



Cambridge International AS & A Level

CHEMISTRY

9701/12

Paper 1 Multiple Choice

October/November 2022

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

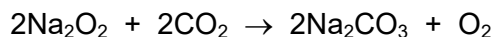
- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **20** pages. Any blank pages are indicated.



- 1 Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?
- A** A phosphorus atom has one more proton in its nucleus.
B The atomic radius of a phosphorus atom is greater.
C The outer electron in a phosphorus atom is more shielded.
D The outer electron in a phosphorus atom is paired.

- 2 Sodium peroxide, Na_2O_2 , is used to absorb carbon dioxide from the atmosphere and release oxygen in closed environments such as space capsules and submarines.

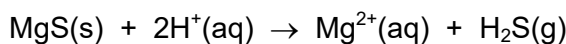
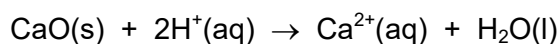


Which mass of sodium peroxide would be required to remove 2.4 dm^3 of carbon dioxide from the atmosphere at room temperature and pressure?

- A** 2.4 g **B** 3.9 g **C** 7.8 g **D** 15.6 g
- 3 In which species are the numbers of protons, neutrons and electrons all different?

- A** ${}_{13}^{27}\text{Al}$ **B** ${}_{17}^{35}\text{Cl}^-$ **C** ${}_{16}^{32}\text{S}^{2-}$ **D** ${}_{19}^{39}\text{K}^+$

- 4 Calcium oxide and magnesium sulfide each react with acid.



A mixture of these two compounds, X, reacts with exactly 0.125 mol of dilute hydrochloric acid.

The amount of hydrogen sulfide formed is 0.0250 mol.

What was the mass of calcium oxide in mixture X?

- A** 1.4 g **B** 2.1 g **C** 2.8 g **D** 4.2 g
- 5 Two moles of VO_2^+ ions react with one mole of zinc atoms in the presence of dilute acid. The products include Zn^{2+} ions and an ion, Y. Ion Y contains vanadium. Only zinc and vanadium change oxidation state in the reaction.

What is ion Y?

- A** VO_3^- **B** VO^+ **C** VO^{2+} **D** VO_2^{2+}

- 6 The compound potassium bismuthate(V), KBiO_3 , is a powerful oxidising agent.

What is the significance of the (V) in potassium bismuthate(V)?

- A It is the oxidation number of the bismuth atom.
 - B It is the charge of the bismuthate ion.
 - C It is the oxidation number of the bismuthate ion.
 - D It is the sum of the charges of the two ions present.
- 7 Hydrogen peroxide decomposes slowly at 20°C to form water and oxygen.

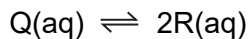


The reaction is faster when a catalyst is present.

Which statement is correct?

- A The catalyst alters the Boltzmann distribution so that the reactant molecules have more energy.
- B The catalyst has no effect on the value of K_c .
- C The catalyst increases the value of K_c .
- D The catalyst provides a different reaction mechanism with a higher activation energy.

- 8 A dimer, Q, is stable when solid but a dynamic equilibrium is set up in solution.



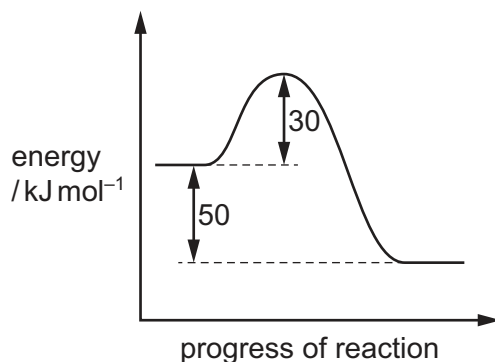
A solution of Q has an initial concentration of 0.50 mol dm^{-3} . When equilibrium has been reached, $[\text{Q(aq)}]$ has fallen to 0.25 mol dm^{-3} .

The changes in $[\text{Q(aq)}]$ and $[\text{R(aq)}]$ are plotted against time until equilibrium is reached. The value of K_c is then calculated.

Which graph and value for K_c are correct?

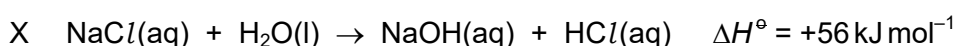
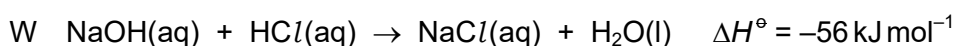
	graph	$K_c / \text{mol dm}^{-3}$
A	<p>Graph A shows concentration in mol dm^{-3} on the y-axis (0 to 0.5) and time on the x-axis. Curve Q starts at 0.5 and decreases to 0.25. Curve R starts at 0 and increases to 0.25.</p>	1
B	<p>Graph B shows concentration in mol dm^{-3} on the y-axis (0 to 0.5) and time on the x-axis. Curve Q starts at 0.5 and decreases to 0.25. Curve R starts at 0 and increases to 0.25.</p>	0.25
C	<p>Graph C shows concentration in mol dm^{-3} on the y-axis (0 to 0.5) and time on the x-axis. Curve Q starts at 0.5 and decreases to 0.25. Curve R starts at 0 and increases to 0.5.</p>	1
D	<p>Graph D shows concentration in mol dm^{-3} on the y-axis (0 to 0.5) and time on the x-axis. Curve Q starts at 0.5 and decreases to 0.25. Curve R starts at 0 and increases to 0.5.</p>	2

- 9 The reaction pathway for the forward reaction of a reversible reaction is shown.



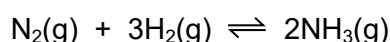
Which statement is correct?

- A** The activation energy of the reverse reaction is $+80 \text{ kJ mol}^{-1}$.
B The enthalpy change for the forward reaction is $+30 \text{ kJ mol}^{-1}$.
C The enthalpy change for the forward reaction is $+50 \text{ kJ mol}^{-1}$.
D The enthalpy change for the reverse reaction is $+30 \text{ kJ mol}^{-1}$.
- 10 The enthalpy changes for the possible reactions W, X, Y and Z are given.



Which statement about the activation energies of these reactions is correct?

- A** X is greater than W; Z is greater than Y.
B X is greater than W; Y is greater than Z.
C W is greater than X; Z is greater than Y.
D W is greater than X; Y is greater than Z.
- 11 The Haber process is carried out with a nitrogen partial pressure of 50 kPa, a hydrogen partial pressure of 150 kPa, a temperature of 400°C and an iron catalyst.



If all other conditions are kept the same, which change will result in a raised activation energy?

- A** Both the nitrogen and hydrogen partial pressures are changed to 100 kPa.
B The iron is removed.
C The nitrogen partial pressure is increased to 150 kPa.
D The temperature is increased to 500°C .

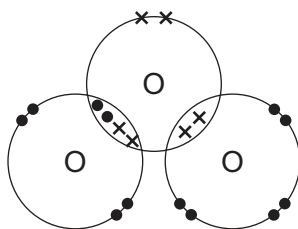
12 The compound $(\text{CH}_3)_3\text{NAlCl}_3$ has a simple molecular structure.

Which statement about $(\text{CH}_3)_3\text{NAlCl}_3$ is correct?

- A $(\text{CH}_3)_3\text{NAlCl}_3$ molecules attract each other by hydrogen bonds.
- B The Al atom in $(\text{CH}_3)_3\text{NAlCl}_3$ has an incomplete valence shell of electrons.
- C The bonds around the Al atom are planar.
- D The molecules contain coordinate bonding.

13 VSEPR theory should be used in answering this question.

The dot-and-cross diagram for an ozone, O_3 , molecule is shown.



What is the predicted bond angle in this molecule?

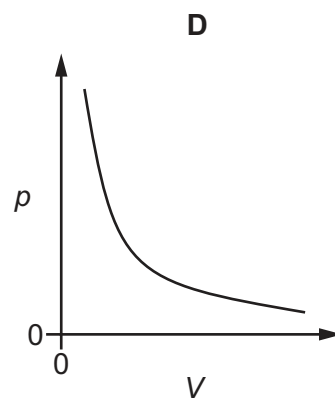
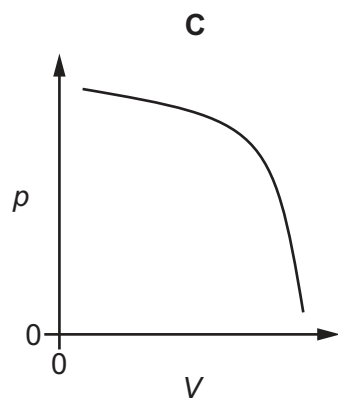
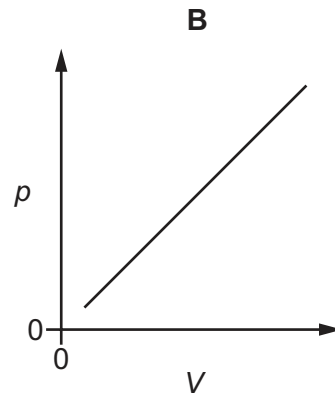
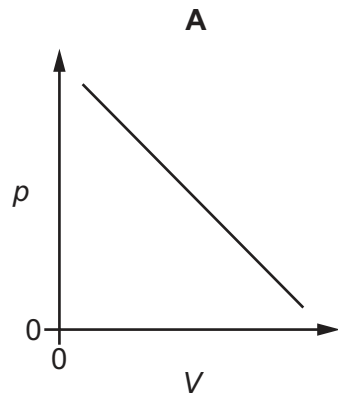
- A 107°
- B 109.5°
- C 117°
- D 120°

14 Each of the substances shown is gaseous.

Which substance is most likely to show ideal behaviour in the conditions shown?

	substance	temperature /K	pressure /Pa
A	carbon dioxide	250	1.00×10^5
B	hydrogen chloride	1000	1.00×10^6
C	nitrogen	1000	1.00×10^5
D	oxygen	250	1.00×10^6

- 15 Which graph represents the variation of pressure p and volume V of a sample of an ideal gas at constant temperature?

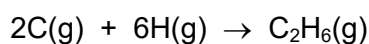


16 Use relevant enthalpy changes from the tables to answer this question.

reaction	$\Delta H/\text{kJ mol}^{-1}$
$\text{C(s)} + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_4(\text{g})$	-76
$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$	-890
$\text{CH}_4(\text{g}) \rightarrow \text{C}(\text{g}) + 4\text{H}(\text{g})$	1648
$3\text{C}(\text{s}) + 4\text{H}_2(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{g})$	-105

bond	bond enthalpy / kJ mol^{-1}
H-H	436
C-C	350
C=C	610
C=O	805

Which value can be calculated for the enthalpy change for the following reaction?



- A $-2822 \text{ kJ mol}^{-1}$
- B $-2122 \text{ kJ mol}^{-1}$
- C $-1998 \text{ kJ mol}^{-1}$
- D $-1772 \text{ kJ mol}^{-1}$

17 Element X requires strong heating to react with oxygen.

Element X reacts with chlorine to give a covalently-bonded chloride.

What could be the identity of element X?

- A magnesium
- B phosphorus
- C sodium
- D silicon

18 The melting points of the Period 3 elements sodium to aluminium are shown in the table.

element	Na	Mg	Al
melting point / K	371	923	932

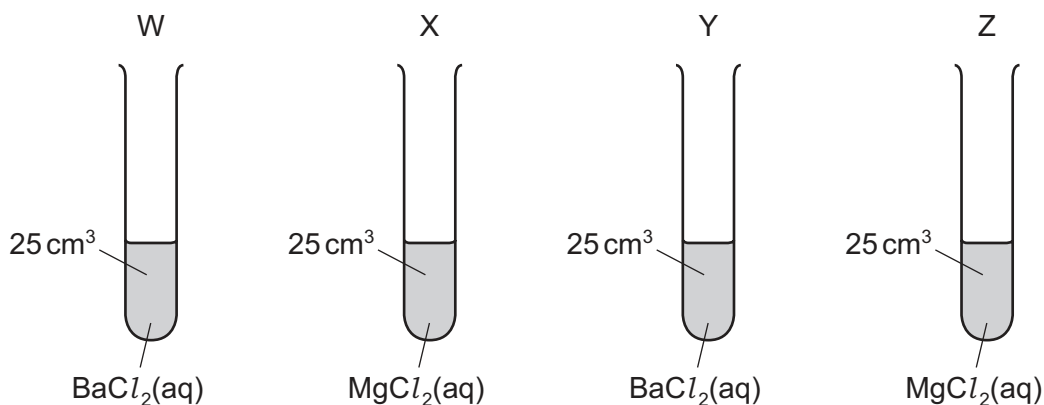
Which factor explains the **increase** in melting points from sodium to aluminium?

- A the change in first ionisation energy from sodium to aluminium
 - B the increase in electronegativity from sodium to aluminium
 - C the increase in the A_r of the elements from sodium to aluminium
 - D the increase in the number of outer electrons in each atom from sodium to aluminium
- 19 The nitrates of beryllium, calcium, magnesium and strontium all decompose in the same way when heated. When 2.00 g of one of these anhydrous nitrates is decomposed, 1.32 g of gas is produced.

What is the nitrate?

- A beryllium nitrate
- B calcium nitrate
- C magnesium nitrate
- D strontium nitrate

20 In the diagram, each test-tube W, X, Y and Z contains 25 cm³ of a 0.1 mol dm⁻³ solution of a salt.



To test-tubes W and X, 25 cm³ of 0.1 mol dm⁻³ NaOH(aq) is added.

To test-tubes Y and Z, 25 cm³ of 0.1 mol dm⁻³ H₂SO₄(aq) is added.

In which of test-tubes W and X does the liquid have the higher pH and which of test-tubes Y and Z has the greater mass of precipitate?

	higher pH	greater mass of precipitate
A	W	Y
B	W	Z
C	X	Y
D	X	Z

21 What is the oxidation state of the chlorine-containing species that kills bacteria in drinking water?

- A** -1 **B** +1 **C** +3 **D** +5

22 Compound Q is a white crystalline solid which dissolves easily in water.

When concentrated sulfuric acid is added to a dry sample of Q, steamy white fumes are formed.

When these white fumes are passed into aqueous silver nitrate solution, a white precipitate forms.

This precipitate is soluble in dilute ammonia solution.

What is compound Q?

- A** AgCl **B** NaBr **C** NaCl **D** PbBr₂

23 R is a solid. R fizzes when hydrochloric acid is added.

R reacts with hot aqueous sodium hydroxide, giving off a gas which turns red litmus blue.

What is the formula of R?

- A NH_4CO_3 B $(\text{NH}_4)_2\text{CO}_3$ C $(\text{NH}_4)_2\text{HCO}_3$ D $(\text{NH}_4)_2\text{SO}_4$

24 Photochemical smog is a type of air pollution produced in urban areas by the effect of sunlight on substances released from vehicle exhausts.

Which mixture of primary pollutants leads to the formation of photochemical smog?

- A carbon dioxide and water vapour
 B carbon monoxide and unburnt hydrocarbons
 C nitrogen oxide and unburnt hydrocarbons
 D sulfur dioxide and water vapour

25 T is an element in Period 3.

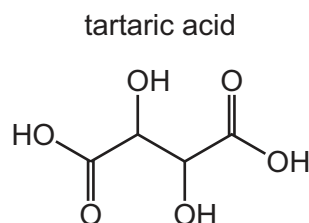
The first ionisation energy of T is lower than that of the element with one less proton.

The oxide of T does not react with water.

What is the identity of T?

- A aluminium
 B silicon
 C sodium
 D sulfur

26 The structure of tartaric acid is shown.



Which statements about tartaric acid are correct?

- 1 A molecule of tartaric acid has more than one chiral centre.
- 2 The molecular formula of tartaric acid is $\text{C}_4\text{H}_4\text{O}_6$.
- 3 One molecule of tartaric acid produces four hydrogen ions in aqueous solution.

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

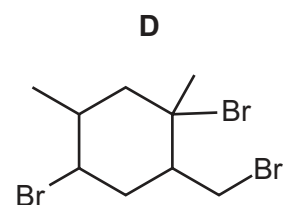
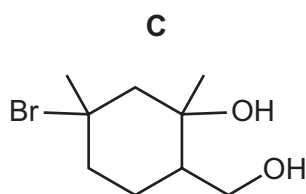
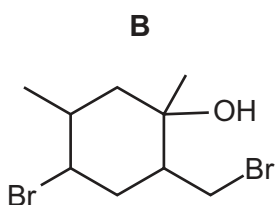
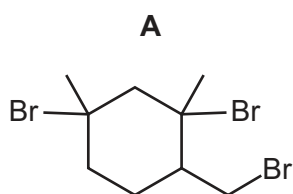
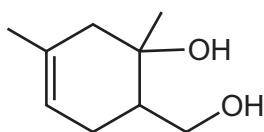
- 27 A carboxylic acid, P, has no chain isomers. It reacts with an alcohol, Q, that has only one positional isomer.

What could be the ester formed from a reaction between P and Q?

- A butyl propanoate
 B ethyl butanoate
 C pentyl ethanoate
 D propyl pentanoate
- 28 Which pair includes a hydrocarbon without a chiral centre?
- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$ $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
 B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_2\text{CH}_3)\text{CH}_3$ $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
 C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$ $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)_2$
 D $\text{CH}_3\text{CH}(\text{CH}_2\text{CH}_3)\text{CH}(\text{CH}_3)\text{CH}_3$ $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}(\text{CH}_3)_2$

- 29 What is the major product formed when compound R is warmed with an excess of HBr?

R



- 30 *cis*-but-2-ene reacts with cold dilute acidified potassium manganate(VII) solution to give product X.

cis-but-2-ene reacts with hot concentrated acidified potassium manganate(VII) solution to give product Y.

Which row describing the reactions of X and Y is correct?

	when sodium metal is added to separate samples of X and Y	when sodium hydroxide solution is added to separate samples of X and Y
A	both X and Y will react	neither X nor Y will react
B	both X and Y will react	only one of X and Y will react
C	only one of X and Y will react	neither X nor Y will react
D	only one of X and Y will react	only one of X and Y will react

- 31 For which reaction will the major organic product have the lowest relative molecular mass?

- A** Bromoethane is heated under reflux with an aqueous solution of sodium hydroxide.
B Bromoethane is heated under reflux with a solution of sodium cyanide in ethanol.
C 2-bromopropane is heated under reflux with an aqueous solution of sodium hydroxide.
D 2-bromopropane is heated under reflux with concentrated ethanolic sodium hydroxide.

- 32 C_4H_9Cl reacts with warm dilute aqueous sodium hydroxide solution.

Which isomer of C_4H_9Cl will form the most stable cation intermediate?

- A** 1-chlorobutane
B 2-chlorobutane
C 1-chloro-2-methylpropane
D 2-chloro-2-methylpropane

33 1.0 mol of an organic compound, J, requires 6.0 mol of oxygen for complete combustion.

1.0 mol of J reacts with sodium, producing 0.50 mol of a gas that gives a 'pop' with a lighted splint.

J reacts with an excess of hot acidified potassium manganate(VII) to produce an organic compound which gives an orange-red precipitate with 2,4-DNPH reagent.

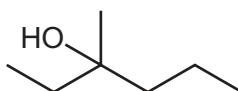
Which compound is J?

- A but-1-ene
- B butan-2-ol
- C propan-2-ol
- D 2-methylpropan-2-ol

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

3-methylhexan-3-ol reacts with hot concentrated sulfuric acid to form several isomeric compounds with the molecular formula C_7H_{14} .

3-methylhexan-3-ol



How many isomeric compounds could be formed in this reaction?

- A 3
- B 4
- C 5
- D 6

35 The table shows a student's predictions for the reactions of three compounds.

	compound	alkaline $I_2(aq)$	Fehling's reagent	Tollens' reagent
1		✓	✓	✓
2		✓	x	x
3		x	x	x

key
 ✓ = reaction occurs
 x = no reaction

Which rows show the correct predictions?

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

36 Which mechanism describes the reaction of aldehydes and ketones with $\text{HCN} + \text{NaCN}$?

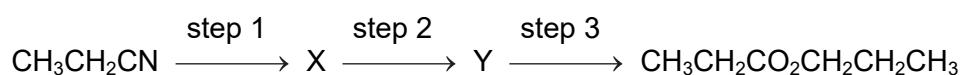
- A electrophilic addition
- B electrophilic substitution
- C nucleophilic addition
- D nucleophilic substitution

37 Propyl propanoate can be synthesised in three steps using propanenitrile as the only organic starting material.

In step 1, the nitrile is converted into compound X.

In step 2, compound X is converted into compound Y.

In step 3, compound Y is reacted with more of compound X to give propyl propanoate.



Which reagents are suitable for carrying out step 1 and step 2?

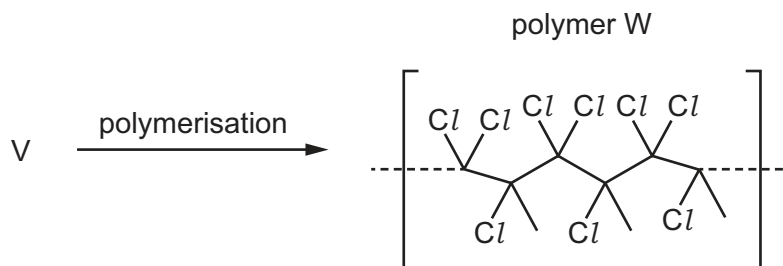
	step 1	step 2
A	$\text{HCl}(\text{aq})$	conc. H_2SO_4
B	$\text{HCl}(\text{aq})$	LiAlH_4
C	$\text{NaOH}(\text{aq})$	conc. H_2SO_4
D	$\text{NaOH}(\text{aq})$	NaBH_4

38 The ester $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$ is hydrolysed by boiling with aqueous sodium hydroxide.

Which compound is one of the products?

- A ethanol
- B propan-1-ol
- C sodium methanoate
- D sodium propanoate

39 Compound V polymerises to form polymer W. A section of polymer W is shown.



What is the correct name of compound V?

- A** 1,1,2-trichlorobutene
- B** 1,1,2-trichloroethene
- C** 1,1,2-trichloropropene
- D** 1,1,2-trichloro-2-methylethene
- 40 A molecule of an organic compound, P, contains three carbon atoms and shows a strong absorption at 1720 cm^{-1} in its infrared spectrum.

P is reacted with an excess of hot acidified potassium dichromate(VI) forming organic product Q.

Q shows a strong absorption at 1700 cm^{-1} and a strong, broad absorption centred at 2800 cm^{-1} in its infrared spectrum.

bond	functional group 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 P?

- A** propanal
- B** propanone
- C** propan-1-ol
- D** propan-2-ol

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	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">1 H hydrogen 1.0</div> <div style="border: 1px solid black; padding: 2px;">2 He helium 4.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">3 Li lithium 6.9</div> <div style="border: 1px solid black; padding: 2px;">4 Be beryllium 9.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">5 B boron 10.8</div> <div style="border: 1px solid black; padding: 2px;">6 C carbon 12.0</div> <div style="border: 1px solid black; padding: 2px;">7 N nitrogen 14.0</div> <div style="border: 1px solid black; padding: 2px;">8 O oxygen 16.0</div> <div style="border: 1px solid black; padding: 2px;">9 F fluorine 19.0</div> <div style="border: 1px solid black; padding: 2px;">10 Ne neon 20.2</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">11 Na sodium 23.0</div> <div style="border: 1px solid black; padding: 2px;">12 Mg magnesium 24.3</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">13 Al aluminium 27.0</div> <div style="border: 1px solid black; padding: 2px;">14 Si silicon 28.1</div> <div style="border: 1px solid black; padding: 2px;">15 P phosphorus 31.0</div> <div style="border: 1px solid black; padding: 2px;">16 S sulfur 32.1</div> <div style="border: 1px solid black; padding: 2px;">17 Cl chlorine 35.5</div> <div style="border: 1px solid black; padding: 2px;">18 Ar argon 39.9</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">19 K potassium 39.1</div> <div style="border: 1px solid black; padding: 2px;">20 Ca calcium 40.1</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">21 Sc scandium 45.0</div> <div style="border: 1px solid black; padding: 2px;">22 Ti titanium 47.9</div> <div style="border: 1px solid black; padding: 2px;">23 V vanadium 50.9</div> <div style="border: 1px solid black; padding: 2px;">24 Cr chromium 52.0</div> <div style="border: 1px solid black; padding: 2px;">25 Mn manganese 54.9</div> <div style="border: 1px solid black; padding: 2px;">26 Fe iron 55.8</div> <div style="border: 1px solid black; padding: 2px;">27 Co cobalt 58.9</div> <div style="border: 1px solid black; padding: 2px;">28 Ni nickel 58.7</div> <div style="border: 1px solid black; padding: 2px;">29 Cu copper 63.5</div> <div style="border: 1px solid black; padding: 2px;">30 Zn zinc 65.4</div> <div style="border: 1px solid black; padding: 2px;">31 Ga gallium 69.7</div> <div style="border: 1px solid black; padding: 2px;">32 Ge germanium 72.6</div> <div style="border: 1px solid black; padding: 2px;">33 As arsenic 74.9</div> <div style="border: 1px solid black; padding: 2px;">34 Se selenium 79.0</div> <div style="border: 1px solid black; padding: 2px;">35 Br bromine 79.9</div> <div style="border: 1px solid black; padding: 2px;">36 Kr krypton 83.8</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">37 Rb rubidium 85.5</div> <div style="border: 1px solid black; padding: 2px;">38 Sr strontium 87.6</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">39 Y yttrium 88.9</div> <div style="border: 1px solid black; padding: 2px;">40 Zr zirconium 91.2</div> <div style="border: 1px solid black; padding: 2px;">41 Nb niobium 92.9</div> <div style="border: 1px solid black; padding: 2px;">42 Mo molybdenum 95.9</div> <div style="border: 1px solid black; padding: 2px;">43 Tc technetium —</div> <div style="border: 1px solid black; padding: 2px;">44 Ru ruthenium 101.1</div> <div style="border: 1px solid black; padding: 2px;">45 Rh rhodium 102.9</div> <div style="border: 1px solid black; padding: 2px;">46 Pd palladium 106.4</div> <div style="border: 1px solid black; padding: 2px;">47 Ag silver 107.9</div> <div style="border: 1px solid black; padding: 2px;">48 Cd cadmium 112.4</div> <div style="border: 1px solid black; padding: 2px;">49 In indium 114.8</div> <div style="border: 1px solid black; padding: 2px;">50 Sn tin 118.7</div> <div style="border: 1px solid black; padding: 2px;">51 Sb antimony 121.8</div> <div style="border: 1px solid black; padding: 2px;">52 Te tellurium 127.6</div> <div style="border: 1px solid black; padding: 2px;">53 I iodine 126.9</div> <div style="border: 1px solid black; padding: 2px;">54 Xe xenon 131.3</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">55 Cs caesium 132.9</div> <div style="border: 1px solid black; padding: 2px;">56 Ba barium 137.3</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">57–71 lanthanoids</div> <div style="border: 1px solid black; padding: 2px;">72 Hf hafnium 178.5</div> <div style="border: 1px solid black; padding: 2px;">73 Ta tantalum 180.9</div> <div style="border: 1px solid black; padding: 2px;">74 W tungsten 183.8</div> <div style="border: 1px solid black; padding: 2px;">75 Re rhenium 186.2</div> <div style="border: 1px solid black; padding: 2px;">76 Os osmium 190.2</div> <div style="border: 1px solid black; padding: 2px;">77 Ir iridium 192.2</div> <div style="border: 1px solid black; padding: 2px;">78 Pt platinum 195.1</div> <div style="border: 1px solid black; padding: 2px;">79 Au gold 197.0</div> <div style="border: 1px solid black; padding: 2px;">80 Hg mercury 200.6</div> <div style="border: 1px solid black; padding: 2px;">81 Tl thallium 204.4</div> <div style="border: 1px solid black; padding: 2px;">82 Pb lead 207.2</div> <div style="border: 1px solid black; padding: 2px;">83 Bi bismuth 209.0</div> <div style="border: 1px solid black; padding: 2px;">84 Po polonium —</div> <div style="border: 1px solid black; padding: 2px;">85 At astatine —</div> <div style="border: 1px solid black; padding: 2px;">86 Rn radon —</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">87 Fr francium —</div> <div style="border: 1px solid black; padding: 2px;">88 Ra radium —</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">89–103 actinoids</div> <div style="border: 1px solid black; padding: 2px;">104 Rf rutherfordium —</div> <div style="border: 1px solid black; padding: 2px;">105 Db dubnium —</div> <div style="border: 1px solid black; padding: 2px;">106 Sg seaborgium —</div> <div style="border: 1px solid black; padding: 2px;">107 Bh bohrium —</div> <div style="border: 1px solid black; padding: 2px;">108 Hs hassium —</div> <div style="border: 1px solid black; padding: 2px;">109 Mt meitnerium —</div> <div style="border: 1px solid black; padding: 2px;">110 Ds darmstadtium —</div> <div style="border: 1px solid black; padding: 2px;">111 Rg roentgenium —</div> <div style="border: 1px solid black; padding: 2px;">112 Cn copernicium —</div> <div style="border: 1px solid black; padding: 2px;">113 Nh nihonium —</div> <div style="border: 1px solid black; padding: 2px;">114 Fl flerovium —</div> <div style="border: 1px solid black; padding: 2px;">115 Mc moscovium —</div> <div style="border: 1px solid black; padding: 2px;">116 Lv livermorium —</div> <div style="border: 1px solid black; padding: 2px;">117 Ts tennessine —</div> <div style="border: 1px solid black; padding: 2px;">118 Og oganesson —</div> </div>															

lanthanoids

actinoids

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
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 —