



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.

This document has **16** pages.

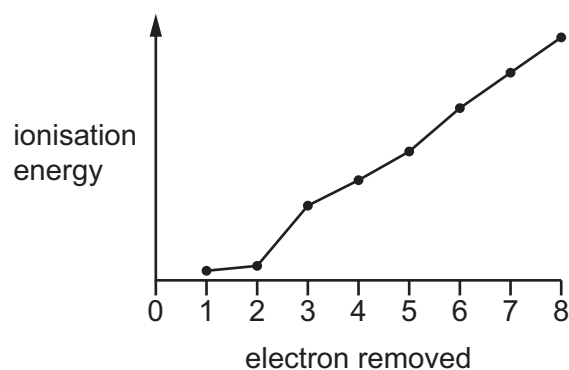
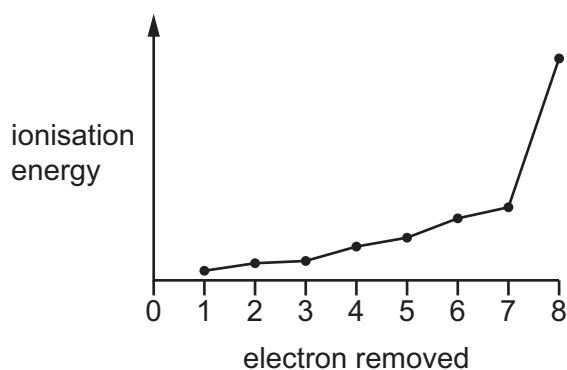
1 Which pair of formulae is correct?

- A Ag_2CO_3 and $(\text{NH}_4)_3\text{NO}_3$
 B K_2HCO_3 and $\text{Zn}_3(\text{PO}_4)_2$
 C AgHCO_3 and K_3PO_4
 D ZnCO_3 and $(\text{NH}_4)_2\text{PO}_4$

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

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** $\underline{\text{B}}\text{F}_3$ **B** $\underline{\text{C}}\text{H}_3^-$ **C** $\text{F}_2\underline{\text{O}}$ **D** $\text{H}_3\underline{\text{O}}^+$

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 dm³ **B** 0.799 dm³ **C** 1.60 dm³ **D** 22.4 dm³

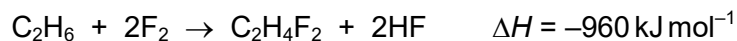
8 Consider the following four compounds.

- 1 $(\text{CH}_3)_3\text{CH}$
- 2 $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- 3 $\text{CH}_3\text{CH}_2\text{CH}_2\text{SH}$
- 4 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$

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

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

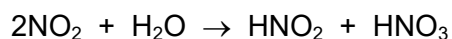
- 9 Ethane can react with fluorine to produce 1,2-difluoroethane, $\text{C}_2\text{H}_4\text{F}_2$.



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?

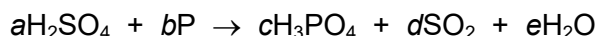
- A** 407 kJ mol^{-1} **B** 474 kJ mol^{-1} **C** 486 kJ mol^{-1} **D** 972 kJ mol^{-1}
- 10 Which equation has an enthalpy change equal to the standard enthalpy of formation of sodium oxide?
- A** $\text{Na(s)} + \frac{1}{4} \text{O}_2(\text{g}) \rightarrow \frac{1}{2} \text{Na}_2\text{O(s)}$
- B** $\text{Na(s)} + \text{O}_2(\text{g}) \rightarrow \text{Na}_2\text{O(s)}$
- C** $2\text{Na(s)} + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{Na}_2\text{O(s)}$
- D** $4\text{Na(s)} + \text{O}_2(\text{g}) \rightarrow 2\text{Na}_2\text{O(s)}$
- 11 Nitrogen dioxide reacts with water.



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.

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



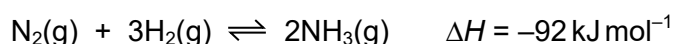
a , b , c , d and e are all whole numbers.

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

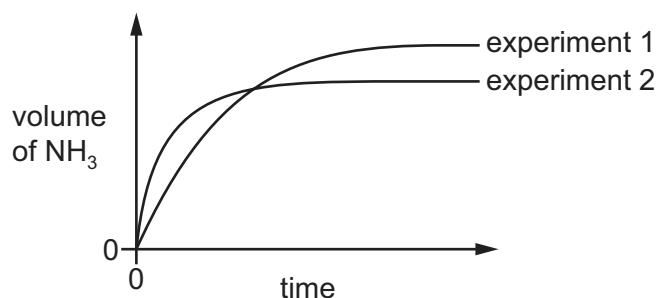
- 13 The volume of ammonia produced against time is measured in two experiments.



In experiment 1, 3 mol of $\text{H}_2(\text{g})$ and 1 mol of $\text{N}_2(\text{g})$ react together at 45°C and a pressure of 200 atm.

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

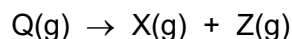
Experiment 2 is then performed. Experiment 2 differs from experiment 1 in **one** condition only.



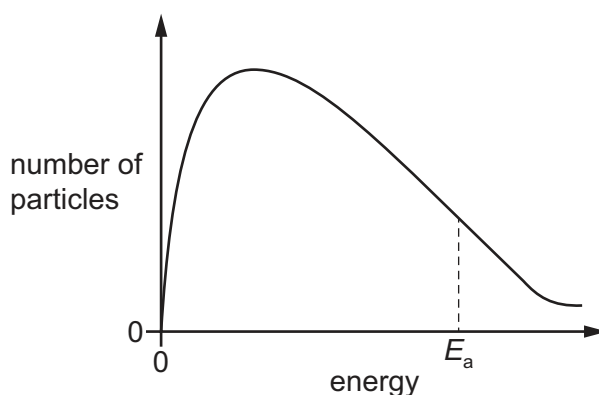
How does experiment 2 differ from experiment 1?

- 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 $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$
 B $3\text{H}_2(\text{g}) + \text{N}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
 C $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$
 D $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$

- 15 Gas Q decomposes slowly at room temperature.



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

- 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 $\text{Al}(\text{OH})_3$
- B MgCl_2 and K_2O
- C NaCl and $\text{Al}(\text{OH})_3$
- 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

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 $3.50 \times 10^{-3} \text{ g cm}^{-3}$ 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 $\text{I}_2(\text{aq})$.

What is compound X?

- A butan-1-ol
- B butan-2-ol
- C methylpropan-1-ol
- D methylpropan-2-ol

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 $\text{C}^{\delta+}$ atom of 1-bromopropane
- B a curly arrow from the $\text{C}^{\delta+}$ atom of 1-bromopropane to the OH^- ion
- C a curly arrow from the $\text{C}-\text{Br}$ bond to the C atom
- D the homolytic fission of the $\text{C}-\text{Br}$ bond

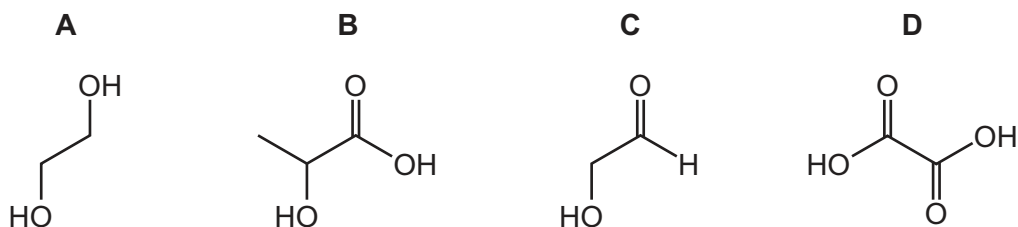
29 In which reaction is the organic compound oxidised?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO} + \text{Tollens' reagent}$
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO} + \text{LiAlH}_4$
- C $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} + \text{concentrated H}_3\text{PO}_4$
- D $\text{CH}_3\text{CO}_2\text{C}_2\text{H}_5 + \text{dilute H}_2\text{SO}_4$

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?

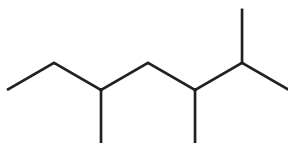


31 Which reaction will distinguish between propan-1-ol and propan-2-ol?

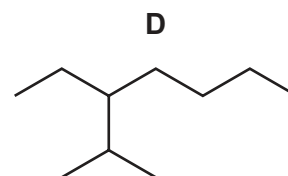
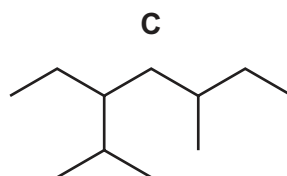
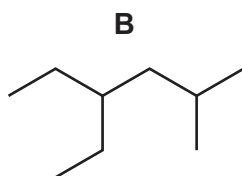
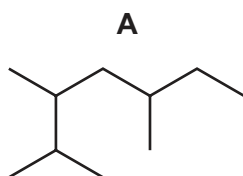
- A warming with acidified KMnO_4
- B warming with acidified $\text{K}_2\text{Cr}_2\text{O}_7$
- C dehydration, followed by reaction with $\text{Br}_2(\text{aq})$
- D mild oxidation, followed by reaction with Fehling's reagent

32 Compound T has the skeletal formula shown.

compound T

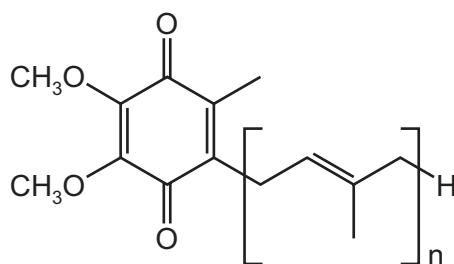


Which structure is a structural isomer of compound T?



33 The diagram shows a simplified structure of coenzyme Q₁₀.

coenzyme Q₁₀



Which row describes the structure of coenzyme Q₁₀ 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, C₁₀H₁₆, 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 dm³ **B** 24 dm³ **C** 48 dm³ **D** 72 dm³

- 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.

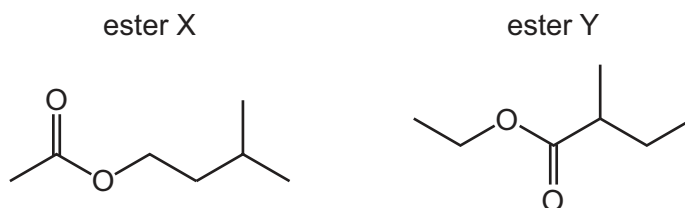
How many stereoisomers are there in the sample?

- 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.

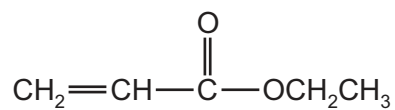


Which carboxylic acids are formed when these esters are hydrolysed by $H_2SO_4(aq)$?

	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	$CH_3CH(CH_3)CH_2COOH$	$CH_3CH_2CH(CH_3)COOH$

39 An addition polymer is made from monomer Z.

monomer Z

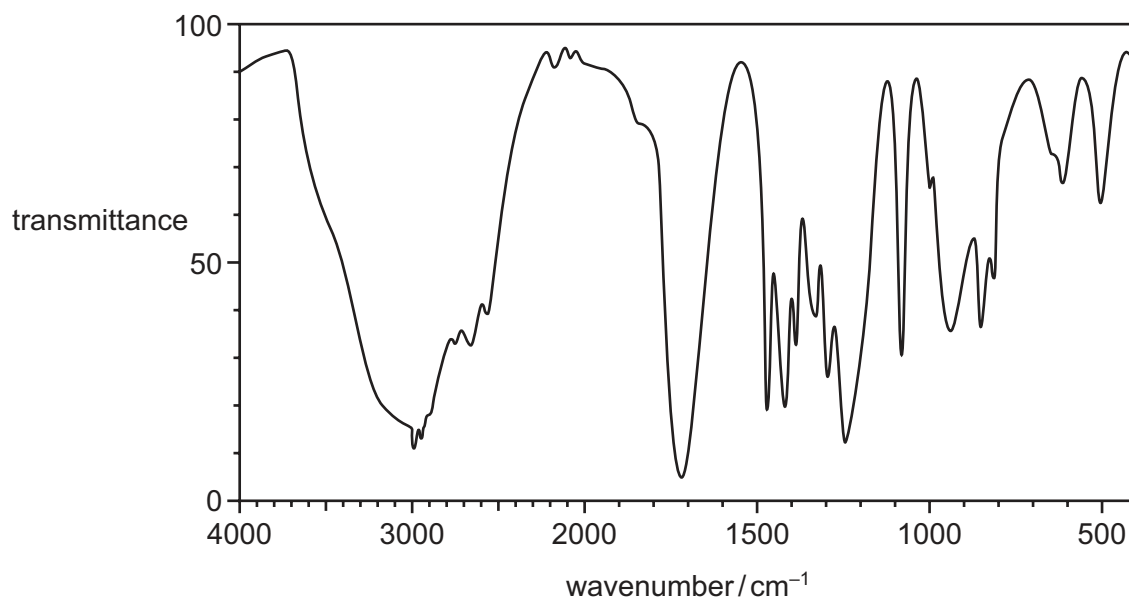


What is the structure of the polymer made from this monomer?

- A $\left[\text{CH}=\text{CH}-\overset{\text{O}}{\parallel}\text{C} \right]_n$
- B $\left[\text{CH}=\text{CH}-\overset{\text{O}}{\parallel}\text{C}-\text{O} \right]_n$
- C $\left[\text{CH}_2-\text{CH}=\underset{\text{OCH}_2\text{CH}_3}{\underset{|}{\text{C}}}-\text{O} \right]_n$
- D $\left[\text{CH}_2-\underset{\underset{\text{O}}{\parallel}}{\underset{|}{\text{C}}}-\text{OCH}_2\text{CH}_3 \right]_n$

40 Compound X reacts with acidified $\text{K}_2\text{Cr}_2\text{O}_7$ 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

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