

CHEMISTRY

9701/11

Paper 1 Multiple Choice

May/June 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

DO **NOT** WRITE IN ANY BARCODES.

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 separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

Electronic calculators may be used.

This document consists of **13** printed pages and **3** blank pages.

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 molecule contains six bonding electrons?

- A** C₂H₄ **B** H₂S **C** NCl₃ **D** SF₆

2 The mass spectrum of a sample of lithium shows that it contains two isotopes, ⁶Li and ⁷Li.

The isotopic abundances are shown in the table.

isotope	isotopic abundance
⁶ Li	7.42%
⁷ Li	92.58%

What is the relative atomic mass of this sample of lithium, given to three significant figures?

- A** 6.07 **B** 6.50 **C** 6.90 **D** 6.93

3 A sports medal has a total surface area of 150 cm². It was evenly coated with silver by electrolysis. Its mass increased by 0.216 g.

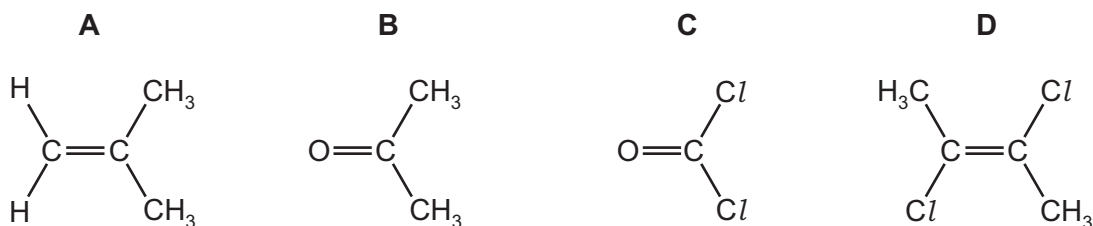
How many atoms of silver were deposited per cm² on the surface of the medal?

- A** 8.0×10^{18} **B** 1.8×10^{19} **C** 8.7×10^{20} **D** 1.2×10^{21}

4 Which property of an atom does **not** affect its first ionisation energy?

- A** the atomic radius
B the number of electron shells
C the number of neutrons
D the number of protons

5 Which molecule has the largest overall dipole?



- 6 The complete combustion of 2 moles of a straight chain alkane produces 400 dm³ of carbon dioxide measured at 301 K and 1×10^5 Pa. Carbon dioxide can be assumed to behave as an ideal gas under these conditions.

What is the formula of the straight chain alkane?

- A** C₈H₁₈ **B** C₁₆H₃₄ **C** C₂₀H₄₂ **D** C₄₀H₈₂

- 7 Which expression gives the standard enthalpy change of combustion of methane?

- A** $\Delta H_f^\ominus(\text{CH}_4) + \Delta H_f^\ominus(\text{CO}_2) - 2\Delta H_f^\ominus(\text{H}_2\text{O})$
B $\Delta H_f^\ominus(\text{CO}_2) + 2\Delta H_f^\ominus(\text{H}_2\text{O}) + \Delta H_f^\ominus(\text{CH}_4)$
C $\Delta H_f^\ominus(\text{CH}_4) + 2\Delta H_f^\ominus(\text{H}_2\text{O}) - \Delta H_f^\ominus(\text{CO}_2)$
D $\Delta H_f^\ominus(\text{CO}_2) + 2\Delta H_f^\ominus(\text{H}_2\text{O}) - \Delta H_f^\ominus(\text{CH}_4)$

- 8 Solutions containing chlorate(I) ions are used as household bleaches and disinfectants. These solutions decompose on heating as shown.



Which oxidation state is shown by chlorine in each of these three ions?

	ClO^-	ClO_3^-	Cl^-
A	+1	+3	-1
B	-1	+3	+1
C	+1	+5	-1
D	-1	+5	+1

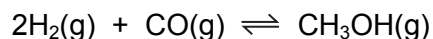
- 9 When K₂MnO₄ is dissolved in water, the following reaction occurs.



What are the values of *a* and *c* in the balanced chemical equation?

	<i>a</i>	<i>c</i>
A	2	1
B	3	2
C	4	3
D	5	4

- 10 Methanol can be produced from hydrogen and carbon monoxide.



What is the expression for K_p for this reaction?

A $K_p = \frac{(2p_{\text{H}_2})^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

B $K_p = \frac{(p_{\text{H}_2})^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

C $K_p = \frac{p_{\text{CH}_3\text{OH}}}{(p_{\text{H}_2})^2 \times p_{\text{CO}}}$

D $K_p = \frac{p_{\text{CH}_3\text{OH}}}{p_{\text{CO}} \times (2p_{\text{H}_2})^2}$

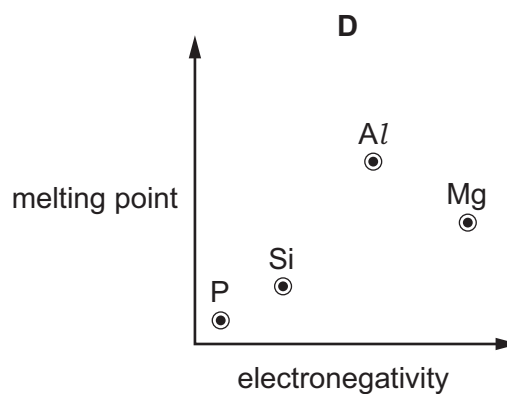
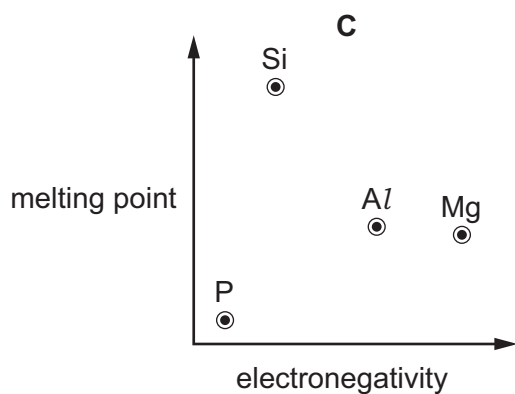
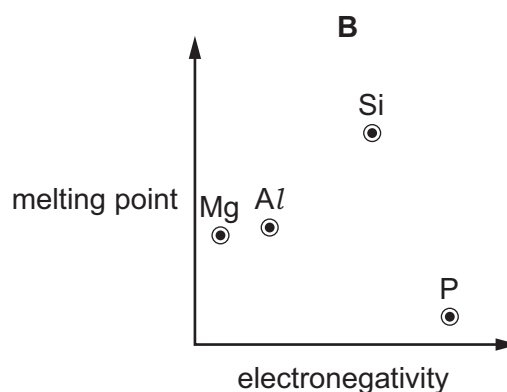
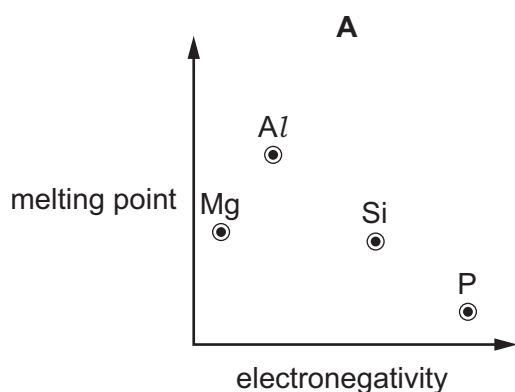
- 11 When 4 g of powdered calcium carbonate, $M_r = 100$, were added to 100 cm³ of 0.10 mol dm⁻³ hydrochloric acid the volume of carbon dioxide produced was recorded.

time / s	30	60	90	120	150	180	210	240
total volume of carbon dioxide given off / cm ³	40	70	88	101	110	116	120	120

Which row gives the correct explanations about these results?

	why the rate of the reaction changes with time	why the reaction stops
A	fewer collisions between reacting molecules occur	the calcium carbonate is used up
B	fewer collisions between reacting molecules occur	the hydrochloric acid is used up
C	more collisions between reacting molecules occur	the calcium carbonate is used up
D	more collisions between reacting molecules occur	the hydrochloric acid is used up

- 12 Why is the second ionisation energy of sodium larger than the second ionisation energy of magnesium?
- A** The attraction between the nucleus and the outer electron is greater in Na^+ than in Mg^+ .
- B** The nuclear charge of Na^+ is greater than that of Mg^+ .
- C** The outer electron of Na^+ is more shielded than the outer electron of Mg^+ .
- D** The outer electron of Na is in the same orbital as the outer electron of Mg.
- 13 Which graph correctly shows the relative melting points of the elements Mg, Al, Si and P plotted against their relative electronegativities?



14 An excess of MgO is shaken with water. The resulting mixture is filtered into test-tube X.

An excess of BaO is shaken with water. The resulting mixture is filtered into test-tube Y.

Which oxide reacts more readily with water and which filtrate has the **lower** pH?

	oxide reacts more readily with water	test-tube with filtrate of lower pH
A	barium oxide	X
B	barium oxide	Y
C	magnesium oxide	X
D	magnesium oxide	Y

15 Samples of magnesium carbonate, MgCO_3 , are placed in crucibles R and S. The sample in crucible R is heated until there is no further loss in mass, and then allowed to cool. The sample in crucible S is left unheated.

Dilute hydrochloric acid is then added to both crucibles.

On adding the dilute hydrochloric acid, which observations are correct?

	R	S
A	gas produced	gas produced
B	gas produced	no gas produced
C	no gas produced	gas produced
D	no gas produced	no gas produced

16 Which statement about nitrogen or its compounds is correct?

- A** In the Haber process the temperature is kept high to give a good equilibrium yield of ammonia.
- B** Nitrogen gas is unreactive because of the strong nitrogen-nitrogen double bond.
- C** Nitrogen monoxide will react with carbon monoxide under suitable conditions.
- D** The formula of ammonium sulfate is NH_4SO_4 .

- 17 When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.

Which statement is correct?

- A Hydrogen sulfide is the product of a reduction reaction.
- B Iodide ions are stronger oxidising agents than sulfate ions.
- C Sulfur atoms from the sulfuric acid are both oxidised and reduced.
- D Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

- 18 A solution of sodium hydroxide reacts with 3 mol of chlorine under certain conditions. The reaction produces 5 mol of sodium chloride and 1 mol of **X**, the only other chlorine-containing product.

What is the formula of compound **X**?

- A NaClO B NaClO_2 C NaClO_3 D NaClO_4

- 19 Redox reactions are common in the chemistry of Group 17.

Which statement is correct?

- A Br^- ions will reduce Cl_2 but not I_2 .
- B Cl_2 will oxidise Br^- ions but not I^- ions.
- C F_2 is the weakest oxidising agent out of F_2 , Cl_2 , Br_2 and I_2 .
- D I^- ions are the weakest reducing agent out of F^- , Cl^- , Br^- and I^- .

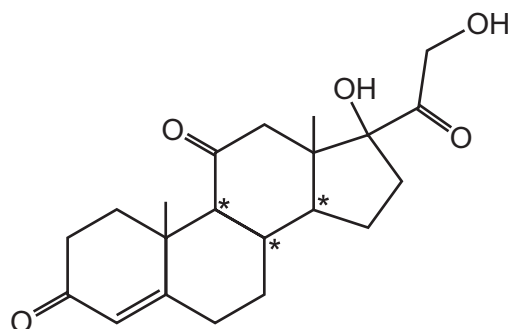
- 20 Structural isomerism and stereoisomerism should be considered when answering this question.

Each of the following carbonyl compounds is reacted with NaBH_4 . The product of each reaction is heated with Al_2O_3 at 600°C , generating one product or a mixture of isomers.

Which carbonyl compound will produce the most isomers?

- A butanal
- B butanone
- C pentan-3-one
- D propanone

21 The drug cortisone has the formula shown.



In addition to those chiral centres marked by an asterisk (*), how many **other** chiral centres are present in the cortisone molecule?

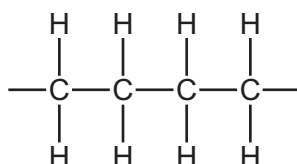
- A** 0 **B** 1 **C** 2 **D** 3

22 An alkene is reacted with acidified manganate(VII) ions, MnO_4^- . The desired organic product has a relative molecular mass greater than that of the alkene by 34.

What conditions should be used?

- A** cold, concentrated MnO_4^-
B cold, dilute MnO_4^-
C hot, concentrated MnO_4^-
D hot, dilute MnO_4^-

23 The diagram shows a short length of an addition polymer chain.

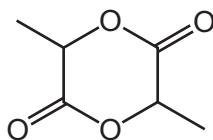


The polymer has a relative molecular mass of approximately 10 000.

Approximately how many monomer units are joined together in each polymer molecule?

- A** 180 **B** 360 **C** 625 **D** 710

- 24 Lactide is an intermediate in the manufacture of a synthetic fibre.



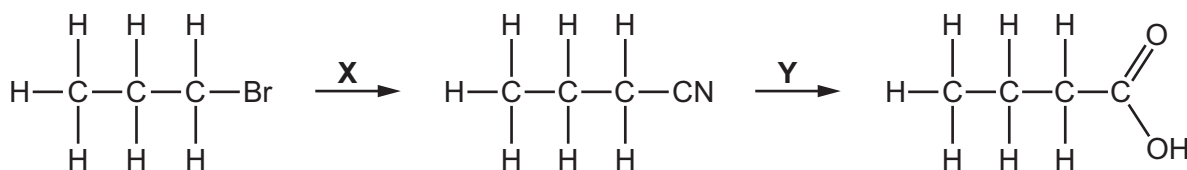
lactide

Which compound, on heating with an acid catalyst, can produce lactide?

- A hydroxyethanoic acid
 - B 2-hydroxybutanoic acid
 - C 2-hydroxypropanoic acid
 - D 3-hydroxypropanoic acid
- 25 Diols in which both hydroxy groups are bonded to the same carbon atom spontaneously eliminate a molecule of water to produce a carbonyl compound.

Which compound is hydrolysed to form a product that gives a positive reaction with 2,4-dinitrophenylhydrazine but **not** with Fehling's reagent?

- A 1,1-dibromopropane
 - B 1,2-dibromopropane
 - C 1,3-dibromopropane
 - D 2,2-dibromopropane
- 26 X and Y are the reagents required to convert 1-bromopropane into butanoic acid.



What are the correct identities of X and Y?

	X	Y
A	NH ₃	HCl(aq)
B	KCN in C ₂ H ₅ OH	NaOH(aq)
C	KCN in C ₂ H ₅ OH	HCl(aq)
D	HCN	NaOH(aq)

- 27 **Q** is a compound with the molecular formula $C_4H_{10}O$. **Q** can be oxidised with acidified potassium dichromate(VI). **Q cannot** be made by reducing a carboxylic acid with $LiAlH_4$.

What is the structure of **Q**?

- A $CH_3CH(OH)CH_2CH_3$
 B $CH_3CH_2CH_2CH_2OH$
 C $(CH_3)_3COH$
 D $(CH_3)_2CHCH_2OH$

- 28 A sample of 2.30 g of ethanol was mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The required organic product was then collected by distillation. The yield of product was 60.0%.

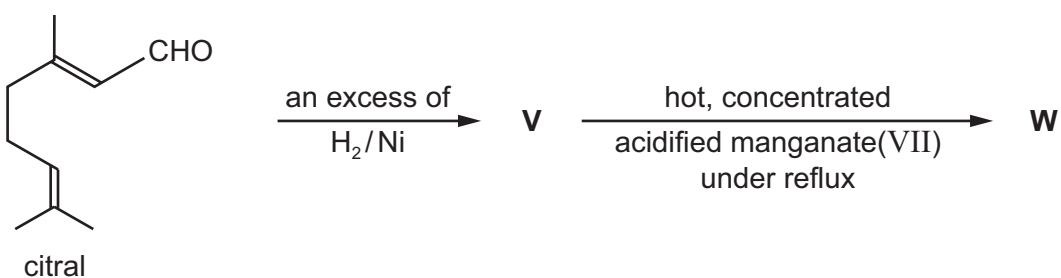
Which mass of product was collected?

- A 1.32 g B 1.38 g C 1.80 g D 3.00 g

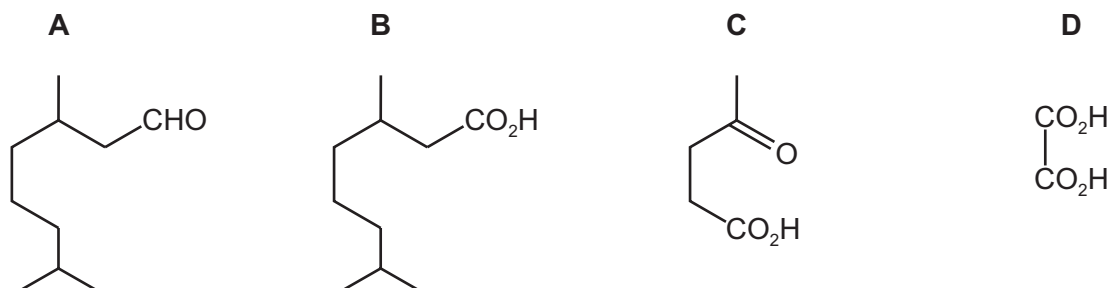
- 29 Which compound gives a positive test with alkaline aqueous iodine and does **not** show optical isomerism?

- A $CH_3COCH_2CH_2OH$
 B $CH_3CH_2CH(OH)CHO$
 C $CH_3COCH(OH)CH_3$
 D $(CH_3)_2C(OH)CHO$

- 30 Citral is found in lemongrass oil. It can react to give compound **W**.



What could compound **W** be?



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** Beams of charged particles are deflected by an electric field. In identical conditions the angle of deflection of a particle is proportional to its charge / mass ratio.

In an experiment, protons are deflected by an angle of $+15^\circ$. In another experiment under identical conditions, particle Y is deflected by an angle of -5° .

What could be the composition of particle Y?

	protons	neutrons	electrons
1	1	2	2
2	3	3	5
3	4	5	1

- 32** Graphene, graphite and the fullerene C_{60} are allotropes of carbon.

Which statements are correct for all three of these allotropes of carbon?

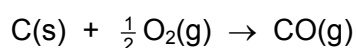
- 1** Delocalised electrons are present in the structure.
- 2** All bond angles are 120° .
- 3** It has a giant molecular crystalline lattice structure.

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 A reaction between carbon and oxygen is shown.



How can the enthalpy change of this reaction be described correctly?

- 1** enthalpy change of formation
- 2** enthalpy change of combustion
- 3** enthalpy change of atomisation

34 Which changes can be used to measure the rates of chemical reactions?

- 1** the decrease in concentration of a reactant per unit time
- 2** the rate of appearance of a product
- 3** the increase in total volume per unit time at constant pressure

35 Which statements describe a trend in Period 3 between **every pair** of adjacent elements from sodium to chlorine?

- 1** The atomic radius decreases.
- 2** The 1st ionisation energy decreases.
- 3** The melting point decreases.

36 X is either nitrogen or sulfur and forms pollutant oxide Y in a car engine.

Further oxidation of Y to Z occurs in the atmosphere. In this further oxidation, 1 mol of Y reacts with 0.5 mol of gaseous oxygen molecules.

Which statements about X, Y and Z can be correct?

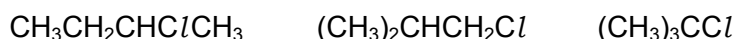
- 1** The oxidation number of X increases by two from Y to Z.
- 2** Y has an unpaired electron in its molecule.
- 3** Y is a polar molecule.

37 P and Q are a pair of cis-trans isomers.

What **must** be the same for P and Q?

- 1 their empirical formula
- 2 their functional groups
- 3 their skeletal formula

38 The following statements are about the reaction of NaOH(aq) with the three chloroalkanes shown.



Which statements are correct?

- 1 $(\text{CH}_3)_2\text{CHCH}_2\text{Cl}$ reacts with NaOH(aq) by an $\text{S}_{\text{N}}2$ mechanism.
- 2 The tertiary chloroalkane reacts more quickly than the others because the carbon atom bonded to the Cl atom is more positive in this molecule.
- 3 The Cl atoms in the three chloroalkanes are attacked by OH^- .

39 For which reactions are the colour changes described correctly?

	reagents	colour change
1	pentanal + hot, acidified potassium dichromate(VI)	orange to green
2	pentan-2-one + warm Fehling's reagent	no change
3	cyclohexane + cold, acidified potassium manganate(VII)	purple to colourless

40 Which statements about ethanol and ethanoic acid are correct?

- 1 Both react with a suitable reagent to form an ester.
- 2 Both react with sodium.
- 3 Both are soluble in water.

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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 In which species are the numbers of protons, neutrons and electrons **all** different?

- A** ${}^{19}_9\text{F}^-$ **B** ${}^{23}_{11}\text{Na}^+$ **C** ${}^{31}_{15}\text{P}$ **D** ${}^{32}_{16}\text{S}^{2-}$

2 Which would contain 9.03×10^{23} oxygen atoms?

- A** 0.25 mol aluminium oxide
B 0.75 mol sulfur dioxide
C 1.5 mol sulfur trioxide
D 3.0 mol water

3 In some fireworks there is a reaction between powdered aluminium and powdered barium nitrate. Heat is evolved, an unreactive gas is produced, and all nitrogen atoms are reduced.

What is the equation for this reaction?

- A** $2\text{Al} + \text{Ba}(\text{NO}_3)_2 \rightarrow \text{Al}_2\text{O}_3 + \text{BaO} + 2\text{NO}$
B $4\text{Al} + 4\text{Ba}(\text{NO}_3)_2 \rightarrow 2\text{Al}_2\text{O}_3 + 4\text{Ba}(\text{NO}_2)_2 + \text{O}_2$
C $10\text{Al} + 3\text{Ba}(\text{NO}_3)_2 \rightarrow 5\text{Al}_2\text{O}_3 + 3\text{BaO} + 3\text{N}_2$
D $10\text{Al} + 18\text{Ba}(\text{NO}_3)_2 \rightarrow 10\text{Al}(\text{NO}_3)_3 + 18\text{BaO} + 3\text{N}_2$

4 Which organic compound has the highest boiling point?

- A** $\text{C}(\text{CH}_3)_4$
B $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
C $\text{CH}_3\text{COCH}_2\text{CH}_3$
D $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$

5 At a temperature of 2500 K and a pressure of 1.00×10^{-4} Pa a sample of 0.321 g of sulfur vapour has a volume of $2.08 \times 10^6 \text{ m}^3$.

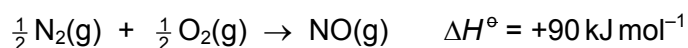
What is the molecular formula of sulfur under these conditions?

- A** S **B** S_2 **C** S_4 **D** S_8

6 Which reaction involves a decrease in the bond angle at a carbon atom?

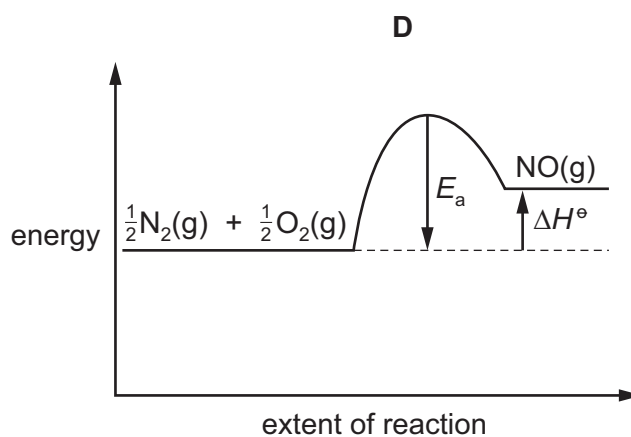
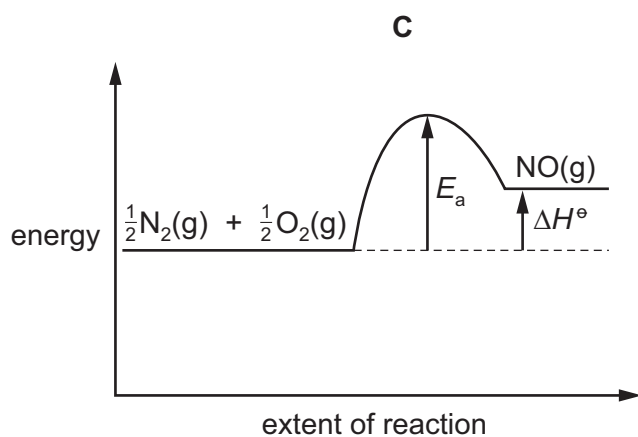
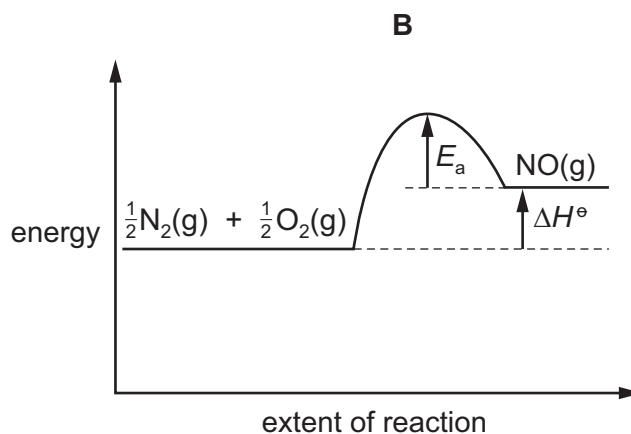
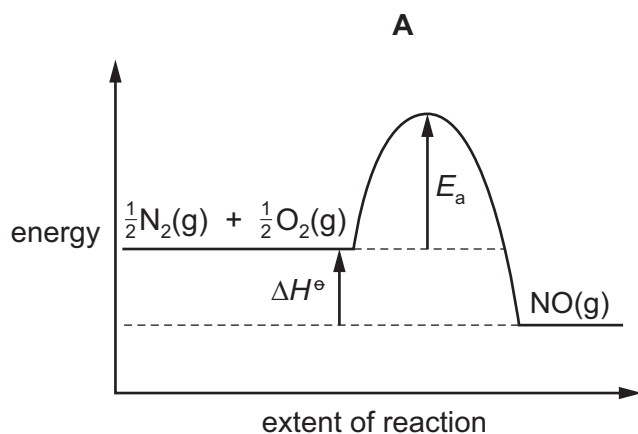
- A bromoethane refluxed with ethanolic sodium hydroxide
- B complete combustion of methane in air
- C ethanol heated with conc. H_2SO_4
- D polymerisation of ethene

7 In the high temperatures of car engines, nitrogen reacts with oxygen to give nitrogen monoxide.

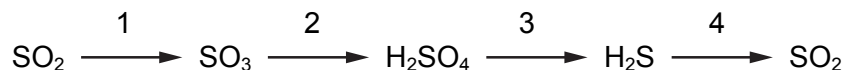


This reaction has activation energy E_a .

Which reaction pathway diagram could correctly represent this reaction?



- 8 A reaction sequence is shown.

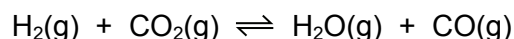


In each stage of this sequence the sulfur is oxidised, reduced or neither oxidised nor reduced.

Which row is correct?

	1	2	3	4
A	neither	oxidised	reduced	reduced
B	oxidised	neither	reduced	reduced
C	oxidised	neither	reduced	oxidised
D	oxidised	oxidised	reduced	oxidised

- 9 Hydrogen and carbon dioxide gases are mixed at 800 K. A reversible reaction takes place.

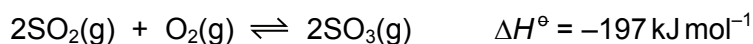


At equilibrium, the partial pressures of H_2 and CO_2 are both 10.0 kPa. K_p is 0.288 at 800 K.

What is the partial pressure of CO in the equilibrium mixture?

- A** 5.37 kPa **B** 18.6 kPa **C** 28.8 kPa **D** 347 kPa

- 10 A reaction involved in the Contact process is shown.

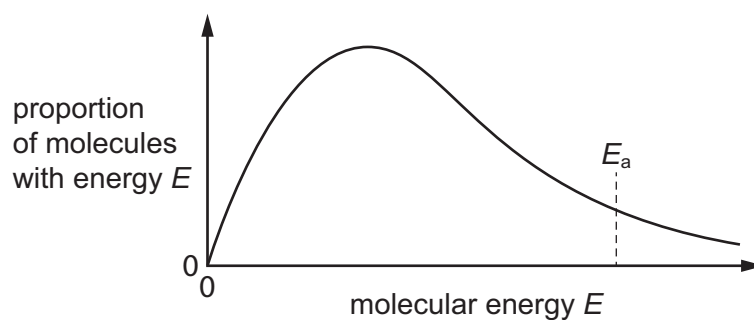


The reaction is investigated at 200 kPa and 700 K and the value of the equilibrium constant, K_p , is found to be Y. The reaction is then investigated at 1000 kPa and 700 K and the value of K_p is found to be Z.

Which statement comparing Y and Z is correct?

- A** Y and Z are the same.
B Y is greater than Z.
C Z is 2.2 times greater than Y.
D Z is 5.0 times greater than Y.

- 11 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 nickel to the reaction vessel?

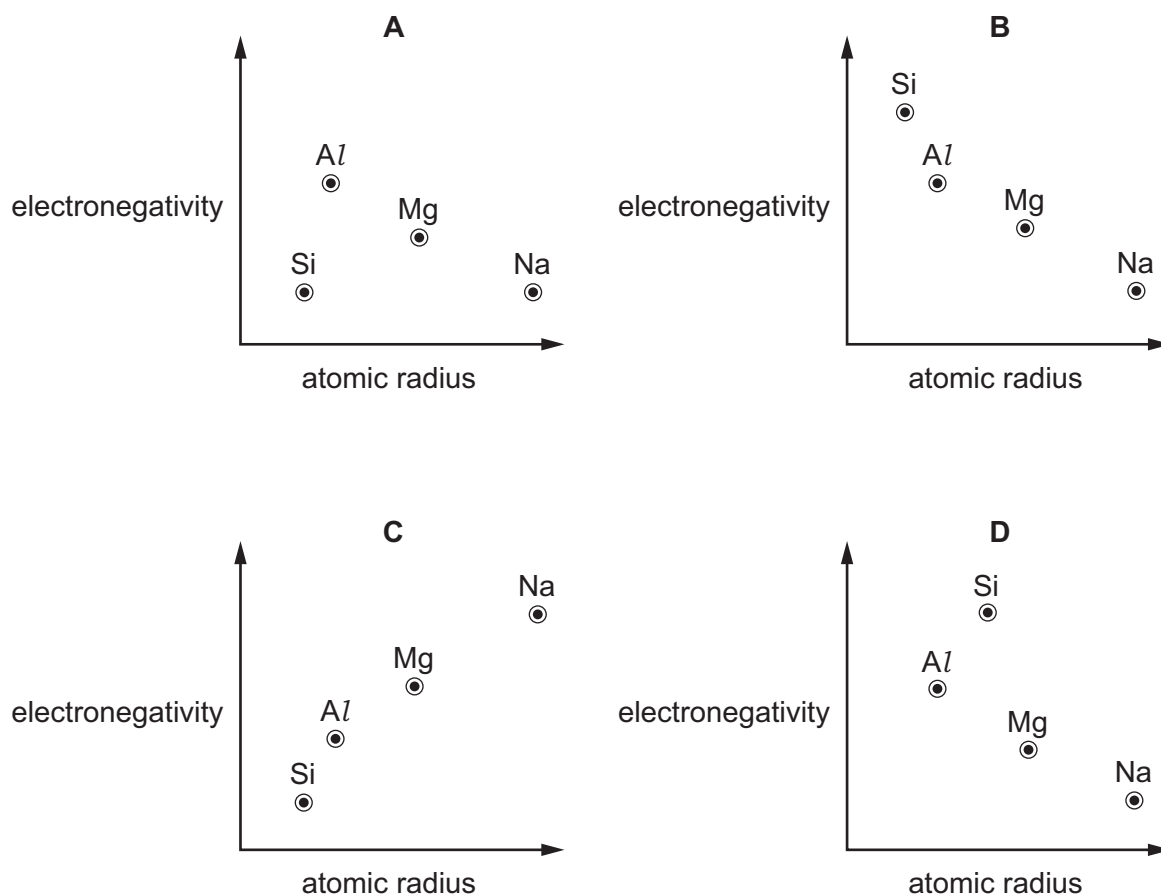
	the shape of the Boltzmann distribution	activation energy, E_a
A	changes	decreases
B	changes	increases
C	does not change	decreases
D	does not change	increases

- 12 The elements magnesium and sulfur each form doubly charged ions.

How do the atomic radii and ionic radii of these elements compare?

	atomic radius	ionic radius	atomic radius	ionic radius
A	Mg	> Mg^{2+}	S	> S^{2-}
B	Mg	> Mg^{2+}	S	< S^{2-}
C	Mg	< Mg^{2+}	S	> S^{2-}
D	Mg	< Mg^{2+}	S	< S^{2-}

- 13 Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?



- 14 Trends are seen in the physical and chemical properties of the elements of Group 2 and their compounds.

Which property shows a **decrease** from magnesium to barium?

- A the rate of the reaction between the element and dilute hydrochloric acid
- B the solubility of the hydroxides
- C the solubility of the sulfates
- D the temperature of decomposition of the carbonates

- 15** Calcium oxide is added to water and the resulting mixture is filtered.

This filtrate is X.

When carbon dioxide is bubbled through filtrate X, a white precipitate is formed.

Which equation for this reaction of filtrate X with carbon dioxide is correct?

- A** $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$
B $\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaO} + \text{H}_2\text{CO}_3$
C $2\text{CaO} + \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{Ca(OH)}_2$
D $\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$

- 16** Element X reacts with cold, dilute, aqueous sodium hydroxide to form two different chlorine-containing products, Y and Z.

What are the oxidation states of chlorine in Y and Z?

	Y	Z
A	0	+1
B	0	+5
C	-1	+1
D	-1	+5

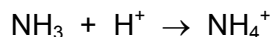
- 17** A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water.

Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was then added, this precipitate partly dissolved leaving a darker yellow precipitate.

What might the powder be?

- A** sodium bromide only
B sodium iodide only
C a mixture of sodium chloride and sodium bromide
D a mixture of sodium chloride and sodium iodide

- 18 The ammonium ion is formed by the following reaction.



Which statement about the species involved in this reaction is correct?

- A The ammonia molecule contains a dative covalent bond.
 - B The ammonium ion is a Brønsted-Lowry base as it has accepted a proton.
 - C The H–N–H bond angle changes from 107° in ammonia to 90° in the ammonium ion.
 - D The number of electrons surrounding each nitrogen atom does not change.
- 19 A chemist took 2.00 dm^3 of nitrogen gas, measured under room conditions, and reacted it with a large volume of hydrogen gas to produce ammonia. Only 15.0% of the nitrogen gas reacted to produce ammonia.

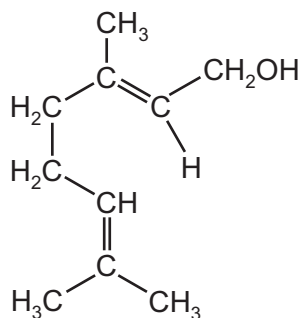
Which mass of ammonia was formed?

- A 0.213 g B 0.425 g C 1.42 g D 2.83 g
- 20 A carbonyl compound **X** will react with HCN in the presence of NaCN to make a compound with M_r 85. Compound **X** does **not** react with Fehling's reagent.

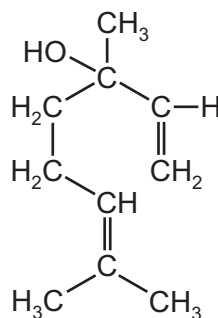
What is **X**?

- A butanal
- B butanone
- C propanal
- D propanone

21 Geraniol and linalool are compounds found in some flower fragrances.



geraniol



linalool

Which statement is correct?

- A They are chain isomers of each other.
 - B They are geometrical isomers of each other.
 - C They are optical isomers of each other.
 - D They are positional isomers of each other.
- 22 Which equation represents the initiation step of the substitution reaction between methane and chlorine?
- A $\text{CH}_4 \rightarrow \text{CH}_3\cdot + \text{H}\cdot$
 - B $\text{CH}_4 \rightarrow \text{CH}_3^- + \text{H}^+$
 - C $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$
 - D $\text{Cl}_2 \rightarrow \text{Cl}^+ + \text{Cl}^-$
- 23 Aqueous sodium hydroxide reacts with 1-bromopropane to give propan-1-ol.

What should be included in a diagram of the first step in the mechanism?

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

- 24** A sample of 2.76 g of ethanol was mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The required organic product was then collected by distillation.

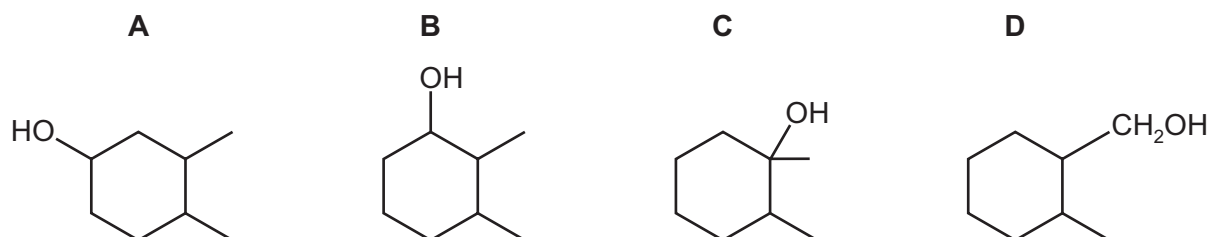
The yield of product was 75.0%.

Which mass of product was collected?

- A** 1.26 g **B** 1.98 g **C** 2.07 g **D** 2.70 g

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

What could X be?



- 26** 2-bromo-2-methylpropane undergoes nucleophilic substitution when heated under reflux with an aqueous solution of sodium hydroxide.

Which row is correct?

	mechanism for this reaction	reason
A	$\text{S}_{\text{N}}1$	the hydroxide ion is helped in its approach to the central carbon atom by the methyl groups
B	$\text{S}_{\text{N}}1$	the intermediate carbocation is stabilised by the inductive effect of the methyl groups
C	$\text{S}_{\text{N}}2$	the hydroxide ion is hindered in its approach to the central carbon atom by the methyl groups
D	$\text{S}_{\text{N}}2$	the intermediate carbocation is destabilised by the inductive effect of the methyl groups

27 $\text{H}_2\text{NNHC}_6\text{H}_3(\text{NO}_2)_2$ is the structural formula of 2,4-DNPH.

Many, but not all, organic reactions need to be heated before reaction occurs.

Which reaction occurs at a good rate at room temperature (20 °C)?

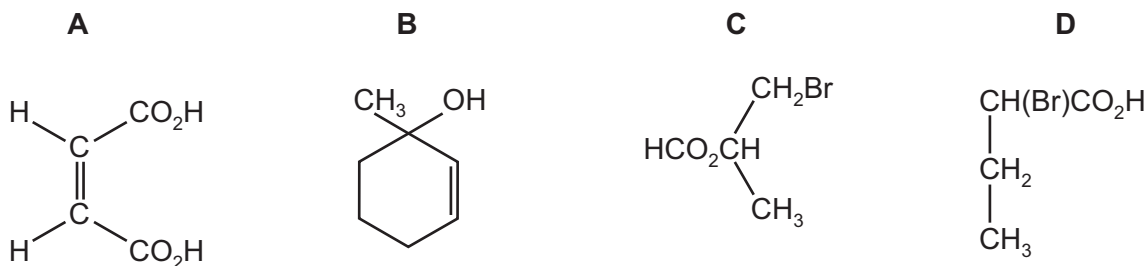
- A $\text{C}_{10}\text{H}_{22} \rightarrow \text{C}_8\text{H}_{18} + \text{C}_2\text{H}_4$
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 + \text{HBr}$
- C $\text{CH}_3\text{CH}_2\text{OH} + \text{KBr} \rightarrow \text{CH}_3\text{CH}_2\text{Br} + \text{KOH}$
- D $(\text{CH}_3)_2\text{CO} + \text{H}_2\text{NNHC}_6\text{H}_3(\text{NO}_2)_2 \rightarrow (\text{CH}_3)_2\text{C}=\text{NNHC}_6\text{H}_3(\text{NO}_2)_2 + \text{H}_2\text{O}$

28 A carboxylic acid, P, has no possible 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

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



30 Which compound, when hydrolysed, gives propanoic acid and propan-2-ol?

- A $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_3$
- B $(\text{CH}_3)_2\text{CHCO}_2\text{CH}_2\text{CH}_3$
- C $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_3$

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** An isolated gaseous atom of element X has paired electrons in at least one of its 3d orbitals and has a filled 4s subshell.

What could be the identity of element X?

- 1** iron
- 2** gallium
- 3** copper

- 32** Which allotropes of carbon have a giant molecular structure?

- 1** buckminsterfullerene
- 2** diamond
- 3** graphite

- 33** Which statements about endothermic reactions are correct?

- 1** On the reaction pathway diagram the products of the reaction are lower than the reactants.
- 2** There is a net transfer of heat energy from the surroundings to the reacting system.
- 3** the total bond energies of the reactants > the total bond energies of the products

- 34 The rate of chemical reactions can be increased by the addition of a suitable catalyst.

For which reactions can a heterogeneous catalyst be used?

- 1 $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$
- 2 $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$
- 3 $2\text{NO} + 2\text{CO} \rightleftharpoons \text{N}_2 + 2\text{CO}_2$

- 35 Which chlorides, when added to water, can produce a solution with a pH of less than 5?

- 1 SiCl_4
- 2 AlCl_3
- 3 MgCl_2

- 36 Acid rain continues to be a problem.

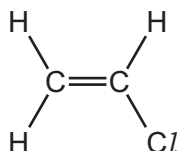
Which statements about acid rain are correct?

- 1 Acid rain is formed when oxides of nitrogen or oxides of sulfur react with water in the atmosphere.
- 2 Acid rain causes an increase in the concentration of heavy metal ions in water courses.
- 3 Nitrogen dioxide will catalyse the formation of SO_3 from SO_2 in the atmosphere.

- 37 Which compounds contain a chiral centre?

- 1 2-hydroxybutanoic acid
- 2 3-hydroxybutanoic acid
- 3 4-hydroxybutanoic acid

- 38 The diagram shows the monomer used to make polyvinyl chloride, PVC.



Assuming that one particular molecule of the polymer forms from n molecules of the monomer (where n is many thousands), which statements are correct?

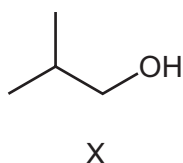
- 1 The relative molecular mass of this polymer molecule is approximately $62.5n$.
- 2 There are n chiral carbon atoms in this polymer molecule.
- 3 There are $5n$ σ bonds in one polymer molecule.

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.

39 An organic compound, X, has the following skeletal formula.



Which statements about X are correct?

- 1** X is a primary alcohol.
- 2** X will dehydrate to give a single alkene.
- 3** X will undergo a substitution reaction with chloride ions.

40 2,2,4-trimethylpentanal is used in the manufacture of adhesives.

Which reagents would 2,2,4-trimethylpentanal react with?

- 1** 2,4-dinitrophenylhydrazine reagent
- 2** Tollens' reagent
- 3** alkaline aqueous iodine

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CHEMISTRY

9701/13

Paper 1 Multiple Choice

May/June 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, Centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

DO **NOT** WRITE IN ANY BARCODES.

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 separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

Electronic calculators may be used.

This document consists of **15** printed pages and **1** blank page.

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 The ion Y^{3-} contains 18 electrons and has a mass number of 31.

How many protons and neutrons does Y^{3-} contain?

	protons	neutrons
A	15	16
B	15	18
C	18	13
D	21	10

- 2 A 0.216 g sample of an aluminium compound X reacts with an excess of water to produce a single hydrocarbon gas. This gas burns completely in O_2 to form H_2O and CO_2 only. The volume of CO_2 at room temperature and pressure is 108 cm^3 .

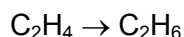
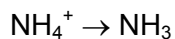
What is the formula of X?

- A** Al_2C_3 **B** Al_3C_2 **C** Al_3C_4 **D** Al_4C_3

- 3 Which equation correctly describes the complete combustion of an alkene, C_nH_{2n} ?

- A** $C_nH_{2n} + \frac{3}{2}nO_2 \rightarrow nCO_2 + 2nH_2O$
B $C_nH_{2n} + \frac{3}{2}nO_2 \rightarrow nCO_2 + nH_2O$
C $C_nH_{2n} + 2nO_2 \rightarrow nCO_2 + nH_2O$
D $C_nH_{2n} + 2nO_2 \rightarrow nCO_2 + 2nH_2O$

- 4 Two conversions are shown.



Which similar feature do these two conversions have?

- A change in oxidation state of an element
 - B decrease in bond angle
 - C formation of a lone pair of electrons
 - D loss of a π bond
- 5 All gases listed are at the same pressure.

Which gas will most closely approach ideal behaviour?

- A ammonia at 100 K
- B ammonia at 500 K
- C neon at 100 K
- D neon at 500 K

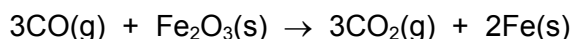
- 6 The following data are needed for this question.

$$\Delta H_f^\ominus(\text{CO(g)}) = -111 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus(\text{CO}_2\text{(g)}) = -394 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus(\text{Fe}_2\text{O}_3\text{(s)}) = -822 \text{ kJ mol}^{-1}$$

Carbon monoxide reacts with iron(III) oxide.



What is the enthalpy change when 55.8 g of iron are produced by this reaction?

- A -27.0 kJ B -13.5 kJ C +13.5 kJ D +27.0 kJ
- 7 Vanadium reacts with dilute sulfuric acid to form $\text{V}_2(\text{SO}_4)_3$ and hydrogen gas.

What happens to vanadium atoms in this reaction?

- A They lose three electrons and are oxidised.
- B They lose three electrons and are reduced.
- C They lose two electrons and are oxidised.
- D They lose two electrons and are reduced.

- 8 $\text{Na}_2\text{S}_2\text{O}_3$ reacts with HCl as shown.



When calculating the oxidation number of sulfur in $\text{Na}_2\text{S}_2\text{O}_3$, the **average** oxidation number of the two sulfur atoms should be found.

What is the oxidation number of sulfur in each of $\text{Na}_2\text{S}_2\text{O}_3$, SO_2 , and S ?

	$\text{Na}_2\text{S}_2\text{O}_3$	SO_2	S
A	+2	+2	+1
B	+2	+4	0
C	+4	+4	0
D	+5	+4	0

- 9 Ammonia is produced by the Haber process.

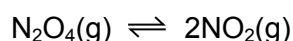


A fault in the temperature control during the process resulted in the temperature changing to 600°C for two hours.

What effect did this have on the ammonia production during this time?

- A** Ammonia was formed faster. The equilibrium yield decreased.
 - B** Ammonia was formed faster. The equilibrium yield increased.
 - C** Ammonia was formed slower. The equilibrium yield decreased.
 - D** Ammonia was formed slower. The equilibrium yield increased.
- 10 For the reaction shown, an equilibrium is established at a temperature of 700 K .

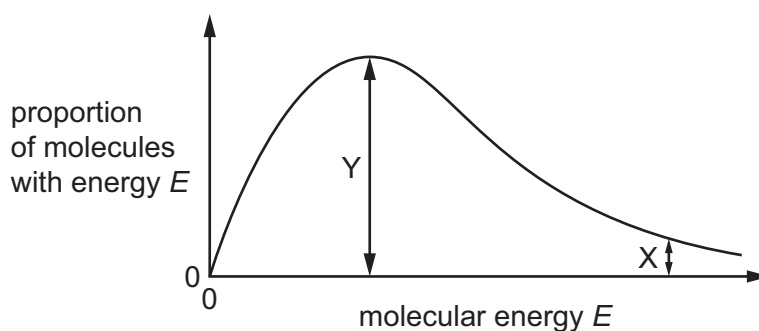
The equilibrium constant, K_p , for the reaction is 9.80 kPa . The partial pressure of N_2O_4 at equilibrium is 80.0 kPa .



What is the partial pressure of NO_2 at equilibrium?

- A** 8.16 kPa **B** 28.0 kPa **C** 66.6 kPa **D** 784 kPa

- 11 The diagram shows the Boltzmann distribution of the energy of gaseous molecules at a particular temperature.



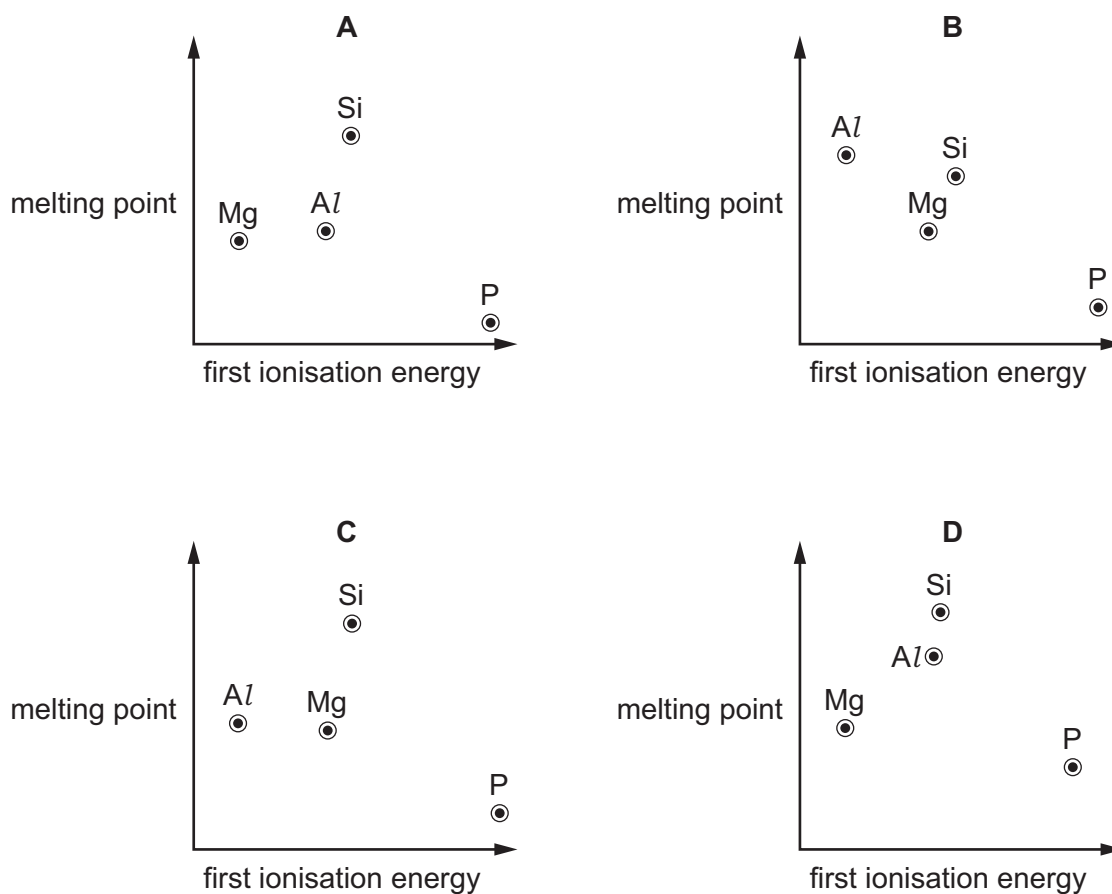
Which statement is correct?

- A If the temperature of the gas is raised, the height of the maximum of the curve increases.
 - B If the temperature of the gas is raised, the maximum of the curve moves to the right.
 - C The length of the line labelled X shows the activation energy for the reaction.
 - D The length of the line labelled Y shows the enthalpy change of the reaction.
- 12 Magnesium chloride, MgCl_2 , and silicon tetrachloride, SiCl_4 , are separately added to water.

What are the approximate pH values of the solutions formed?

	MgCl_2	SiCl_4
A	0–3	0–3
B	0–3	6–7
C	6–7	0–3
D	6–7	6–7

- 13 Which graph correctly shows the relative melting points of the elements Mg, Al, Si and P plotted against their relative first ionisation energies?



- 14 The table gives information about calcium carbonate and calcium hydroxide.

Which row is correct?

	calcium carbonate is more soluble than calcium hydroxide	calcium hydroxide can be manufactured using calcium carbonate as a starting material
A	no	no
B	no	yes
C	yes	no
D	yes	yes

15 Which row correctly describes the reactions of calcium and strontium with water?

	substance reduced	substance oxidised	more vigorous reaction
A	calcium or strontium	water	calcium + water
B	calcium or strontium	water	strontium + water
C	water	calcium or strontium	calcium + water
D	water	calcium or strontium	strontium + water

16 Chlorine gas is added to cold, aqueous sodium hydroxide.

In a separate experiment, chlorine gas is added to hot, aqueous sodium hydroxide.

Which oxidation states of chlorine are found in the reactants and products of the two reactions that take place?

- A** 0, -1, +1 and +5
- B** 0, -1 and +1 only
- C** 0, -1 and +5 only
- D** 0, +1 and +5 only

17 A test-tube of HBr(g) and a separate test-tube of HI(g) are heated to the same temperature.

Which combination of observations is possible?

	test-tube of HBr(g)	test-tube of HI(g)
A	a brown vapour appears	no change
B	a purple vapour appears	no change
C	no change	a brown vapour appears
D	no change	a purple vapour appears

18 Ammonia exists as simple covalent molecules, NH_3 . Ammonia can react with suitable reagents to form products containing ammonium ions, NH_4^+ . Ammonia can also react with suitable reagents to form products containing amide ions, NH_2^- .

Which of these nitrogen-containing species are present in an aqueous solution of ammonia?

- A** ammonia molecules and amide ions only
- B** ammonia molecules and ammonium ions only
- C** ammonia molecules only
- D** ammonium ions only

19 What would be produced when 60 g of nitrogen monoxide react with an excess of carbon monoxide in a catalytic converter?

- A 12 g of carbon and 92 g of nitrogen dioxide
- B 24 g of carbon and 92 g of nitrogen dioxide
- C 88 g of carbon dioxide and 28 g of nitrogen
- D 88 g of carbon dioxide and 56 g of nitrogen

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

Which formula identifies a **single** substance?

- A $\text{CH}_3\text{CHClCH}_2\text{CHO}$
- B $\text{CH}_3\text{CHCHCH}_3$
- C $\text{CH}_2\text{ClCH}_2\text{CHCl}_2$
- D C_4H_{10}

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

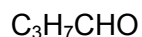
If a molecule contains two non-identical chiral carbon atoms, four optical isomers exist.

How many isomers are there with

- molecular formula $\text{C}_7\text{H}_{14}\text{O}$ **and**
- a five-membered ring **and**
- a tertiary alcohol group?

- A 4 B 5 C 9 D 13

22 The formulae of three compounds are shown.



Only one of these compounds will decolourise bromine water. Only one of these compounds will produce a silver mirror with Tollens' reagent.

Which row shows the correct results?

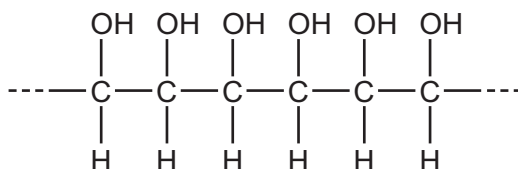
	decolourises bromine water	forms a silver mirror with Tollens' reagent
A	$\text{C}_3\text{H}_7\text{CHO}$	$\text{C}_2\text{H}_5\text{COCH}_3$
B	$\text{C}_2\text{H}_5\text{COCH}_3$	$\text{C}_3\text{H}_7\text{CHO}$
C	$\text{CH}_2\text{CHCH}_2\text{CH}_2\text{OH}$	$\text{C}_2\text{H}_5\text{COCH}_3$
D	$\text{CH}_2\text{CHCH}_2\text{CH}_2\text{OH}$	$\text{C}_3\text{H}_7\text{CHO}$

23 Carboxylic acids may be prepared by several different methods.

In which reaction would propanoic acid be formed?

- A** adding ammonium propanoate to dilute sulfuric acid
- B** heating ethyl propanoate with aqueous sodium hydroxide
- C** heating propan-2-ol with acidified potassium manganate(VII) under reflux
- D** heating propyl ethanoate with dilute sulfuric acid

24 The diagram represents the structure of a polymer.



By which method might this polymer be made?

- A** polymerise ethene followed by hydration
- B** polymerise ethene followed by oxidation with cold, acidified KMnO_4
- C** polymerise 1,2-dichloroethene followed by hydrolysis
- D** polymerise 1,2-dichloroethene followed by oxidation with cold, acidified KMnO_4

25 Bromine reacts with ethene in the dark.

Which description of the organic intermediate in this reaction is correct?

- A It has a negative charge.
- B It is a free radical.
- C It is a nucleophile.
- D It is an electrophile.

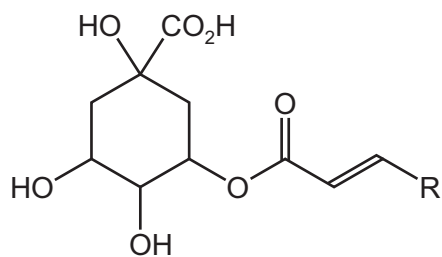
26 Which statement about butan-1-ol, butan-2-ol, and 2-methylbutan-2-ol is **not** correct?

- A They all react with methanoic acid to form an ester.
- B They all react with sodium.
- C They can all be dehydrated to form an alkene.
- D They can all be oxidised to a carbonyl compound.

27 Which compound will react with acidified potassium dichromate(VI) **and** with alkaline aqueous iodine?

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

28 Chlorogenic acid is found in green coffee beans and is used in treatments for weight loss.

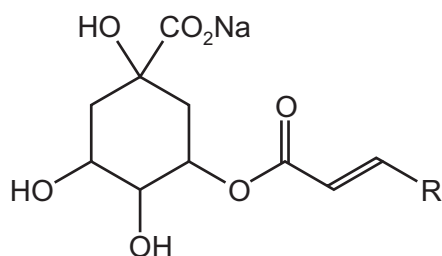


$R = C_6H_5O_2$ and takes no part in the reaction with sodium carbonate.

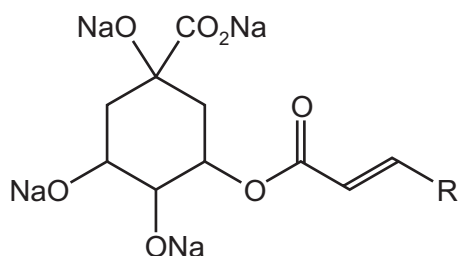
chlorogenic acid

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

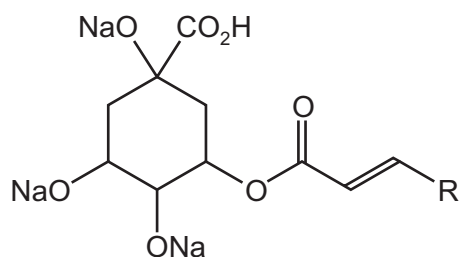
A



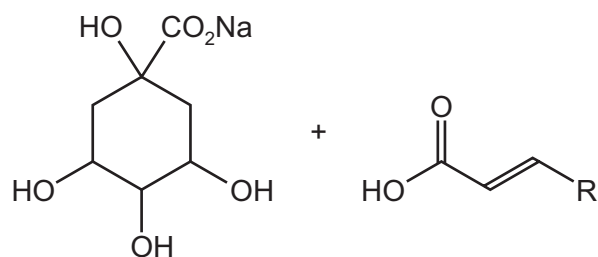
B



C



D



- 29 Butanoic acid can be produced from 1-bromopropane using reagents X and Y as shown.



What could be reagents X and Y?

	X	Y
A	KCN in ethanol	HCl(aq)
B	KCN in ethanol	NaOH(aq)
C	NH ₃ in ethanol	HCl(aq)
D	NaOH(aq)	H ⁺ /Cr ₂ O ₇ ²⁻ (aq)

- 30 How many esters with the molecular formula C₅H₁₀O₂ can be made by reacting a **primary** alcohol with a carboxylic acid?

A 4 **B** 5 **C** 6 **D** 8

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 Which statements about the atoms ^{23}Na and ^{24}Mg are correct?

- 1** They have the same number of filled electron orbitals.
- 2** They have the same number of neutrons.
- 3** They are both reducing agents.

32 Which compounds contain covalent bonds?

- 1** aluminium chloride
- 2** ammonia
- 3** calcium fluoride

33 Ethylene glycol, $\text{HOCH}_2\text{CH}_2\text{OH}$, is used as a de-icer. It allows ice to melt at temperatures below 0°C .

Which statements are correct?

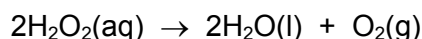
- 1** Ethylene glycol changes the extensive network of hydrogen bonds in ice.
- 2** Ethylene glycol molecules form hydrogen bonds with other ethylene glycol molecules.
- 3** Ethylene glycol molecules will dissolve in the water formed from the ice.

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.

- 34** A student carried out two experiments using MnO_2 as a catalyst to decompose hydrogen peroxide. The equation for this reaction is shown.



The student's results are recorded in the table.

	mass MnO_2	conditions	vol H_2O_2	final vol O_2	time taken
experiment 1	0.25 g	room conditions	10.0 cm^3	480 cm^3	200 s
experiment 2	0.25 g	room conditions	10.0 cm^3	480 cm^3	500 s

Which statements are correct?

- 1** The activation energy was the same for both experiments.
 - 2** The concentration of the hydrogen peroxide solution used was 4.0 mol dm^{-3} .
 - 3** The MnO_2 used in experiment 1 was in larger pieces than the MnO_2 used in experiment 2.
- 35** The formula of a solid magnesium compound is $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$. When the solid compound is heated in a hard-glass test-tube, one or more changes are observed.

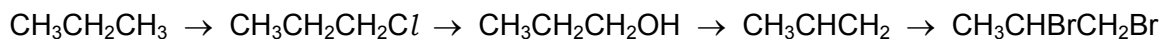
Which statements are correct?

- 1** Strong heating produces a basic residue.
 - 2** Strong heating produces a brown gas.
 - 3** Gentle heating produces colourless droplets of liquid on the upper parts of the test-tube.
- 36** Sulfur dioxide is an atmospheric pollutant.

What might result from the release of sulfur dioxide gas into the atmosphere?

- 1** reduction of NO_2 to NO
- 2** depletion of aquatic life
- 3** corrosion of limestone statues

37 Which mechanisms are represented in this sequence of reactions?



- 1 electrophilic addition
- 2 nucleophilic substitution
- 3 free radical substitution

38 Which compounds, on heating with ethanolic NaOH, produce more than one product with molecular formula C_4H_8 ?

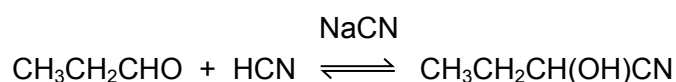
- 1 2-bromobutane
- 2 2-bromo-2-methylpropane
- 3 1-bromo-2-methylpropane

39 Substance M is refluxed with aqueous sodium hydroxide. One of the products of this reaction reacts with alkaline aqueous iodine to give a pale yellow precipitate.

Which compounds could be substance M?

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

40 Propanal will react with hydrogen cyanide to form 2-hydroxybutanenitrile. A suitable catalyst for this reaction is sodium cyanide.



Which statements about this reaction of propanal with hydrogen cyanide are correct?

- 1 The CN^- ion attacks the propanal molecule to form an intermediate ion.
- 2 The product of the reaction has a chiral carbon atom.
- 3 The CN^- ion is a stronger electrophile than the HCN molecule.

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