Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/11**

Paper 1 Multiple Choice **May/June 2025**

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

5656730284

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 **20** pages. Any blank pages are indicated.

1 ICl_3 reacts with water in a redox reaction.

$$v ICl_3 + w H_2O \rightarrow x HCl + y HI + z HIO_3 + z HClO_3$$

What are the numbers *v*, *x* and *z* in the correctly balanced equation?

	v	*x*	*z*
A	2	8	1
B	2	5	1
C	3	8	1
D	3	5	1

2 The rate of the reaction between a reactive metal and an excess of a dilute acid is investigated.

The total volume of hydrogen gas produced is recorded every 30 seconds for 3 minutes.

time / s	total volume of hydrogen gas / cm^3
0	0
30	64
60	105
90	132
120	151
150	161
180	167

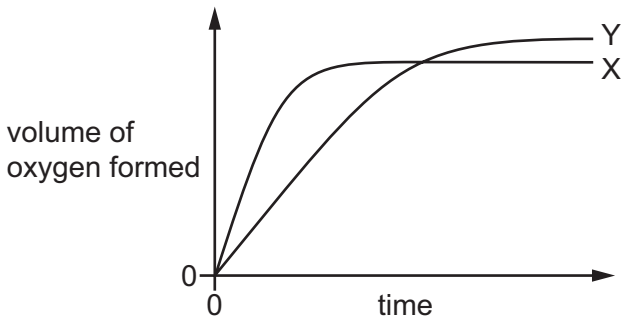
The average rate of reaction during the first 30 seconds is P.

The average rate of reaction during the last 30 seconds is Q.

What is the value of P – Q?

A $1.21\,cm^3\,s^{-1}$ **B** $1.93\,cm^3\,s^{-1}$ **C** $2.13\,cm^3\,s^{-1}$ **D** $3.43\,cm^3\,s^{-1}$

3 In the diagram, curve X was obtained by measuring the volume of oxygen produced during the decomposition of 100 cm^3 of 1.0 mol dm^{-3} hydrogen peroxide. A catalyst of manganese(IV) oxide was used.



Which alteration to the original experimental conditions would produce curve Y?

A adding more manganese(IV) oxide

B adding some 0.1 mol dm^{-3} hydrogen peroxide

C adding water

D raising the temperature

4 The first seven ionisation energies of an element between lithium and neon in the Periodic Table are shown.

1310 3390 5320 7450 11 000 13 300 71 000 kJ mol^{-1}

What is the outer electronic configuration of the element?

A $2s^2$ **B** $2s^2 2p^1$ **C** $2s^2 2p^4$ **D** $2s^2 2p^6$

5 The reaction of hydrogen with oxygen is shown.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

Which expression corresponds to the standard enthalpy change of this reaction?

A $2 \times \Delta H_f^{\ominus}(H_2O)$

B $\Delta H_c^{\ominus}(H_2O) - \Delta H_c^{\ominus}(H_2)$

C $\Delta H_c^{\ominus}(H_2)$

D $2 \times \Delta H_f^{\ominus}(H_2O) + 2 \times \Delta H_c^{\ominus}(H_2)$

6 P is a compound that burns in an excess of oxygen to give carbon dioxide and water only.

2.20 g of P contains 1.20 g of carbon and 0.20 g of hydrogen.

When P is added to a solution of sodium carbonate, bubbles of gas are seen.

What is P?

A CH_3CHO

B CH_3CO_2H

C $CH_3COCH_2CH_2OH$

D $CH_3CH_2CH_2CO_2H$

7 Substance W has the physical properties shown.

m.p. / °C	b.p. / °C	electrical conductivity		
		of solid	of liquid	in water
2072	2980	poor	good	insoluble

What is substance W?

A aluminium oxide

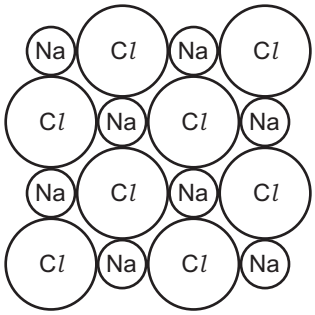
B iron

C silicon dioxide

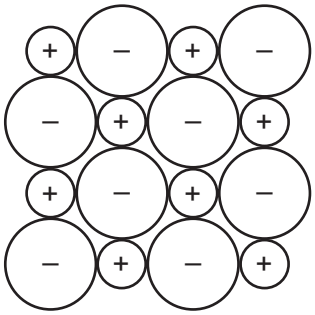
D sodium fluoride

8 Which diagram represents the lattice structure of sodium chloride?

A



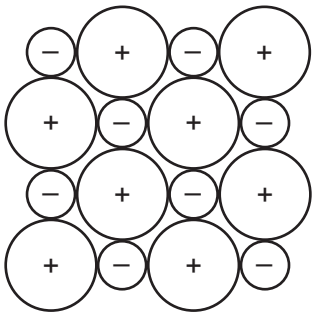
B



key

Cl = chlorine atom
Na = sodium atom
– = chloride ion
+ = sodium ion

C



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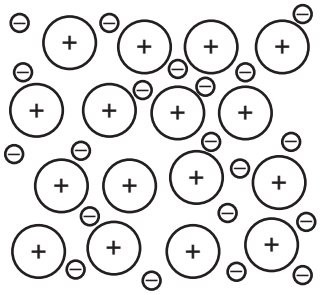


9 An aqueous solution X contains substance HQ which behaves as a weak acid.

$$HQ(aq) \rightleftharpoons H^+(aq) + Q^-(aq)$$

The soluble salt NaQ is added to X.

What happens to the $[H^+(aq)]$ and the pH in X?

	$[H^+(aq)]$	pH
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

10 Dinitrogen tetroxide, N_2O_4, decomposes reversibly.

$$N_2O_4 \rightleftharpoons 2NO_2 \qquad \Delta H = +58.0\,kJ\,mol^{-1}$$

An equilibrium mixture of N_2O_4 and NO_2 gases is placed in a closed container under standard conditions.

$$K_c = 1.15 \times 10^{-1}\,mol\,dm^{-3}$$

The conditions are changed.

Under the new conditions, $K_c = 1.70 \times 10^{3}\,mol\,dm^{-3}$.

Which change in conditions occurs?

A The pressure increases.

B The pressure decreases.

C The temperature increases.

D The temperature decreases.

11 $50\,cm^3$ of $1.0\,mol\,dm^{-3}$ H_2SO_4 is added to $100\,cm^3$ of $1.0\,mol\,dm^{-3}$ NaOH in an insulated vessel.

Both solutions are at a temperature of 20 °C before mixing. After mixing, the temperature rises and the highest temperature reached is 29 °C.

Assume that:

- all the energy released in the reaction goes into raising the temperature of the aqueous reaction mixture
- the specific heat capacity of the mixture is $4.2\,J\,cm^{-3}\,K^{-1}$.

What is the value of the enthalpy of neutralisation determined from this experiment?

A $-113.4\,kJ\,mol^{-1}$

B $-56.7\,kJ\,mol^{-1}$

C $-37.8\,kJ\,mol^{-1}$

D $-18.9\,kJ\,mol^{-1}$

12 Barium dithionate, $BaS_2O_6 \cdot 2H_2O$, is soluble in water.

$S_2O_6^{2-}$ ions slowly decompose in acidic solution.

$$S_2O_6^{2-}(aq) \rightarrow SO_2(g) + SO_4^{2-}(aq)$$

3.513 g of $BaS_2O_6 \cdot 2H_2O$ is dissolved in water in a 100 cm^3 volumetric flask and the solution made up to the mark with HCl(aq).

At time *x* min, a white precipitate of mass 0.661 g is present in the flask.

What is the concentration of BaS_2O_6 in the volumetric flask at time *x* min?

A 0.0077 mol dm^{-3}

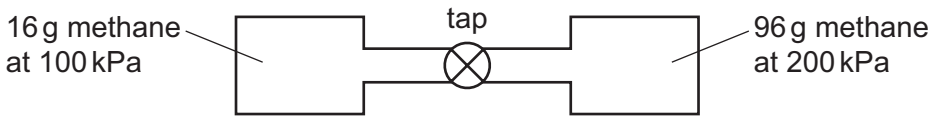
B 0.0090 mol dm^{-3}

C 0.077 mol dm^{-3}

D 0.090 mol dm^{-3}

13 The diagram shows two containers of methane connected by a closed tap.

Each container has a volume of 1.00 m^3.



The tap is opened. The temperature of the system is changed to 800 K.

The system reaches constant pressure.

What is the pressure of methane within the system?

A 23.3 kPa **B** 46.6 kPa **C** 186 kPa **D** 372 kPa

14 Which statement about a 3p orbital is correct?

A It can hold a maximum of six electrons.

B It has the highest energy of the orbitals with principal quantum number 3.

C It is at a higher energy level than a 3s orbital but has the same shape.

D It is occupied by one electron in an isolated phosphorus atom.

15 In which pair do both species:

- have the same shape
- have the same number of covalent bonds?

A methane and the ammonium ion

B carbon dioxide and nitrogen

C boron trifluoride and ammonia

D water and oxygen

16 A reaction involving ammonium ions is shown.

$$NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$$

Four statements about this reaction are listed.

1 The ammonium ions are reduced.

2 In the reverse reaction, ammonia acts as a Brønsted–Lowry base.

3 The ammonium ion and the ammonia molecule have the same bond angle.

4 This reaction is **not** a redox reaction.

Which statements are correct?

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

17 Which reduction process occurs on the surface of a catalytic converter?

A reduction of carbon dioxide and nitrogen oxides

B reduction of carbon dioxide only

C reduction of nitrogen oxides only

D reduction of carbon monoxide

18 Three statements about the halogens, chlorine, bromine and iodine and their compounds are listed.

1 The halogen with the highest boiling point has atoms which form the strongest bond to hydrogen.

2 The halogen with the strongest instantaneous dipole (id–id) attractions forms the most thermally stable hydrogen halide.

3 The most volatile element most rapidly oxidises hydrogen.

Which statements are correct?

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

19 Which reagent or reagents and conditions will oxidise chlorine, Cl_2, into a compound containing chlorine in the +5 oxidation state?

A $AgNO_3(aq)$ followed by $NH_3(aq)$ at room temperature

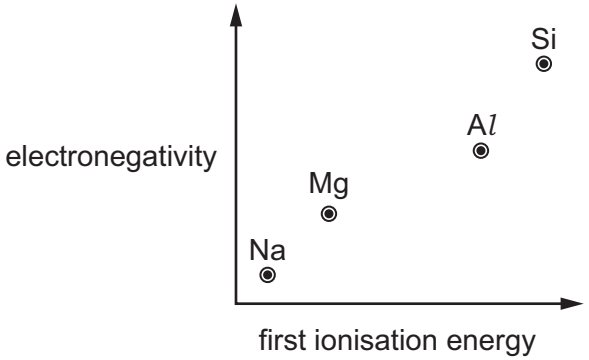
B concentrated H_2SO_4 at room temperature

C cold dilute NaOH(aq)

D hot concentrated NaOH(aq)

20 Which diagram shows the electronegativity of the elements Na, Mg, Al and Si plotted against their first ionisation energies?

A



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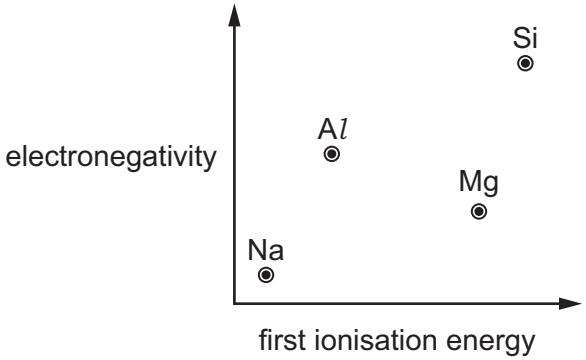

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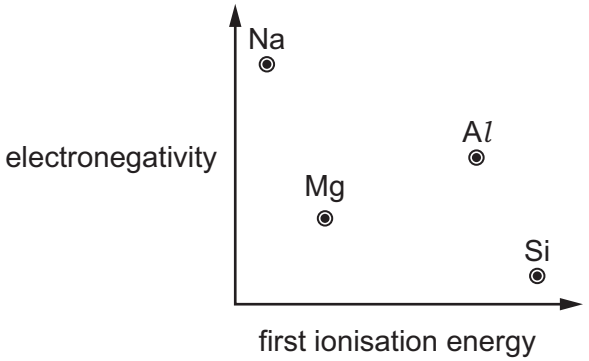

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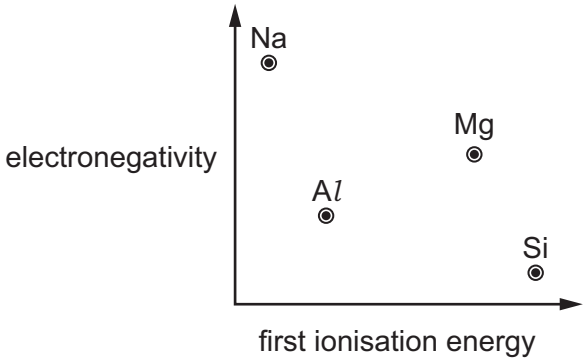


21 Radium is an element below barium in Group 2 of the Periodic Table.

Which equation shows what happens when solid radium nitrate, $Ra(NO_3)_2$, is heated strongly?

A $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 4NO_2(g) + O_2(g)$

B $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 2N_2(g) + 5O_2(g)$

C $Ra(NO_3)_2(s) \rightarrow RaO(s) + N_2O(g) + 2O_2(g)$

D $4Ra(NO_3)_2(s) \rightarrow 2Ra_2O(s) + 8NO_2(g) + 3O_2(g)$

22 The table shows some data for the elements in Period 3 of the Periodic Table.

	melting point / K	electrical conductivity
sodium	371	good
magnesium	922	good
aluminium	933	good
silicon	1693	poor
phosphorus	317	does not conduct
sulfur	386	does not conduct
chlorine	172	does not conduct
argon	84	does not conduct

Which statements are correct?

1 All the elements in the table with a giant structure have a higher melting point than each of the elements in the table with a simple molecular structure.

2 Magnesium has a higher melting point than sodium because it has more delocalised electrons and stronger electrostatic attraction between the delocalised electrons and the metal ions.

3 Phosphorus and sulfur do **not** conduct electricity because they are simple molecular solids at room conditions.

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

23 Each mineral listed behaves as a mixture of two carbonate compounds. They can be used as fire retardants because they decompose in the heat, producing CO_2. This gas smothers the fire.

barytocite, $BaCa(CO_3)_2$

dolomite, $CaMg(CO_3)_2$

huntite, $Mg_3Ca(CO_3)_4$

What is the order of effectiveness as fire retardants, from best to worst?

	best →		worst
A	dolomite	barytocite	huntite
B	dolomite	huntite	barytocite
C	huntite	barytocite	dolomite
D	huntite	dolomite	barytocite

24 Compound X contains two Period 3 elements, Y and Z.

Compound X reacts with water to form only two products: a slightly soluble hydroxide and compound Q.

Q is a compound of element Z and hydrogen.

Compound Q burns in moist air to produce an oxide and water. The oxidation number of element Z in the oxide is +5.

Which row identifies element Y and element Z?

	element Y	element Z
A	Mg	P
B	Na	S
C	Na	P
D	Mg	S

25 Three reagents are listed.

1 aqueous sodium carbonate

2 $LiAlH_4$

3 water

Which reagents react with pure ethanoic acid to give a solution containing ethanoate ions?

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

26 Complete combustion of compound T produces carbon dioxide and water only. Compound T produces steamy fumes with PCl_5. Compound T does not give any visible product with 2,4-dinitrophenylhydrazine reagent.

What can be deduced with certainty from this information?

A Compound T is a carboxylic acid.

B Compound T is a hydrocarbon.

C Compound T is an alcohol.

D Compound T is **not** an aldehyde.

27 Information about carbonyl compound X is given.

- Compound X reacts with $LiAlH_4$ to produce a secondary alcohol.
- Compound X reacts with alkaline I_2(aq) to give a yellow precipitate.

What is compound X?

A butanal

B butanone

C ethanal

D pentan-3-one

28 An organic compound J reacts with an excess of sodium to produce an organic ion with a charge of –3. J reacts with an excess of NaOH(aq) to produce an organic ion with a charge of –1.

What is the structural formula of J?

A $HOCH_2CH(OH)CH_2CO_2H$

B $HO_2CCH(OH)CH_2CHO$

C $HO_2CCH(OH)CH_2CO_2H$

D $HOCH_2COCH_2CHO$

29 Which formula represents the organic compound formed by the reaction of propanoic acid with methanol in the presence of concentrated sulfuric acid as a catalyst?

A $CH_3CH_2COCH_3$

B $CH_3CH_2CO_2CH_3$

C $CH_3CO_2CH_2CH_3$

D $CH_3CH_2CH_2CO_2CH_3$

30 Structural isomerism and stereoisomerism should be considered when answering this question.

2,5-dibromohexane is heated under reflux with ethanolic KOH.

How many isomeric compounds are formed with molecular formula C_6H_{10}?

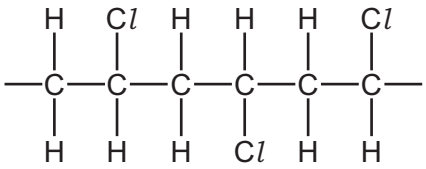
A 3 **B** 5 **C** 6 **D** 7

31 Considering **only** structural isomers, what is the number of alcohols of each type with the formula $C_5H_{12}O$?

	primary	secondary	tertiary
A	3	3	2
B	4	2	2
C	4	3	1
D	5	2	1

32 Which structure represents part of the polymer chain of PVC?

A



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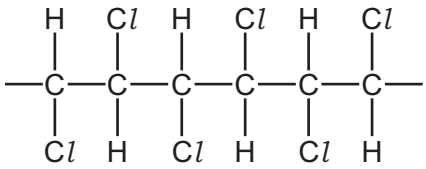

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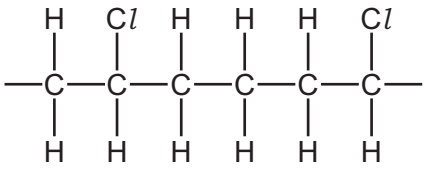

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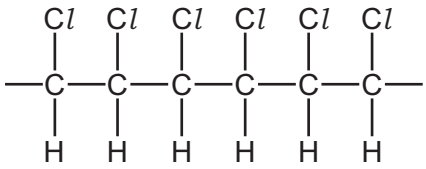
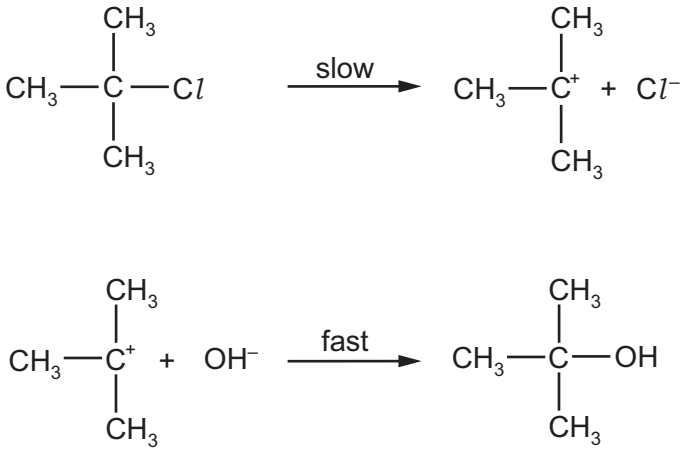
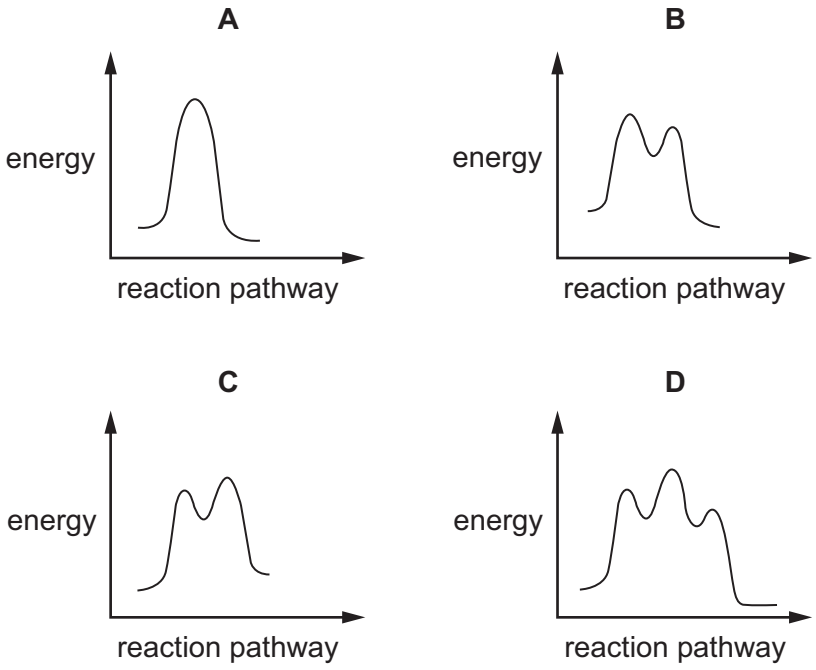


33 A possible mechanism for the exothermic hydrolysis of 2-chloro-2-methylpropane is shown.



Which diagram represents the reaction pathway diagram for this mechanism?



34 Compound W contains atoms of carbon, nitrogen and hydrogen.

Compound W reacts with HCl(aq) to produce propanoic acid.

Which row is correct?

	functional group in compound W	name of compound W
A	amine	ethylamine
B	nitrile	ethanenitrile
C	amine	propylamine
D	nitrile	propanenitrile

35 Two reactions are described.

1 2-bromo-2-methylbutane heated with NaOH(aq)

2 2-chloro-2-methylbutane heated with NaOH(aq)

In both reactions, the conditions are the same and NaOH(aq) is in excess.

30.18 g of 2-bromo-2-methylbutane forms 12.32 g of product X.

[M_r: 2-bromo-2-methylbutane, 150.9; 2-chloro-2-methylbutane, 106.5]

Which row is correct?

	percentage yield of product X / %	relative rate of reaction
A	41	1 is faster than 2
B	41	2 is faster than 1
C	70	1 is faster than 2
D	70	2 is faster than 1

36 An alkene P reacts with an excess of hot concentrated acidified $KMnO_4$(aq).

Methylpropanoic acid is the only organic product.

What is alkene P?

A 2,5-dimethylhex-3-ene

B 2-methylbut-2-ene

C methylpropene

D oct-4-ene, C_8H_{16}

37 Three substances are listed.

1 butane

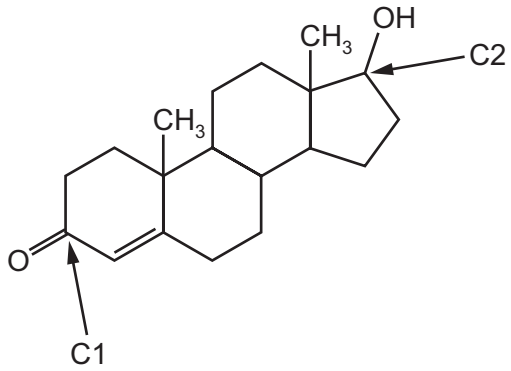
2 hydrogen

3 hydrogen bromide

Which substances are possible products of the free-radical substitution reaction between ethane and bromine?

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

38 The structure of the testosterone molecule is shown.



Which statements are correct?

1 Carbon atoms C1 and C2 can be oxidised with acidified $K_2Cr_2O_7$.

2 There are fewer than 27 hydrogen atoms in one testosterone molecule.

3 There are six chiral carbon atoms in one testosterone molecule.

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

39 The structural formula of hept-1,4,5-triene is shown.

$CH_2CHCH_2CHCCHCH_3$

How many of the carbon atoms in one molecule of hept-1,4,5-triene are sp^2 hybridised?

A 4 **B** 5 **C** 6 **D** 7

40 Hydrocarbon X is saturated. Each molecule contains one ring of carbon atoms.

The mass spectrum of hydrocarbon X is measured.

The peak representing the M+ ion is 14 mm high.

The peak representing the $[M+1]^+$ ion is 0.77 mm high.

What is the *m* / *e* value for the M+ ion of X?

A 56 **B** 58 **C** 70 **D** 72

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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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

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 –