Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/11**

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.

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1 Sample X is added to water and made up to a total volume of 200 cm^3. This gives a solution of 0.100 mol dm^{-3} HCl.

What is X?

A 10 cm^3 of 1.00 mol dm^{-3} HCl

B 30 cm^3 of 0.90 mol dm^{-3} HCl

C 50 cm^3 of 0.40 mol dm^{-3} HCl

D 100 cm^3 of 0.30 mol dm^{-3} HCl

2 A mixture of 10 cm^3 of methane and 10 cm^3 of ethane was sparked with an excess of oxygen. After cooling, the residual gas was passed through aqueous potassium hydroxide.

All gas volumes were measured at the same temperature and pressure.

Which volume of gas was absorbed by the alkali?

A 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 40 cm^3

3 Z is a compound of two elements, X and Y.

Element X shows a very large increase between its 5th and 6th ionisation energies. It has the second largest 1st ionisation energy in its group.

Element Y shows a very large increase between its 6th and 7th ionisation energies. It has the largest 1st ionisation energy in its group.

What is compound Z?

A NO_2 **B** PCl_5 **C** P_4O_{10} **D** SF_6

4 Which statement about $^{131}_{53}I$ is correct?

A A negative ion of $^{131}_{53}I$ contains 53 neutrons and 52 electrons.

B A negative ion of $^{131}_{53}I$ contains 53 neutrons and 54 electrons.

C A negative ion of $^{131}_{53}I$ contains 78 neutrons and 52 electrons.

D A negative ion of $^{131}_{53}I$ contains 78 neutrons and 54 electrons.

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5 When solid aluminium chloride is heated, Al_2Cl_6 is formed.

Which bonding is present in Al_2Cl_6?

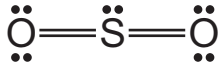
A covalent and coordinate (dative covalent)

B covalent only

C ionic and coordinate (dative covalent)

D ionic only

6 The structure of the sulfur dioxide molecule is shown.



What is the shape of the sulfur dioxide molecule?

A linear

B non-linear

C pyramidal

D tetrahedral

7 What is the density of a sample of fluorine gas at 32 °C and 100 000 Pa? Assume fluorine behaves as an ideal gas under these conditions.

A $1.4\,g\,dm^{-3}$ **B** $1.5\,g\,dm^{-3}$ **C** $1.6\,g\,dm^{-3}$ **D** $1.7\,g\,dm^{-3}$

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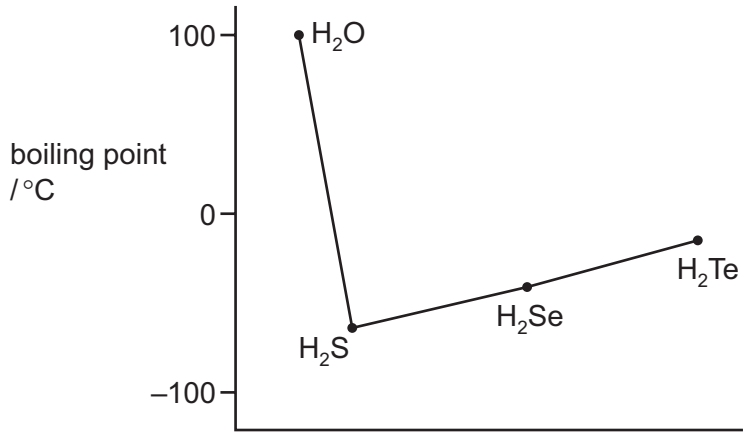
8 The graph shows the boiling points of the hydrogen compounds of Group 16 elements.



Which statement correctly explains why water does **not** fit the trend of the other compounds?

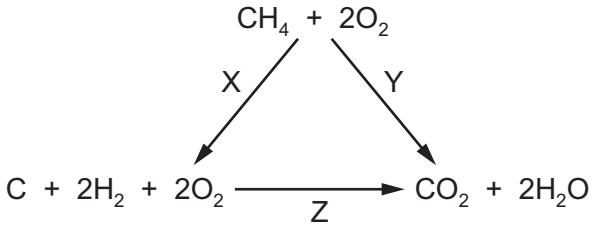
A There are fewer electrons in the oxygen atoms so there is less shielding of the nuclear charge.

B There are strong hydrogen bonds in water but **not** in the other compounds.

C The covalent bonds in water are much stronger than in the other compounds.

D The water molecules are smaller and so have stronger van der Waals' forces.

9 An energy cycle is shown.



The energy changes involved are X, Y and Z.

The numerical value of energy change Y is either –890 or +890.

The numerical value of energy change Z is either –964 or +964.

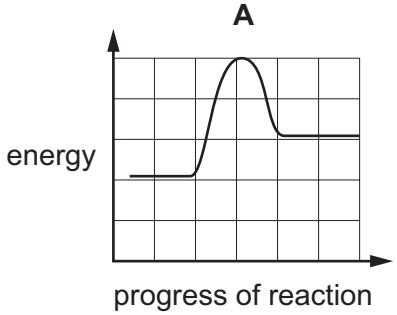
Which of the three values are negative?

A X and Z **B** X only **C** Y and Z **D** Y only

10 For a certain endothermic reaction, the activation energy is numerically equal to twice the enthalpy change of reaction.

Which reaction pathway diagram is correct for this reaction?

A



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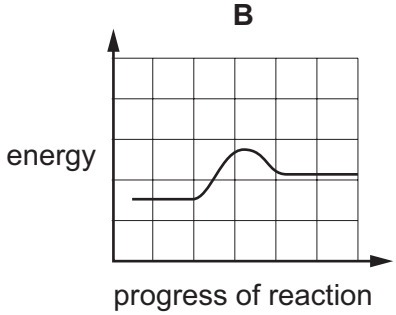

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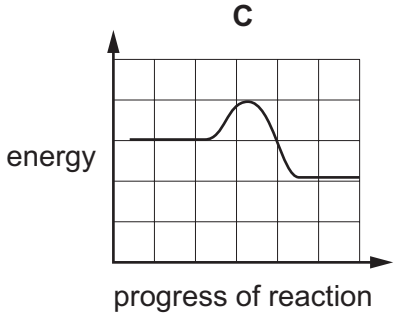

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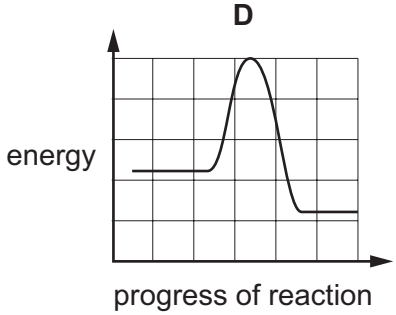

11 Sodium chromate(VI), Na_2CrO_4, is manufactured by heating chromite, $FeCr_2O_4$, with sodium carbonate in an oxidising atmosphere. Chromite contains $Cr_2O_4^{2-}$ ions.

$$2FeCr_2O_4 + 4Na_2CO_3 + 3\tfrac{1}{2}O_2 \rightarrow 4Na_2CrO_4 + Fe_2O_3 + 4CO_2$$

What happens in this reaction?

A Chromium and iron are the only elements oxidised.

B Chromium, iron and carbon are oxidised.

C Only chromium is oxidised.

D Only iron is oxidised.

12 Oxygen can be prepared by the reaction of potassium manganate(VII), $KMnO_4$, hydrogen peroxide, H_2O_2, and sulfuric acid, H_2SO_4. Each H_2O_2 molecule loses two electrons in this reaction. The other products of the reaction are potassium sulfate, manganese(II) sulfate and water.

How many moles of oxygen gas are produced when 1.0 mol of $KMnO_4$ reacts with an excess of H_2O_2 in acidic conditions?

A 2.0 mol **B** 2.5 mol **C** 4.5 mol **D** 5.0 mol

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13 An alcohol, ROH, reacts reversibly with ethanoic acid to produce an ester.

$$ROH(l) + CH_3COOH(l) \rightleftharpoons CH_3COOR(l) + H_2O(l)$$

3.0 mol of ROH, 2.0 mol of ethanoic acid and 1.0 mol of water are mixed together. At equilibrium, 1.5 mol of CH_3COOR is present.

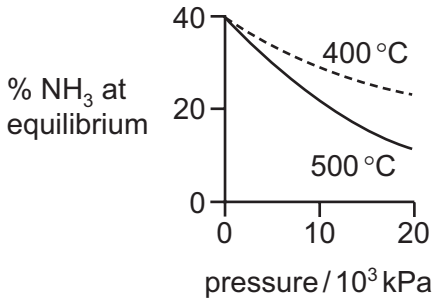
What is the value of the equilibrium constant, K_c, for this reaction?

A 0.20 **B** 0.25 **C** 2.00 **D** 5.00

14 Graphs can be drawn to show the percentage of ammonia at equilibrium when nitrogen and hydrogen are mixed at different temperatures and pressures.

Which diagram correctly represents these two graphs?

A



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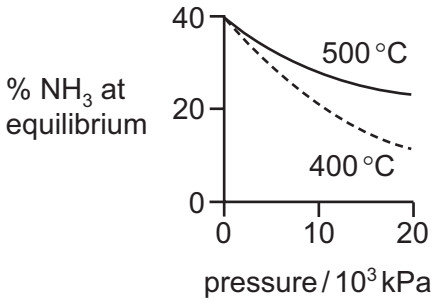

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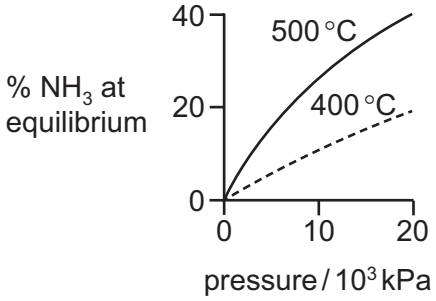

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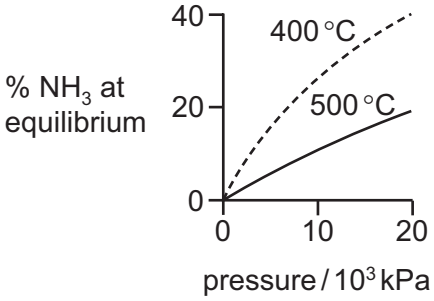

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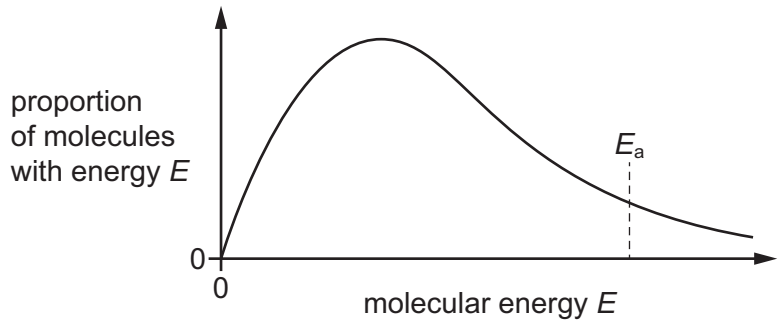
15 The Boltzmann distribution for the hydrogenation of an alkene at a particular temperature in the absence of a catalyst is shown.



Which row correctly describes the effects of adding a nickel catalyst to the reaction vessel?

	the shape of the Boltzmann distribution	activation energy, E_a
A	changes	decreases
B	changes	increases
C	does **not** change	decreases
D	does **not** change	increases

16 Elements Y and Z are both in Period 3 of the Periodic Table.

When the chloride of element Y is added to water, it reacts and a solution of pH 2 is produced.

When the chloride of element Z is added to water, it dissolves and a solution of pH 7 is produced.

Which statement explains these observations?

A Both chlorides hydrolyse in water.

B Element Y is magnesium and element Z is sodium.

C Element Y is phosphorus and element Z is aluminium.

D Element Y is silicon and element Z is sodium.

17 Aluminium, silicon and phosphorus are elements in Period 3 of the Periodic Table. Each element forms an oxide.

Which row is correct?

	Al_2O_3	SiO_2	P_4O_{10}
A	basic	amphoteric	acidic
B	giant ionic	giant ionic	simple molecular
C	high melting point	high melting point	low melting point
D	vigorous reaction with water	slight reaction with water	vigorous reaction with water

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18 Which statement is correct?

A The atomic radius of silicon is larger than that of aluminium.

B The boiling point of chlorine is higher than that of silicon.

C The first ionisation energy of sulfur is greater than that of phosphorus.

D The electrical conductivity of magnesium is greater than that of sodium.

19 All solubility data in this question is given at the same temperature.

The table gives some data for compounds of calcium and for compounds of X, an unidentified element in Group 2.

element	decomposition temperature of carbonate / °C	solubility of sulfate / mol per 100 g of water	solubility of hydroxide / mol per 100 g of water
Ca	840	4.66×10^{-3}	1.53×10^{-3}
X	1150		

What is the missing data for element X?

	solubility of sulfate / mol per 100 g of water	solubility of hydroxide / mol per 100 g of water
A	7.11×10^{-5}	2.00×10^{-5}
B	7.11×10^{-5}	3.37×10^{-3}
C	1.83×10^{-1}	2.00×10^{-5}
D	1.83×10^{-1}	3.37×10^{-3}

20 What is the total volume of gas produced, measured at room conditions, when 0.010 mol of anhydrous magnesium nitrate is completely decomposed by heating?

A 240 cm^3 **B** 480 cm^3 **C** 600 cm^3 **D** 720 cm^3

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21 A solid sodium halide, NaX, is reacted with concentrated sulfuric acid. The **lowest** oxidation state of sulfur in the products is +4.

Halogen Y_2 is less volatile than halogen X_2.

What are the identities of sodium halide NaX and halogen Y_2?

	sodium halide NaX	halogen Y_2
A	sodium bromide	chlorine
B	sodium bromide	iodine
C	sodium iodide	bromine
D	sodium iodide	astatine

22 Compound Q dissolves in water. Q(aq) does **not** react with dilute sulfuric acid.

Q(aq) forms a precipitate when aqueous silver nitrate is added. This precipitate is partially soluble in aqueous ammonia.

What could be compound Q?

A barium bromide

B barium iodide

C magnesium bromide

D magnesium iodide

23 Nitrogen dioxide is a gas that contributes to air pollution. It is produced in internal combustion engines.

Which statement is correct?

A Nitrogen dioxide acts as a catalyst in the atmospheric oxidation of sulfur dioxide to sulfur trioxide.

B Nitrogen dioxide reacts to form nitrogen monoxide in the catalytic converter of a car exhaust system.

C PAN forms when nitrogen dioxide reacts with the gases formed by complete combustion of the fuel.

D Under high pressure in an internal combustion engine, nitrogen dioxide forms from impurities in the fuel.

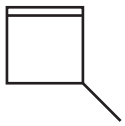
24 What is the bond angle in the ammonium ion?

A 90° **B** 107° **C** 109.5° **D** 120°

25 Structural isomerism and stereoisomerism should be taken into account when answering this question.

The structure of 3-methylcyclobutene is shown.

3-methylcyclobutene



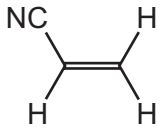
A mixture containing all stereoisomers of 3-methylcyclobutene is treated with HBr. This produces a mixture of isomeric bromomethylcyclobutanes.

How many stereoisomers does 3-methylcyclobutene have, and how many isomeric bromomethylcyclobutanes are present in the product mixture?

	3-methylcyclobutene	bromomethylcyclobutanes
A	2	4
B	2	6
C	4	4
D	4	8

26 The diagram shows the structure of X.

X



Which row is correct?

	number of σ bonds in X	type of hybridisation of the carbon atoms in X
A	4	sp and sp^2
B	4	sp^2 and sp^3
C	6	sp and sp^2
D	6	sp^2 and sp^3

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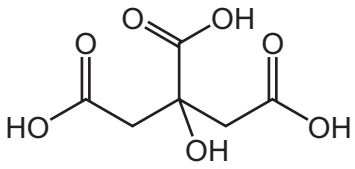
27 The diagram shows the skeletal formula of citric acid.

citric acid



What is the molecular formula of citric acid?

A $C_6H_8O_7$ **B** $C_6H_4O_7$ **C** $C_8H_8O_7$ **D** $C_{10}H_8O_7$

28 Which reaction occurs when ethane and chlorine are mixed in diffused sunlight?

A a free-radical substitution with hydrogen given off

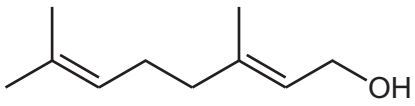
B a free-radical substitution with hydrogen chloride given off

C a free-radical substitution with no gas given off

D a nucleophilic substitution with hydrogen chloride given off

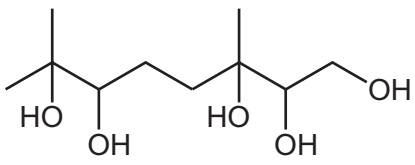
29 A molecule of geraniol is shown.

geraniol



What is formed when geraniol is reacted with an excess of cold dilute acidified MnO_4^-?

A



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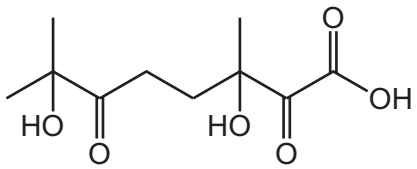

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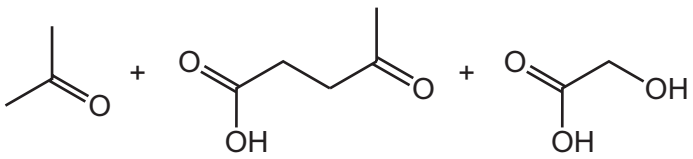

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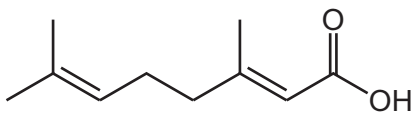


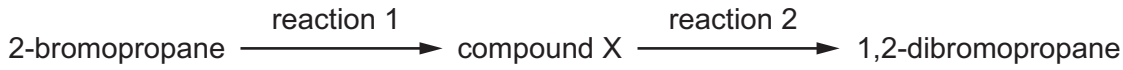
30 Q is either a primary or a tertiary halogenoalkane. Q undergoes hydrolysis with aqueous sodium hydroxide.

The first step in the mechanism of this reaction involves two species reacting together.

Which row is correct?

	Q	behaviour of hydroxide ion
A	primary halogenoalkane	electrophile
B	primary halogenoalkane	nucleophile
C	tertiary halogenoalkane	electrophile
D	tertiary halogenoalkane	nucleophile

31 2-bromopropane is converted to 1,2-dibromopropane in a pathway involving two reactions.



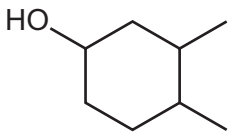
What are the reagents and conditions for the two reactions?

	reaction 1	reaction 2
A	heat under reflux with aqueous NaOH	HBr(g) at room temperature
B	heat under reflux with aqueous NaOH	Br_2(l) at room temperature
C	heat under reflux with ethanolic NaOH	HBr(g) at room temperature
D	heat under reflux with ethanolic NaOH	Br_2(l) at room temperature

32 Compound X is a single, pure, optical isomer. Compound X is heated with an excess of concentrated H_2SO_4. Only **one** organic product is formed.

What is compound X?

A



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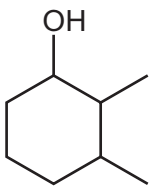

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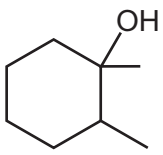

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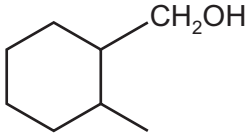

33 Which reagents could be used to form 2-bromobutane from butan-1-ol?

A bromine and ultraviolet light

B concentrated sulfuric acid with potassium bromide, under reflux

C concentrated sulfuric acid followed by bromine

D concentrated sulfuric acid followed by hydrogen bromide

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34 X is a non-cyclic ketone with a single carbonyl group and no other functional groups. Ketone X has the following properties.

- When ketone X is treated with $NaBH_4$, the organic product has a M_r 2.3256% greater than the M_r of ketone X.
- Ketone X gives a yellow precipitate with alkaline I_2(aq).

How many isomeric ketones could be ketone X?

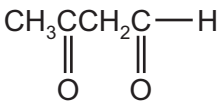
A 1 **B** 2 **C** 3 **D** 4

35 Compound Y:

- changes the colour of acidified $K_2Cr_2O_7$ from orange to green
- has no effect on Fehling's reagent
- produces an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

What is compound Y?

A



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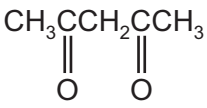

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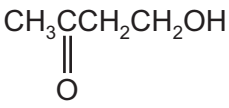

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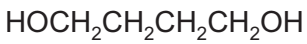

36 The product of the reaction between propanone and hydrogen cyanide is hydrolysed under acidic conditions.

What is the formula of the final product?

A $CH_3CH(OH)COOH$

B $CH_3CH_2CH_2COOH$

C $(CH_3)_2CHCONH_2$

D $(CH_3)_2C(OH)COOH$

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37 P is a carboxylic acid with molecular formula $C_5H_{10}O_2$.

Carboxylic acid P reacts with an excess of $LiAlH_4$ to form compound Q.

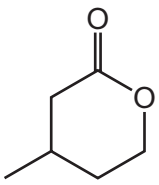
Which pairs of molecules could be carboxylic acid P and compound Q?

	carboxylic acid P	compound Q
1	$CH_3(CH_2)_3COOH$	$CH_3(CH_2)_3OH$
2	$CH_3(CH_2)_3COOH$	$CH_3(CH_2)_3CHO$
3	$(CH_3)_3CCOOH$	$(CH_3)_3CCH_2OH$

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

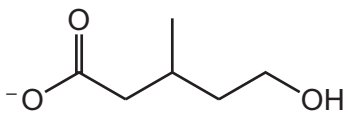
38 Compound X is treated with an excess of dilute aqueous potassium hydroxide.

X

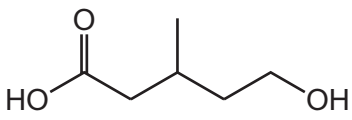


What is the structure of the organic product?

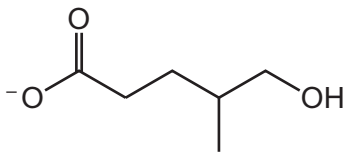
A



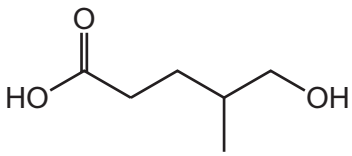
B



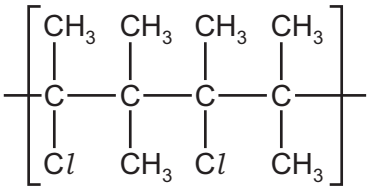
C



D



39 A section showing two repeat units of an addition polymer is shown.



What is the identity of the monomer that produced this polymer?

A 2-chloro-3-methylbutane

B 2-chloro-3-methylbut-2-ene

C 2-chloropent-2-ene

D 2,4-dichloro-3,3,4,5-tetramethylhexane

40 The relative atomic mass of antimony is 121.76.

Antimony has **two** isotopes. The mass numbers of the two isotopes differ by two. The isotope with the lower mass number is the more abundant.

What is the percentage abundance of the isotope with the **higher** mass number?

A 12% **B** 38% **C** 62% **D** 88%

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

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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 144.4	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 –