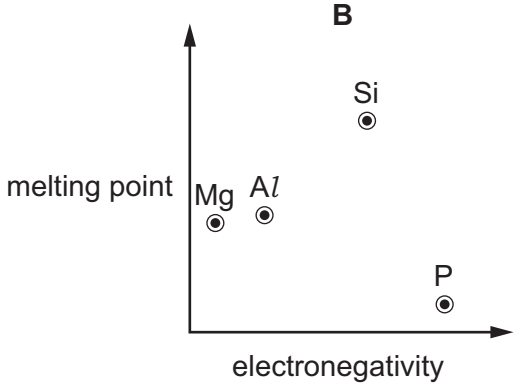
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17 Which graph shows the relative melting points of the elements Mg, A*l*, Si and P plotted against their relative electronegativities?

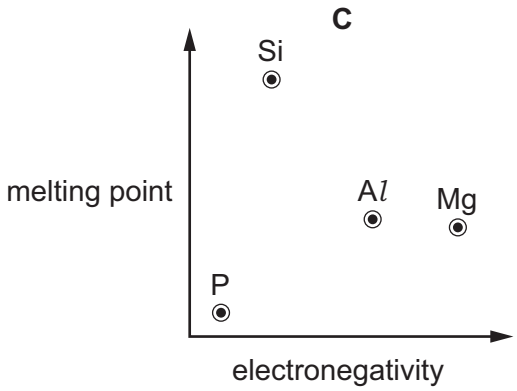
A



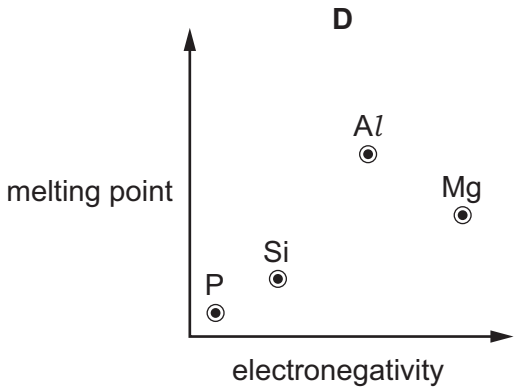
B



C



D



18 Caesium and barium are in Period 6 of the Periodic Table.

Which row is correct?

	the larger ionic radius	the higher melting point
A	Ba^{2+}	barium
B	Ba^{2+}	caesium
C	Cs^{+}	barium
D	Cs^{+}	caesium

19 Magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is oxygen.

29.7 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

Which mass of oxygen is produced?

A 3.2 g **B** 6.4 g **C** 12.8 g **D** 19.2 g

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20 Which row shows the trends in the named properties going down the Group 2 nitrates?

	thermal stability	volume of gas produced, measured at room conditions, when 1.0 g of anhydrous solid nitrate is thermally decomposed
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

21 X, Y and Z are three aqueous solutions. Equal volumes of pairs of the solutions are mixed and observations noted.

X mixed with Y shows no reaction.

X mixed with Z shows an immediate reaction.

Z mixed with Y shows no reaction.

What are X, Y and Z?

	X	Y	Z
A	$Br_2(aq)$	$I_2(aq)$	HBr(aq)
B	$Cl_2(aq)$	$I_2(aq)$	HBr(aq)
C	$HCl(aq)$	HI(aq)	$Br_2(aq)$
D	$HCl(aq)$	$Br_2(aq)$	HBr(aq)

22 An excess of chlorine gas is bubbled into hot potassium hydroxide solution.

Which chlorine-containing species are present in the final solution?

A Cl^- and ClO^-

B Cl^- and ClO_3^-

C ClO^- and ClO_3^-

D ClO_3^- only

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23 The oxides of nitrogen, NO and NO_2, act as pollutants in the Earth's atmosphere in a number of different ways.

Three statements about the oxides of nitrogen are listed.

1 They react with oxygen and water vapour to form nitric acid, a constituent of acid rain.

2 They react with carbon monoxide to form photochemical smog.

3 They catalyse the oxidation of sulfur dioxide in the formation of sulfuric acid, another constituent of acid rain.

Which statements are correct?

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

24 Which reagent, when mixed with ammonium sulfate and then heated, liberates ammonia?

A aqueous bromine

B dilute hydrochloric acid

C aqueous calcium hydroxide

D potassium dichromate(VI) in acidic solution

25 Two hydrocarbons, $CH_3CHC(CH_3)CH_3$ and $CH_3CH(CH_3)CH_2CH_3$, react separately with chlorine in the presence of ultraviolet light.

In each reaction, free-radical substitution occurs.

Which row is correct?

	identity of the hydrocarbon that can also undergo electrophilic addition	a termination stage of the free-radical substitution of the saturated hydrocarbon
A	$CH_3CHC(CH_3)CH_3$	$CH_3CH(CH_3)CH_2CH_2\bullet + Cl\bullet \rightarrow CH_3CH(CH_3)CH_2CH_2Cl$
B	$CH_3CHC(CH_3)CH_3$	$CH_3CHC(CH_3)CH_2\bullet + Cl\bullet \rightarrow CH_3CHC(CH_3)CH_2Cl$
C	$CH_3CH(CH_3)CH_2CH_3$	$CH_3CH(CH_3)CH_2CH_2\bullet + Cl\bullet \rightarrow CH_3CH(CH_3)CH_2CH_2Cl$
D	$CH_3CH(CH_3)CH_2CH_3$	$CH_3CHC(CH_3)CH_2\bullet + Cl\bullet \rightarrow CH_2CHC(CH_3)CH_2Cl$

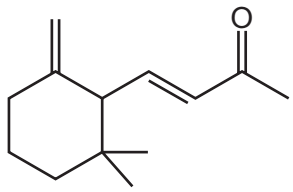
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26 The structure of the compound γ-ionone is shown.

γ-ionone



Including γ-ionone, how many stereoisomers exist with this molecular formula?

A 1 **B** 2 **C** 4 **D** 8

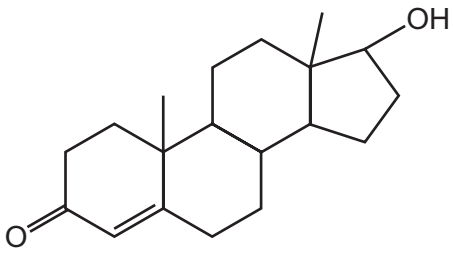
27 Structural and stereoisomerism should be considered when answering this question.

A mixture of 1-chlorobutane and 2-chlorobutane is heated with an excess of NaOH in ethanol.

How many different organic molecules will be produced?

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

28 The diagram shows the skeletal formula of the hormone testosterone.



What is the molecular formula of testosterone?

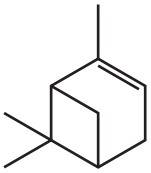
A $C_{19}H_{28}O_2$ **B** $C_{17}H_{22}O_2$ **C** $C_{17}H_{24}O_2$ **D** $C_{19}H_{26}O_2$

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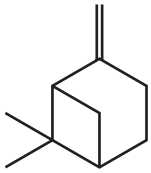
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29 Pinenes are unsaturated compounds. The structures of two pinenes are shown.

α-pinene



β-pinene



A mixture of these two pinenes reacts with hot concentrated acidified $KMnO_4$.

What are the molecular formulae of the organic products?

A $C_9H_{14}O$ and $C_{10}H_{16}O_3$

B $C_9H_{14}O$ and $C_{10}H_{14}O_4$

C $C_9H_{16}O_2$ and $C_{10}H_{16}O_3$

D $C_9H_{16}O_2$ and $C_{10}H_{14}O_4$

30 An organic ion containing a carbon atom with a negative charge is called a carbanion.

An organic ion containing a carbon atom with a positive charge is called a carbocation.

The reaction between NaOH(aq) and 1-bromobutane proceeds by an S_N2 mechanism.

What is the first step in the mechanism?

A attack by a nucleophile on a carbon atom with a partial positive charge

B heterolytic bond fission followed by attack by an electrophile on a carbanion

C heterolytic bond fission followed by attack by a nucleophile on a carbocation

D homolytic bond fission followed by attack by a nucleophile on a carbocation

31 2-chloropropane and 2-bromopropane react separately with aqueous NaOH.

Which row is correct?

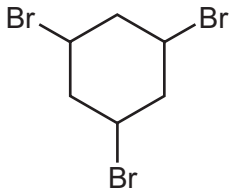
	comparison of rates of reaction	explanation of the difference in reaction rates
A	2-chloropropane reacts faster	chlorine is more reactive than bromine
B	2-chloropropane reacts faster	the C–C*l* bond is more polar than the C–Br bond
C	2-bromopropane reacts faster	the first ionisation energy of bromine is lower than chlorine's
D	2-bromopropane reacts faster	the C–Br bond is weaker than the C–C*l* bond

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32 The diagram shows the structure of compound X.



X

X undergoes hydrolysis to form product Y in which all of the bromine atoms are replaced by hydroxyl groups. Product Z is formed by oxidation of Y.

Two suggestions are listed.

1 Y is a secondary alcohol.

2 Z is a ketone.

Which suggestions are correct?

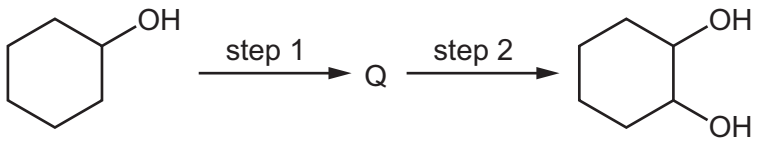
A both 1 and 2

B 1 only

C 2 only

D neither 1 nor 2

33 Cyclohexanol is converted to cyclohexane-1,2-diol via a two-step synthesis that proceeds via intermediate Q.



Which row identifies the type of reaction in step 1 and in step 2?

	step 1	step 2
A	dehydration	oxidation
B	dehydration	nucleophilic substitution
C	reduction	oxidation
D	reduction	nucleophilic substitution

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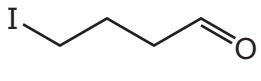
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34 Three tests were performed on an unknown organic compound.

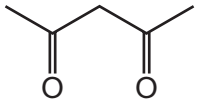
test reagent	test result
2,4-DNPH reagent	orange ppt
Tollens' reagent	no change
alkaline I_2(aq)	yellow ppt

What is the organic compound tested?

A



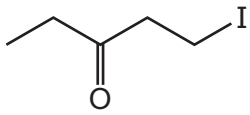
B



C



D



35 Butanone, $CH_3CH_2COCH_3$, and HCN mixed with a little KCN react together in a nucleophilic addition reaction.

Which description of the mechanism of this nucleophilic addition reaction is correct?

A The π bond pair of C=O accepts H^+ from HCN and then CN^- acts as a nucleophile.

B A π bond pair from CN^- attacks the δ+ C and HCN then donates H^+ to O.

C The lone pair on O accepts H^+ from HCN and then CN^- acts as a nucleophile.

D A lone pair from CN^- attacks the δ+ C and then O^- accepts H^+ from HCN.

36 The structural formula of compound P is $CH_3CH_2COOCH_2CH_3$.

P can be formed by reacting together two organic compounds in the presence of a suitable catalyst.

Which pair of compounds could react together to produce P?

A ethanoic acid and propanoic acid

B ethanoic acid and propan-1-ol

C ethanol and propanoic acid

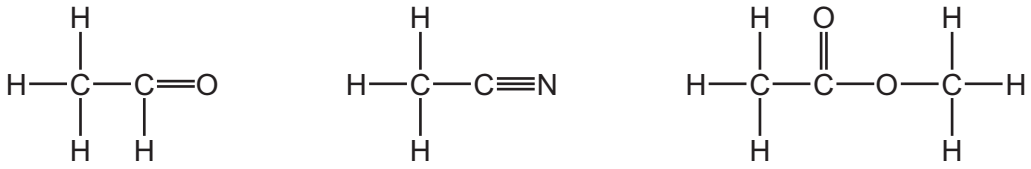
D ethanol and propan-1-ol

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37 The structures of three organic compounds are shown.



1 2 3

Which compounds produce ethanoic acid when heated with HCl(aq)?

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

38 When bromoethane, C_2H_5Br, is heated with NaOH in ethanol, which type of reaction occurs?

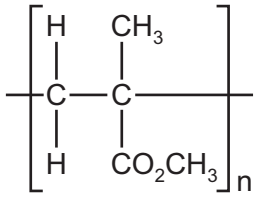
A electrophilic substitution

B elimination

C nucleophilic substitution, mainly via an S_N1 mechanism

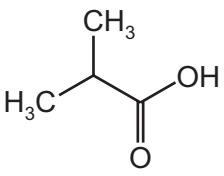
D nucleophilic substitution, mainly via an S_N2 mechanism

39 PMMA is a rigid polymer. The repeat unit of PMMA is shown.

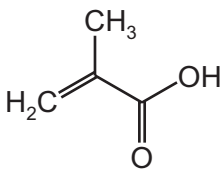


Which monomer is used to make PMMA?

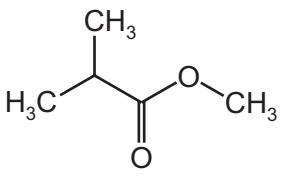
A



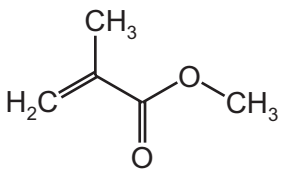
B



C



D



40 A sample of gallium contains two isotopes only.

In every 10 atoms in the sample, there are 6 that have 38 neutrons and 4 that have 40 neutrons.

What is the relative atomic mass, A_r, of the gallium in the sample?

A 69.7 **B** 69.8 **C** 70.0 **D** 70.2

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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											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 144.2	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 –

GradeMax