



Cambridge International AS & A Level

CHEMISTRY

9701/11

Paper 1 Multiple Choice

October/November 2020

1 hour

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)
Data booklet

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. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **16** pages. Blank pages are indicated.



Section A

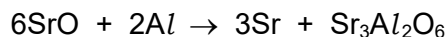
For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 Which statement is correct?

- A** Cl has a relative isotopic mass of 35.5.
- B** Cl_2 has a relative molecular mass of 70.
- C** ICl has a relative molecular mass of 162.4.
- D** NaCl has a relative molecular mass of 58.5.

2 Strontium metal can be extracted from strontium oxide, SrO , by reduction with aluminium. One of the possible reactions is shown.



What is the maximum mass of strontium metal that can be produced from the reduction of 100 g of strontium oxide using this reaction?

- A** 41.3 g **B** 42.3 g **C** 84.6 g **D** 169.2 g

3 A single ^{32}P nucleus can be produced when a single ^{32}S nucleus joins with particle X. In the process a proton is emitted.

What is particle X?

- A** a deuteron, $^2_1\text{H}^+$
- B** an electron
- C** a neutron
- D** a proton

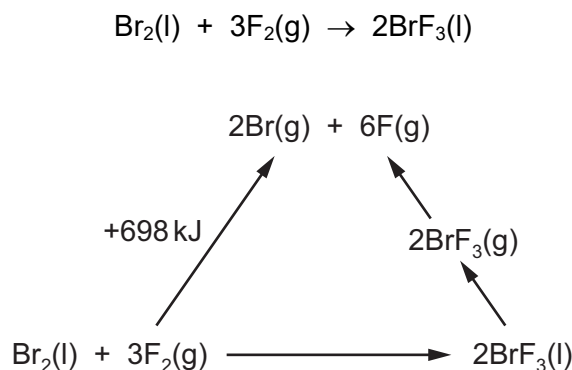
4 In which of the following, when in liquid form, are there only intermolecular forces based on temporary dipoles between the particles?

- A** bromine
- B** ethanol
- C** hydrogen chloride
- D** water

- 5 Copper has a high melting point.

What is the reason for the high melting point of copper?

- A** strong attractive forces between copper atoms only
B strong attractive forces between copper ions and delocalised electrons
C strong attractive forces between copper ions only
D strong attractive forces between copper atoms and delocalised electrons
- 6 Which pair of standard enthalpy changes are numerically equal?
- A** atomisation of $\text{CH}_4(\text{g})$ and formation of $\text{CH}_4(\text{g})$
B combustion of $\text{CH}_3\text{OH}(\text{l})$ and combustion of graphite + 2(combustion of $\text{H}_2(\text{g})$)
C combustion of graphite and formation of $\text{CO}_2(\text{g})$
D neutralisation of $\text{HCl}(\text{aq})$ with $\text{NaOH}(\text{aq})$ and formation of $\text{H}_2\text{O}(\text{l})$
- 7 An energy cycle is drawn for the following reaction.



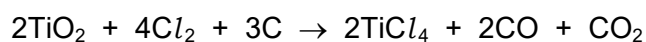
The standard enthalpy of formation of $\text{BrF}_3(\text{l}) = -301 \text{ kJ mol}^{-1}$.

The enthalpy change of $\text{BrF}_3(\text{l})$ to $\text{BrF}_3(\text{g})$ is $+44 \text{ kJ mol}^{-1}$.

What is the average bond energy of the Br–F bond in BrF_3 ?

- A** 152 kJ mol^{-1} **B** 202 kJ mol^{-1} **C** 304 kJ mol^{-1} **D** 404 kJ mol^{-1}
- 8 In which reaction does the greatest change in the oxidation number of sulfur occur?
- A** $\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g})$
B $\text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g})$
C $\text{SO}_3(\text{g}) + \text{H}_2\text{SO}_4(\text{l}) \rightarrow \text{H}_2\text{S}_2\text{O}_7(\text{l})$
D $\text{H}_2\text{S}_2\text{O}_7(\text{l}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{H}_2\text{SO}_4(\text{l})$

- 9 The first stage in the chloride process for the manufacture of titanium consists of the following reaction.



What is reduced in this reaction?

- A carbon
 - B chlorine
 - C oxygen
 - D titanium
- 10 In aqueous solution, sulfuric acid dissociates as shown.

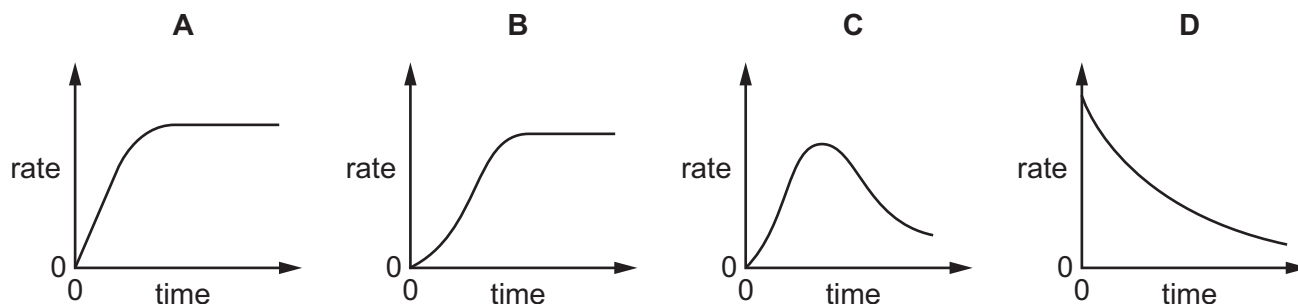


Analysis of a 2.00 mol dm^{-3} solution of H_2SO_4 found the HSO_4^- concentration to be $1.988 \text{ mol dm}^{-3}$.

What is K_c ?

- A $1.381 \times 10^5 \text{ dm}^3 \text{ mol}^{-1}$
 - B $82.34 \text{ dm}^3 \text{ mol}^{-1}$
 - C $1.214 \times 10^{-2} \text{ mol dm}^{-3}$
 - D $7.244 \times 10^{-5} \text{ mol dm}^{-3}$
- 11 An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve would be obtained if the rate of an autocatalytic reaction is plotted against time?



- 12** X and Y are two elements in Period 3 of the Periodic Table. They combine to form compound Z.

X forms a soluble acidic oxide. The oxidation number of X in this oxide is +4.

Y forms an amphoteric oxide.

What is the formula of compound Z?

- A** AlP **B** Al_2S_3 **C** Si_2P_5 **D** SiS_2

- 13** This question is about two elements in Group 2, Q and R.

Three of the statements shown are correct for metal Q.

The one remaining statement is correct for metal R.

Which statement applies to R?

- A** A saturated solution of the hydroxide of this metal has the higher pH value.
B This metal has a carbonate that is used in agriculture to reduce the acidity of soil.
C This metal has the greater atomic radius.
D This metal reacts more quickly with cold water.

- 14** The electronic arrangement for atoms of four elements is given.

Which element is the strongest oxidising agent?

- A** $1s^2 2s^2 2p^5$
B $1s^2 2s^2 2p^6 3s^2$
C $1s^2 2s^2 2p^6 3s^2 3p^5$
D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

- 15** A student mixes pairs of chemicals together in separate test-tubes.

- excess calcium (s) + water (l)
- barium chloride (aq) + strontium hydroxide (aq)
- calcium carbonate (s) + excess hydrochloric acid (aq)
- magnesium sulfate (aq) + barium nitrate (aq)

How many of the mixtures produce a white, solid product?

- A** 0 **B** 1 **C** 2 **D** 3

16 With which compound does concentrated sulfuric acid react **both** as a strong acid **and** as an oxidising agent?

- A** magnesium carbonate
- B** potassium chloride
- C** sodium bromide
- D** sulfur trioxide

17 Ammonia can undergo an acid–base reaction with hydrogen chloride to form ammonium chloride.

Which statement is correct?

- A** The ammonium ion is basic.
- B** The hydrogen atom from HCl donates a lone pair of electrons to the nitrogen atom.
- C** The H–N–H bond angle in ammonia is the same as the H–N–H bond angle in the ammonium ion.
- D** The H–N–H bond angle in the ammonium ion is the same as the H–C–H bond angle in methane.

18 What are the trends in the stated properties as Group 2 is descended from magnesium to barium?

	decomposition temperature of the carbonate	first ionisation energy
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

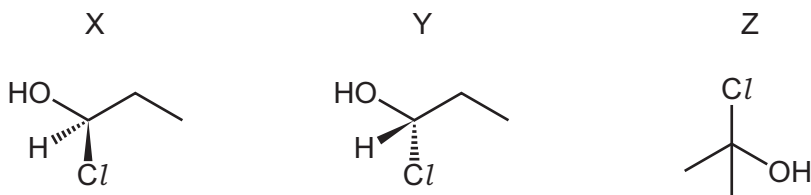
19 Sulfur dioxide, SO_2 , reacts with calcium hydroxide in aqueous solution.

What is the main product that is first formed?

- A** $\text{Ca}(\text{HSO}_4)_2$ **B** CaS **C** CaSO_3 **D** CaSO_4

- 20 Structural and stereoisomerism should be considered when answering this question.

Compounds X, Y and Z are shown.



How many other isomers of C_3H_7ClO are there that are alcohols?

- A** 2 **B** 3 **C** 4 **D** 5
- 21 Two students each make a statement about 2-methylbut-1-ene.
- Student 1 states that 2-methylbut-1-ene has geometrical isomers.
- Student 2 states that 2-methylbut-1-ene reacts with HBr in an addition reaction to give 1-bromo-2-methylbutane as the main product.
- Which students are correct?
- A** both 1 and 2
B 1 only
C 2 only
D neither 1 nor 2
- 22 Which statement is correct when referring to the complete combustion of PVC?
- A** A gas is made which contributes to global warming.
B Carbon dioxide and water are the only products.
C If water is used to clean the exhaust gases, the water becomes alkaline.
D There is no need to treat the exhaust gases as the products are non-hazardous.
- 23 Iodoethane, CH_3CH_2I , reacts with aqueous silver nitrate at $50^\circ C$. A precipitate forms during this reaction.

Which row of the table is correct about this reaction?

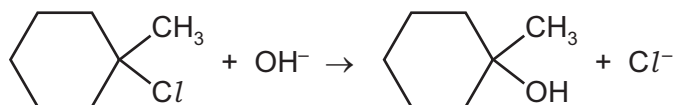
	type of organic reaction	colour of precipitate
A	electrophilic substitution	cream
B	electrophilic substitution	yellow
C	nucleophilic substitution	cream
D	nucleophilic substitution	yellow

- 24** A student converts 1-iodopropane, $\text{C}_3\text{H}_7\text{I}$, into butanoic acid, $\text{C}_3\text{H}_7\text{CO}_2\text{H}$, by a two-stage chemical synthesis.

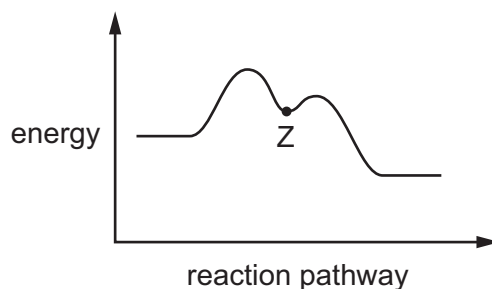
In the **first** of the two stages, which reagent is reacted with 1-iodopropane?

- A** aqueous sodium hydroxide
- B** ethanolic ammonia
- C** ethanolic potassium cyanide
- D** ethanolic sodium hydroxide

- 25** 1-chloro-1-methylcyclohexane is hydrolysed by heating with NaOH(aq) .



The reaction pathway is shown.



One carbon atom in 1-chloro-1-methylcyclohexane is bonded to three other carbon atoms.

What is the charge on this carbon atom at point Z?

- A** 1–
- B** $\delta-$
- C** $\delta+$
- D** 1+

- 26** An alcohol with the molecular formula $\text{C}_5\text{H}_{12}\text{O}$ decolourises warm acidified potassium manganate(VII). The alcohol also gives a yellow precipitate with alkaline aqueous iodine.

What could be the identity of the alcohol?

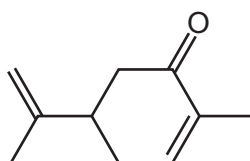
- A** 2-methylbutan-2-ol
- B** 3-methylbutan-2-ol
- C** pentan-1-ol
- D** pentan-3-ol

27 Which pair of test results would prove that a substance, X, is a ketone?

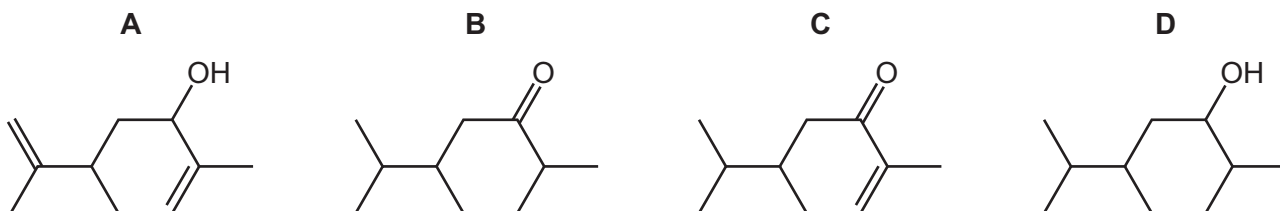
- A X has no reaction with Tollens' reagent. X reacts with alkaline aqueous iodine.
- B X is reduced by lithium aluminium hydride. X is oxidised by acidified dichromate(VI).
- C X reacts with 2,4-DNPH reagent. X has no reaction with Fehling's reagent.
- D X reacts with hydrogen cyanide. X is reduced by lithium aluminium hydride.

28 Carvone is found in spearmint oil.

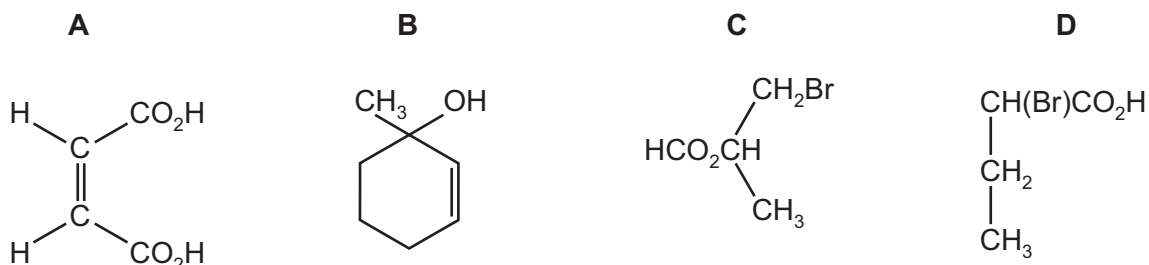
carvone



Which product is formed when carvone is reacted with NaBH_4 ?

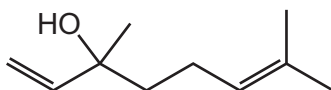


29 Which compound is chiral and reacts with Na_2CO_3 to give CO_2 ?



30 The skeletal formula of compound X is shown.

compound X



What is the molecular formula of compound X?

- A $\text{C}_{10}\text{H}_{18}\text{O}$
- B $\text{C}_{10}\text{H}_{20}\text{O}$
- C $\text{C}_{11}\text{H}_{22}\text{O}$
- D $\text{C}_{11}\text{H}_{24}\text{O}$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 Nitrogen forms a number of oxides. Their enthalpies of formation are given.

$$\Delta H_f^\circ[\text{NO}(\text{g})] = +90 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ[\text{N}_2\text{O}(\text{g})] = +82 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ[\text{NO}_2(\text{g})] = +33 \text{ kJ mol}^{-1}$$

Which statements are correct?

- 1** If $\text{N}_2\text{O}(\text{g})$ is oxidised by $\text{O}_2(\text{g})$ to $\text{NO}_2(\text{g})$, 16 kJ is released per mole of N_2O .
- 2** The decomposition of $\text{N}_2\text{O}(\text{g})$ to $\text{N}_2(\text{g})$ and $\text{O}_2(\text{g})$ is exothermic.
- 3** The reaction between NO and oxygen is exothermic.

32 Which statements are correct?

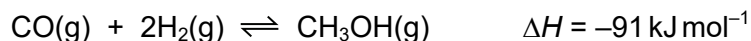
- 1** enthalpy of combustion of H_2 = enthalpy of formation of H_2O
- 2** enthalpy of formation of H_2 = $-(\text{enthalpy of atomisation of } \text{H}_2)$
- 3** enthalpy of solution of HCl = enthalpy of hydration of H^+ + enthalpy of hydration of Cl^-

33 The units of K_c for an equilibrium reaction are $\text{mol}^{-1} \text{ dm}^3$.

What could be the equation for the equilibrium?

- 1** $\text{A}(\text{aq}) + \text{B}(\text{aq}) \rightleftharpoons \text{C}(\text{s}) + \text{D}(\text{aq})$
- 2** $\text{P}(\text{aq}) + \text{Q}(\text{aq}) \rightleftharpoons \text{R}(\text{aq})$
- 3** $\text{W}(\text{aq}) + 2\text{X}(\text{aq}) \rightleftharpoons \text{Y}(\text{aq}) + \text{Z}(\text{aq})$

34 Methanol, CH_3OH , can be produced industrially by reacting CO with H_2 .



The process can be carried out at $4 \times 10^3 \text{ kPa}$ and 1150 K .

Which statements about this reaction are correct?

- 1** Increasing the temperature will increase the rate of reaction because more effective collisions will occur.
- 2** Lowering the temperature will reduce the rate of reaction because the forward reaction is exothermic.
- 3** Increasing the pressure will reduce the rate of reaction because there are a larger number of moles on the left-hand side of the equation.

35 Which rows correctly show the relative electrical conductivities of the sets of three Period 3 elements?

	greatest conductivity	→	least conductivity
1	sodium	silicon	chlorine
2	aluminium	magnesium	phosphorus
3	sulfur	silicon	phosphorus

36 Three test-tubes, X, Y and Z, each contain water.

- A small amount of NaCl is added to test-tube X.
- A small amount of SiCl_4 is added to test-tube Y.
- A small amount of AlCl_3 is added to test-tube Z.

After a short time, two drops of universal indicator solution are added to each test-tube.

Which statements can be correct?

- 1** The pH in test-tube X is 7.
- 2** The pH in test-tube Y is 2.
- 3** The pH in test-tube Z is 2.

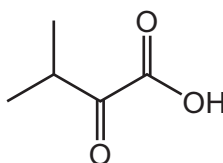
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A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

37 The structure of compound R is shown.

compound R



Which statements about compound R are correct?

- 1** It has an M_r of 116.
- 2** It contains two groups that show strong absorptions between 1640 and 1740 cm^{-1} in its infrared spectrum.
- 3** Its only infrared absorption between 2500 and 3000 cm^{-1} is sharp and strong.

38 During the bromination of methane, the free radical $\text{CH}_3\cdot$ is generated. A possible termination step of this reaction is the formation of C_2H_6 by the combination of two free radicals.

What could be produced in a termination step during the bromination of **propane**?

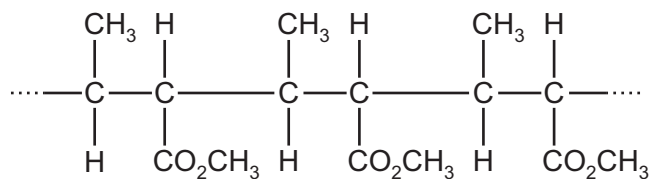
- 1** $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- 2** $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)_2$
- 3** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$

39 Three reactions of primary alcohols are listed.

Which reactions give water as one of the products?

- 1 reaction with ethanoic acid
- 2 reaction with concentrated HBr
- 3 passing the alcohol vapour over heated Al_2O_3

40 The diagram shows part of the structure of polymer X.



Which reagents react with polymer X?

- 1 aqueous sulfuric acid
- 2 aqueous sodium hydroxide
- 3 sodium

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Section A

For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

- 1 What is the average oxidation number of sulfur in each compound?

	$\text{Ca}(\text{HSO}_3)_2$	$\text{Na}_2\text{S}_2\text{O}_3$
A	4	2
B	4	4
C	6	2
D	6	4

- 2 An ore of manganese contains 4% by mass of MnO_2 and no other manganese compound.

Which mass of manganese would be obtained from 1 tonne of this ore?

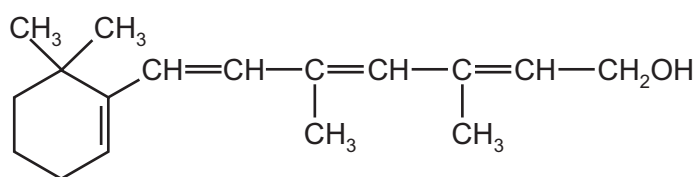
- A** 25.3 kg **B** 40.0 kg **C** 63.3 kg **D** 632 kg

- 3 Which atomic orbitals are occupied in an atom of phosphorus?

- A** 1p2s2p **B** 2s2p2d **C** 2s2p3s **D** 2p3s3d

- 4 The structure of compound A is shown.

compound A



Some of the carbon atoms in compound A have a tetrahedral arrangement of bonds.

Some of the carbon atoms in compound A have a trigonal planar arrangement of bonds.

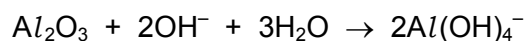
How many carbon atoms are there of each type?

	tetrahedral	trigonal planar
A	5	12
B	8	8
C	9	6
D	9	8

- 5 A white powder is known to be a mixture of magnesium oxide and aluminium oxide.

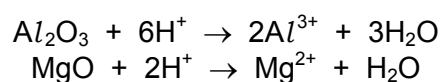
100 cm³ of 2 mol dm⁻³ NaOH(aq) is just enough to dissolve the aluminium oxide in x grams of the mixture.

The reaction is shown.



800 cm³ of 2 mol dm⁻³ HCl(aq) is just enough to dissolve **all** of the oxide in x grams of the mixture.

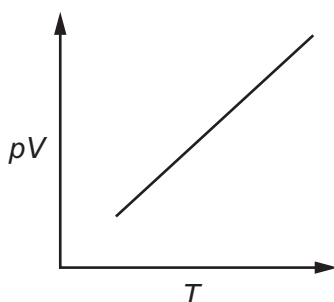
The reactions are shown.



How many moles of each oxide are present in x grams of the mixture?

	aluminium oxide	magnesium oxide
A	0.05	0.25
B	0.05	0.50
C	0.10	0.25
D	0.10	0.50

- 6 A graph of pV against T is shown for a fixed mass of gas. (p = pressure, V = volume and T = temperature in K.)



Which gas gives this graph over the widest range of temperatures and pressures?

- A** hydrogen, H₂
- B** hydrogen chloride, HCl
- C** hydrogen fluoride, HF
- D** oxygen, O₂

- 7 A weather balloon is filled with 12.0 kg helium. The weather balloon reaches a height of 20 km, the pressure inside the balloon is 6000 Pa and the temperature is 216 K.

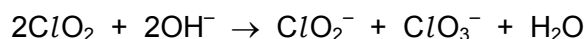
What is the volume of the weather balloon at this height, correct to three significant figures?

- A 897 dm³ B 1790 dm³ C 897 000 dm³ D 1 790 000 dm³

- 8 Which pair of enthalpy changes will **always** share the same sign (i.e. both are always exothermic **or** both are always endothermic)?

- A enthalpy change of atomisation and enthalpy change of neutralisation
B enthalpy change of atomisation and enthalpy change of solution
C enthalpy change of combustion and enthalpy change of hydration
D enthalpy change of solution and enthalpy change of hydration

- 9 Chlorine dioxide, ClO₂, reacts with sodium hydroxide in the reaction shown.



Which statement correctly describes this redox reaction?

- A Chlorine atoms are oxidised and oxygen atoms are reduced.
B Chlorine atoms are reduced and oxygen atoms are oxidised.
C Some chlorine atoms are oxidised and some chlorine atoms are reduced.
D Some oxygen atoms are oxidised and some oxygen atoms are reduced.

- 10 Sulfur dioxide and oxygen react to form sulfur trioxide. The reaction is reversible.

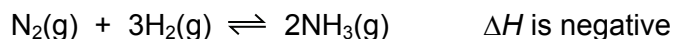


The reaction is allowed to reach equilibrium at 700 °C. The partial pressure of O₂(g) is 375 kPa and the partial pressure of SO₃(g) is 20.3 kPa.

What is the partial pressure of SO₂(g)?

- A 19.3 kPa B 609 kPa C 18 300 kPa D 609 000 kPa

11 Ammonia is made by the Haber process. The reactants are nitrogen and hydrogen.



What will increase the rate of the forward reaction?

- A adding argon to the mixture but keeping the total volume constant
- B decreasing the temperature
- C increasing the total pressure by reducing the total volume at constant temperature
- D removing ammonia as it is made but keeping the total volume of the mixture the same

12 Element X, in Period 3, has the following properties.

- Its oxide has a giant structure.
- It forms covalent bonds with chlorine.
- Its oxide will neutralise $\text{HCl}(\text{aq})$.

What is element X?

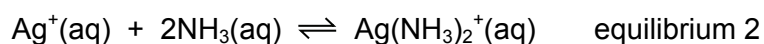
- A Mg B Al C Si D P

13 Which row could refer to barium metal and barium hydroxide?

	colour seen when the metal is burnt in O_2	pH of a saturated solution of the hydroxide
A	green flame	8
B	green flame	13
C	white flame	8
D	white flame	13

- 14** $\text{AgNO}_3(\text{aq})$ is added to a solution of a halide ion, $\text{X}^-(\text{aq})$, and aqueous ammonia is then added.

The ionic equations for the two reactions that occur are shown.



Which statement is correct?

- A** The position of equilibrium 1 lies to the left when $\text{X}^- = \text{I}^-$.
- B** Increasing the concentration of ammonia causes the position of equilibrium 1 to move to the left.
- C** K_c for equilibrium 2 is larger when $\text{X}^- = \text{Cl}^-$ than when $\text{X}^- = \text{I}^-$.
- D** Equilibrium 2 is a redox reaction.

- 15** Water and ammonia take part in a reaction that produces the ammonium ion.

Which statement about this reaction is correct?

- A** The ammonia molecule and the ammonium ion do not have dipole moments.
- B** The bond angle changes from 109.5° in the ammonia molecule to 107° in the ammonium ion.
- C** The reaction is a redox reaction.
- D** The water is acting as an acid.

- 16** Due to their similar ionic radii, the reactions of lithium and magnesium and their corresponding compounds are very similar.

Which statement about the reactions of lithium or its compounds can be predicted from this statement?

- A** Lithium burns very slowly in oxygen.
- B** Lithium carbonate decomposes on heating in a blue Bunsen burner flame, forming lithium oxide and carbon dioxide.
- C** Lithium nitrate decomposes on heating, forming lithium nitrite, LiNO_2 , and oxygen.
- D** Lithium reacts very violently with cold water, producing hydrogen.

- 17** Which statement about Group 17 elements and their compounds is correct?

- A** Chlorine reacts with cold concentrated sodium hydroxide to form NaCl and NaClO_3 .
- B** HCl is more thermally stable than HBr because chlorine is less electronegative than bromine.
- C** Iodide ions are oxidised to iodine by concentrated sulfuric acid.
- D** Silver iodide is soluble in dilute aqueous ammonia.

- 18 Which substance, when warmed with aqueous ammonium chloride, would produce an alkaline gas?

A $\text{CH}_3\text{CO}_2\text{H}$ B $\text{CH}_3\text{CH}_2\text{OH}$ C $\text{CH}_3\text{CO}_2\text{CH}_3$ D $\text{CH}_3\text{CH}_2\text{ONa}$

- 19 Compound X is the oxide of a Period 3 element. Compound X reacts with water to give an acidic solution.

A solution is prepared by reacting 0.100 g of compound X with an excess of water. This solution is neutralised by exactly 25.0 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution.

What could be the identity of compound X?

A Al_2O_3 B MgO C P_4O_{10} D SO_3

- 20 The unsaturated hydrocarbon octa-1,3,5,7-tetraene, C_8H_{10} , can display geometric isomerism.

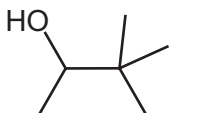
octa-1,3,5,7-tetraene



How many isomers exist?

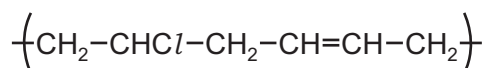
A 2 B 3 C 4 D 8

- 21 What is the correct name for the compound shown?



- A 1,2,2-trimethylbutan-3-ol
 B 2-ethyl-2-methylbutan-2-ol
 C 3,3-dimethylpentan-2-ol
 D 4-hydroxy-3,3-dimethylpentane

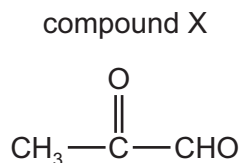
- 22 A polymer has the following repeat unit. It is made from two different monomers.



Which pair of monomers could be used to make this polymer?

- A $\text{CH}_2=\text{CHCl}$ and $\text{CH}_2=\text{CH}_2$
 B $\text{CH}_2=\text{CHCl}$ and $\text{CH}_2=\text{CH}-\text{CH}=\text{CH}_2$
 C $\text{CH}_3-\text{CH}_2\text{Cl}$ and $\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3$
 D $\text{CH}_3-\text{CH}=\text{CH}-\text{CH}_3$ and $\text{CH}_2=\text{CHCl}$

- 23 Compound X contains two functional groups.



Which reagent will react with **only one** of the functional groups?

- A acidified potassium dichromate(VI)
- B 2,4-DNPH reagent
- C hydrogen cyanide
- D NaBH_4

- 24 Ethanol can be converted into ethene in a single reaction.

Ethanol can be converted into bromoethane in a single reaction.

Under standard laboratory conditions, is a catalyst used in these reactions?

	ethanol to ethene	ethanol to bromoethane
A	yes	yes
B	yes	no
C	no	yes
D	no	no

- 25 Diols in which both hydroxy groups are bonded to the same carbon atom can spontaneously eliminate a molecule of water to produce a carbonyl compound.

Which compound, after complete hydrolysis, gives a silver mirror with Tollens' reagent?

- A 1,1-dibromobutane
- B 1,2-dibromobutane
- C 1,3-dibromobutane
- D 2,2-dibromobutane

- 26 Which alcohol will give a yellow precipitate when warmed with alkaline aqueous iodine?

- A $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$
- B $(\text{CH}_3)_3\text{COH}$
- C $\text{CH}_3\text{CH}_2\text{C}(\text{OH})(\text{CH}_3)_2$
- D $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$

27 How many structural isomers are there of molecular formula $C_5H_{10}O$ that give a red precipitate with Fehling's solution?

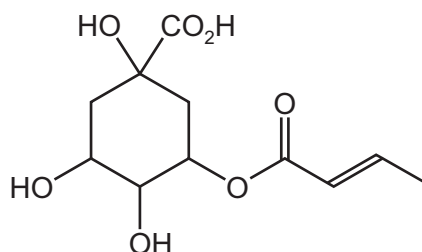
- A 1 B 2 C 3 D 4

28 Which statement about the use of alkane fuels in internal combustion engines is correct?

- A C_8H_{18} is used as fuel in internal combustion engines and reacts with oxygen and nitrogen from the air.
 B In limited oxygen, CO is produced which oxidises SO_2 to SO_3 in the atmosphere.
 C The catalytic converter removes polluting gases including NO_2 and CO_2 .
 D Unburnt hydrocarbons and NO_2 can react in sunlight to produce photochemical smog.

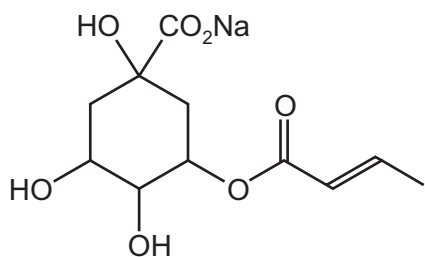
29 Compound Z is shown.

compound Z

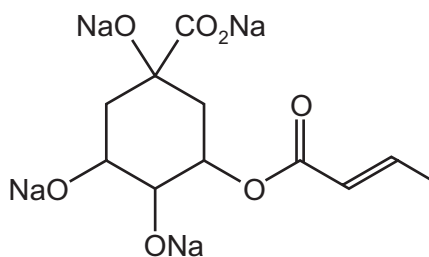


What is produced in good yield when compound Z is treated with an excess of sodium carbonate solution at room temperature?

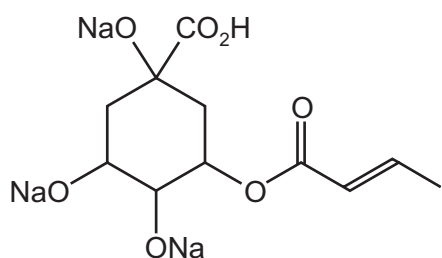
A



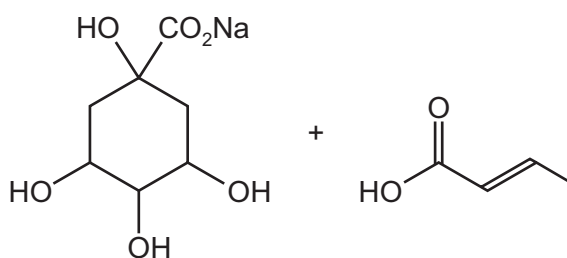
B



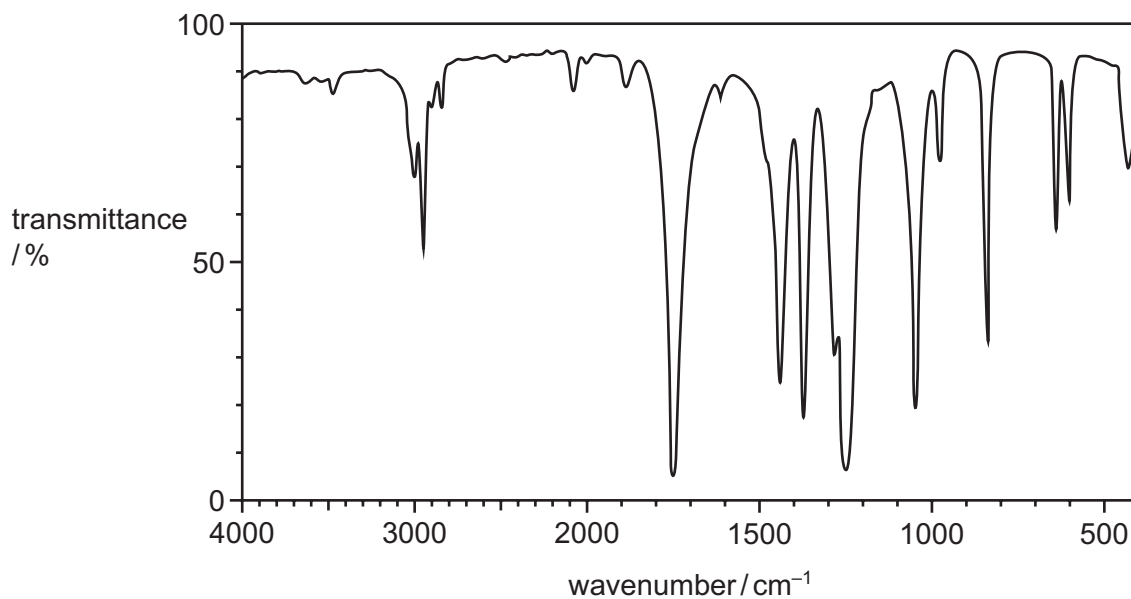
C



D



30 The infra-red spectrum shown was obtained from compound G.



What could be compound G?

- A** $\text{CH}_3\text{COCH}_2\text{OH}$
- B** $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$
- C** $\text{CH}_3\text{CO}_2\text{CH}_3$
- D** $\text{CH}_3\text{CHCHCH}_3$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

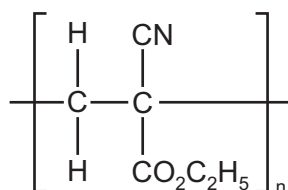
31 The symbol for a phosphorus ion is $^{33}_{15}\text{P}^{3-}$.

The symbol for a potassium ion is $^{37}_{19}\text{K}^{+}$.

What do these two ions have in common?

- 1** the same number of electrons
- 2** the same number of neutrons
- 3** the same number of protons

32 The repeat unit of a polymer is shown.



Which types of intermolecular forces exist in the solid polymer?

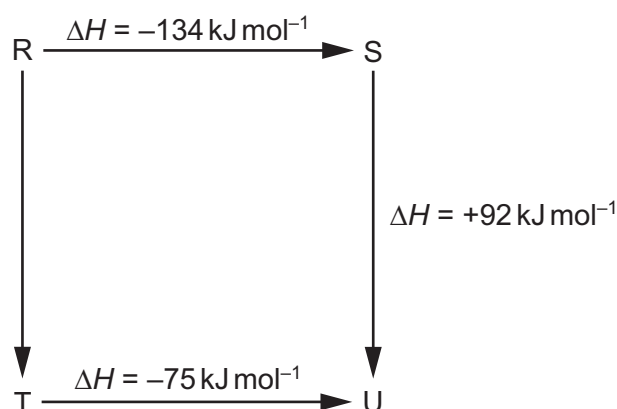
- 1** temporary dipole – induced dipole interactions
- 2** permanent dipole – permanent dipole interactions
- 3** hydrogen bonds

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

33 The diagram illustrates the enthalpy changes of a set of reactions.



Which statements are correct?

- 1 The enthalpy change for the transformation $U \rightarrow R$ is $+42 \text{ kJ mol}^{-1}$.
- 2 The enthalpy change for the transformation $T \rightarrow S$ is endothermic.
- 3 The enthalpy change for the transformation $R \rightarrow T$ is -33 kJ mol^{-1} .

34 Which statements about a reaction that has reached dynamic equilibrium are correct?

- 1 The rate of the forward reaction equals the rate of the reverse reaction.
- 2 There is no overall change in the concentrations of reactants and products.
- 3 There is no change in the measurable properties of the system.

35 Group 2 elements and their compounds show trends in their physical and chemical properties. Barium is above radium in Group 2 of the Periodic Table.

Which statements are likely to be correct?

- 1 Barium hydroxide is less soluble than radium hydroxide.
- 2 Barium reacts less vigorously with water than radium does.
- 3 Barium sulfate is more soluble than radium sulfate.

36 Which statements are correct?

- 1 The empirical formula of silicon(IV) oxide is SiO_2 .
- 2 The molecular formula of phosphorus(V) oxide is P_2O_5 .
- 3 Silicon(IV) oxide and phosphorus(V) oxide are both simple molecular compounds.

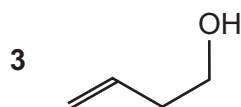
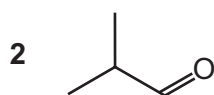
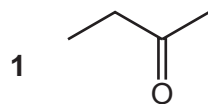
37 Which reagents could be used, under suitable conditions, to oxidise $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ to $\text{CH}_3\text{CH}_2\text{CHO}$?

- 1 acidified potassium manganate(VII)
- 2 acidified potassium dichromate(VI)
- 3 Tollens' reagent

38 Which free radicals can be generated during a free-radical substitution reaction between chlorine and ethane?

- 1 $\text{CH}_3\cdot$
- 2 $\text{CH}_2\text{ClCH}_2\cdot$
- 3 $\text{CH}_3\text{CCl}_2\cdot$

39 Which substances have molecular formula $\text{C}_4\text{H}_8\text{O}$?



40 Which reactions produce pentanoic acid?

- 1 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_3 + \text{H}^+/\text{MnO}_4^-(\text{aq})$
- 2 $\text{CH}_3\text{OCO}(\text{CH}_2)_3\text{CH}_3 + \text{HCl}(\text{aq})$
- 3 $\text{CH}_3(\text{CH}_2)_3\text{CN} + \text{H}_2\text{SO}_4(\text{aq})$

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Cambridge International AS & A Level

CHEMISTRY

9701/13

Paper 1 Multiple Choice

October/November 2020

1 hour

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)
Data booklet

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. A mark will not be deducted for a wrong answer.
- Any rough working should be done on this question paper.

This document has **16** pages. Blank pages are indicated.



Section A

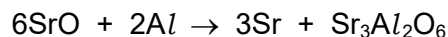
For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

Use of the Data Booklet may be appropriate for some questions.

1 Which statement is correct?

- A** Cl has a relative isotopic mass of 35.5.
- B** Cl_2 has a relative molecular mass of 70.
- C** ICl has a relative molecular mass of 162.4.
- D** NaCl has a relative molecular mass of 58.5.

2 Strontium metal can be extracted from strontium oxide, SrO , by reduction with aluminium. One of the possible reactions is shown.



What is the maximum mass of strontium metal that can be produced from the reduction of 100 g of strontium oxide using this reaction?

- A** 41.3 g **B** 42.3 g **C** 84.6 g **D** 169.2 g

3 A single ^{32}P nucleus can be produced when a single ^{32}S nucleus joins with particle X. In the process a proton is emitted.

What is particle X?

- A** a deuteron, $^2_1\text{H}^+$
- B** an electron
- C** a neutron
- D** a proton

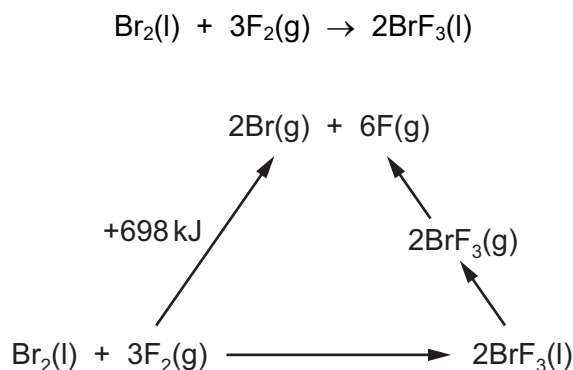
4 In which of the following, when in liquid form, are there only intermolecular forces based on temporary dipoles between the particles?

- A** bromine
- B** ethanol
- C** hydrogen chloride
- D** water

- 5 Copper has a high melting point.

What is the reason for the high melting point of copper?

- A** strong attractive forces between copper atoms only
B strong attractive forces between copper ions and delocalised electrons
C strong attractive forces between copper ions only
D strong attractive forces between copper atoms and delocalised electrons
- 6 Which pair of standard enthalpy changes are numerically equal?
- A** atomisation of $\text{CH}_4(\text{g})$ and formation of $\text{CH}_4(\text{g})$
B combustion of $\text{CH}_3\text{OH}(\text{l})$ and combustion of graphite + 2(combustion of $\text{H}_2(\text{g})$)
C combustion of graphite and formation of $\text{CO}_2(\text{g})$
D neutralisation of $\text{HCl}(\text{aq})$ with $\text{NaOH}(\text{aq})$ and formation of $\text{H}_2\text{O}(\text{l})$
- 7 An energy cycle is drawn for the following reaction.



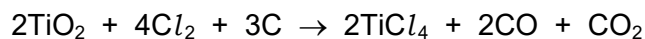
The standard enthalpy of formation of $\text{BrF}_3(\text{l}) = -301 \text{ kJ mol}^{-1}$.

The enthalpy change of $\text{BrF}_3(\text{l})$ to $\text{BrF}_3(\text{g})$ is $+44 \text{ kJ mol}^{-1}$.

What is the average bond energy of the Br–F bond in BrF_3 ?

- A** 152 kJ mol^{-1} **B** 202 kJ mol^{-1} **C** 304 kJ mol^{-1} **D** 404 kJ mol^{-1}
- 8 In which reaction does the greatest change in the oxidation number of sulfur occur?
- A** $\text{S}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{SO}_2(\text{g})$
B $\text{SO}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightleftharpoons \text{SO}_3(\text{g})$
C $\text{SO}_3(\text{g}) + \text{H}_2\text{SO}_4(\text{l}) \rightarrow \text{H}_2\text{S}_2\text{O}_7(\text{l})$
D $\text{H}_2\text{S}_2\text{O}_7(\text{l}) + \text{H}_2\text{O}(\text{l}) \rightarrow 2\text{H}_2\text{SO}_4(\text{l})$

- 9 The first stage in the chloride process for the manufacture of titanium consists of the following reaction.



What is reduced in this reaction?

- A carbon
 - B chlorine
 - C oxygen
 - D titanium
- 10 In aqueous solution, sulfuric acid dissociates as shown.

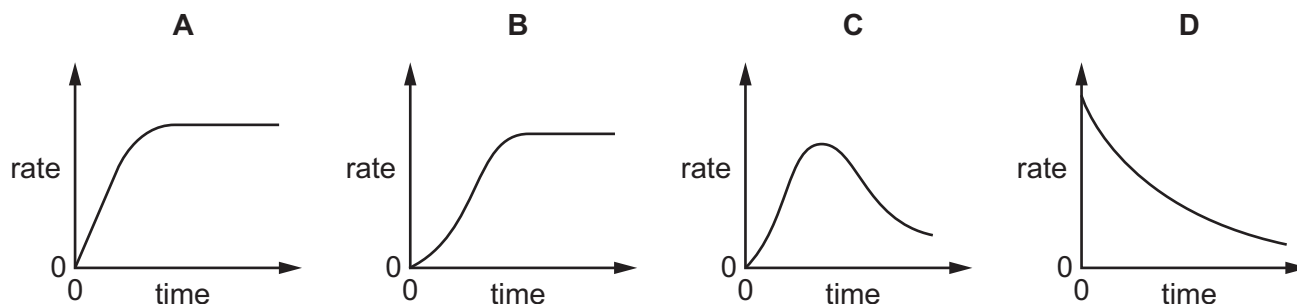


Analysis of a 2.00 mol dm^{-3} solution of H_2SO_4 found the HSO_4^- concentration to be $1.988 \text{ mol dm}^{-3}$.

What is K_c ?

- A $1.381 \times 10^5 \text{ dm}^3 \text{ mol}^{-1}$
 - B $82.34 \text{ dm}^3 \text{ mol}^{-1}$
 - C $1.214 \times 10^{-2} \text{ mol dm}^{-3}$
 - D $7.244 \times 10^{-5} \text{ mol dm}^{-3}$
- 11 An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve would be obtained if the rate of an autocatalytic reaction is plotted against time?



12 X and Y are two elements in Period 3 of the Periodic Table. They combine to form compound Z.

X forms a soluble acidic oxide. The oxidation number of X in this oxide is +4.

Y forms an amphoteric oxide.

What is the formula of compound Z?

- A** AlP **B** Al_2S_3 **C** Si_2P_5 **D** SiS_2

13 This question is about two elements in Group 2, Q and R.

Three of the statements shown are correct for metal Q.

The one remaining statement is correct for metal R.

Which statement applies to R?

- A** A saturated solution of the hydroxide of this metal has the higher pH value.
B This metal has a carbonate that is used in agriculture to reduce the acidity of soil.
C This metal has the greater atomic radius.
D This metal reacts more quickly with cold water.

14 The electronic arrangement for atoms of four elements is given.

Which element is the strongest oxidising agent?

- A** $1s^2 2s^2 2p^5$
B $1s^2 2s^2 2p^6 3s^2$
C $1s^2 2s^2 2p^6 3s^2 3p^5$
D $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

15 A student mixes pairs of chemicals together in separate test-tubes.

- excess calcium (s) + water (l)
- barium chloride (aq) + strontium hydroxide (aq)
- calcium carbonate (s) + excess hydrochloric acid (aq)
- magnesium sulfate (aq) + barium nitrate (aq)

How many of the mixtures produce a white, solid product?

- A** 0 **B** 1 **C** 2 **D** 3

16 With which compound does concentrated sulfuric acid react **both** as a strong acid **and** as an oxidising agent?

- A** magnesium carbonate
- B** potassium chloride
- C** sodium bromide
- D** sulfur trioxide

17 Ammonia can undergo an acid–base reaction with hydrogen chloride to form ammonium chloride.

Which statement is correct?

- A** The ammonium ion is basic.
- B** The hydrogen atom from HCl donates a lone pair of electrons to the nitrogen atom.
- C** The H–N–H bond angle in ammonia is the same as the H–N–H bond angle in the ammonium ion.
- D** The H–N–H bond angle in the ammonium ion is the same as the H–C–H bond angle in methane.

18 What are the trends in the stated properties as Group 2 is descended from magnesium to barium?

	decomposition temperature of the carbonate	first ionisation energy
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

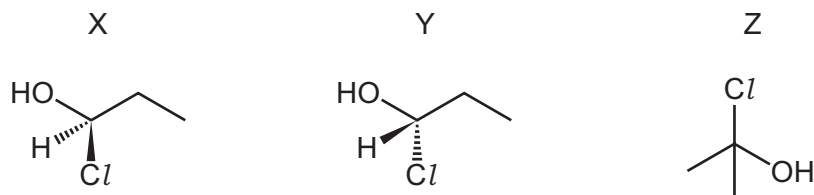
19 Sulfur dioxide, SO_2 , reacts with calcium hydroxide in aqueous solution.

What is the main product that is first formed?

- A** $\text{Ca}(\text{HSO}_4)_2$ **B** CaS **C** CaSO_3 **D** CaSO_4

- 20 Structural and stereoisomerism should be considered when answering this question.

Compounds X, Y and Z are shown.



How many other isomers of C_3H_7ClO are there that are alcohols?

- A** 2 **B** 3 **C** 4 **D** 5
- 21 Two students each make a statement about 2-methylbut-1-ene.
- Student 1 states that 2-methylbut-1-ene has geometrical isomers.
- Student 2 states that 2-methylbut-1-ene reacts with HBr in an addition reaction to give 1-bromo-2-methylbutane as the main product.
- Which students are correct?
- A** both 1 and 2
B 1 only
C 2 only
D neither 1 nor 2
- 22 Which statement is correct when referring to the complete combustion of PVC?
- A** A gas is made which contributes to global warming.
B Carbon dioxide and water are the only products.
C If water is used to clean the exhaust gases, the water becomes alkaline.
D There is no need to treat the exhaust gases as the products are non-hazardous.
- 23 Iodoethane, CH_3CH_2I , reacts with aqueous silver nitrate at $50^\circ C$. A precipitate forms during this reaction.

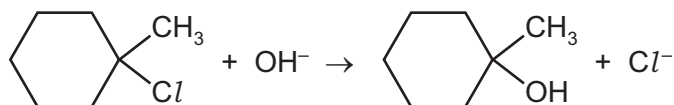
Which row of the table is correct about this reaction?

	type of organic reaction	colour of precipitate
A	electrophilic substitution	cream
B	electrophilic substitution	yellow
C	nucleophilic substitution	cream
D	nucleophilic substitution	yellow

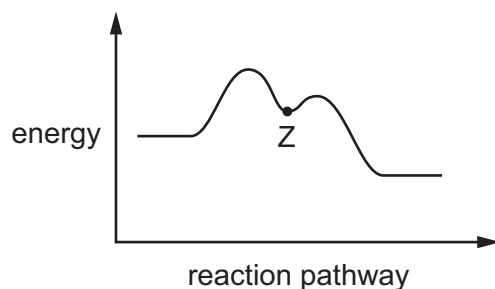
- 24** A student converts 1-iodopropane, $\text{C}_3\text{H}_7\text{I}$, into butanoic acid, $\text{C}_3\text{H}_7\text{CO}_2\text{H}$, by a two-stage chemical synthesis.

In the **first** of the two stages, which reagent is reacted with 1-iodopropane?

- A** aqueous sodium hydroxide
 - B** ethanolic ammonia
 - C** ethanolic potassium cyanide
 - D** ethanolic sodium hydroxide
- 25** 1-chloro-1-methylcyclohexane is hydrolysed by heating with NaOH(aq) .



The reaction pathway is shown.



One carbon atom in 1-chloro-1-methylcyclohexane is bonded to three other carbon atoms.

What is the charge on this carbon atom at point Z?

- A** 1–
 - B** $\delta-$
 - C** $\delta+$
 - D** 1+
- 26** An alcohol with the molecular formula $\text{C}_5\text{H}_{12}\text{O}$ decolourises warm acidified potassium manganate(VII). The alcohol also gives a yellow precipitate with alkaline aqueous iodine.

What could be the identity of the alcohol?

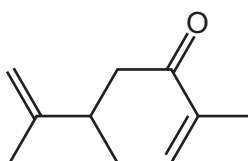
- A** 2-methylbutan-2-ol
- B** 3-methylbutan-2-ol
- C** pentan-1-ol
- D** pentan-3-ol

27 Which pair of test results would prove that a substance, X, is a ketone?

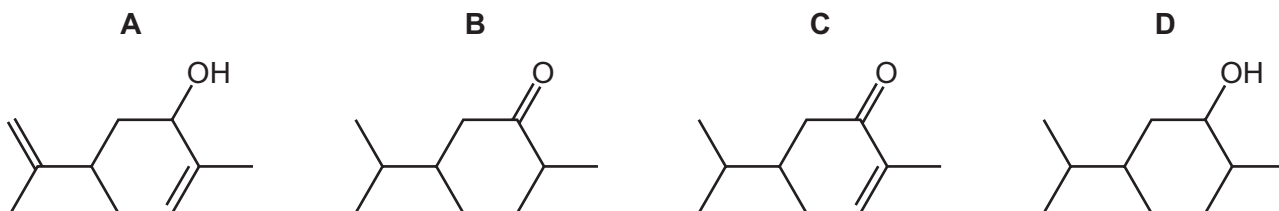
- A X has no reaction with Tollens' reagent. X reacts with alkaline aqueous iodine.
- B X is reduced by lithium aluminium hydride. X is oxidised by acidified dichromate(VI).
- C X reacts with 2,4-DNPH reagent. X has no reaction with Fehling's reagent.
- D X reacts with hydrogen cyanide. X is reduced by lithium aluminium hydride.

28 Carvone is found in spearmint oil.

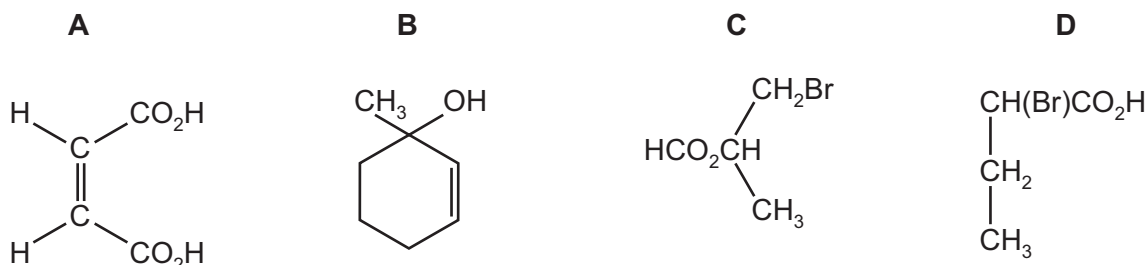
carvone



Which product is formed when carvone is reacted with NaBH_4 ?

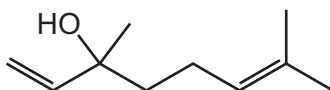


29 Which compound is chiral and reacts with Na_2CO_3 to give CO_2 ?



30 The skeletal formula of compound X is shown.

compound X



What is the molecular formula of compound X?

- A $\text{C}_{10}\text{H}_{18}\text{O}$
- B $\text{C}_{10}\text{H}_{20}\text{O}$
- C $\text{C}_{11}\text{H}_{22}\text{O}$
- D $\text{C}_{11}\text{H}_{24}\text{O}$

Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 Nitrogen forms a number of oxides. Their enthalpies of formation are given.

$$\Delta H_f^\circ[\text{NO}(\text{g})] = +90 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ[\text{N}_2\text{O}(\text{g})] = +82 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ[\text{NO}_2(\text{g})] = +33 \text{ kJ mol}^{-1}$$

Which statements are correct?

- 1** If $\text{N}_2\text{O}(\text{g})$ is oxidised by $\text{O}_2(\text{g})$ to $\text{NO}_2(\text{g})$, 16 kJ is released per mole of N_2O .
- 2** The decomposition of $\text{N}_2\text{O}(\text{g})$ to $\text{N}_2(\text{g})$ and $\text{O}_2(\text{g})$ is exothermic.
- 3** The reaction between NO and oxygen is exothermic.

32 Which statements are correct?

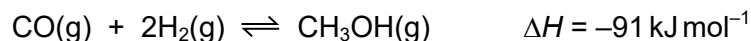
- 1** enthalpy of combustion of H_2 = enthalpy of formation of H_2O
- 2** enthalpy of formation of H_2 = $-(\text{enthalpy of atomisation of } \text{H}_2)$
- 3** enthalpy of solution of HCl = enthalpy of hydration of H^+ + enthalpy of hydration of Cl^-

33 The units of K_c for an equilibrium reaction are $\text{mol}^{-1} \text{ dm}^3$.

What could be the equation for the equilibrium?

- 1** $\text{A}(\text{aq}) + \text{B}(\text{aq}) \rightleftharpoons \text{C}(\text{s}) + \text{D}(\text{aq})$
- 2** $\text{P}(\text{aq}) + \text{Q}(\text{aq}) \rightleftharpoons \text{R}(\text{aq})$
- 3** $\text{W}(\text{aq}) + 2\text{X}(\text{aq}) \rightleftharpoons \text{Y}(\text{aq}) + \text{Z}(\text{aq})$

34 Methanol, CH_3OH , can be produced industrially by reacting CO with H_2 .



The process can be carried out at $4 \times 10^3 \text{ kPa}$ and 1150 K .

Which statements about this reaction are correct?

- 1 Increasing the temperature will increase the rate of reaction because more effective collisions will occur.
- 2 Lowering the temperature will reduce the rate of reaction because the forward reaction is exothermic.
- 3 Increasing the pressure will reduce the rate of reaction because there are a larger number of moles on the left-hand side of the equation.

35 Which rows correctly show the relative electrical conductivities of the sets of three Period 3 elements?

	greatest conductivity	→	least conductivity
1	sodium	silicon	chlorine
2	aluminium	magnesium	phosphorus
3	sulfur	silicon	phosphorus

36 Three test-tubes, X, Y and Z, each contain water.

- A small amount of NaCl is added to test-tube X.
- A small amount of SiCl_4 is added to test-tube Y.
- A small amount of AlCl_3 is added to test-tube Z.

After a short time, two drops of universal indicator solution are added to each test-tube.

Which statements can be correct?

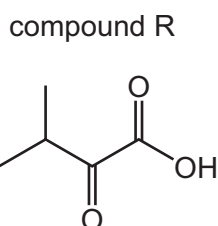
- 1 The pH in test-tube X is 7.
- 2 The pH in test-tube Y is 2.
- 3 The pH in test-tube Z is 2.

The responses **A** to **D** should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is used as a correct response.

37 The structure of compound R is shown.



Which statements about compound R are correct?

- 1** It has an M_r of 116.
- 2** It contains two groups that show strong absorptions between 1640 and 1740 cm^{-1} in its infrared spectrum.
- 3** Its only infrared absorption between 2500 and 3000 cm^{-1} is sharp and strong.

38 During the bromination of methane, the free radical $\text{CH}_3\cdot$ is generated. A possible termination step of this reaction is the formation of C_2H_6 by the combination of two free radicals.

What could be produced in a termination step during the bromination of **propane**?

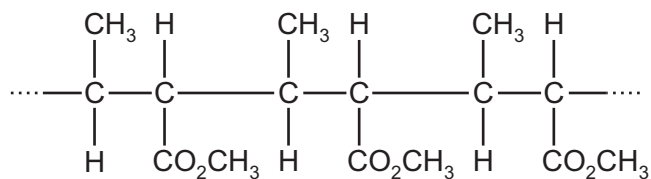
- 1** $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- 2** $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}(\text{CH}_3)_2$
- 3** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)_2$

39 Three reactions of primary alcohols are listed.

Which reactions give water as one of the products?

- 1 reaction with ethanoic acid
- 2 reaction with concentrated HBr
- 3 passing the alcohol vapour over heated Al_2O_3

40 The diagram shows part of the structure of polymer X.



Which reagents react with polymer X?

- 1 aqueous sulfuric acid
- 2 aqueous sodium hydroxide
- 3 sodium

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