



# Cambridge International AS & A Level

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## CHEMISTRY

9701/12

Paper 1 Multiple Choice

October/November 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)

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### 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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This document has **16** pages.

1 Which species contains a different number of electrons from the other three?

**A**  $\text{ClO}_4^-$       **B**  $\text{H}_2\text{SO}_4$       **C**  $\text{SO}_4^{2-}$       **D**  $\text{Te}^{2-}$

2 Which factor causes helium to have a higher first ionisation energy than hydrogen?

**A** In the 1s orbital in helium, electrons are paired.  
**B** The lowest energy level in helium is filled.  
**C** The nuclear charge in helium is higher than in hydrogen.  
**D** There is less shielding of the outer shell in helium.

3 A 0.216 g sample of aluminium carbide reacts with an excess of water to produce methane gas. This is the only carbon-containing product formed in the reaction. This methane gas burns completely in  $\text{O}_2$  to form  $\text{H}_2\text{O}$  and  $\text{CO}_2$  only. The volume of  $\text{CO}_2$  produced at room temperature and pressure is 108  $\text{cm}^3$ .

What is the formula of aluminium carbide?

**A**  $\text{Al}_2\text{C}_3$       **B**  $\text{Al}_3\text{C}_2$       **C**  $\text{Al}_3\text{C}_4$       **D**  $\text{Al}_4\text{C}_3$

4 A reaction between two gases takes place on the surface of the catalytic converter of a petrol-engined car.

In this reaction, four reactant molecules produce three product molecules.

What could be the two reactant gases in this reaction?

**A** nitrogen and carbon dioxide  
**B** nitrogen monoxide and carbon dioxide  
**C** nitrogen monoxide and carbon monoxide  
**D** nitrogen dioxide and carbon monoxide

5 An ion contains 1 nitrogen atom and 2 hydrogen atoms. It has an H–N–H bond angle of approximately 105°.

Which row is correct?

	number of lone pairs around N in ion	overall charge on ion
<b>A</b>	1	+1
<b>B</b>	2	+1
<b>C</b>	1	-1
<b>D</b>	2	-1

6 Why does  $\text{ICl}$  have a higher boiling point than  $\text{Br}_2$ ?

A because of the difference in the bond energies of the covalent bonds within  $\text{ICl}$  and  $\text{Br}_2$   
 B because of the difference in the polar nature of  $\text{ICl}$  and  $\text{Br}_2$   
 C because of the difference in the number of electrons contained within  $\text{ICl}$  and  $\text{Br}_2$   
 D because of the difference in the relative molecular mass of  $\text{ICl}$  and  $\text{Br}_2$

7 In this question you may assume that nitrogen behaves as an ideal gas. One atmosphere pressure = 101 kPa.

Which volume does 1.0 g of nitrogen occupy at 50 °C and a pressure of 2.0 atmospheres?

A 70  $\text{cm}^3$       B 150  $\text{cm}^3$       C 470  $\text{cm}^3$       D 950  $\text{cm}^3$

8 Which statement about the properties associated with the different types of bonding involved is correct?

A Any covalent compound that contains both oxygen and hydrogen in its molecule forms hydrogen bonds.  
 B Ionic bonds and covalent bonds cannot both occur in the same compound.  
 C Ionic compounds differ from metals in that ionic compounds do not conduct electricity in the solid state.  
 D The only covalent compounds with high melting points are those in which hydrogen bonds occur.

9 For which reaction is the enthalpy change an enthalpy change of formation?

A  $\text{C(g)} + 2\text{H}_2\text{(g)} \rightarrow \text{CH}_4\text{(g)}$   
 B  $\frac{1}{2}\text{N}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{NO(g)}$   
 C  $\text{Na}_2\text{O(s)} + \text{SO}_3\text{(g)} \rightarrow \text{Na}_2\text{SO}_4\text{(s)}$   
 D  $\text{PCl}_3\text{(g)} + \text{Cl}_2\text{(g)} \rightarrow \text{PCl}_5\text{(g)}$

10 Two standard enthalpy change of formation values are given.

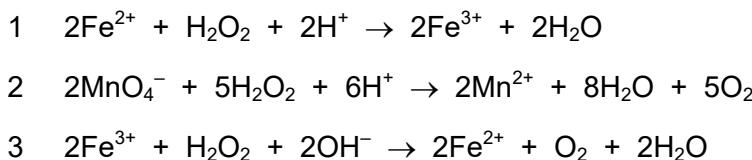
$$\Delta H_f^\ominus [\text{VCl}_2] = -452 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus [\text{VCl}_3] = -573 \text{ kJ mol}^{-1}$$

What is the enthalpy change for the reaction  $3\text{VCl}_2 \rightarrow 2\text{VCl}_3 + \text{V}$ ?

A  $-210 \text{ kJ mol}^{-1}$     B  $-121 \text{ kJ mol}^{-1}$     C  $+121 \text{ kJ mol}^{-1}$     D  $+210 \text{ kJ mol}^{-1}$

11 Equations for some reactions of hydrogen peroxide are given.



In which reactions is hydrogen peroxide acting as a reducing agent?

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

12 The equation for the reaction of aqueous thiosulfate ions,  $\text{S}_2\text{O}_3^{2-}$ , and aqueous dioxo-vanadium ions,  $\text{VO}_2^+$ , is shown.



Which row shows two correct statements about the equation for this reaction?

	comparison of $x$ and $y$ to $z$	change in oxidation number of vanadium
<b>A</b>	$x$ and $z$ are the same value and quarter the value of $y$	from +4 to +5
<b>B</b>	$x$ and $z$ are the same value and quarter the value of $y$	from +5 to +4
<b>C</b>	$x$ and $z$ are the same value and half the value of $y$	from +5 to +4
<b>D</b>	$x$ and $z$ are the same value and half the value of $y$	from +4 to +5

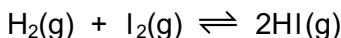
13 When some solid  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$  is added to a beaker of water, an equilibrium is set up.



Which compound, when added to the equilibrium mixture, increases the amount of  $\text{Ca}_5(\text{PO}_4)_3\text{OH}(s)$  present?

**A**  $\text{NH}_3$       **B**  $\text{NH}_4\text{Cl}$       **C**  $\text{CH}_3\text{CO}_2\text{H}$       **D**  $\text{NaCl}$

14 Gaseous hydrogen and gaseous iodine react to form gaseous hydrogen iodide.



In an experiment, 2.0 mol of hydrogen and 2.0 mol of iodine are placed in a sealed container of volume 1.0 dm<sup>3</sup>.

The  $K_c$  value for this reaction under the conditions used is 9.0.

How many moles of hydrogen iodide are present at equilibrium?

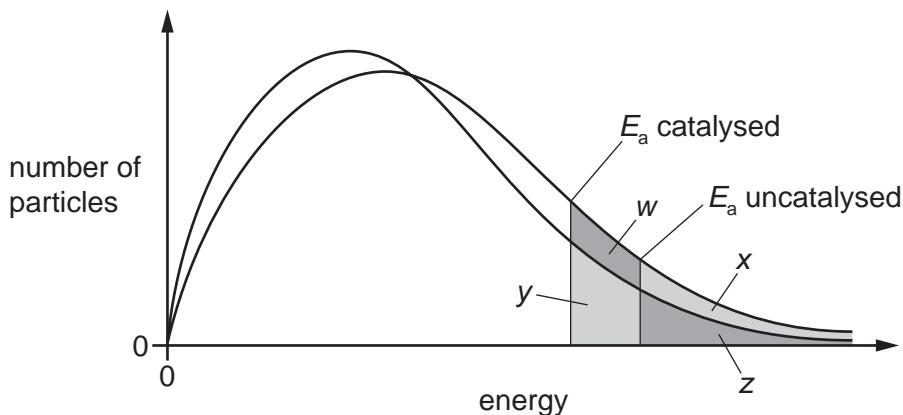
A 0.57 mol      B 1.2 mol      C 1.5 mol      D 2.4 mol

15 Why does the rate of a gaseous reaction increase when the pressure is increased at a constant temperature?

A More particles have energy that exceeds the activation energy.  
 B The particles have more space in which to move.  
 C The particles move faster.  
 D There are more frequent collisions between particles.

16 The Boltzmann distribution for a mixture of gases capable of reaction is shown.

The two curves represent the mixture of gases at 25 °C and at 35 °C. The activation energies for the catalysed and uncatalysed reactions are shown.



Which row is correct?

	number of particles with enough energy to react at 25 °C in the catalysed reaction	number of particles with enough energy to react at 35 °C in the uncatalysed reaction
<b>A</b>	$w + x + y + z$	$z$
<b>B</b>	$w + x + y + z$	$x + z$
<b>C</b>	$y + z$	$z$
<b>D</b>	$y + z$	$x + z$

17 Which oxide is insoluble in aqueous sodium hydroxide?

**A** MgO      **B**  $Al_2O_3$       **C**  $P_4O_{10}$       **D**  $SO_2$

18 Sodium and sulfur are burned separately in oxygen.

Each reaction has a distinctive coloured flame.

Which row is correct?

	Na + O <sub>2</sub>	S + O <sub>2</sub>
<b>A</b>	white flame	blue flame
<b>B</b>	white flame	yellow flame
<b>C</b>	yellow flame	blue flame
<b>D</b>	yellow flame	yellow flame

19 X and Y are elements in Period 3 of the Periodic Table.

Y has a greater atomic number than X.

The stable ion formed by Y has a greater radius than the stable ion formed by X.

The stable ion formed by Y has 18 electrons.

Which row is correct?

	number of electrons in the stable ion of X	element with the greater atomic radius
<b>A</b>	10	X
<b>B</b>	10	Y
<b>C</b>	18	X
<b>D</b>	18	Y

20 X is a Group 2 element in either Period 3 or Period 5.  $\text{X}(\text{OH})_2$  is less soluble in water than  $\text{Ca}(\text{OH})_2$ .

When  $\text{X}(\text{NO}_3)_2$  is heated, it decomposes.

Which row is correct?

	identity of X	equation describing decomposition of $\text{X}(\text{NO}_3)_2$
<b>A</b>	Mg	$\text{X}(\text{NO}_3)_2 \rightarrow \text{X} + 2\text{NO}_2 + \text{O}_2$
<b>B</b>	Mg	$2\text{X}(\text{NO}_3)_2 \rightarrow 2\text{XO} + 4\text{NO}_2 + \text{O}_2$
<b>C</b>	Sr	$\text{X}(\text{NO}_3)_2 \rightarrow \text{X} + 2\text{NO}_2 + \text{O}_2$
<b>D</b>	Sr	$2\text{X}(\text{NO}_3)_2 \rightarrow 2\text{XO} + 4\text{NO}_2 + \text{O}_2$

21 Which statement comparing magnesium and barium, or their compounds, is correct?

- A** Magnesium reacts with dilute hydrochloric acid more rapidly than barium does.
- B** One mole of magnesium carbonate gives off a greater amount of gas when it reacts with an excess of dilute hydrochloric acid than one mole of barium carbonate does.
- C** The solubility of magnesium sulfate in water is greater than the solubility of barium sulfate in water.
- D** Magnesium carbonate undergoes thermal decomposition **less** readily than barium carbonate does.

22 The colours of the silver halides  $\text{AgCl}$ ,  $\text{AgBr}$  and  $\text{AgI}$  differ.

The solubilities of these halides in aqueous ammonia also differ.

Which row is correct?

	colour of $\text{AgBr}$	silver halide that is most soluble in $\text{NH}_3(\text{aq})$
<b>A</b>	cream	$\text{AgCl}$
<b>B</b>	cream	$\text{AgI}$
<b>C</b>	yellow	$\text{AgCl}$
<b>D</b>	yellow	$\text{AgI}$

23 The name 'chlorate' is used for an anion consisting of chlorine and oxygen only.

In a molecule of  $\text{ICl}$ , the iodine atom has oxidation number  $x$  and the chlorine atom has oxidation number  $y$ .

When  $\text{ICl}$  is added to  $\text{H}_2\text{O}$ , iodine is reduced.



Which statement about the value of  $x$  or  $y$  is correct?

A  $x$  is the same as the oxidation number of  $\text{Cl}$  in the chlorate ion formed when  $\text{Cl}_2(\text{aq})$  is added to cold  $\text{NaOH}(\text{aq})$ .

B  $x$  is the same as the oxidation number of  $\text{Cl}$  in the chlorate ion formed when  $\text{Cl}_2(\text{aq})$  is added to hot  $\text{NaOH}(\text{aq})$ .

C  $y$  is the same as the oxidation number of  $\text{Cl}$  in the chlorate ion formed when  $\text{Cl}_2(\text{aq})$  is added to cold  $\text{NaOH}(\text{aq})$ .

D  $y$  is the same as the oxidation number of  $\text{Cl}$  in the chlorate ion formed when  $\text{Cl}_2(\text{aq})$  is added to hot  $\text{NaOH}(\text{aq})$ .

24 Which statement is correct?

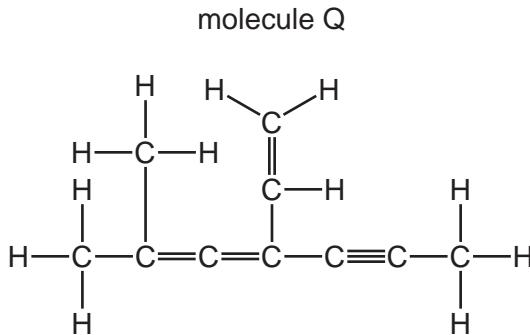
A An ammonium ion is basic due to a lone pair of electrons on the nitrogen atom.

B Nitrogen monoxide,  $\text{NO}$ , reacts with peroxyacetyl nitrate to produce a component of photochemical smog.

C Nitrogen dioxide catalyses the oxidation of atmospheric sulfur dioxide.

D Nitrogen is very unreactive due to the very strong permanent dipole–permanent dipole attractions between the nitrogen atoms.

25 The diagram shows the structural formula of a hydrocarbon molecule Q.

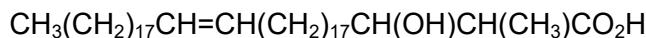


How many of the carbon atoms in molecule Q are  $\text{sp}^2$  hybridised?

A 3      B 4      C 7      D 10

26 Compound X is found in cell walls of some bacteria. Its structural formula is shown.

compound X



How many stereoisomers are there with this structural formula?

A 2

B 4

C 6

D 8

27 Structural isomerism **only** should be considered when answering this question.

How many straight-chain isomers are there with molecular formula  $\text{C}_4\text{H}_8\text{Cl}_2$ ?

A 6

B 7

C 8

D 9

28 What is true of **every** nucleophile?

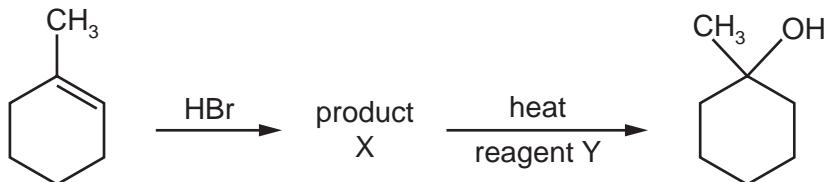
A It attacks a double bond.

B It donates a lone pair of electrons.

C It is a single atom.

D It is negatively charged.

29 The diagram shows a synthetic route to produce 1-methylcyclohexanol.



What is reagent Y?

A aqueous  $\text{NaOH}$

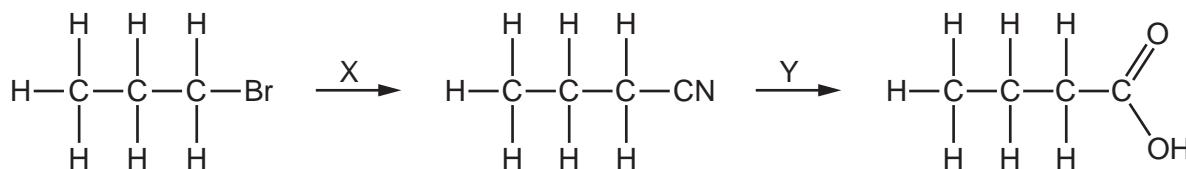
B cold dilute  $\text{KMnO}_4$

C ethanolic  $\text{NaOH}$

D hot concentrated  $\text{KMnO}_4$

10

30 X and Y are the reagents required to convert 1-bromopropane into butanoic acid.



What are the correct identities of reagents X and Y?

	X	Y
<b>A</b>	$\text{NH}_3$	$\text{HCl(aq)}$
<b>B</b>	$\text{KCN in C}_2\text{H}_5\text{OH}$	$\text{NaOH(aq)}$
<b>C</b>	$\text{KCN in C}_2\text{H}_5\text{OH}$	$\text{HCl(aq)}$
<b>D</b>	$\text{HCN}$	$\text{NaOH(aq)}$

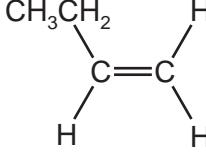
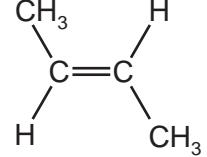
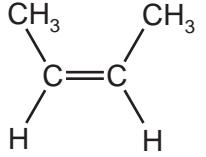
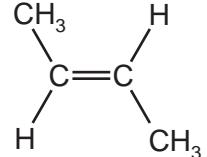
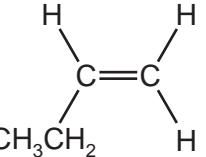
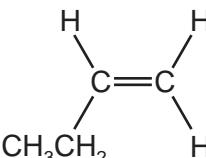
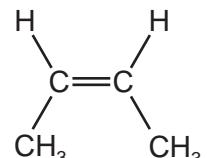
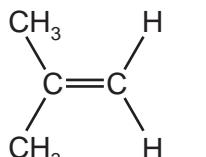
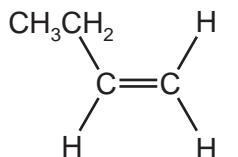
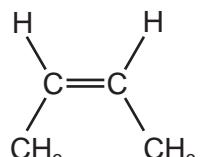
31 The table shows three sets of reagents and reaction conditions.

	reagents	reaction conditions
1	$\text{CH}_2\text{C}(\text{CH}_3)\text{CH}_3$ and $\text{HCl(g)}$	room temperature
2	$\text{CH}_3\text{C}(\text{CH}_3)(\text{OH})\text{CH}_3$ and $\text{SOCl}_2$	room temperature
3	$\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_3$ and $\text{Cl}_2$	the presence of ultraviolet light

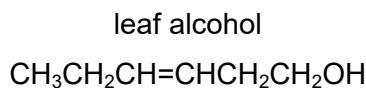
Which sets of reagents and conditions can be used to produce 2-chloro-2-methylpropane as one of the organic products?

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

32 What are the **only** structures formed when butan-2-ol is heated with concentrated  $\text{H}_2\text{SO}_4$ ?

A			
B			
C			
D			

33 The compound 'leaf alcohol' is partly responsible for the smell of new-mown grass.



What will be formed when 'leaf alcohol' is oxidised using an excess of hot acidified  $\text{K}_2\text{Cr}_2\text{O}_7\text{(aq)}$ ?

- A  $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$
- B  $\text{CH}_3\text{CH}_2\text{COCOCH}_2\text{CO}_2\text{H}$
- C  $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CO}_2\text{H}$
- D  $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$  and  $\text{HO}_2\text{CCH}_2\text{CO}_2\text{H}$

34 Compound X:

- does **not** react with Tollens' reagent
- forms a yellow precipitate with alkaline  $I_2(aq)$
- does **not** react with sodium.

What could be the identity of X?

A  $CH_3CHO$   
B  $C_2H_5COCH_3$   
C  $CH_3COOC_2H_5$   
D  $CH_3CHOHCH_3$

35 Which compound can undergo nucleophilic addition?

A bromoethane,  $C_2H_5Br$   
B ethanal,  $CH_3CHO$   
C ethane,  $C_2H_6$   
D ethene,  $C_2H_4$

36  $C_2H_5COOCH_3$  is reacted with aqueous acid.

The products from this reaction are reacted with  $LiAlH_4$  to form two molecules Y and Z.

What are the identities of molecules Y and Z?

A both molecules are  $C_2H_5OH$   
B  $CH_3OH$  and  $CH_3CHOHCH_3$   
C  $CH_3OH$  and  $C_2H_5OH$   
D  $CH_3OH$  and  $C_2H_5CH_2OH$

37 A sample of propanoic acid of mass 3.70 g reacts with an excess of magnesium.

A second sample of propanoic acid of mass 3.70 g reacts with an excess of sodium.

Both reactions go to completion forming a gas.

Which row is correct?

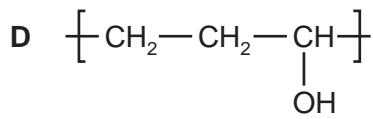
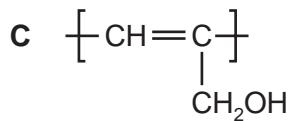
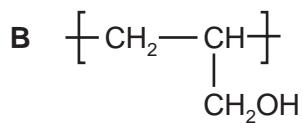
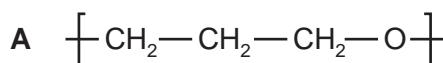
	volume of gas formed with magnesium at s.t.p. / cm <sup>3</sup>	volume of gas formed with sodium at s.t.p. / cm <sup>3</sup>
<b>A</b>	560	560
<b>B</b>	560	1120
<b>C</b>	1120	560
<b>D</b>	1120	1120

38 Which statement about  $\text{H}_2\text{C}=\text{C}(\text{CH}_3)\text{CH}_2\text{CO}_2\text{CH}_3$  is correct?

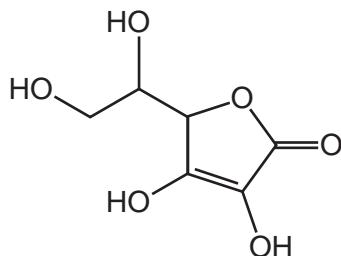
- A** It can be hydrolysed to a secondary alcohol.
- B** It can be made using ethanoic acid and a suitable alcohol.
- C** It gives a positive test with alkaline  $\text{I}_2(\text{aq})$ .
- D** When treated with hot concentrated acidified  $\text{KMnO}_4$  it gives  $\text{CH}_3\text{COCH}_2\text{COOH}$  as one product.

39 Synthetic resins can be made by polymerisation of a variety of monomers including prop-2-en-1-ol,  $\text{CH}_2=\text{CHCH}_2\text{OH}$ .

Which structure represents the repeat unit in the polymer poly(prop-2-en-1-ol)?



40 Vitamin C has the structure shown.



The mass spectrum of vitamin C has a molecular ion peak with an *m/e* value of 176 and a relative abundance of 7.0%.

What is the abundance of the  $M + 1$  peak?

A 0.462%      B 0.539%      C 0.616%      D 0.693%

### 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

1		2		Group													
13		14		15		16		17		18							
3	Li	4	Be	5	H	6	C	7	N	8	O	9	F	10	<sup>2</sup> He		
lithium	beryllium			hydrogen	1.0	neon	20.2	nitrogen	14.0	oxygen	16.0	fluorine	19.0	neon	4.0		
6.9	9.0					20.2	carbon	12.0	14.0	16.0	18.0	19.0	20.2	20.2	39.9		
11	Na	12	Mg	13		14	Si	15	P	16	S	17	Cl	18	Ar		
sodium	magnesium			1.0		23.0	silicon	28.1	31.0	32.1	33.0	35.5	35.5	35.5	39.9		
23.0	24.3					27.0	aluminum	—	31.0	32.1	33.0	35.5	35.5	35.5	39.9		
19	K	20	Ca	21	Ti	22	Cr	23	Fe	24	Mn	25	Co	26	B		
potassium	calcium			47.9	titanium	50.9	chromium	52.0	iron	55.8	manganese	54.9	cobalt	58.9	boron	10.8	
39.1	40.1															10.8	
37	Rb	38	Sr	39	Y	40	Nb	41	Mo	42	Tc	43	Ru	44	C		
rubidium	strontium			88.9	yttrium	88.9	niobium	91.2	molybdenum	95.9	technetium	—	rhodium	102.9	carbon	10.8	
85.5	87.6															10.8	
55	Cs	56	Ba	57–71	Hf	72	Ta	73	Re	74	W	75	Os	76	T		
caesium	barium			lanthanoids	hafnium	178.5	tantalum	180.9	rhenium	186.2	tungsten	183.8	osmium	190.2	rhodium	102.9	
132.9	137.3															102.9	
87	Fr	88	Ra	89–103	Rf	104	Db	105	Sg	106	Bh	107	Hs	108	B		
francium	radium			actinoids	rutherfordium	—	dubnium	—	seaborgium	—	bohrium	—	meitnerium	—	terbium	158.9	
—	—															158.9	
57	La	58	Ce	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	D		
lanthanum	cerium			praseodymium	140.1	neodymium	144.2	promethium	—	150.4	152.0	157.3	152.0	157.3	158.9	158.9	
138.9	140.1															158.9	
89	Ac	90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	C		
actinium	thorium			protactinium	232.0	protactinium	231.0	neptunium	—	uranium	238.0	americium	—	curium	—	berkelium	—
—	—															—	

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57	La	58	Ce	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Ho	67	Er	68	Tm	69	Yb	70	Lu		
lanthanum	cerium			praseodymium	140.1	neodymium	140.9	promethium	—	150.4	152.0	157.3	152.0	157.3	152.0	157.3	158.9	158.9	164.9	167.3	167.3	168.9	168.9	173.1	173.1	175.0	175.0		
138.9	140.1																												
89	Ac	90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Fm	100	Md	101	No	102	Lr	103	lawrencium
actinium	thorium			protactinium	232.0	protactinium	231.0	neptunium	—	uranium	238.0	americium	—	curium	—	berkelium	—	—	—	—	—	—	—	—	—	—	—	—	