



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY

Paper 1 Multiple Choice

9701/11

May/June 2011

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, highlighters, 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.

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.

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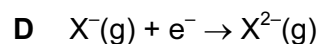
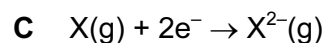
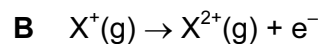
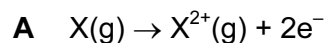
This document consists of **15** printed pages and **1** blank page.



Section A

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

1 Which equation represents the second ionisation energy of an element X?



2 In flooded soils, like those used for rice cultivation, the oxygen content is low. In such soils, anaerobic bacteria cause the loss of nitrogen from the soil as shown in the following sequence.

In which step is the change in oxidation number (oxidation state) of nitrogen different to the changes in the other steps?



3 In the extraction of aluminium by the electrolysis of molten aluminium oxide, why is cryolite added to the aluminium oxide?

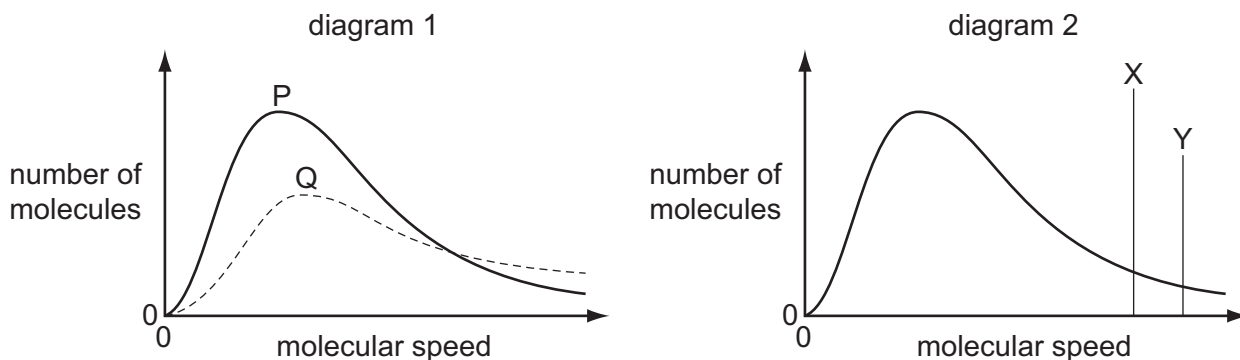
A to ensure the aluminium is not oxidised

B to ensure the anode is not oxidised

C to lower the melting point of the aluminium oxide

D to prevent corrosion of the cathode

4 Different Boltzmann distributions are shown in the diagrams.



In diagram 1, one curve P or Q corresponds to a temperature higher than that of the other curve.

In diagram 2, one line X or Y corresponds to the activation energy for a catalysed reaction and the other line corresponds to the activation energy of the same reaction when uncatalysed.

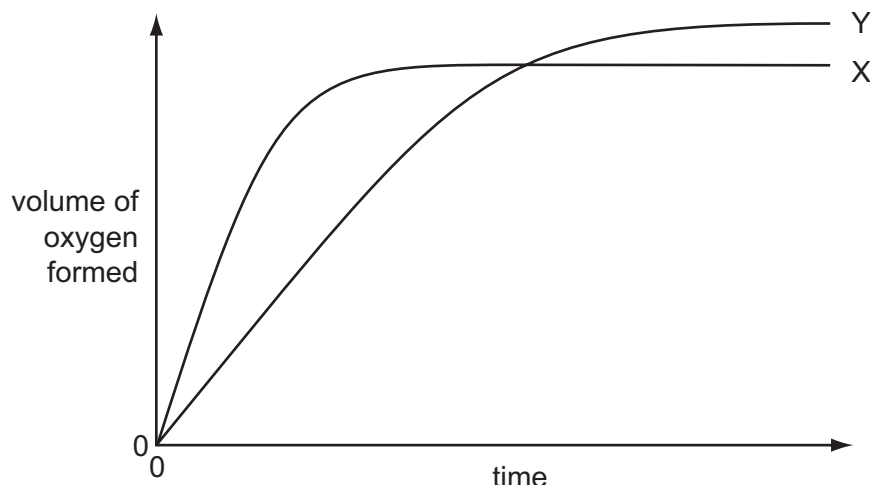
Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

5 Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?

- A** The nuclear charge of the elements increases.
- B** The outer electron is in an 's' subshell.
- C** The repulsion between spin-paired electrons increases.
- D** The shielding effect of the inner shells increases.

- 6 In the diagram, curve X was obtained by observing the decomposition of 100 cm^3 of 1.0 mol dm^{-3} hydrogen peroxide, catalysed by manganese(IV) oxide.

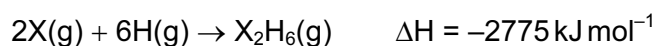


Which alteration to the original experimental conditions would produce curve Y?

- A adding some 0.1 mol dm^{-3} hydrogen peroxide
 - B adding water
 - C lowering the temperature
 - D using less manganese(IV) oxide
- 7 In the last century the Haber process was sometimes run at pressures of 1000 atm and higher. Now it is commonly run at pressures below 100 atm.

What is the reason for this change?

- A An iron catalyst is used.
 - B Maintaining the higher pressures is more expensive.
 - C The equilibrium yield of ammonia is increased at lower pressures.
 - D The rate of the reaction is increased at lower pressures.
- 8 The equation below represents the combination of gaseous atoms of non-metal X and of hydrogen to form gaseous X_2H_6 molecules.



The bond energy of an X–H bond is 395 kJ mol^{-1} .

What is the bond energy of an X–X bond?

- A $-405.0\text{ kJ mol}^{-1}$
- B $-202.5\text{ kJ mol}^{-1}$
- C $+202.5\text{ kJ mol}^{-1}$
- D $+405.0\text{ kJ mol}^{-1}$

- 9 50 cm³ of 2.50 mol dm⁻³ hydrochloric acid was placed in a polystyrene beaker of negligible heat capacity. Its temperature was recorded and then 50 cm³ of 2.50 mol dm⁻³ NaOH at the same temperature was quickly added, with stirring. The temperature rose by 17 °C.

The resulting solution may be considered to have a specific heat capacity of 4.2 J g⁻¹ K⁻¹.

What is an approximate value for the molar enthalpy change of neutralisation of hydrochloric acid and sodium hydroxide from this experiment?

- A $\frac{-(50 \times 4.2 \times 17)}{(0.050 \times 2.5)} \text{ J mol}^{-1}$
- B $\frac{-(50 \times 4.2 \times 17)}{(0.10 \times 2.5)} \text{ J mol}^{-1}$
- C $\frac{-(100 \times 4.2 \times 17)}{(0.050 \times 2.5)} \text{ J mol}^{-1}$
- D $\frac{-(100 \times 4.2 \times 17)}{(50 \times 2.5)} \text{ J mol}^{-1}$

- 10 Three substances, R, S and T, have physical properties as shown.

substance	R	S	T
mp/°C	801	2852	3550
bp/°C	1413	3600	4827
electrical conductivity of solid	poor	poor	good

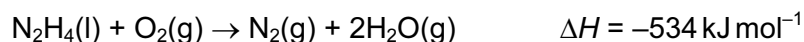
What could be the identities of R, S and T?

	R	S	T
A	MgO	NaCl	C [graphite]
B	MgO	NaCl	SiO ₂
C	NaCl	MgO	C [graphite]
D	NaCl	MgO	SiO ₂

- 11 In which change would only van der Waals' forces have to be overcome?

- A evaporation of ethanol $\text{C}_2\text{H}_5\text{OH}(\text{l}) \rightarrow \text{C}_2\text{H}_5\text{OH}(\text{g})$
- B melting of ice $\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\text{l})$
- C melting of solid carbon dioxide $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{l})$
- D solidification of butane $\text{C}_4\text{H}_{10}(\text{l}) \rightarrow \text{C}_4\text{H}_{10}(\text{s})$

- 12 Hydrazine, N_2H_4 , is widely used as a rocket fuel because it reacts with oxygen as shown, producing 'environmentally friendly' gases.



Despite its use as a rocket fuel, hydrazine does not burn spontaneously in oxygen.

Which statement explains why hydrazine does **not** burn spontaneously?

- A Hydrazine is a liquid.
 - B The activation energy is too high.
 - C The $\text{N}\equiv\text{N}$ bond is very strong.
 - D The reaction is exothermic.
- 13 0.02 mol of aluminium is burned in oxygen and the product is reacted with 2.00 mol dm^{-3} hydrochloric acid.

What minimum volume of acid will be required for complete reaction?

- A 15 cm^3 B 20 cm^3 C 30 cm^3 D 60 cm^3
- 14 Steam is passed over heated magnesium to give compound X and hydrogen.

What is **not** a property of compound X?

- A It has an M_r of 40.3.
- B It is basic.
- C It is a white solid.
- D It is very soluble in water.

- 15 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 in 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^-

- 16 A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. The observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

Which deduction can be made from these observations?

- A** Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.
B Concentrated phosphoric acid is a stronger oxidising agent than iodine.
C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.
D Concentrated sulfuric acid is a stronger oxidising agent than iodine.
- 17 Ammonium nitrate, NH_4NO_3 , is manufactured in large quantities for use in fertiliser.

Which statement about ammonium nitrate fertiliser is **not** correct?

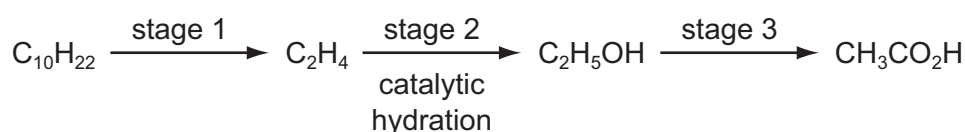
- A** It can cause environmental problems.
B It consists of 35 % nitrogen by mass.
C It is insoluble in water.
D Nitric acid is used in its manufacture.

- 18 Nitrogen monoxide, NO, is a primary pollutant produced by petrol engines and is found in their exhaust gases.

Which reaction occurs in a catalytic converter and decreases the emission of nitrogen monoxide?

- A $\text{NO(g)} + \text{CO(g)} \rightarrow \text{NO}_2\text{(g)} + \text{C(s)}$
 B $\text{NO(g)} + \text{CO}_2\text{(g)} \rightarrow \text{NO}_2\text{(g)} + \text{CO(g)}$
 C $2\text{NO(g)} + 2\text{CO(g)} \rightarrow \text{N}_2\text{(g)} + 2\text{CO}_2\text{(g)}$
 D $2\text{NO(g)} + \text{CO}_2\text{(g)} \rightarrow 2\text{NO}_2\text{(g)} + \text{C(s)}$

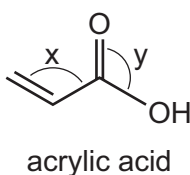
- 19 In the reaction pathway below, an alkane is converted into a carboxylic acid through several stages.



Which processes occur at stage 1 and at stage 3?

	stage 1	stage 3
A	condensation	combustion
B	cracking	dehydration
C	cracking	oxidation
D	dehydration	combustion

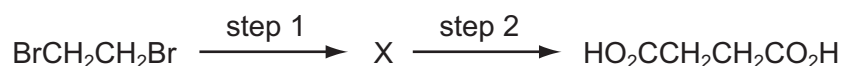
- 20 Acrylic acid is produced from propene, a gaseous product of oil refineries.



Which statement about acrylic acid is **not** correct?

- A Both bond angles x and y are approximately 120° .
 B It decolourises aqueous bromine.
 C It gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent.
 D It reacts with an alcohol to give an ester.

- 21 Butanedioic acid occurs in amber, algae, lichens, sugar cane and beets. It may be synthesised in two steps from 1,2-dibromoethane.



Which reagents could be used for this synthesis?

	step 1	step 2
A	HCN(g)	HCl(aq)
B	HCO ₂ Na(aq)	HCl(aq)
C	KCN(aq/alcoholic)	H ₂ SO ₄ (aq)
D	NaOH(aq)	K ₂ Cr ₂ O ₇ /H ₂ SO ₄ (aq)

- 22 The formula CH₃ can represent an anion, a cation or a free radical. Species with the molecular formula CH₃ can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons must be present for CH₃ to act in these different ways?

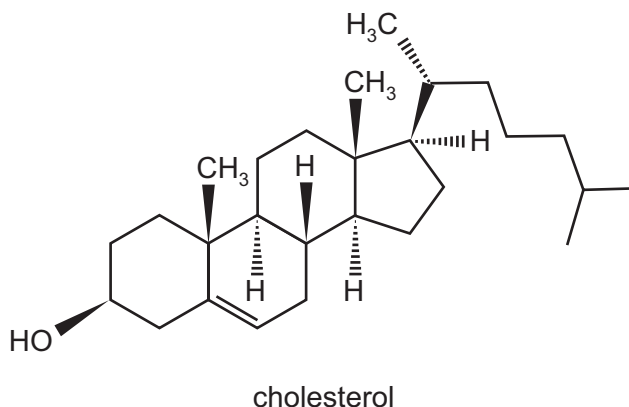
	CH ₃ as an electrophile	CH ₃ as a free radical	CH ₃ as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

- 23 Pentanol, C₅H₁₁OH, has four structural isomers that are primary alcohols.

How many of these primary alcohols contain a chiral carbon atom?

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

- 24 The diagram shows the structure of the naturally-occurring molecule cholesterol.

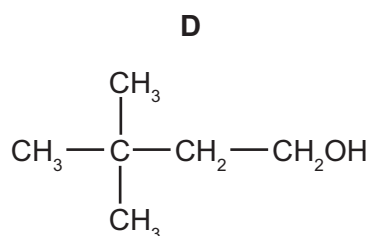
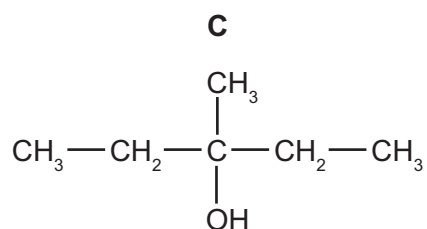
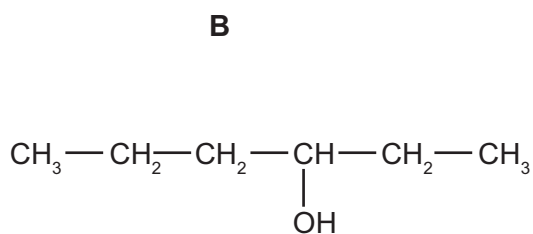
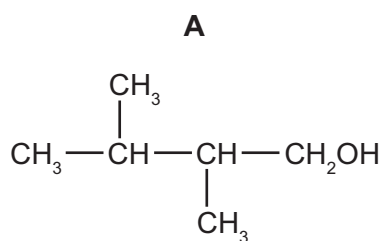


Student X claimed that the seventeen carbon atoms in the four rings all lie in the same plane.

Student Y claimed that this molecule displays *cis-trans* isomerism at the C=C double bond.

Which of the students are correct?

- A both X and Y
 B neither X nor Y
 C X only
 D Y only
- 25 Which isomer of $C_6H_{13}OH$ gives the greatest number of different alkenes when it is dehydrated?

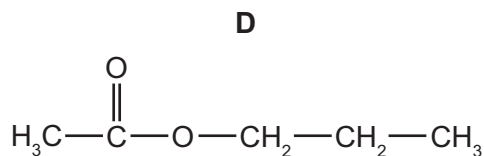
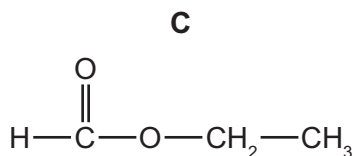
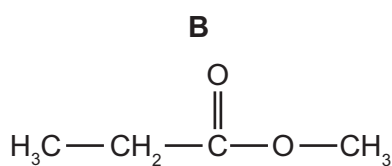
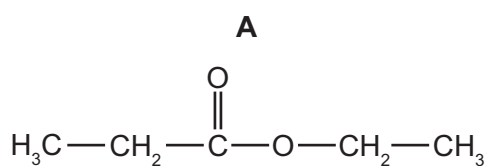


- 26 Compound X changes the colour of warm acidified sodium dichromate(VI) from orange to green. 1 mol of X reacts with 2 mol of HCN in the presence of KCN.

What could X be?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
- B $\text{CH}_3\text{COCH}_2\text{COCH}_3$
- C $\text{H}_2\text{C}=\text{CHCH}_2\text{CHO}$
- D $\text{OHCCH}_2\text{CH}_2\text{CHO}$

- 27 Which formula represents an ester which will form sodium ethanoate on hydrolysis with aqueous sodium hydroxide?



- 28 A compound Y is treated with warm acidified potassium dichromate(VI). The resulting organic product gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent but does not give a silver mirror with Tollens' reagent.

What is Y?

- A butan-1-ol
- B butan-2-ol
- C butanal
- D 2-methylpropan-2-ol

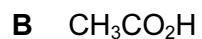
- 29 Aldehydes and ketones are carbonyl compounds.

Which of them react with NaBH_4 **and** react with Fehling's reagent?

- A both aldehydes and ketones
- B aldehydes only
- C ketones only
- D neither aldehydes nor ketones

30 The functional group in a primary alcohol is $\text{-CH}_2\text{OH}$.

Which reagent reacts with a primary alcohol, under suitable conditions, to give an organic product with the same number of oxygen atoms as the alcohol?



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 Which statements are correct in terms of the Brønsted-Lowry theory of acids and bases?

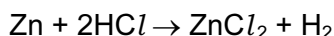
- 1** Water can act as either an acid or a base.
- 2** Sulfuric acid, H_2SO_4 , does not behave as an acid when dissolved in ethanol, $\text{C}_2\text{H}_5\text{OH}$.
- 3** The ammonium ion acts as a base when dissolved in liquid ammonia.

32 Which are features of the structure of metallic copper?

- 1** a lattice of ions
- 2** delocalised electrons
- 3** ionic bonds

33 *Use of the Data Booklet is relevant to this question.*

Zinc reacts with hydrochloric acid according to the following equation.



Which statements are correct?

[All volumes are measured at room conditions.]

- 1** A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.050 mol of zinc chloride.
- 2** A 6.54 g sample of zinc reacts completely with exactly 100 cm^3 of 1.00 mol dm^{-3} hydrochloric acid.
- 3** A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm^3 of hydrogen.

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 Which statements are correct?

- 1** Aluminium chloride dissolves in water to give an acidic solution.
- 2** Magnesium chloride dissolves in water to give a slightly acidic solution.
- 3** Sodium chloride dissolves in water to give an alkaline solution.

35 Which oxides react with water to give a solution of pH 10 or higher?

- 1** CaO
- 2** Na₂O
- 3** SrO

36 *Use of the Data Booklet is relevant to this question.*

The element astatine lies below iodine in Group VII of the Periodic Table.

What will be the properties of astatine?

- 1** It forms diatomic molecules which dissociate more readily than chlorine molecules.
- 2** It reacts explosively with hydrogen.
- 3** It can oxidise iodide to iodine.

37 Which descriptions of the ammonium ion are correct?

- 1** It contains ten electrons.
- 2** It has a bond angle of 109.5°.
- 3** It has only three bonding pairs of electrons.

38 Which alkenes, on reaction with steam at 600 K and 6×10^6 Pa pressure in the presence of a phosphoric acid catalyst, could produce an alcohol containing a chiral carbon atom?

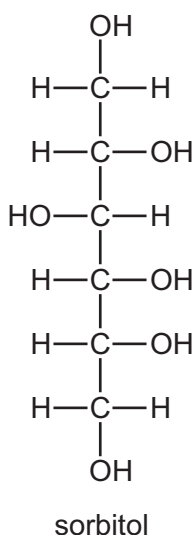
- 1 $(\text{CH}_3)_2\text{C}=\text{CH}_2$
- 2 $\text{CH}_3\text{CH}=\text{CHCH}_3$
- 3 $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$

39 Bromoethane undergoes all of the conversions shown.

Which conversions are examples of nucleophilic substitution?

- 1 $\text{C}_2\text{H}_5\text{Br} \rightarrow \text{C}_2\text{H}_5\text{CN}$
- 2 $\text{C}_2\text{H}_5\text{Br} \rightarrow \text{C}_2\text{H}_5\text{OH}$
- 3 $\text{C}_2\text{H}_5\text{Br} \rightarrow \text{C}_2\text{H}_5\text{NH}_2$

40 Sorbitol is an artificial sweetener used to sweeten chocolate which is suitable for diabetics.



Which functional groups can be produced when this molecule is subjected to oxidation under suitable conditions?

- 1 aldehyde
- 2 carboxylic acid
- 3 ketone

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1 hour

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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.

- 1 Helium, He, is the second element in the Periodic Table.

Tritium is the isotope of hydrogen ^3H .

What is the same in an atom of ^4He and an atom of ^3H ?

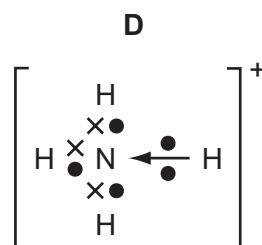
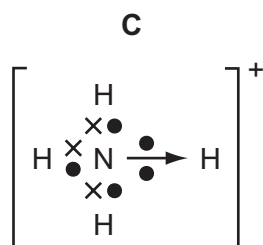
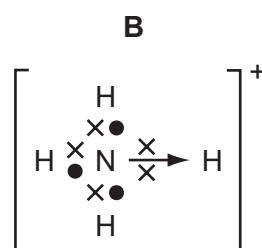
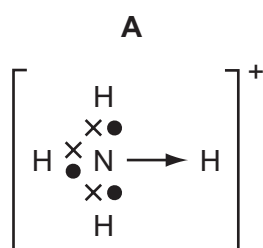
- A** the number of electrons
- B** the number of neutrons
- C** the number of protons
- D** the relative atomic mass

- 2 Which diagram correctly shows the bonding in the ammonium ion, NH_4^+ ?

key

• N electron

× H electron



- 3 Aluminium is the most abundant metal in the Earth's crust. The extraction of aluminium is carried out by the electrolysis of aluminium oxide dissolved in molten cryolite.

Which material is used for each of the electrodes in this electrolysis?

	anode	cathode
A	aluminium	carbon
B	carbon	carbon
C	carbon	steel
D	steel	aluminium

- 4 The esterification reaction



is an equilibrium. The forward reaction is exothermic.

How can the value of the equilibrium constant K_C be increased?

- A** by adding a little concentrated sulfuric acid as a catalyst
 - B** by increasing the initial concentration of ethanol
 - C** by lowering the temperature
 - D** by raising the temperature
- 5 Ammonia is manufactured on a large scale by the Haber process.

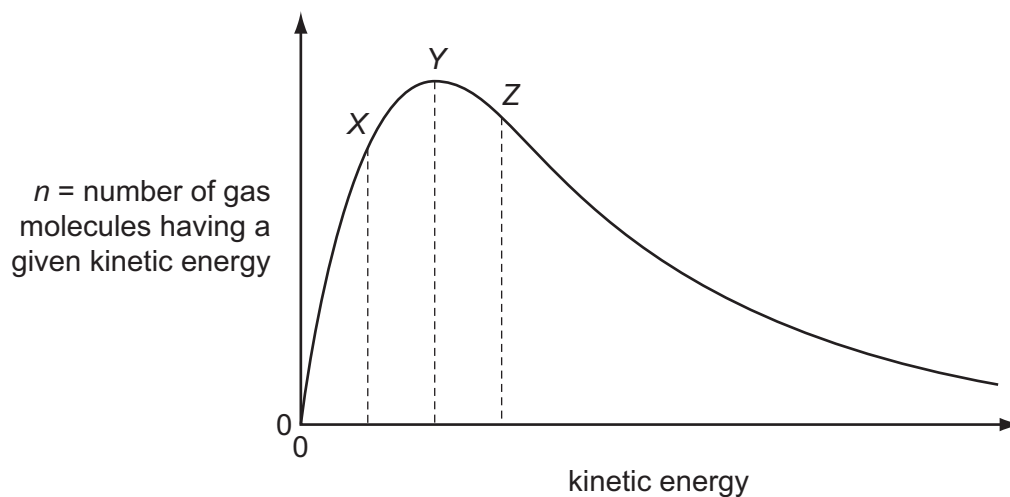
In a particular plant, conditions of 400 °C and 250 atm in the presence of an iron catalyst are used.



What could contribute most to increasing the equilibrium yield of ammonia?

- A** adding more catalyst
- B** increasing the pressure to 400 atm
- C** increasing the temperature to 1000 °C
- D** using air rather than nitrogen

- 6 The Boltzmann distribution for a gas at constant temperature is shown below.

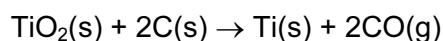


If the temperature of the gas is **reduced** by 10°C the graph changes shape.

What happens to the values of n for the points marked X, Y and Z?

	X	Y	Z
A	higher	lower	higher
B	higher	lower	lower
C	lower	higher	lower
D	lower	lower	lower

- 7 Titanium occurs naturally as the mineral rutile, TiO_2 . One possible method of extraction of titanium is to reduce the rutile by heating with carbon.



The standard enthalpy changes of formation of $\text{TiO}_2(\text{s})$ and $\text{CO}(\text{g})$ are -940 kJ mol^{-1} and -110 kJ mol^{-1} respectively.

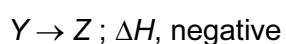
What is the standard enthalpy change of this reaction?

- A** -830 kJ mol^{-1}
- B** -720 kJ mol^{-1}
- C** $+720 \text{ kJ mol}^{-1}$
- D** $+830 \text{ kJ mol}^{-1}$

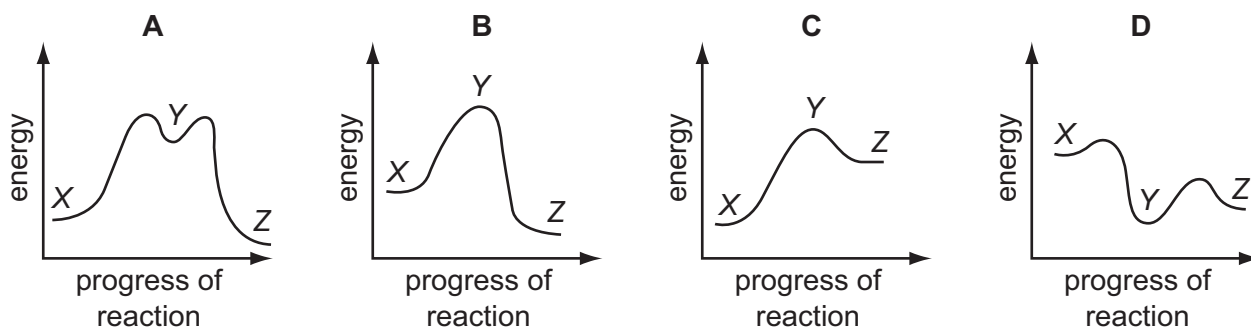
- 8 Which reaction has an enthalpy change equal to the standard enthalpy change of formation of propane?

- A $3\text{C}(\text{g}) + 4\text{H}_2(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{g})$
 B $3\text{C}(\text{g}) + 8\text{H}(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{g})$
 C $3\text{C}(\text{s}) + 4\text{H}_2(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{g})$
 D $3\text{C}(\text{s}) + 4\text{H}_2(\text{g}) \rightarrow \text{C}_3\text{H}_8(\text{l})$

- 9 In the conversion of compound X into compound Z, it was found that the reaction proceeded by way of compound Y, which could be isolated. The following steps were involved.



Which reaction profile fits these data?



- 10 Tanzanite is used as a gemstone for jewellery. It is a hydrated calcium aluminium silicate mineral with a chemical formula $\text{Ca}_2\text{Al}_x\text{Si}_y\text{O}_{12}(\text{OH}) \cdot 6\frac{1}{2}\text{H}_2\text{O}$. Tanzanite has M_r of 571.5.

Its chemical composition is 14.04 % calcium, 14.17 % aluminium, 14.75 % silicon, 54.59 % oxygen and 2.45 % hydrogen.

(A_r values: H = 1.0, O = 16.0, Al = 27.0, Si = 28.1, Ca = 40.1)

What are the values of x and y?

	x	y
A	1	1
B	2	3
C	3	3
D	6	1

- 11 0.144 g of an aluminium compound **X** react with an excess of water, to produce a gas. This gas burns completely in O_2 to form H_2O and 72 cm^3 of CO_2 only. The volume of CO_2 was measured at room temperature and pressure.

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

[C = 12.0, Al = 27.0; 1 mole of any gas occupies 24 dm^3 at room temperature and pressure]

- A** Al_2C_3 **B** Al_3C_4 **C** Al_4C_3 **D** Al_5C_3

- 12 *Use of the Data Booklet is relevant to this question.*

Which element is likely to have an electronegativity similar to that of aluminium?

- A** barium
B beryllium
C magnesium
D strontium

- 13 In 1999, researchers working in the USA believed that they had made a new element and that it had the following electronic configuration.

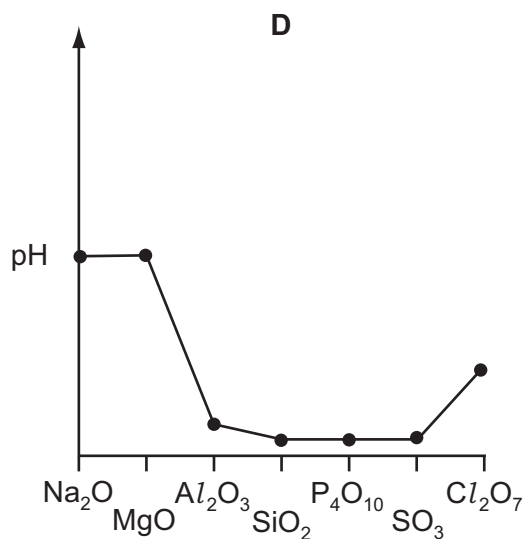
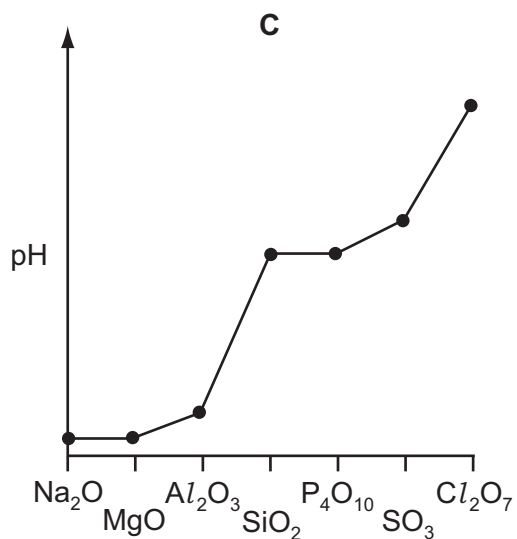
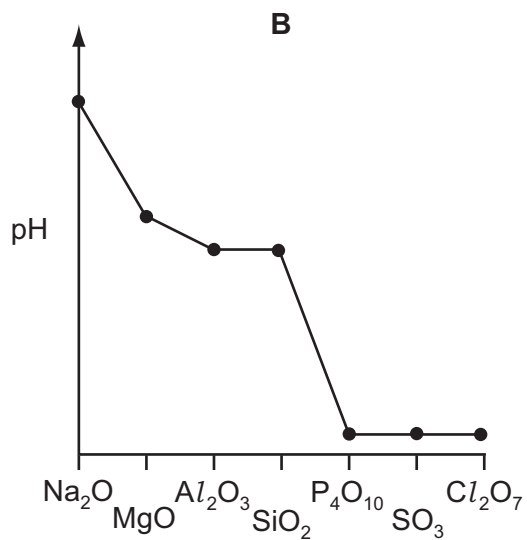
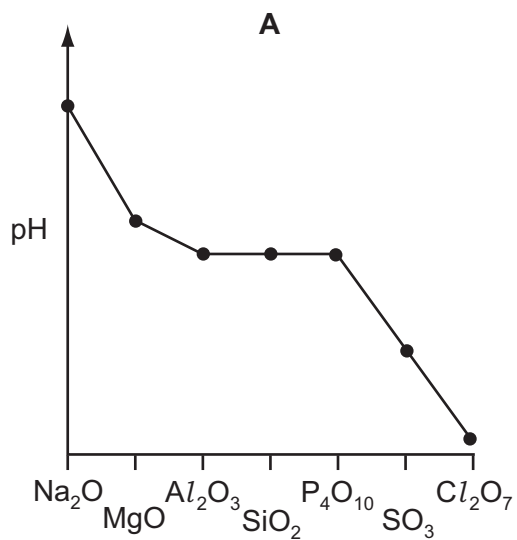


In which Group of the Periodic Table would you expect to find this element?

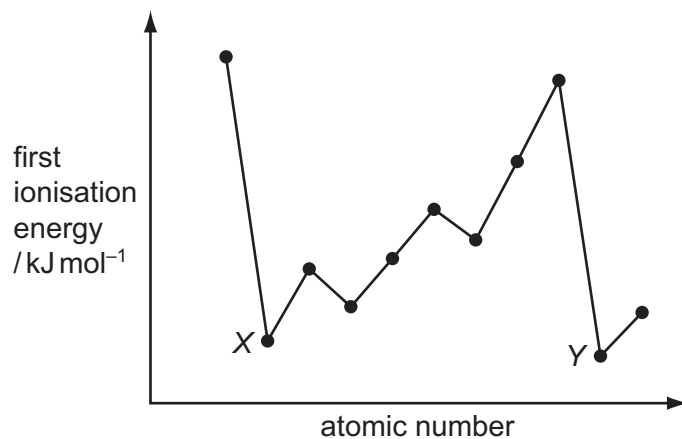
- A** II **B** IV **C** VI **D** 0

14 The highest oxides of the elements sodium to chlorine are separately added to water.

Which diagram best represents the pH of the resulting mixtures?



15 The diagram shows the first ionisation energies of 11 consecutive elements.



Which type of elements are labelled X and Y?

- A Group I metals
- B Group II metals
- C halogens
- D noble gases

16 Why does aluminium oxide dissolve in sodium hydroxide solution?

- A Aluminium oxide can behave as a base.
- B Aluminium oxide can behave as an acid.
- C Aluminium oxide has a giant structure.
- D The bonding in aluminium oxide is ionic.

17 Concentrated sulfuric acid can behave **both** as a strong acid **and** as an oxidising agent.

With which compound does concentrated sulfuric acid react in this way?

- A ethanol
- B magnesium carbonate
- C propanenitrile
- D sodium bromide

- 18 In the Contact process, what is the nature of the gaseous product and what is the identity of the catalyst?

	nature of gaseous product	catalyst
A	acidic	Fe
B	acidic	V_2O_5
C	basic	Fe
D	basic	V_2O_5

- 19 Which compound contains two different elements with identical oxidation states?

A $HClO$ **B** $Mg(OH)_2$ **C** Na_2SO_4 **D** NH_4Cl

- 20 Which reagent gives the same visible result with propanal and with propan-2-ol?

A 2,4-dinitrophenylhydrazine reagent
B acidified potassium dichromate(VI)
C sodium
D Tollens' reagent

- 21 Which halogenoalkane will undergo an S_N1 reaction and produce a yellow precipitate when $AgNO_3(aq)$ is added to it?

A 1-chlorobutane
B 1-iodobutane
C 2-chloro-2-methylpropane
D 2-iodo-2-methylpropane

- 22 Which reaction will give 2-chloropropane in the best yield?

A propane gas with chlorine gas in the presence of ultraviolet light
B propan-2-ol with dilute $NaCl(aq)$
C propan-2-ol with $SOCl_2$
D propene with dilute $HCl(aq)$

- 23 The products obtained by cracking an alkane, **X**, are methane, ethene and propene.

The mole fraction of ethene in the products is 0.5.

What is the identity of **X**?

- A** C_6H_{14} **B** C_8H_{18} **C** C_9H_{20} **D** $C_{11}H_{24}$

- 24 Which compound does **not** show cis-trans isomerism?

- A** 2-methylpent-2-ene
B 3-methylpent-2-ene
C 3,4-dimethylhex-3-ene
D pent-2-ene

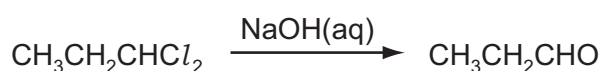
- 25 Which formulae show propanone and propanal as different compounds?

- A** empirical, molecular, structural **and** displayed formulae
B molecular, structural and displayed formulae **only**
C structural and displayed formulae **only**
D displayed formulae **only**

- 26 How many isomers with the formula C_5H_{10} have structures that involve π bonding?

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

- 27 1,1-dichloropropane reacts with aqueous sodium hydroxide in a series of steps to give propanal.



Which term describes the first step of this reaction?

- A** electrophilic addition
B elimination
C nucleophilic substitution
D oxidation

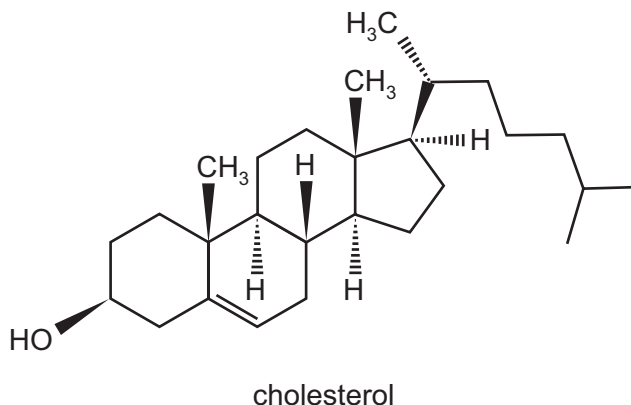
28 The ester $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_3$ is responsible for the aroma of apples.

When this ester is hydrolysed by acid in the stomach, what is the empirical formula of the organic acid produced?

- A CH_2O B CH_4O C $\text{C}_2\text{H}_4\text{O}$ D $\text{C}_3\text{H}_6\text{O}_2$

29 This question should be answered by considering the reactions of KMnO_4 with different functional groups under the stated conditions.

The diagram shows the structure of the naturally-occurring molecule cholesterol.



Cholesterol is separately treated with

- cold, dilute acidified KMnO_4 ,
- hot, concentrated acidified KMnO_4 .

What is the change in the **number** of chiral carbon atoms in the molecule during each reaction?

	cold, dilute acidified KMnO_4	hot, concentrated acidified KMnO_4
A	+1	0
B	+1	-1
C	+2	0
D	+2	-1

30 Which reaction would **not** give ethanoic acid as a product?

- 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)

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** Solid calcium carbonate is added to 100 cm³ of dilute hydrochloric acid and the rate of the reaction is measured. 100 cm³ of distilled water is then added to a second 100 cm³ portion of the acid, and the experiment repeated under the same conditions.

Why does the addition of water decrease the rate of the reaction?

- 1** Adding water reduces the frequency of collisions between reactant molecules.
- 2** Adding water reduces the proportion of effective collisions between reactant molecules.
- 3** Adding water reduces the proportion of reactant molecules possessing the activation energy.

- 32** When a sample of a gas is compressed at constant temperature from 1500 kPa to 6000 kPa, its volume changes from 76.0 cm³ to 20.5 cm³.

Which statements are possible explanations for this behaviour?

- 1** The gas behaves non-ideally.
- 2** The gas partially liquefies.
- 3** Gas is adsorbed on to the vessel walls.

- 33** Which equations apply to an ideal gas?

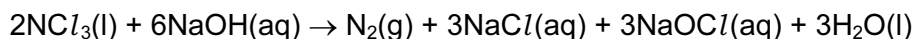
[p = pressure, V = volume, M = molar mass, ρ = density, c = concentration, R = gas constant, T = temperature]

- 1** $p = \frac{\rho RT}{M}$
- 2** $pV = MRT$
- 3** $pV = \frac{cRT}{M}$

34 What is involved when a hydrogen bond is formed between two molecules?

- 1 a hydrogen atom bonded to an atom less electronegative than itself
- 2 a lone pair of electrons
- 3 an electrostatic attraction between opposite charges

35 When the yellow liquid NCl_3 is stirred into aqueous sodium hydroxide, the reaction that occurs can be represented by the following equation.



What will be the result of this reaction?

- 1 The nitrogen undergoes a redox reaction.
- 2 A bleaching solution remains after the reaction.
- 3 The final solution gives a precipitate with acidified silver nitrate.

36 In a car engine pollutant oxide **Y**, which contains non-metallic element **X**, is formed.

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.

X could be either nitrogen or sulfur.

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** may have an unpaired electron in its molecule.
- 3 **Y** is a polar molecule.

37 Which compounds can be obtained from ethene in a **single** reaction?

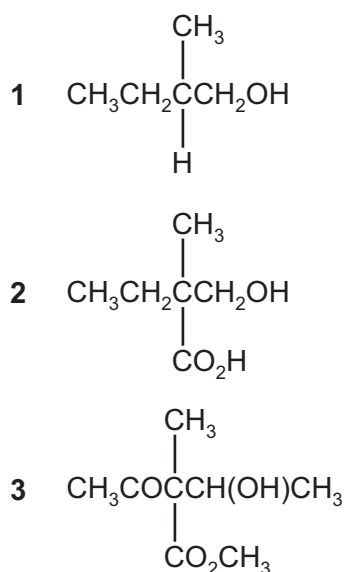
- 1 CH_3CH_3
- 2 $\text{-(CH}_2\text{CH}_2\text{)}_n\text{-}$
- 3 $\text{HOCH}_2\text{CH}_2\text{OH}$

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.

- 38** Which compounds when heated under reflux with an excess of hot acidified potassium dichromate(VI), give a product with a chiral centre?



- 39** In the reaction between an aldehyde and HCN, catalysed by NaCN, which statements about the reaction mechanism are correct?

- 1** A new carbon-carbon bond is formed.
- 2** In the intermediate, the oxygen carries a negative charge.
- 3** The last stage involves the formation of a hydrogen-oxygen bond.

- 40** An organic compound, **X**, will react with an excess of calcium metal to produce a salt with the empirical formula $\text{CaC}_4\text{H}_6\text{O}_4$.

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

- 1** ethanoic acid
- 2** butanedioic acid
- 3** methylpropanedioic acid

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UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CHEMISTRY

9701/13

Paper 1 Multiple Choice

May/June 2011

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, highlighters, 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.

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.

This document consists of **14** printed pages and **2** blank pages.

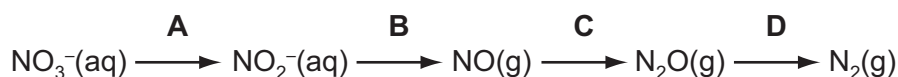


Section A

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

- 1 Which equation represents the second ionisation energy of an element X?
- A** $X(g) \rightarrow X^{2+}(g) + 2e^{-}$
- B** $X^{+}(g) \rightarrow X^{2+}(g) + e^{-}$
- C** $X(g) + 2e^{-} \rightarrow X^{2-}(g)$
- D** $X^{-}(g) + e^{-} \rightarrow X^{2-}(g)$
- 2 Which factor helps to explain why the first ionisation energies of the Group I elements decrease from lithium to sodium to potassium to rubidium?
- A** The nuclear charge of the elements increases.
- B** The outer electron is in an 's' subshell.
- C** The repulsion between spin-paired electrons increases.
- D** The shielding effect of the inner shells increases.
- 3 In the extraction of aluminium by the electrolysis of molten aluminium oxide, why is cryolite added to the aluminium oxide?
- A** to ensure the aluminium is not oxidised
- B** to ensure the anode is not oxidised
- C** to lower the melting point of the aluminium oxide
- D** to prevent corrosion of the cathode
- 4 In flooded soils, like those used for rice cultivation, the oxygen content is low. In such soils, anaerobic bacteria cause the loss of nitrogen from the soil as shown in the following sequence.

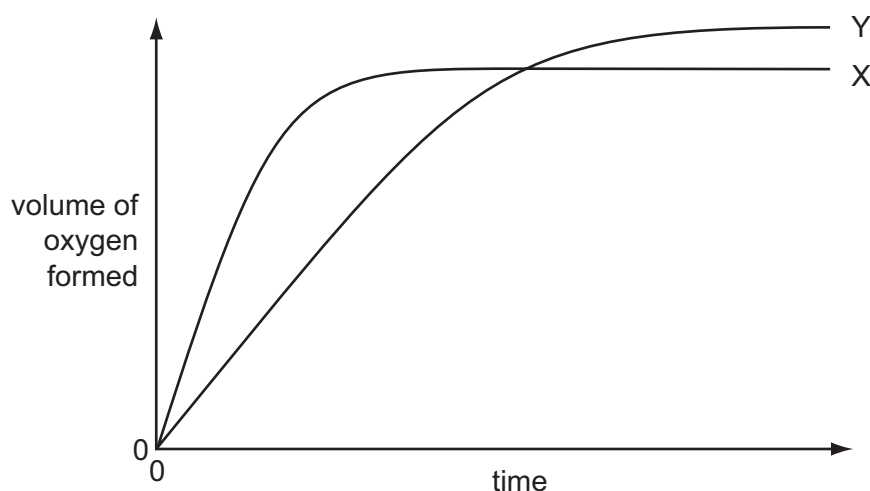
In which step is the change in oxidation number (oxidation state) of nitrogen different to the changes in the other steps?



- 5 In the last century the Haber process was sometimes run at pressures of 1000 atm and higher. Now it is commonly run at pressures below 100 atm.

What is the reason for this change?

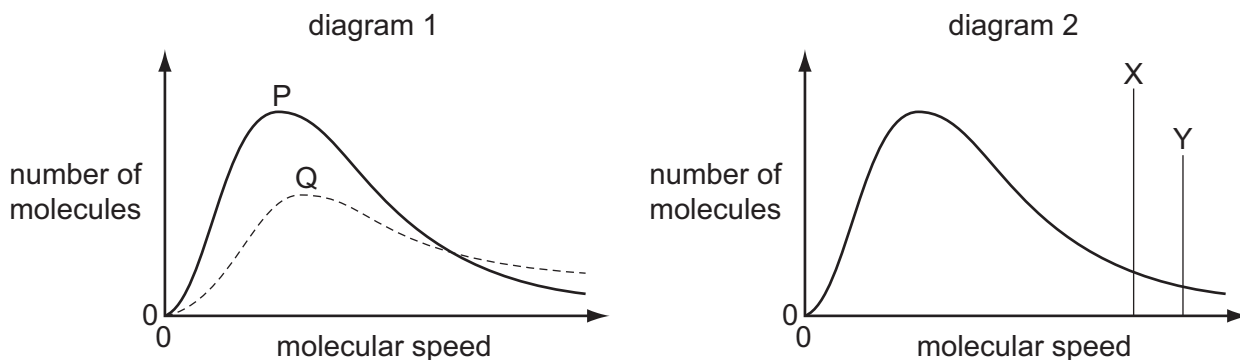
- A An iron catalyst is used.
 - B Maintaining the higher pressures is more expensive.
 - C The equilibrium yield of ammonia is increased at lower pressures.
 - D The rate of the reaction is increased at lower pressures.
- 6 In the diagram, curve X was obtained by observing the decomposition of 100 cm^3 of 1.0 mol dm^{-3} hydrogen peroxide, catalysed by manganese(IV) oxide.



Which alteration to the original experimental conditions would produce curve Y?

- A adding some 0.1 mol dm^{-3} hydrogen peroxide
- B adding water
- C lowering the temperature
- D using less manganese(IV) oxide

7 Different Boltzmann distributions are shown in the diagrams.



In diagram 1, one curve P or Q corresponds to a temperature higher than that of the other curve.

In diagram 2, one line X or Y corresponds to the activation energy for a catalysed reaction and the other line corresponds to the activation energy of the same reaction when uncatalysed.

Which combination gives the correct curve and line?

	higher temperature	presence of catalyst
A	P	X
B	P	Y
C	Q	X
D	Q	Y

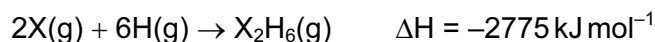
- 8 50 cm³ of 2.50 mol dm⁻³ hydrochloric acid was placed in a polystyrene beaker of negligible heat capacity. Its temperature was recorded and then 50 cm³ of 2.50 mol dm⁻³ NaOH at the same temperature was quickly added, with stirring. The temperature rose by 17 °C.

The resulting solution may be considered to have a specific heat capacity of 4.2 J g⁻¹ K⁻¹.

What is an approximate value for the molar enthalpy change of neutralisation of hydrochloric acid and sodium hydroxide from this experiment?

- A** $\frac{-(50 \times 4.2 \times 17)}{(0.050 \times 2.5)} \text{ J mol}^{-1}$
- B** $\frac{-(50 \times 4.2 \times 17)}{(0.10 \times 2.5)} \text{ J mol}^{-1}$
- C** $\frac{-(100 \times 4.2 \times 17)}{(0.050 \times 2.5)} \text{ J mol}^{-1}$
- D** $\frac{-(100 \times 4.2 \times 17)}{(50 \times 2.5)} \text{ J mol}^{-1}$

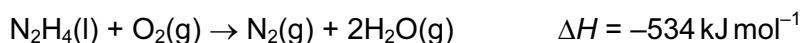
- 9 The equation below represents the combination of gaseous atoms of non-metal X and of hydrogen to form gaseous X_2H_6 molecules.



The bond energy of an X–H bond is 395 kJ mol^{-1} .

What is the bond energy of an X–X bond?

- A** $-405.0 \text{ kJ mol}^{-1}$
B $-202.5 \text{ kJ mol}^{-1}$
C $+202.5 \text{ kJ mol}^{-1}$
D $+405.0 \text{ kJ mol}^{-1}$
- 10 In which change would only van der Waals' forces have to be overcome?
- A** evaporation of ethanol $C_2H_5OH(l) \rightarrow C_2H_5OH(g)$
B melting of ice $H_2O(s) \rightarrow H_2O(l)$
C melting of solid carbon dioxide $CO_2(s) \rightarrow CO_2(l)$
D solidification of butane $C_4H_{10}(l) \rightarrow C_4H_{10}(s)$
- 11 Hydrazine, N_2H_4 , is widely used as a rocket fuel because it reacts with oxygen as shown, producing 'environmentally friendly' gases.



Despite its use as a rocket fuel, hydrazine does not burn spontaneously in oxygen.

Which statement explains why hydrazine does **not** burn spontaneously?

- A** Hydrazine is a liquid.
B The activation energy is too high.
C The $N \equiv N$ bond is very strong.
D The reaction is exothermic.
- 12 0.02 mol of aluminium is burned in oxygen and the product is reacted with 2.00 mol dm^{-3} hydrochloric acid.

What minimum volume of acid will be required for complete reaction?

- A** 15 cm^3 **B** 20 cm^3 **C** 30 cm^3 **D** 60 cm^3

- 13 Three substances, R, S and T, have physical properties as shown.

substance	R	S	T
mp/°C	801	2852	3550
bp/°C	1413	3600	4827
electrical conductivity of solid	poor	poor	good

What could be the identities of R, S and T?

	R	S	T
A	MgO	NaCl	C [graphite]
B	MgO	NaCl	SiO ₂
C	NaCl	MgO	C [graphite]
D	NaCl	MgO	SiO ₂

- 14 Steam is passed over heated magnesium to give compound X and hydrogen.

What is **not** a property of compound X?

- A** It has an M_r of 40.3.
 - B** It is basic.
 - C** It is a white solid.
 - D** It is very soluble in water.
- 15 Nitrogen monoxide, NO, is a primary pollutant produced by petrol engines and is found in their exhaust gases.

Which reaction occurs in a catalytic converter and decreases the emission of nitrogen monoxide?

- A** $\text{NO(g)} + \text{CO(g)} \rightarrow \text{NO}_2\text{(g)} + \text{C(s)}$
- B** $\text{NO(g)} + \text{CO}_2\text{(g)} \rightarrow \text{NO}_2\text{(g)} + \text{CO(g)}$
- C** $2\text{NO(g)} + 2\text{CO(g)} \rightarrow \text{N}_2\text{(g)} + 2\text{CO}_2\text{(g)}$
- D** $2\text{NO(g)} + \text{CO}_2\text{(g)} \rightarrow 2\text{NO}_2\text{(g)} + \text{C(s)}$

- 16 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 in 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^-

- 17 A student observed the reactions when sodium chloride and sodium iodide were each reacted separately with concentrated sulfuric acid and with concentrated phosphoric acid. The observations are recorded in the table.

	sodium chloride	sodium iodide
conc. H_2SO_4	colourless acidic gas formed	purple vapour formed
conc. H_3PO_4	colourless acidic gas formed	colourless acidic gas formed

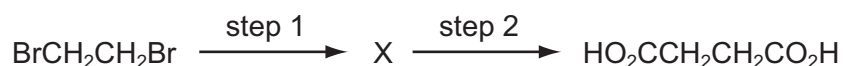
Which deduction can be made from these observations?

- A** Concentrated phosphoric acid is a stronger oxidising agent than concentrated sulfuric acid.
B Concentrated phosphoric acid is a stronger oxidising agent than iodine.
C Concentrated sulfuric acid is a stronger oxidising agent than chlorine.
D Concentrated sulfuric acid is a stronger oxidising agent than iodine.
- 18 Ammonium nitrate, NH_4NO_3 , is manufactured in large quantities for use in fertiliser.

Which statement about ammonium nitrate fertiliser is **not** correct?

- A** It can cause environmental problems.
B It consists of 35 % nitrogen by mass.
C It is insoluble in water.
D Nitric acid is used in its manufacture.

- 19 Butanedioic acid occurs in amber, algae, lichens, sugar cane and beets. It may be synthesised in two steps from 1,2-dibromoethane.



Which reagents could be used for this synthesis?

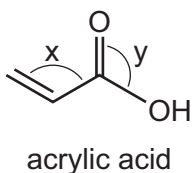
	step 1	step 2
A	HCN(g)	HCl(aq)
B	HCO ₂ Na(aq)	HCl(aq)
C	KCN(aq/alcoholic)	H ₂ SO ₄ (aq)
D	NaOH(aq)	K ₂ Cr ₂ O ₇ /H ₂ SO ₄ (aq)

- 20 The formula CH₃ can represent an anion, a cation or a free radical. Species with the molecular formula CH₃ can act as an electrophile, a free radical or a nucleophile depending on the number of outer shell electrons on the central carbon atom.

How many outer shell electrons must be present for CH₃ to act in these different ways?

	CH ₃ as an electrophile	CH ₃ as a free radical	CH ₃ as a nucleophile
A	6	7	8
B	6	8	7
C	7	6	8
D	8	7	6

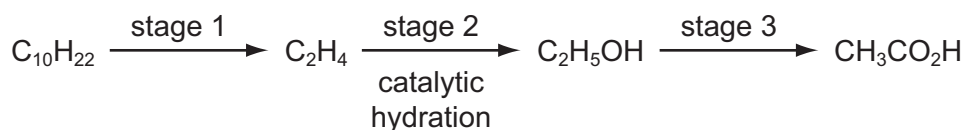
- 21 Acrylic acid is produced from propene, a gaseous product of oil refineries.



Which statement about acrylic acid is **not** correct?

- A** Both bond angles x and y are approximately 120°.
- B** It decolourises aqueous bromine.
- C** It gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent.
- D** It reacts with an alcohol to give an ester.

- 22 In the reaction pathway below, an alkane is converted into a carboxylic acid through several stages.



Which processes occur at stage 1 and at stage 3?

	stage 1	stage 3
A	condensation	combustion
B	cracking	dehydration
C	cracking	oxidation
D	dehydration	combustion

- 23 A compound Y is treated with warm acidified potassium dichromate(VI). The resulting organic product gives an orange precipitate with 2,4-dinitrophenylhydrazine reagent but does not give a silver mirror with Tollens' reagent.

What is Y?

- A** butan-1-ol
B butan-2-ol
C butanal
D 2-methylpropan-2-ol
- 24 Compound X changes the colour of warm acidified sodium dichromate(VI) from orange to green. 1 mol of X reacts with 2 mol of HCN in the presence of KCN.

What could X be?

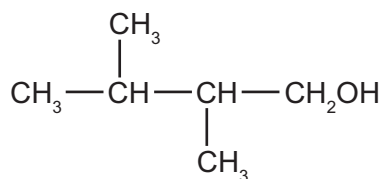
- A** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
B $\text{CH}_3\text{COCH}_2\text{COCH}_3$
C $\text{H}_2\text{C}=\text{CHCH}_2\text{CHO}$
D $\text{OHCCH}_2\text{CH}_2\text{CHO}$
- 25 Pentanol, $\text{C}_5\text{H}_{11}\text{OH}$, has four structural isomers that are primary alcohols.

How many of these primary alcohols contain a chiral carbon atom?

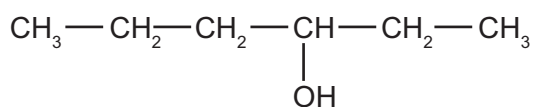
- A** 0 **B** 1 **C** 2 **D** 3

26 Which isomer of $C_6H_{13}OH$ gives the greatest number of different alkenes when it is dehydrated?

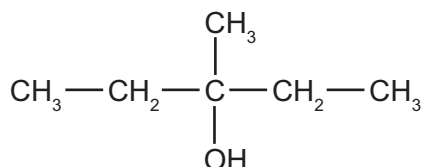
A



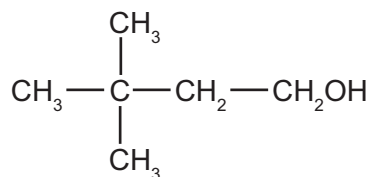
B



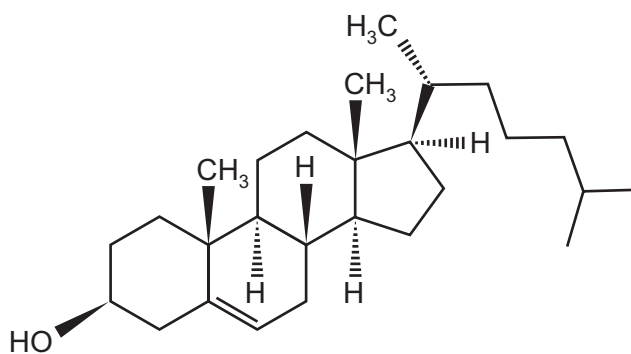
C



D



27 The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

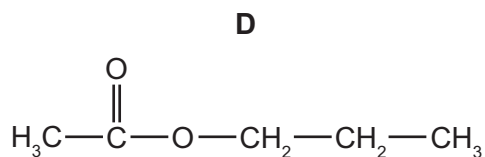
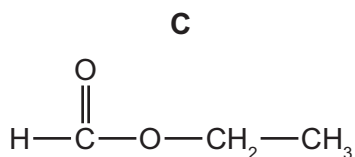
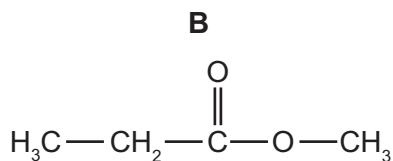
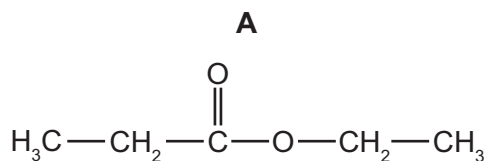
Student X claimed that the seventeen carbon atoms in the four rings all lie in the same plane.

Student Y claimed that this molecule displays *cis-trans* isomerism at the $C=C$ double bond.

Which of the students are correct?

- A** both X and Y
- B** neither X nor Y
- C** X only
- D** Y only

- 28 Which formula represents an ester which will form sodium ethanoate on hydrolysis with aqueous sodium hydroxide?



- 29 The functional group in a primary alcohol is $-\text{CH}_2\text{OH}$.

Which reagent reacts with a primary alcohol, under suitable conditions, to give an organic product with the same number of oxygen atoms as the alcohol?

- A** Al_2O_3 **B** $\text{CH}_3\text{CO}_2\text{H}$ **C** HBr **D** Na

- 30 Aldehydes and ketones are carbonyl compounds.

Which of them react with NaBH_4 **and** react with Fehling's reagent?

- A** both aldehydes and ketones
B aldehydes only
C ketones only
D neither aldehydes nor ketones

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

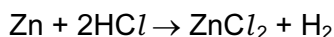
No other combination of statements is used as a correct response.

31 Which are features of the structure of metallic copper?

- 1** a lattice of ions
- 2** delocalised electrons
- 3** ionic bonds

32 *Use of the Data Booklet is relevant to this question.*

Zinc reacts with hydrochloric acid according to the following equation.



Which statements are correct?

[All volumes are measured at room conditions.]

- 1** A 3.27 g sample of zinc reacts with an excess of hydrochloric acid to give 0.050 mol of zinc chloride.
- 2** A 6.54 g sample of zinc reacts completely with exactly 100 cm³ of 1.00 mol dm⁻³ hydrochloric acid.
- 3** A 13.08 g sample of zinc reacts with an excess of hydrochloric acid to give 9.60 dm³ of hydrogen.

33 Which statements are correct in terms of the Brønsted-Lowry theory of acids and bases?

- 1** Water can act as either an acid or a base.
- 2** Sulfuric acid, H₂SO₄, does not behave as an acid when dissolved in ethanol, C₂H₅OH.
- 3** The ammonium ion acts as a base when dissolved in liquid ammonia.

34 Which descriptions of the ammonium ion are correct?

- 1 It contains ten electrons.
- 2 It has a bond angle of 109.5° .
- 3 It has only three bonding pairs of electrons.

35 *Use of the Data Booklet is relevant to this question.*

The element astatine lies below iodine in Group VII of the Periodic Table.

What will be the properties of astatine?

- 1 It forms diatomic molecules which dissociate more readily than chlorine molecules.
- 2 It reacts explosively with hydrogen.
- 3 It can oxidise iodide to iodine.

36 Which statements are correct?

- 1 Aluminium chloride dissolves in water to give an acidic solution.
- 2 Magnesium chloride dissolves in water to give a slightly acidic solution.
- 3 Sodium chloride dissolves in water to give an alkaline solution.

37 Which alkenes, on reaction with steam at 600 K and 6×10^6 Pa pressure in the presence of a phosphoric acid catalyst, could produce an alcohol containing a chiral carbon atom?

- 1 $(\text{CH}_3)_2\text{C}=\text{CH}_2$
- 2 $\text{CH}_3\text{CH}=\text{CHCH}_3$
- 3 $\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$

38 Which oxides react with water to give a solution of pH 10 or higher?

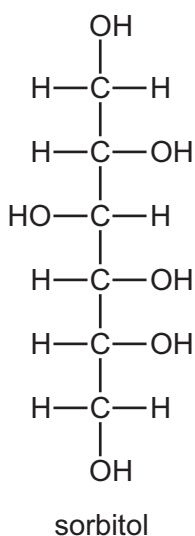
- 1 CaO
- 2 Na_2O
- 3 SrO

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 Sorbitol is an artificial sweetener used to sweeten chocolate which is suitable for diabetics.



Which functional groups can be produced when this molecule is subjected to oxidation under suitable conditions?

- 1** aldehyde
- 2** carboxylic acid
- 3** ketone

40 Bromoethane undergoes all of the conversions shown.

Which conversions are examples of nucleophilic substitution?

- 1** $\text{C}_2\text{H}_5\text{Br} \rightarrow \text{C}_2\text{H}_5\text{CN}$
- 2** $\text{C}_2\text{H}_5\text{Br} \rightarrow \text{C}_2\text{H}_5\text{OH}$
- 3** $\text{C}_2\text{H}_5\text{Br} \rightarrow \text{C}_2\text{H}_5\text{NH}_2$

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