

CHEMISTRY

9701/11

Paper 1 Multiple Choice

October/November 2016

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.

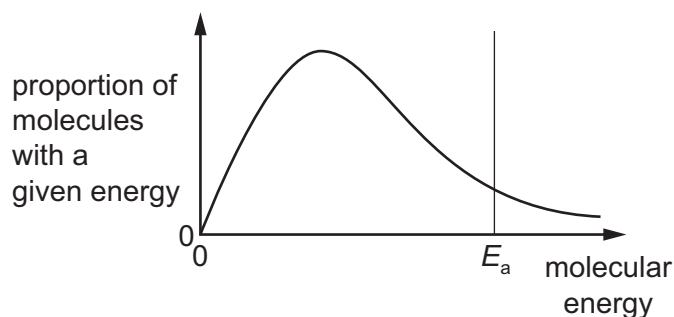
This document consists of **16** printed pages.

Section A

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

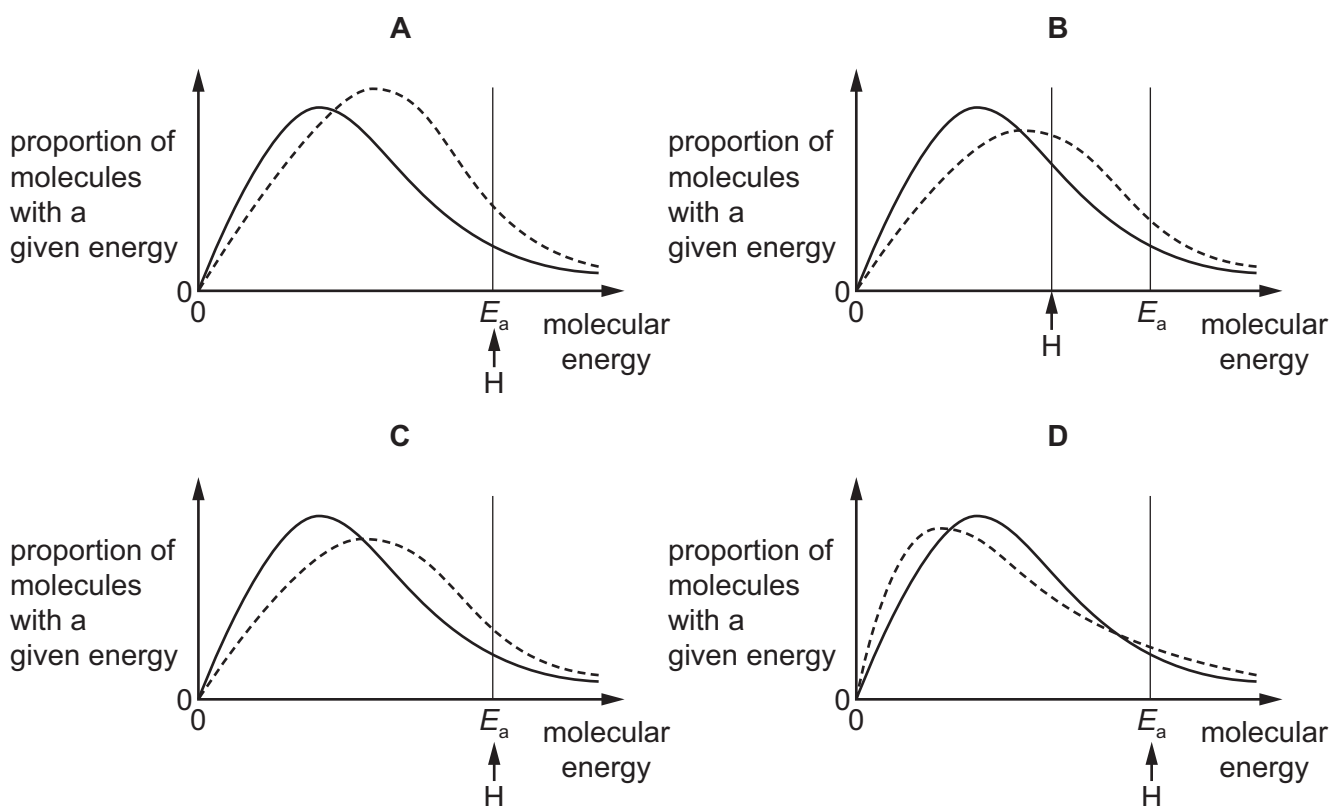
Use of the Data Booklet may be appropriate for some questions.

- 1 The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that react together. The activation energy for the reaction, E_a , is marked.



The dotted curves below show the Boltzmann distribution for the same reaction at a higher temperature. On these diagrams, H represents the activation energy at the higher temperature.

Which diagram is correct?



- 2 In the ideal gas equation, $pV = nRT$, what are the units of n and T ?

	n	T
A	no units	°C
B	no units	K
C	mol	°C
D	mol	K

- 3 The reaction between acidified dichromate(VI) ions, $\text{Cr}_2\text{O}_7^{2-}$, and aqueous Fe^{2+} ions results in the dichromate(VI) ions being reduced to Cr^{3+} ions.

What is the correct equation for this reaction?

- A** $\text{Cr}_2\text{O}_7^{2-} + \text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + \text{Fe}^{3+} + 7\text{H}_2\text{O}$
- B** $\text{Cr}_2\text{O}_7^{2-} + 2\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 2\text{Fe}^{3+} + 7\text{H}_2\text{O}$
- C** $\text{Cr}_2\text{O}_7^{2-} + 3\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 3\text{Fe}^{3+} + 7\text{H}_2\text{O}$
- D** $\text{Cr}_2\text{O}_7^{2-} + 6\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$
- 4 Sodium azide, NaN_3 is an explosive used to inflate airbags in cars when they crash. It consists of positive sodium ions and negative azide ions.

What are the numbers of electrons in the sodium ion and the azide ion?

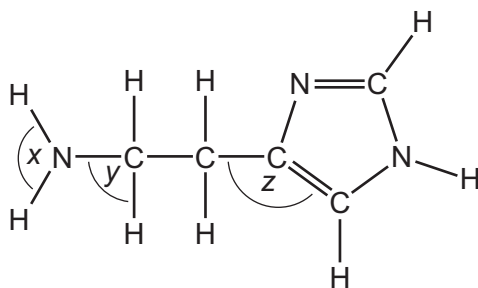
	sodium ion	azide ion
A	10	20
B	10	22
C	12	20
D	12	22

- 5 The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give an isotope of a different element, ^{68}X , which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus and changes a proton into a neutron.

Which statement about the composition of an atom of ^{68}X is correct?

- A** It has 4 electrons in its outer p orbitals.
- B** It has 13 electrons in its outer shell.
- C** It has 37 neutrons.
- D** Its proton number is 32.

- 6 Histamine is produced in the body to help fight infection. Its shape allows it to fit into receptors which expand blood vessels.



histamine

What are the bond angles x , y and z in histamine, from the smallest to the largest?

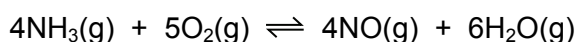
	smallest bond angle	→	largest bond angle
A	x	y	z
B	y	x	z
C	y	z	x
D	z	y	x

- 7 The approximate percentage composition of the atmospheres on four different planets is given in the table below.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules		
		H ₂	He	CH ₄
A	Jupiter	89.8	10.2	0.0
B	Neptune	80.0	19.0	1.0
C	Saturn	96.3	3.3	0.4
D	Uranus	82.5	15.2	2.3

- 8 An important reaction in the manufacture of nitric acid is the catalytic oxidation of ammonia.



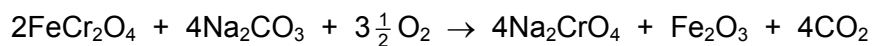
For every mole of O₂ that reacts in this way, 181.8 kJ of energy are released.

A factory makes 2.50×10^5 mol of NO every day.

How much energy, in kJ, is released every day?

- A** 3.64×10^7 **B** 4.55×10^7 **C** 5.68×10^7 **D** 2.27×10^8

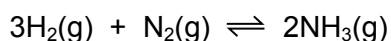
- 9 Sodium chromate(VI), Na_2CrO_4 , is manufactured by heating chromite, FeCr_2O_4 , with sodium carbonate in an oxidising atmosphere. Chromite contains $\text{Cr}_2\text{O}_4^{2-}$ ions.



What happens in this reaction?

- A Chromium and iron are the only elements oxidised.
 B Chromium, iron and carbon are oxidised.
 C Only chromium is oxidised.
 D Only iron is oxidised.
- 10 The table shows the partial pressures in an equilibrium mixture formed by the Haber process.

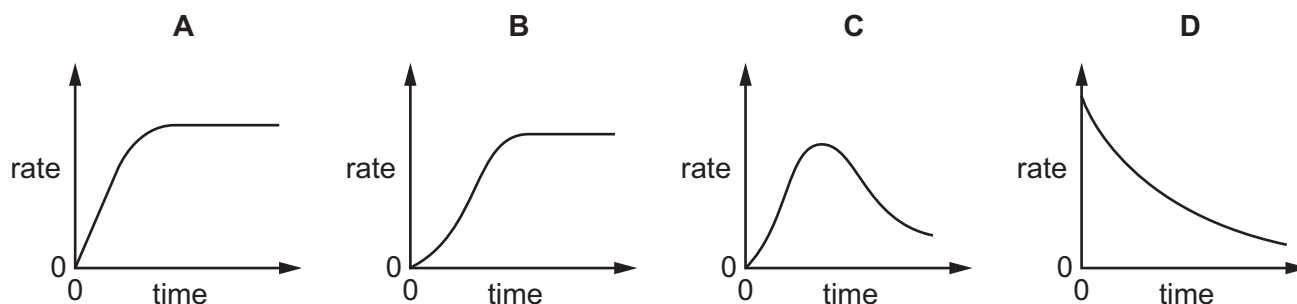
substance	partial pressure / kPa
nitrogen	7000
hydrogen	8000
ammonia	4000



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

- A 4.46×10^{-9}
 B 4.76×10^{-5}
 C 7.14×10^{-5}
 D 2.24×10^8
- 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?



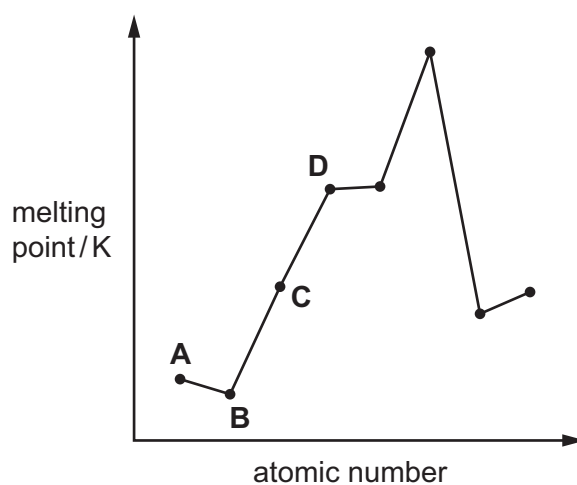
- 12 1.15 g of a metallic element needs 300 cm^3 of oxygen for complete reaction, at 298 K and 1 atm pressure, to form an oxide which contains O^{2-} ions.

What could be the identity of this metallic element?

- A calcium
- B magnesium
- C potassium
- D sodium

- 13 The diagram shows the melting points of eight elements with consecutive atomic numbers.

Which element could be sodium?

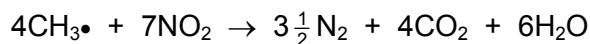


- 14 The properties of chlorine, bromine and their compounds are compared.

Which property is **smaller** for chlorine than for bromine?

- A bond strength of the hydrogen-halide bond
- B first ionisation energy
- C solubility of the silver halide in $\text{NH}_3(\text{aq})$
- D strength of the van der Waals' forces between molecules of the element

- 15** At 550°C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as $\text{CH}_3\bullet$ in the catalytic converter of a motor vehicle.



The following table lists types of energy change for this reaction and possible reasons for them.

Which row gives the energy change for this reaction and the reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the $\text{N}\equiv\text{N}$ bond energy is very high
C	exothermic	CO_2 and H_2O have large negative $\Delta H_f^\ominus$ values
D	exothermic	double bonds are broken in NO_2

- 16** Magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.

7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of X is produced?

- A** 1.5 g **B** 2.3 g **C** 3.0 g **D** 4.6 g

- 17** Compound **T** is a white crystalline solid.

When a sample of **T** was mixed with aqueous sodium hydroxide and heated, a pungent smelling gas was produced which turned damp red litmus paper blue. This same gas produced dense white smoke with hydrogen chloride gas.

Further testing of a solution of **T** with barium chloride solution produced a dense white precipitate which did not dissolve when dilute hydrochloric acid was added to the mixture.

What is the identity of compound **T**?

- A** ammonium carbonate
B ammonium sulfate
C sodium carbonate
D sodium sulfate

- 18 Which row of the table gives correct comparisons between the solubilities of calcium and barium hydroxide and the thermal stabilities of calcium and barium carbonate?

	solubility		thermal stability	
	calcium hydroxide	barium hydroxide	calcium carbonate	barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

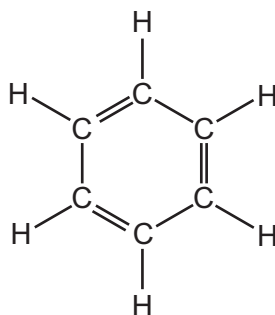
- 19 X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2 , Y_2 and Z_2 were separately added to separate aqueous solutions containing X^- , Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row of the following table contains the ions X^- , Y^- and Z^- in order of their **decreasing** strength as reducing agents?

	strongest	—————→	weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

- 20 In 1865 Kekulé suggested a ring structure for benzene, C_6H_6 , in which a hydrogen atom is attached to each carbon atom.

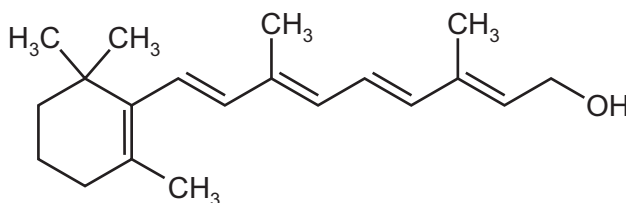


Kekulé structure

In this structure all of the bonds remain in the places shown. Assuming this is the structure of benzene, how many isomers of dichlorobenzene, $C_6H_4Cl_2$, would exist?

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

- 21 The diagram shows the structure of vitamin A.



vitamin A

How many chiral centres are present in one vitamin A molecule?

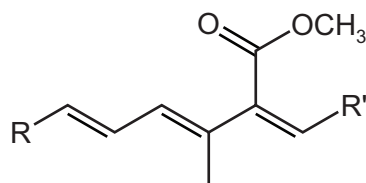
- A** 0 **B** 1 **C** 2 **D** 3

- 22 PVC is difficult to dispose of. Two possible methods are burying it in landfill sites and disposal by combustion.

Which row of the table is correct?

	rate of biodegradation of PVC in landfill sites	gases produced when PVC combusts
A	fast	CO_2 , H_2O , HCl
B	fast	CO_2 , H_2O , Cl_2
C	slow	CO_2 , H_2O , Cl_2
D	slow	CO_2 , H_2O , HCl

- 23 Part of the structure of a fungicide, strobilurin, is shown. R and R' are inert groups.

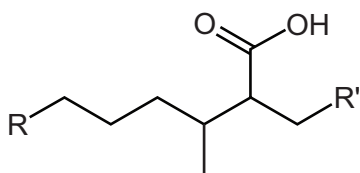


strobilurin

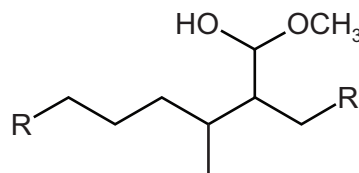
In this reaction, strobilurin is warmed with aqueous sulfuric acid producing compound X. Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.

What could be the structure of compound Y?

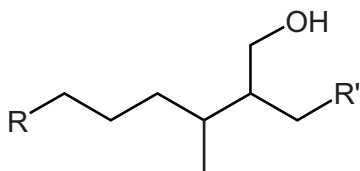
A



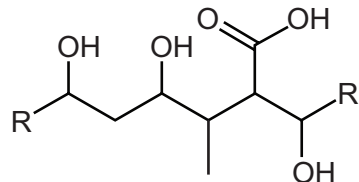
B



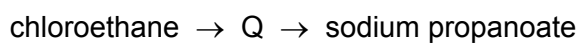
C



D



- 24 Chloroethane can be used to make sodium propanoate.

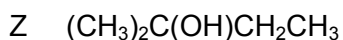


The intermediate, Q, is hydrolysed with boiling aqueous sodium hydroxide to give sodium propanoate.

Which reagent would produce the intermediate, Q, from chloroethane?

- A** concentrated ammonia solution
- B** dilute sulfuric acid
- C** hydrogen cyanide in water
- D** potassium cyanide in ethanol

25 X, Y and Z are three isomeric alcohols.



Two or more of these alcohols react with mild oxidising agents.

One of these alcohols, when dehydrated, will give a pair of cis-trans isomers with molecular formula C_5H_{10} .

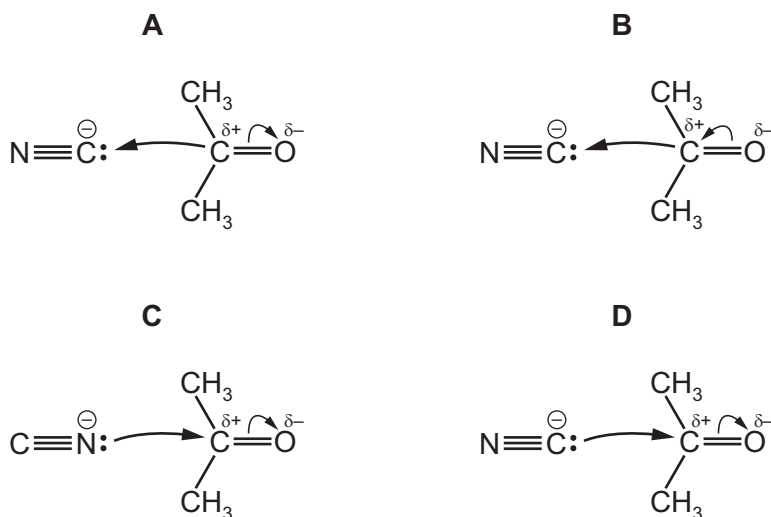
Which row is correct?

	reacts with mild oxidising reagents	gives cis-trans isomers
A	X, Y and Z	Y only
B	X, Y and Z	Z only
C	X and Y only	Y only
D	X and Y only	Z only

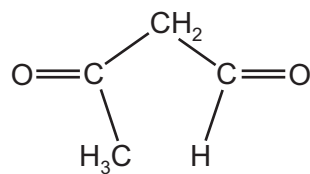
26 Propanone reacts with an aqueous mixture of HCN and NaCN by a nucleophilic addition mechanism.

The first stage of the mechanism involves attack by cyanide ions.

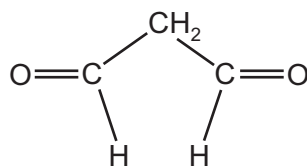
Which diagram correctly represents this?



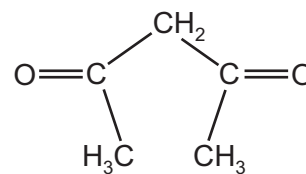
27 P, Q and R are carbonyl compounds.



P



Q



R

Fehling's solution can be used to help identify these compounds.

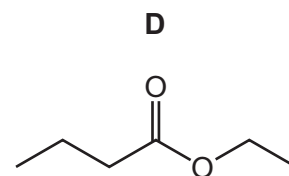
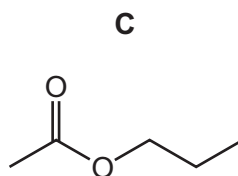
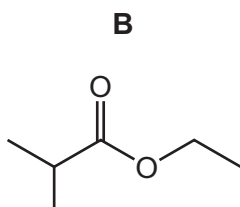
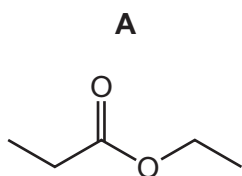
Which compounds form a red-brown precipitate on warming with Fehling's solution?

- A** P, Q and R **B** P and Q only **C** P only **D** Q only

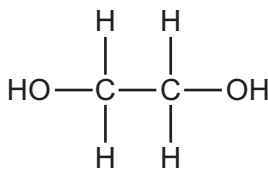
28 Which reaction would **not** give ethanoic acid?

- A** heating ethanenitrile under reflux with dilute sodium hydroxide
B heating ethanenitrile under reflux with dilute sulfuric acid
C heating ethanal under reflux with acidified sodium dichromate(VI)
D heating ethanol under reflux with acidified sodium dichromate(VI)

29 Which formula represents an ester that will form propanoic acid on hydrolysis with dilute sulfuric acid?

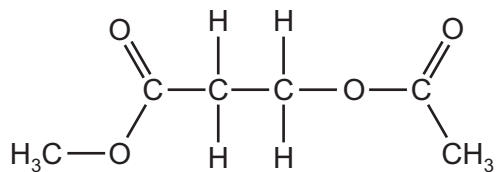
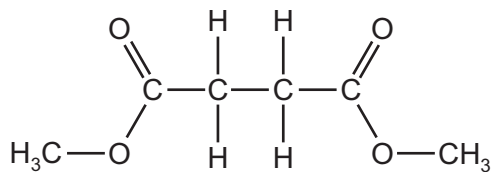
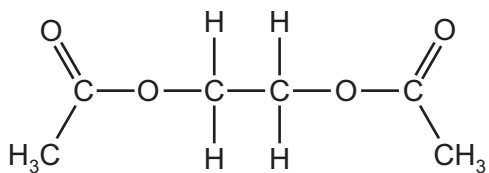
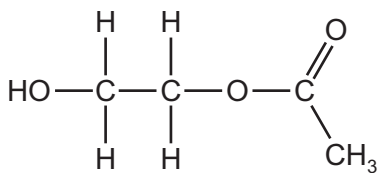


- 30** A solvent, **X**, used in printing inks has a molecular formula $\text{C}_6\text{H}_{10}\text{O}_4$. It may be made by reacting ethane-1,2-diol with ethanoic acid in the presence of an acid catalyst.



ethane-1,2-diol

What is the structure of solvent **X**?



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.

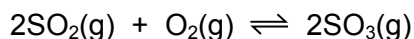
- 31** A sample of boron contains aluminium as the only impurity. A mass spectrum of the mixture shows three lines corresponding to three ions, X^+ , Y^+ and Z^+ .

ion	X^+	Y^+	Z^+
m/e	10	11	27
percentage abundance	15.52	74.48	10.00

Which statements are correct?

- 1** There are more electrons in Z^+ than in X^+ .
 - 2** The A_r of boron in the sample is 10.83 to four significant figures.
 - 3** There are more protons in Y^+ than in X^+ .
- 32** Which elements can form π bonds in their compounds?
- 1** carbon
 - 2** oxygen
 - 3** nitrogen
- 33** For which enthalpy changes is the value of ΔH always negative?
- 1** combustion
 - 2** hydration
 - 3** solution

- 34 In the manufacture of sulfuric acid, the following exothermic reaction occurs.



Which changes will move the position of the equilibrium to the right?

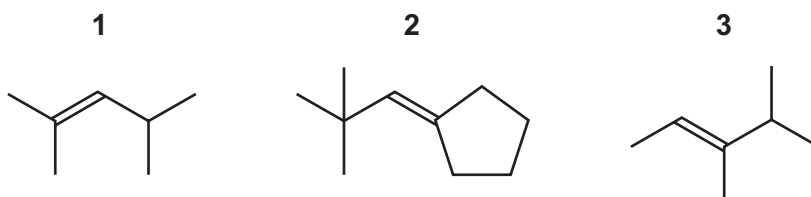
- 1 increasing the pressure
 - 2 increasing the temperature
 - 3 using twice as much catalyst
- 35 Water is added to anhydrous aluminium chloride to make a 0.1 mol dm^{-3} solution.

Which observations are correct?

- 1 The reaction is endothermic.
 - 2 The solution is acidic.
 - 3 The solution contains the ion $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$.
- 36 Catalytic converters are used to modify exhaust emissions from motor vehicles.

Which reactions occur in catalytic converters?

- 1 $\text{C}_8\text{H}_{18} + 12\frac{1}{2}\text{O}_2 \rightarrow 8\text{CO}_2 + 9\text{H}_2\text{O}$
 - 2 $2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$
 - 3 $\text{NO} + \text{SO}_3 \rightarrow \text{NO}_2 + \text{SO}_2$
- 37 Which compounds would produce a carboxylic acid and a ketone when treated with hot, concentrated, acidified KMnO_4 ?



- 38 Bromoethane reacts with NaOH in different ways depending on the solvent used.

Which statements about these reactions are correct?

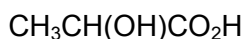
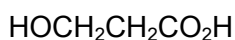
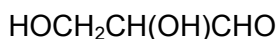
	solvent used	main organic product
1	water	ethane-1,2-diol
2	ethanol	ethene
3	water	ethanol

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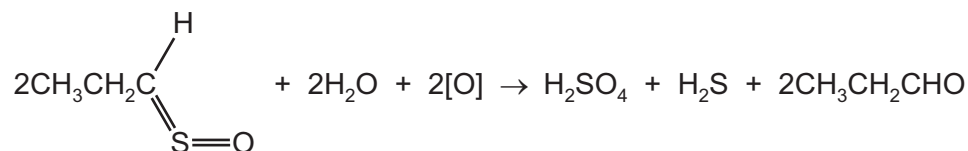
39 Several structural isomers of $C_3H_6O_3$ are listed below.



Which statements about these structural isomers are correct?

- 1** One mole of each reacts with two moles of sodium.
- 2** Only one of the isomers contains a tertiary alcohol group.
- 3** They all contain a primary alcohol group.

40 When onions are peeled in air, the reaction shown is thought to occur.



Which tests would give a positive reaction with the organic product?

- 1** warming with Tollens' reagent
- 2** warming with acidified potassium manganate(VII)
- 3** warming with alkaline aqueous iodine

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CHEMISTRY

Paper 1 Multiple Choice

9701/12

October/November 2016

1 hour

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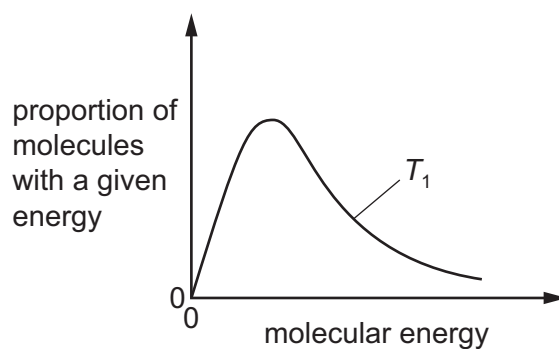
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Section A

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

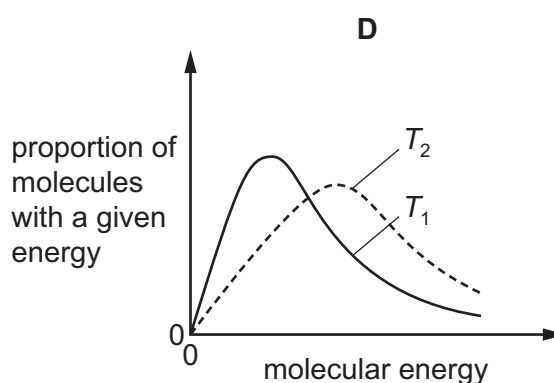
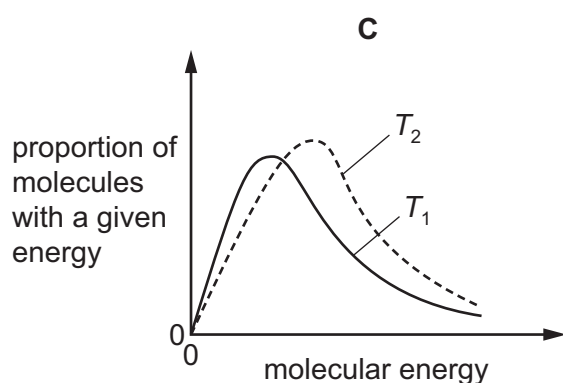
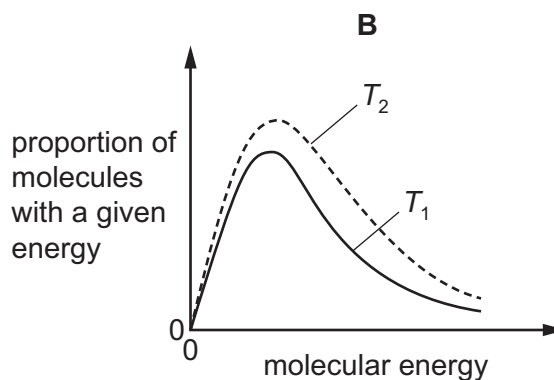
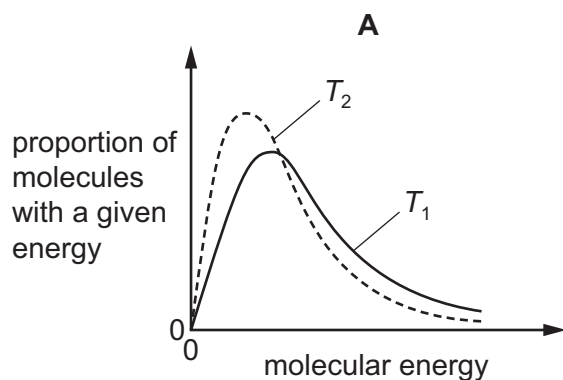
Use of the Data Booklet may be appropriate for some questions.

- 1 The molecules of a gas at a constant temperature, T_1 , have the distribution of molecular energies shown in the diagram.



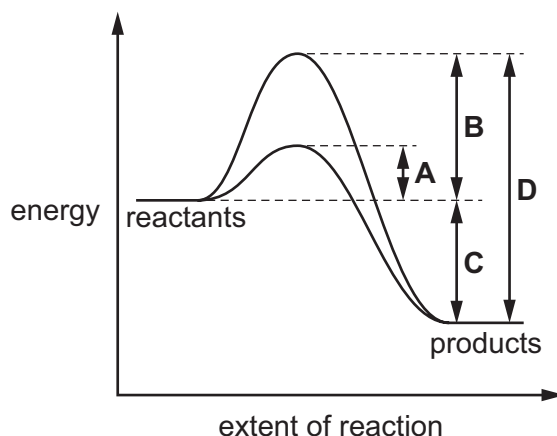
When the temperature is **increased** to T_2 , the distribution of molecular energies changes.

Which diagram correctly shows this change?



- 2 The diagram shows the pathways of a reaction, with and without a catalyst.

Which letter represents the overall energy change for the reaction?



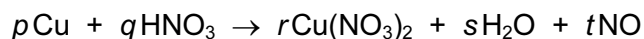
- 3 People are advised to eat less than 6.00 g of salt (sodium chloride) per day for health reasons.

Which mass of sodium is present in 6.00 g of sodium chloride?

- A** 0.261 g **B** 2.36 g **C** 3.64 g **D** 3.88 g

- 4 When copper reacts with a 50% solution of nitric acid, nitrogen monoxide is evolved and a blue solution results.

The balanced equation for this reaction is shown.



What are the values of the integers p , q , r , s and t ?

	p	q	r	s	t
A	1	4	1	2	2
B	2	6	2	3	2
C	2	8	2	4	4
D	3	8	3	4	2

- 5 What is the electronic configuration of an isolated Ni^{2+} ion?

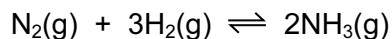
- A** $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$
B $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$
C $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
D $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8$

- 6 When solid aluminium chloride is heated, Al_2Cl_6 is formed.

Which bonding is present in Al_2Cl_6 ?

- A** covalent and co-ordinate (dative covalent)
B covalent only
C ionic and co-ordinate (dative covalent)
D ionic only
- 7 In which hydride is the H–X–H bond angle the smallest?
- A** BH_3 **B** CH_4 **C** C_2H_6 **D** NH_3
- 8 In an experiment, a sample of a pure gas is put into a gas syringe at a temperature of 300 K and pressure of 16 kPa. The gas is compressed until the volume occupied by the gas is halved.
- After compression, the temperature of the gas in the syringe is 375 K and the pressure is 40 kPa.
- Which statement is correct?
- A** Intermolecular forces between the gas molecules are significant.
B It is possible to calculate the number of moles of gas present using these data alone.
C The gas is behaving ideally.
D The pressures used are too high for ideal gas behaviour.
- 9 In a calorimetric experiment 1.60 g of a fuel are burnt. 45.0% of the energy released is absorbed by 200 g of water. The temperature of the water rises from 18.0 °C to 66.0 °C.
- What is the total energy released per gram of fuel burnt (to 3 significant figures)?
- A** 25 100 J **B** 55 700 J **C** 89 200 J **D** 143 000 J

10 Nitrogen reacts with hydrogen to produce ammonia.



A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3 . It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c ?

A $\frac{(1.76)^2}{(2.32)(6.96)^3}$

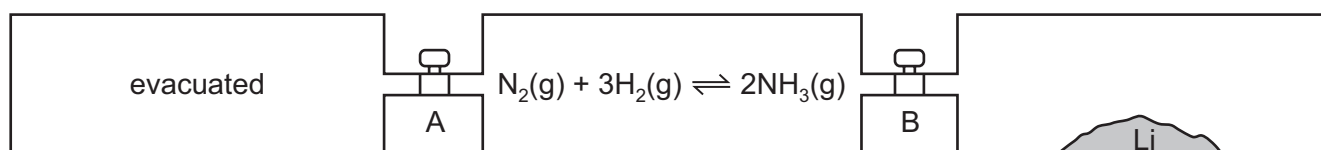
B $\frac{(1.76)^2}{(2.32)(6.32)^3}$

C $\frac{(2.08)^2}{(2.32)(6.32)^3}$

D $\frac{(2.40)^2}{(2.32)(6.00)^3}$

11 Lithium reacts with nitrogen at room temperature to form solid Li_3N .

Three vessels of equal volume are connected by taps, A and B, as shown.



At the start, A and B are closed, the left-hand vessel is evacuated, the middle vessel has the indicated reaction at equilibrium and the right-hand vessel contains lithium only.

Which action would allow the equilibrium mixture to contain the **most** ammonia?

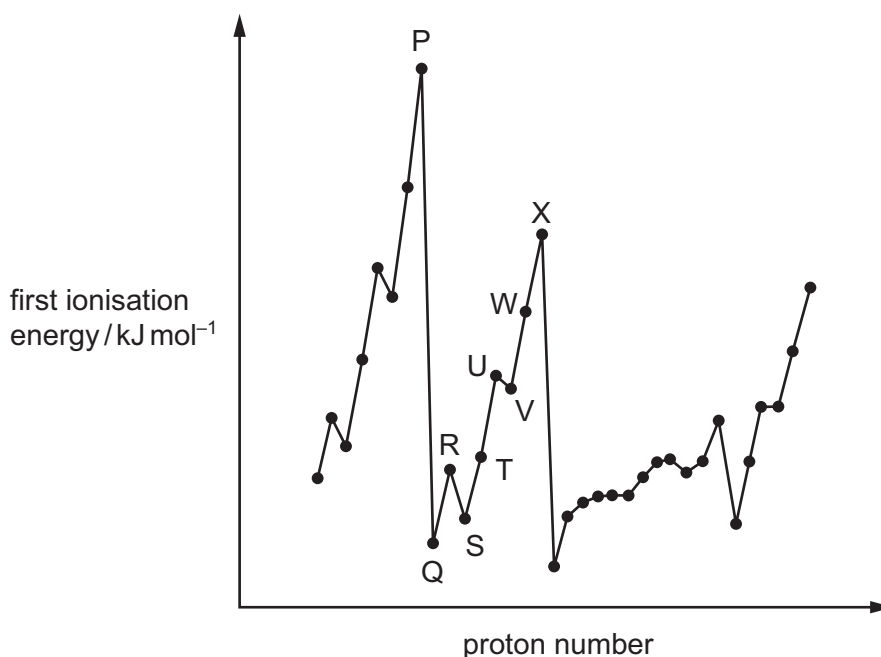
A Keep both A and B closed.

B Open both A and B.

C Open A only.

D Open B only.

- 12 The graph below shows the variation of the first ionisation energy with proton number for some elements. The letters used are not the usual symbols for the elements.



Which statement about the elements is correct?

- A** P and X are in the same period in the Periodic Table.
 - B** The general increase from Q to X is due to increasing atomic radius.
 - C** The small decrease from R to S is due to decreased shielding.
 - D** The small decrease from U to V is due to repulsion between paired electrons.
- 13 Which element shows the greatest tendency to form covalent compounds?
- A** boron
 - B** magnesium
 - C** neon
 - D** potassium

- 14 Elements Y and Z are both in Period 3.

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

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

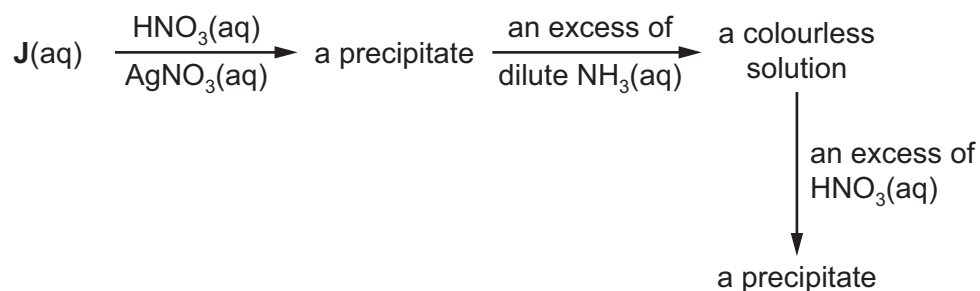
Which statement explains these observations?

- A Both chlorides hydrolyse in water.
 B Y is magnesium and Z is sodium.
 C Y is phosphorus and Z is aluminium.
 D Y is silicon and Z is sodium.
- 15 When chlorine reacts with hot aqueous sodium hydroxide, two chlorine-containing ions are formed. One of these is the chloride ion, Cl^- .

What is the other ion?

- A ClO^- B ClO_2^- C ClO_3^- D ClO_4^-
- 16 J is a salt of one of the halogens chlorine, bromine, iodine or astatine.

The reaction scheme shows a series of reactions using a solution of J as the starting reagent.



What could J be?

- A sodium chloride
 B sodium bromide
 C potassium iodide
 D potassium astatide

17 When heated, magnesium nitrate decomposes.

Which equation for the thermal decomposition of magnesium nitrate is correct?

- A** $\text{Mg}(\text{NO}_3)_2 \rightarrow \text{MgO} + \text{NO}_2 + \text{NO} + \text{O}_2$
- B** $2\text{Mg}(\text{NO}_3)_2 \rightarrow 2\text{MgO} + 4\text{NO} + 3\text{O}_2$
- C** $2\text{Mg}(\text{NO}_3)_2 \rightarrow 2\text{MgO} + 4\text{NO}_2 + \text{O}_2$
- D** $3\text{Mg}(\text{NO}_3)_2 \rightarrow \text{Mg}_2\text{N}_3 + \text{MgO} + 3\text{NO} + 7\text{O}_2$

18 Chlorine and bromine have different volatilities.

Which row identifies the more volatile of the two elements, and gives the correct explanation?

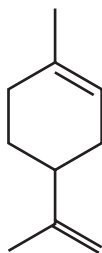
	identity of the more volatile element	explanation for the difference in volatility
A	bromine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
B	bromine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine
C	chlorine	instantaneous dipole-induced dipole forces are greater in bromine than they are in chlorine
D	chlorine	instantaneous dipole-induced dipole forces are greater in chlorine than they are in bromine

19 Water and ammonia take part in a reaction that produces the ammonium ion.

Which statement about this reaction is correct?

- A** Neither the ammonia molecule nor the ammonium ion has a dipole moment.
- 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.

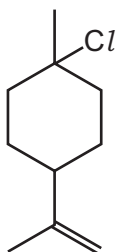
20 Limonene is found in lemon and orange oils.



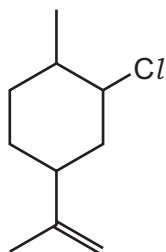
limonene

What will be the major product when limonene is reacted with an excess of dry hydrogen chloride?

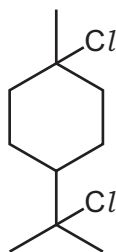
A



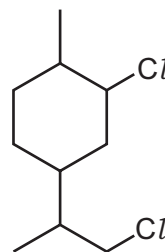
B



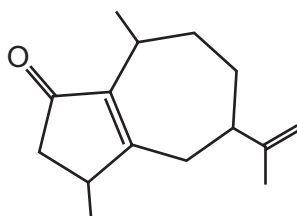
C



D



21 The compound rotundone is responsible for the peppery smell of pepper and is also found in some red wines.



rotundone

How many hydrogen atoms are in one molecule of rotundone?

A 15

B 19

C 22

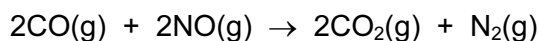
D 24

- 22 The reaction $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + \text{Br}^-$ proceeds via an $\text{S}_{\text{N}}2$ mechanism.

The reaction $(\text{CH}_3)_3\text{CBr} + \text{OH}^- \rightarrow (\text{CH}_3)_3\text{COH} + \text{Br}^-$ proceeds via an $\text{S}_{\text{N}}1$ mechanism.

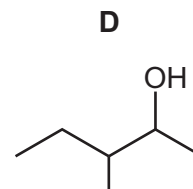
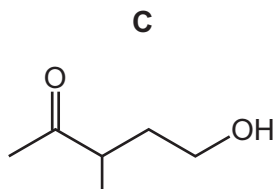
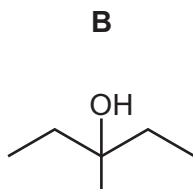
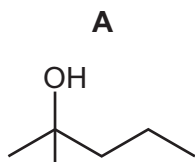
Which statement about these two reactions is correct?

- A Both reactions involve homolytic bond fission.
 - B Both reactions involve hydroxide ions acting as electron pair donors.
 - C Both reactions involve the formation of a positively-charged intermediate.
 - D Both reactions occur in a single step.
- 23 The equation shows a reaction that occurs between carbon monoxide and nitrogen monoxide in a catalytic converter.



Which statement is correct?

- A The catalyst used is finely divided iron.
 - B The reaction prevents greenhouse gas emissions into the atmosphere.
 - C The reaction reduces the possibility of the formation of photochemical smog.
 - D The reaction results in increased ozone depletion.
- 24 Which statement about stereoisomers is correct?
- A Cis-trans isomers are mirror images of each other.
 - B Optical isomers must contain a double bond that restricts rotation.
 - C Stereoisomers have the same structural formula as each other.
 - D Stereoisomers must contain a chiral centre.
- 25 Which compound can be oxidised by acidified potassium manganate(VII) to give 3-methylpentan-2-one?



- 26 Ethane-1,2-diol, $\text{HOCH}_2\text{CH}_2\text{OH}$, reacts with an excess of ethanoic acid, $\text{CH}_3\text{CO}_2\text{H}$, in the presence of an acid catalyst. A compound is formed with the molecular formula $\text{C}_6\text{H}_{10}\text{O}_4$.

What is the structure of this compound?

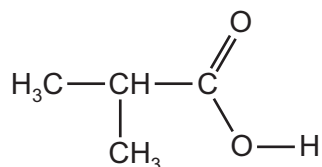
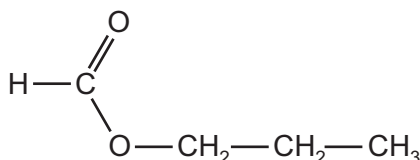
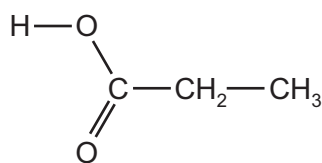
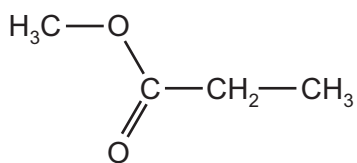
- A $\text{CH}_3\text{OCOCH}_2\text{CH}_2\text{CO}_2\text{CH}_3$
 B $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_3$
 C $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_2\text{OCOCH}_3$
 D $\text{HOCH}_2\text{CH}_2\text{COCH}_2\text{OCOCH}_3$
- 27 Compound **X** is heated with a mild oxidising agent. One of the products of the reaction will react with hydrogen cyanide, forming 2-hydroxybutanenitrile.

What is compound **X**?

- A butan-1-ol
 B butan-2-ol
 C propan-1-ol
 D propan-2-ol
- 28 Which row correctly describes the reactivity of aldehydes and ketones?

	with NaBH_4	with $\text{H}^+ / \text{Cr}_2\text{O}_7^{2-}(\text{aq})$
A	both react	both react
B	both react	only aldehydes react
C	only ketones react	both react
D	only ketones react	only aldehydes react

- 29 How many of the compounds shown will react with aqueous sodium hydroxide to form the sodium salt of a carboxylic acid?



A 1

B 2

C 3

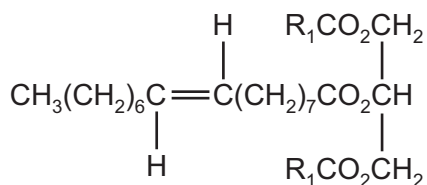
D 4

- 30 Some vegetable oils contain 'trans fats' that are associated with undesirable increases in the amount of cholesterol in the blood. In these oils the word 'trans' describes, in the usual way, the arrangement of groups at a C=C double bond.

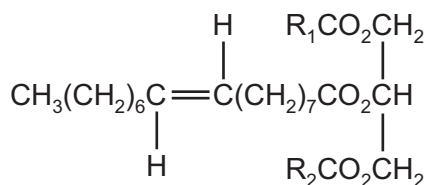
In the diagrams below, R_1 and R_2 are different unbranched hydrocarbon chains.

Which diagram correctly shows an optically active 'trans fat'?

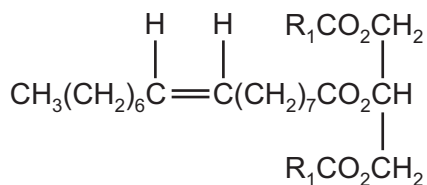
A



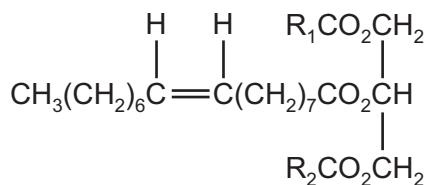
B



C



D



Section B

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

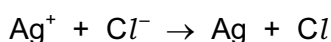
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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

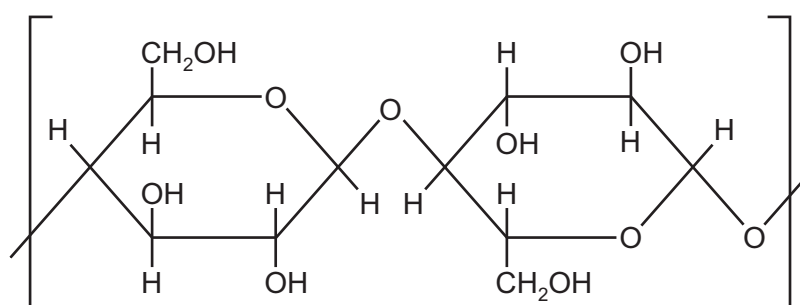
No other combination of statements is used as a correct response.

- 31** Photochromic lenses in spectacles darken in sunlight because silver crystals are produced by the reaction shown.



Which statements are correct for this reaction?

- 1** Both silver and chlorine atoms have an oxidation number of zero.
 - 2** The oxidation number of chlorine increases.
 - 3** Electrons are transferred from Cl^- ions to Ag^+ ions.
- 32** A cathedral in New Zealand has been constructed from cardboard. Cardboard contains polymer molecules. Part of one such polymer molecule is shown below.



Which statements about this polymer are correct?

- 1** The polymer molecules can form hydrogen bonds with each other.
- 2** The polymer can form intermolecular forces with water molecules.
- 3** The polymer will not burn easily because it is a secondary alcohol.

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.

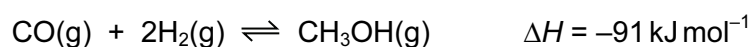
33 **X** is an element that has

- its outer electrons in the 4th principal quantum shell,
- a higher 1st ionisation energy than calcium.

What could be the identity of **X**?

- 1 bromine
- 2 krypton
- 3 xenon

34 Methanol, CH₃OH, can be produced industrially by reacting CO with H₂.



The process can be carried out at 4×10^3 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 Equal masses of barium carbonate and magnesium carbonate powders are mixed together. The mixture is then heated using a Bunsen burner flame until there is no further change. A gas is given off.

Which statements are correct?

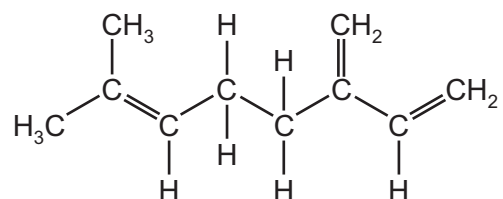
- 1 The residue left after heating reacts with aqueous hydrochloric acid to produce carbon dioxide.
- 2 The percentage decrease in mass after heating is 26% (to 2 significant figures).
- 3 The gas given off during heating relights a glowing splint.

36 Oxides of both sulfur and nitrogen are present in the atmosphere.

Which statements are correct?

- 1 Oxides of both sulfur and nitrogen can be formed in internal combustion engines.
- 2 Oxides of both sulfur and nitrogen can be produced by direct combination of the elements.
- 3 Oxides of both sulfur and nitrogen are involved in the formation of acid rain.

37 A species of termite produces a chemical defence secretion which contains the molecule shown.



To help determine the structure of this compound, it is treated with hot, concentrated, acidified manganate(VII) ions.

Which compounds are produced in this reaction?

- 1 CO_2
- 2 CH_3COCH_3
- 3 $\text{CH}_3\text{CO}_2\text{H}$

38 1-bromopropane reacts with NaOH in different ways depending on the solvent used.

Which statements about this reaction are correct?

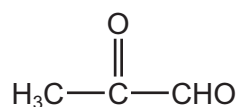
	solvent used	main organic product
1	ethanol	propene
2	water	propan-1-ol
3	ethanol	propane-1-2-diol

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 The compound shown is produced when sugar burns.



Which reagents would give a positive result with this compound?

- 1** alkaline aqueous iodine
- 2** 2,4-dinitrophenylhydrazine
- 3** Fehling's solution

40 Which statements about the formation of a carboxylic acid are correct?

- 1** A carboxylic acid can be produced by hydrolysis of a nitrile.
- 2** A carboxylic acid can be produced by oxidation of a primary alcohol.
- 3** A carboxylic acid can be produced by reduction of an aldehyde.

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CHEMISTRY

9701/13

Paper 1 Multiple Choice

October/November 2016

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.

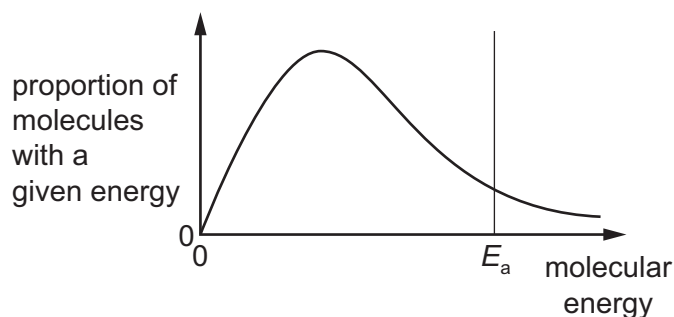
This document consists of **16** printed pages.

Section A

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

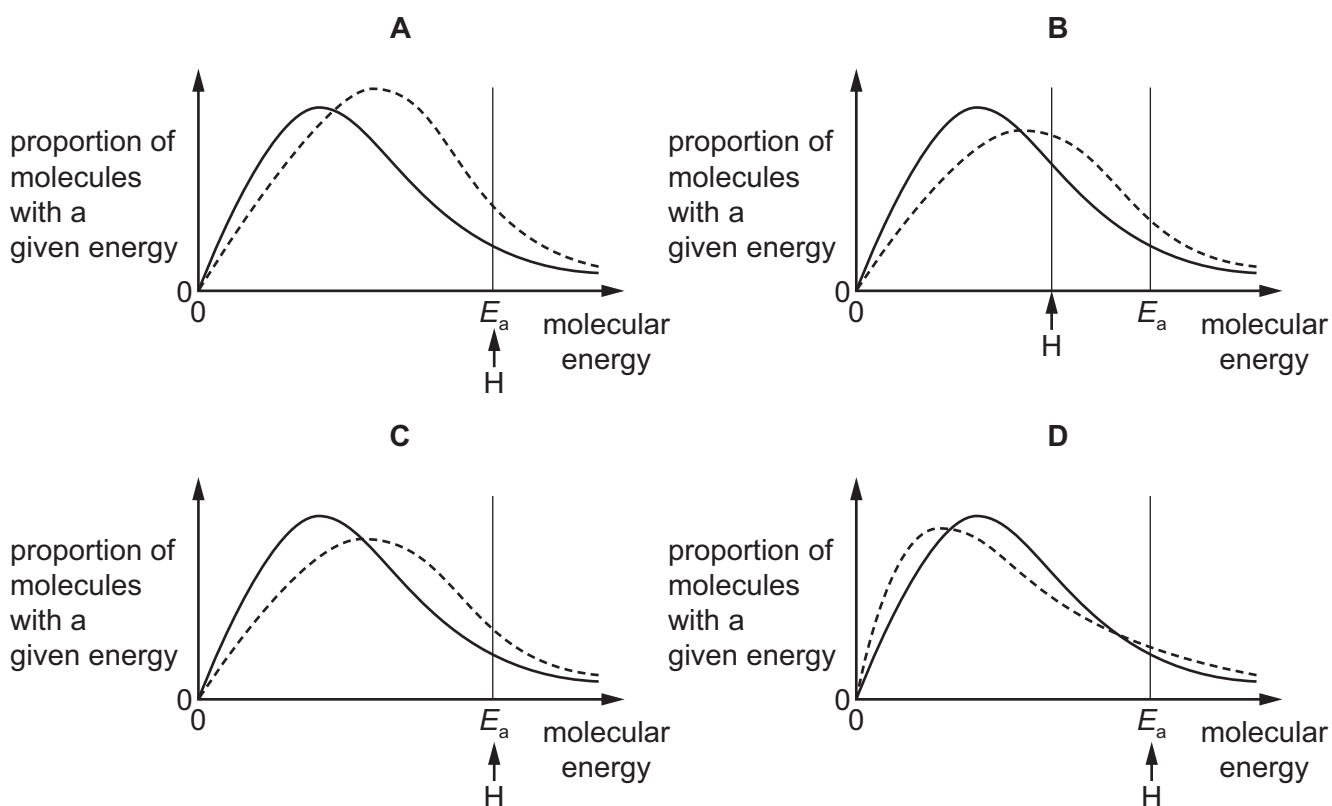
Use of the Data Booklet may be appropriate for some questions.

- 1 The diagram represents, for a given temperature, the Boltzmann distribution of the kinetic energies of the molecules in a mixture of two gases that react together. The activation energy for the reaction, E_a , is marked.



The dotted curves below show the Boltzmann distribution for the same reaction at a higher temperature. On these diagrams, H represents the activation energy at the higher temperature.

Which diagram is correct?



- 2 In the ideal gas equation, $pV = nRT$, what are the units of n and T ?

	n	T
A	no units	°C
B	no units	K
C	mol	°C
D	mol	K

- 3 The reaction between acidified dichromate(VI) ions, $\text{Cr}_2\text{O}_7^{2-}$, and aqueous Fe^{2+} ions results in the dichromate(VI) ions being reduced to Cr^{3+} ions.

What is the correct equation for this reaction?

- A** $\text{Cr}_2\text{O}_7^{2-} + \text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + \text{Fe}^{3+} + 7\text{H}_2\text{O}$
- B** $\text{Cr}_2\text{O}_7^{2-} + 2\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 2\text{Fe}^{3+} + 7\text{H}_2\text{O}$
- C** $\text{Cr}_2\text{O}_7^{2-} + 3\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 3\text{Fe}^{3+} + 7\text{H}_2\text{O}$
- D** $\text{Cr}_2\text{O}_7^{2-} + 6\text{Fe}^{2+} + 14\text{H}^+ \rightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$
- 4 Sodium azide, NaN_3 is an explosive used to inflate airbags in cars when they crash. It consists of positive sodium ions and negative azide ions.

What are the numbers of electrons in the sodium ion and the azide ion?

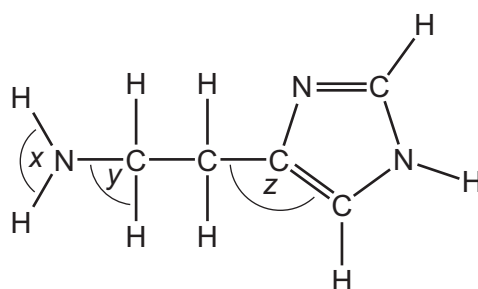
	sodium ion	azide ion
A	10	20
B	10	22
C	12	20
D	12	22

- 5 The ^{68}Ge isotope is medically useful because it undergoes a natural radioactive process to give an isotope of a different element, ^{68}X , which can be used to detect tumours. This transformation of ^{68}Ge occurs when an electron enters the nucleus and changes a proton into a neutron.

Which statement about the composition of an atom of ^{68}X is correct?

- A** It has 4 electrons in its outer p orbitals.
- B** It has 13 electrons in its outer shell.
- C** It has 37 neutrons.
- D** Its proton number is 32.

- 6 Histamine is produced in the body to help fight infection. Its shape allows it to fit into receptors which expand blood vessels.



histamine

What are the bond angles x , y and z in histamine, from the smallest to the largest?

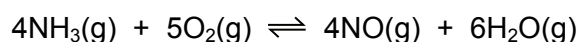
	smallest bond angle	→	largest bond angle
A	x	y	z
B	y	x	z
C	y	z	x
D	z	y	x

- 7 The approximate percentage composition of the atmospheres on four different planets is given in the table below.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules		
		H ₂	He	CH ₄
A	Jupiter	89.8	10.2	0.0
B	Neptune	80.0	19.0	1.0
C	Saturn	96.3	3.3	0.4
D	Uranus	82.5	15.2	2.3

- 8 An important reaction in the manufacture of nitric acid is the catalytic oxidation of ammonia.



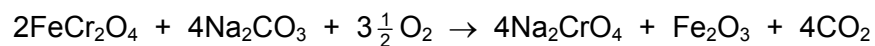
For every mole of O₂ that reacts in this way, 181.8 kJ of energy are released.

A factory makes 2.50×10^5 mol of NO every day.

How much energy, in kJ, is released every day?

- A** 3.64×10^7 **B** 4.55×10^7 **C** 5.68×10^7 **D** 2.27×10^8

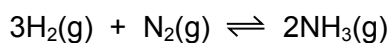
- 9 Sodium chromate(VI), Na_2CrO_4 , is manufactured by heating chromite, FeCr_2O_4 , with sodium carbonate in an oxidising atmosphere. Chromite contains $\text{Cr}_2\text{O}_4^{2-}$ ions.



What happens in this reaction?

- A Chromium and iron are the only elements oxidised.
 B Chromium, iron and carbon are oxidised.
 C Only chromium is oxidised.
 D Only iron is oxidised.
- 10 The table shows the partial pressures in an equilibrium mixture formed by the Haber process.

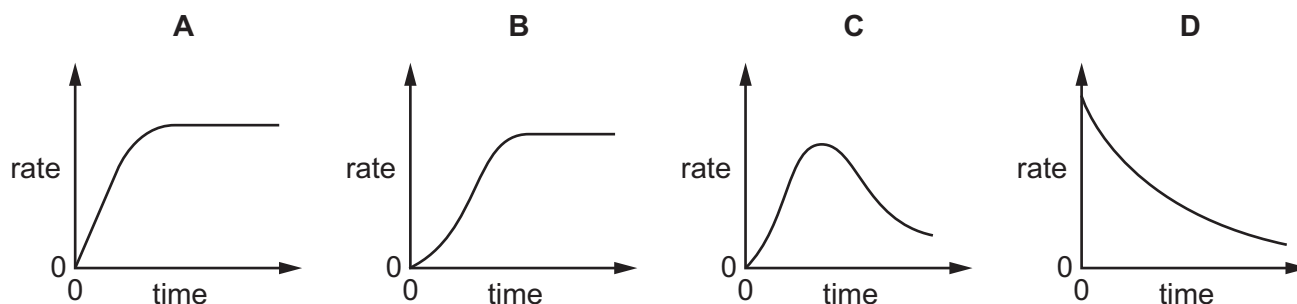
substance	partial pressure / kPa
nitrogen	7000
hydrogen	8000
ammonia	4000



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

- A 4.46×10^{-9}
 B 4.76×10^{-5}
 C 7.14×10^{-5}
 D 2.24×10^8
- 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?



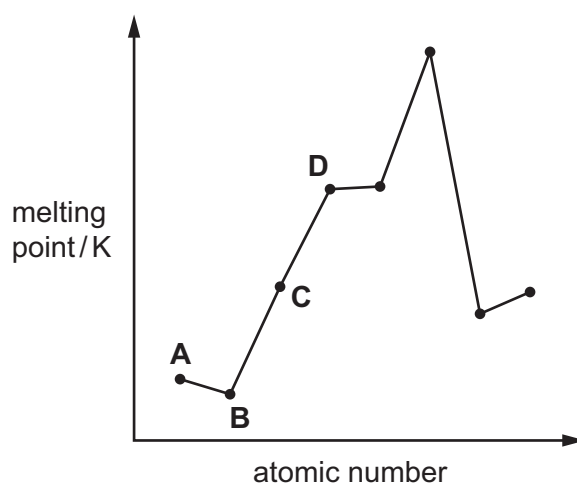
- 12 1.15 g of a metallic element needs 300 cm^3 of oxygen for complete reaction, at 298 K and 1 atm pressure, to form an oxide which contains O^{2-} ions.

What could be the identity of this metallic element?

- A calcium
- B magnesium
- C potassium
- D sodium

- 13 The diagram shows the melting points of eight elements with consecutive atomic numbers.

Which element could be sodium?

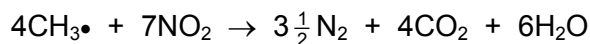


- 14 The properties of chlorine, bromine and their compounds are compared.

Which property is **smaller** for chlorine than for bromine?

- A bond strength of the hydrogen-halide bond
- B first ionisation energy
- C solubility of the silver halide in $\text{NH}_3(\text{aq})$
- D strength of the van der Waals' forces between molecules of the element

- 15** At 550°C nitrogen dioxide reacts with unburnt hydrocarbon fragments such as $\text{CH}_3\bullet$ in the catalytic converter of a motor vehicle.



The following table lists types of energy change for this reaction and possible reasons for them.

Which row gives the energy change for this reaction and the reason for it?

	energy change of reaction	reason why the reaction is endothermic or exothermic
A	endothermic	chemical energy is converted to heat energy
B	endothermic	the $\text{N}\equiv\text{N}$ bond energy is very high
C	exothermic	CO_2 and H_2O have large negative $\Delta H_f^\ominus$ values
D	exothermic	double bonds are broken in NO_2

- 16** Magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.

7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of X is produced?

- A** 1.5 g **B** 2.3 g **C** 3.0 g **D** 4.6 g

- 17** Compound **T** is a white crystalline solid.

When a sample of **T** was mixed with aqueous sodium hydroxide and heated, a pungent smelling gas was produced which turned damp red litmus paper blue. This same gas produced dense white smoke with hydrogen chloride gas.

Further testing of a solution of **T** with barium chloride solution produced a dense white precipitate which did not dissolve when dilute hydrochloric acid was added to the mixture.

What is the identity of compound **T**?

- A** ammonium carbonate
B ammonium sulfate
C sodium carbonate
D sodium sulfate

- 18 Which row of the table gives correct comparisons between the solubilities of calcium and barium hydroxide and the thermal stabilities of calcium and barium carbonate?

	solubility		thermal stability	
	calcium hydroxide	barium hydroxide	calcium carbonate	barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

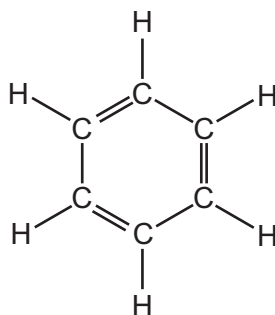
- 19 X, Y and Z represent different halogens. The table shows the results of nine experiments in which aqueous solutions of X_2 , Y_2 and Z_2 were separately added to separate aqueous solutions containing X^- , Y^- and Z^- ions.

	$X^-(aq)$	$Y^-(aq)$	$Z^-(aq)$
$X_2(aq)$	no reaction	no reaction	no reaction
$Y_2(aq)$	X_2 formed	no reaction	Z_2 formed
$Z_2(aq)$	X_2 formed	no reaction	no reaction

Which row of the following table contains the ions X^- , Y^- and Z^- in order of their **decreasing** strength as reducing agents?

	strongest	—————→	weakest
A	X^-	Y^-	Z^-
B	X^-	Z^-	Y^-
C	Y^-	Z^-	X^-
D	Z^-	X^-	Y^-

- 20 In 1865 Kekulé suggested a ring structure for benzene, C_6H_6 , in which a hydrogen atom is attached to each carbon atom.

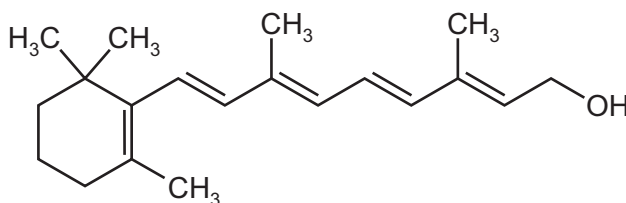


Kekulé structure

In this structure all of the bonds remain in the places shown. Assuming this is the structure of benzene, how many isomers of dichlorobenzene, $C_6H_4Cl_2$, would exist?

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

- 21 The diagram shows the structure of vitamin A.



vitamin A

How many chiral centres are present in one vitamin A molecule?

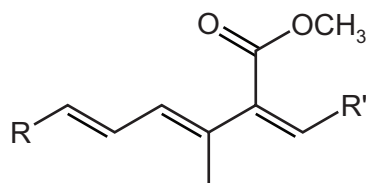
- A** 0 **B** 1 **C** 2 **D** 3

- 22 PVC is difficult to dispose of. Two possible methods are burying it in landfill sites and disposal by combustion.

Which row of the table is correct?

	rate of biodegradation of PVC in landfill sites	gases produced when PVC combusts
A	fast	CO_2 , H_2O , HCl
B	fast	CO_2 , H_2O , Cl_2
C	slow	CO_2 , H_2O , Cl_2
D	slow	CO_2 , H_2O , HCl

- 23 Part of the structure of a fungicide, strobilurin, is shown. R and R' are inert groups.

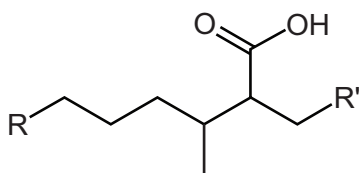


strobilurin

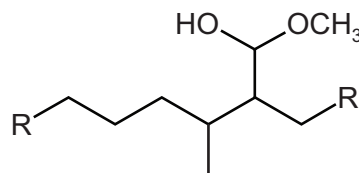
In this reaction, strobilurin is warmed with aqueous sulfuric acid producing compound X. Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.

What could be the structure of compound Y?

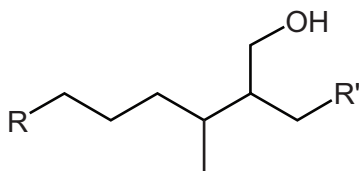
A



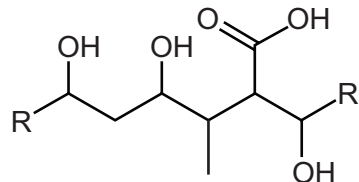
B



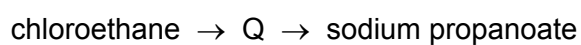
C



D



- 24 Chloroethane can be used to make sodium propanoate.

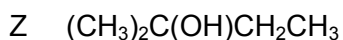


The intermediate, Q, is hydrolysed with boiling aqueous sodium hydroxide to give sodium propanoate.

Which reagent would produce the intermediate, Q, from chloroethane?

- A** concentrated ammonia solution
- B** dilute sulfuric acid
- C** hydrogen cyanide in water
- D** potassium cyanide in ethanol

25 X, Y and Z are three isomeric alcohols.



Two or more of these alcohols react with mild oxidising agents.

One of these alcohols, when dehydrated, will give a pair of cis-trans isomers with molecular formula C_5H_{10} .

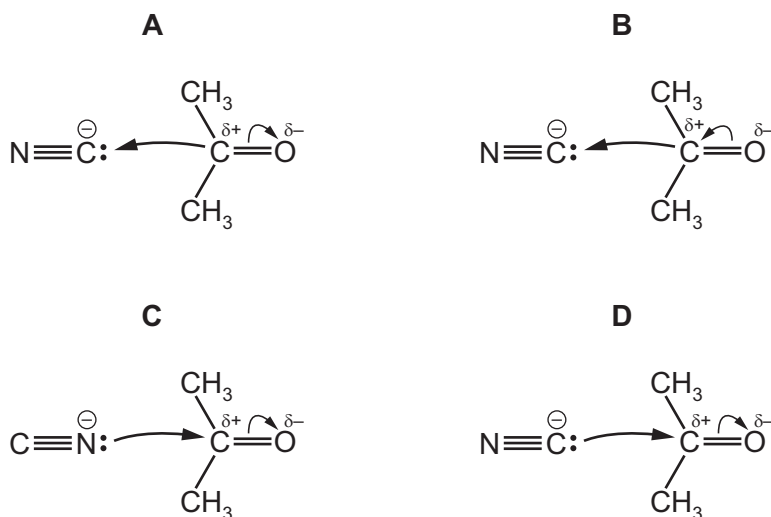
Which row is correct?

	reacts with mild oxidising reagents	gives cis-trans isomers
A	X, Y and Z	Y only
B	X, Y and Z	Z only
C	X and Y only	Y only
D	X and Y only	Z only

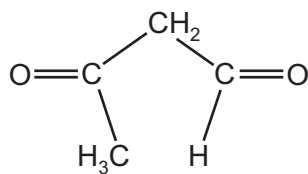
26 Propanone reacts with an aqueous mixture of HCN and NaCN by a nucleophilic addition mechanism.

The first stage of the mechanism involves attack by cyanide ions.

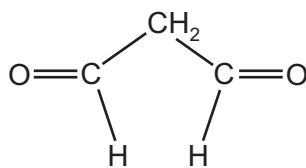
Which diagram correctly represents this?



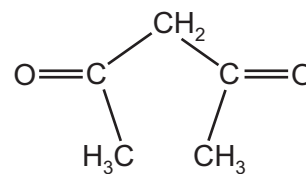
27 P, Q and R are carbonyl compounds.



P



Q



R

Fehling's solution can be used to help identify these compounds.

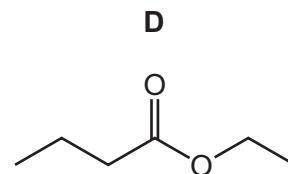
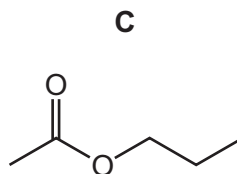
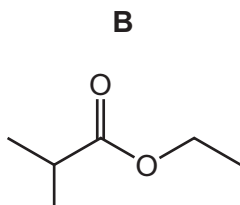
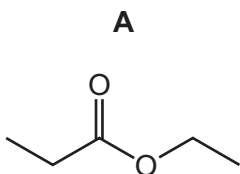
Which compounds form a red-brown precipitate on warming with Fehling's solution?

- A** P, Q and R **B** P and Q only **C** P only **D** Q only

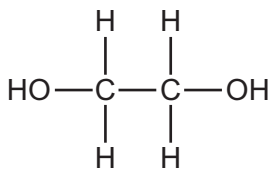
28 Which reaction would **not** give ethanoic acid?

- A** heating ethanenitrile under reflux with dilute sodium hydroxide
B heating ethanenitrile under reflux with dilute sulfuric acid
C heating ethanal under reflux with acidified sodium dichromate(VI)
D heating ethanol under reflux with acidified sodium dichromate(VI)

29 Which formula represents an ester that will form propanoic acid on hydrolysis with dilute sulfuric acid?

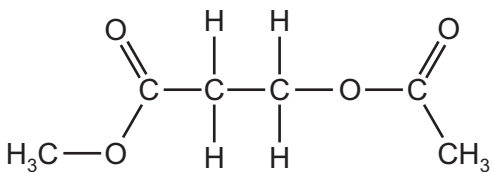
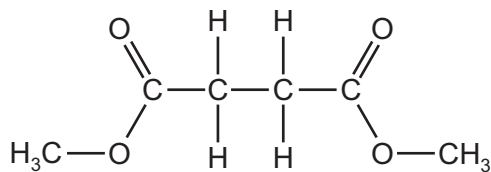
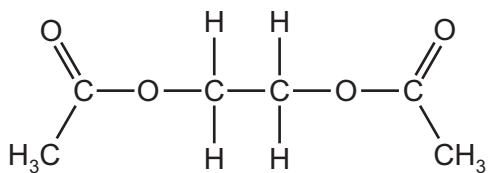
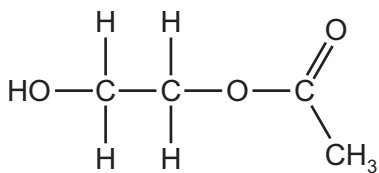


- 30** A solvent, **X**, used in printing inks has a molecular formula $\text{C}_6\text{H}_{10}\text{O}_4$. It may be made by reacting ethane-1,2-diol with ethanoic acid in the presence of an acid catalyst.



ethane-1,2-diol

What is the structure of solvent **X**?



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.

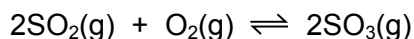
- 31** A sample of boron contains aluminium as the only impurity. A mass spectrum of the mixture shows three lines corresponding to three ions, X^+ , Y^+ and Z^+ .

ion	X^+	Y^+	Z^+
m/e	10	11	27
percentage abundance	15.52	74.48	10.00

Which statements are correct?

- 1** There are more electrons in Z^+ than in X^+ .
 - 2** The A_r of boron in the sample is 10.83 to four significant figures.
 - 3** There are more protons in Y^+ than in X^+ .
- 32** Which elements can form π bonds in their compounds?
- 1** carbon
 - 2** oxygen
 - 3** nitrogen
- 33** For which enthalpy changes is the value of ΔH always negative?
- 1** combustion
 - 2** hydration
 - 3** solution

- 34 In the manufacture of sulfuric acid, the following exothermic reaction occurs.



Which changes will move the position of the equilibrium to the right?

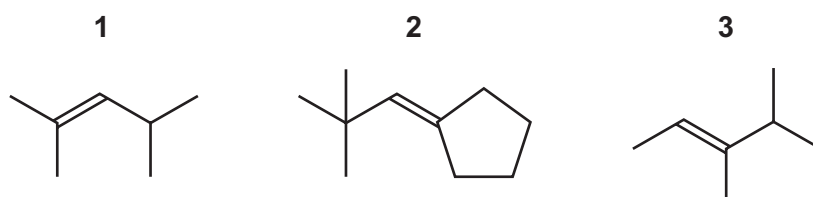
- 1 increasing the pressure
 - 2 increasing the temperature
 - 3 using twice as much catalyst
- 35 Water is added to anhydrous aluminium chloride to make a 0.1 mol dm^{-3} solution.

Which observations are correct?

- 1 The reaction is endothermic.
 - 2 The solution is acidic.
 - 3 The solution contains the ion $[\text{Al}(\text{H}_2\text{O})_6]^{3+}$.
- 36 Catalytic converters are used to modify exhaust emissions from motor vehicles.

Which reactions occur in catalytic converters?

- 1 $\text{C}_8\text{H}_{18} + 12\frac{1}{2}\text{O}_2 \rightarrow 8\text{CO}_2 + 9\text{H}_2\text{O}$
 - 2 $2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$
 - 3 $\text{NO} + \text{SO}_3 \rightarrow \text{NO}_2 + \text{SO}_2$
- 37 Which compounds would produce a carboxylic acid and a ketone when treated with hot, concentrated, acidified KMnO_4 ?



- 38 Bromoethane reacts with NaOH in different ways depending on the solvent used.

Which statements about these reactions are correct?

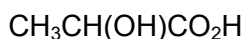
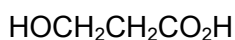
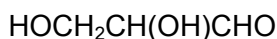
	solvent used	main organic product
1	water	ethane-1,2-diol
2	ethanol	ethene
3	water	ethanol

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.

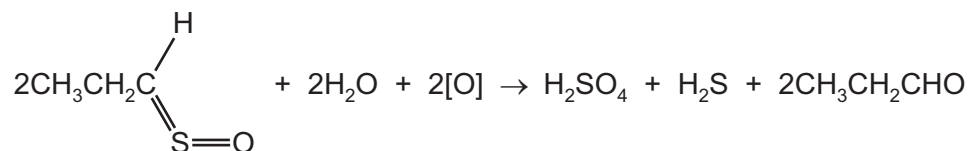
39 Several structural isomers of $C_3H_6O_3$ are listed below.



Which statements about these structural isomers are correct?

- 1** One mole of each reacts with two moles of sodium.
- 2** Only one of the isomers contains a tertiary alcohol group.
- 3** They all contain a primary alcohol group.

40 When onions are peeled in air, the reaction shown is thought to occur.



Which tests would give a positive reaction with the organic product?

- 1** warming with Tollens' reagent
- 2** warming with acidified potassium manganate(VII)
- 3** warming with alkaline aqueous iodine

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