



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

CHEMISTRY

9701/11

Paper 1 Multiple Choice

October/November 2010

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 **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 Every year millions of tonnes each of chlorine and sodium hydroxide are manufactured by the electrolysis of brine using a 'diaphragm cell'.

What is the purpose of the diaphragm in such a cell?

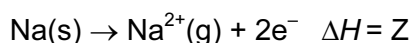
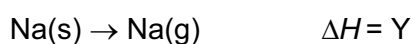
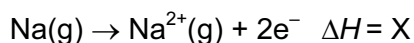
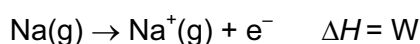
- A** to prevent chlorine gas escaping into the factory
- B** to prevent the build up of pressure in the electrolysis cell
- C** to provide a large surface area of electrode
- D** to stop the products of electrolysis from reacting together

- 2 A simple ion X^+ contains eight protons.

What is the electronic configuration of X^+ ?

- A** $1s^2 \quad 2s^1 \quad 2p^6$
- B** $1s^2 \quad 2s^2 \quad 2p^3$
- C** $1s^2 \quad 2s^2 \quad 2p^5$
- D** $1s^2 \quad 2s^2 \quad 2p^7$

- 3 Equations involving four enthalpy changes are shown.



What is the second ionisation energy of sodium?

- A** $2W$
- B** $X - W$
- C** $Y - W$
- D** $Z - Y$

- 4 Sulfur dioxide, SO_2 , is added to wines to prevent oxidation of ethanol by air. To determine the amount of SO_2 , a sample of wine is titrated with iodine, I_2 . In this reaction, **one** mole of SO_2 is oxidised by **one** mole of I_2 .

What is the change in oxidation number of sulfur in this reaction?

- A** +2 to +4
- B** +2 to +6
- C** +4 to +5
- D** +4 to +6

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

Nickel makes up 20 % of the total mass of a coin. The coin has a mass of 10.0 g.

How many nickel atoms are in the coin?

- A 2.05×10^{22} B 4.30×10^{22} C 1.03×10^{23} D 1.20×10^{24}

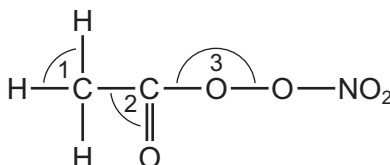
- 6 Which ion has more electrons than protons and more protons than neutrons?

[H = ${}^1_1\text{H}$; D = ${}^2_1\text{H}$; O = ${}^{16}_8\text{O}$]

- A D^- B H_3O^+ C OD^- D OH^-

- 7 Organic nitrates in photochemical smog can cause breathing difficulties.

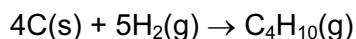
The diagram shows an example of an organic nitrate molecule.



What is the correct order of the bond angles shown in ascending order (smallest first)?

- A $1 \rightarrow 2 \rightarrow 3$ B $2 \rightarrow 1 \rightarrow 3$ C $3 \rightarrow 1 \rightarrow 2$ D $3 \rightarrow 2 \rightarrow 1$

- 8 Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.



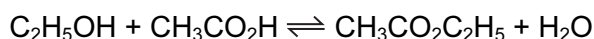
By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, $\Delta H_f^\ominus$, for this reaction?

compound	$\Delta H_c^\ominus / \text{kJ mol}^{-1}$
carbon	−394
hydrogen	−286
butane	−2877

- A −5883 kJ mol^{−1}
 B −129 kJ mol^{−1}
 C +129 kJ mol^{−1}
 D +2197 kJ mol^{−1}
- 9 In a calorimetric experiment 1.60 g of a fuel is burnt. 45 % of the energy released is absorbed by 200 g of water whose temperature rises from 18 °C to 66 °C. The specific heat capacity of water is 4.2 J g^{−1} K^{−1}.

What is the total energy released per gram of fuel burnt?

- A 25 200 J B 56 000 J C 89 600 J D 143 360 J
- 10 The value of the equilibrium constant, K_c , for the reaction to form ethyl ethanoate from ethanol and ethanoic acid is 4.0 at 60 °C.



When 1.0 mol of ethanol and 1.0 mol of ethanoic acid are allowed to reach equilibrium at 60 °C, what is the number of moles of ethyl ethanoate formed?

- A $\frac{1}{3}$ B $\frac{2}{3}$ C $\frac{1}{4}$ D $\frac{3}{4}$
- 11 Which equation represents the change corresponding to the enthalpy change of atomisation of iodine?
- A $\frac{1}{2} \text{I}_2\text{(g)} \rightarrow \text{I(g)}$
 B $\text{I}_2\text{(g)} \rightarrow 2\text{I(g)}$
 C $\frac{1}{2} \text{I}_2\text{(s)} \rightarrow \text{I(g)}$
 D $\text{I}_2\text{(s)} \rightarrow 2\text{I(g)}$

- 12 Camphor is a white solid which was used to make the early plastic celluloid. Camphor contains the same percentage by mass of hydrogen and oxygen.

What is the molecular formula of camphor?

- A $C_{10}H_6O_6$ B $C_{10}H_8O$ C $C_{10}H_{16}O$ D $C_{10}H_{10}O_2$

- 13 Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?

- A A phosphorus atom has one more proton in its nucleus.
 B The atomic radius of a phosphorus atom is greater.
 C The outer electron in a phosphorus atom is more shielded.
 D The outer electron in a phosphorus atom is paired.

- 14 When magnesium nitrate, $Mg(NO_3)_2 \cdot 7H_2O$, is heated, which three gases are given off?

- A dinitrogen oxide, oxygen, water vapour
 B hydrogen, nitrogen, oxygen
 C hydrogen, nitrogen dioxide, oxygen
 D nitrogen dioxide, oxygen, water vapour

- 15 Ammonium sulfate in nitrogenous fertilisers in the soil can be slowly oxidised by air producing sulfuric acid, nitric acid and water.

How many moles of oxygen gas are needed to oxidise completely one mole of ammonium sulfate?

- A 1 B 2 C 3 D 4

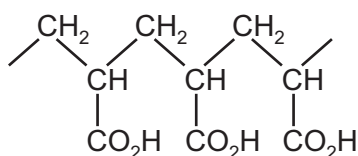
- 16 Chile saltpetre, $NaNO_3$, contains sodium iodide as an impurity.

Aqueous silver nitrate is added to an aqueous solution of Chile saltpetre. Concentrated aqueous ammonia is then added.

Which observations are made?

	with acidified silver nitrate	with concentrated aqueous ammonia
A	no precipitate	no further reaction
B	no precipitate	precipitate forms
C	precipitate forms	precipitate dissolves
D	precipitate forms	precipitate remains

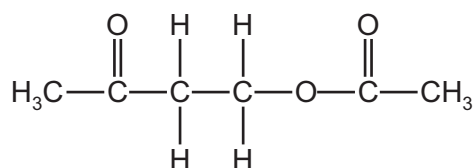
- 17 Which statement describes the halogens chlorine, bromine and iodine?
- A Their bond energies decrease with increasing proton number.
 - B Their first ionisation energies increase with increasing proton number.
 - C They are all coloured gases at room temperature.
 - D They are all good reducing agents.
- 18 Sulfur dioxide is used to bleach wood pulp in the production of paper. It is also used as an additive in the production of jam and marmalade, often in the form of sulfite compounds. When it is present in quantities greater than 10 mg / kg it is required to be listed as an ingredient of the jam.
- Why is sulfur dioxide added to jam?
- A It is a bleaching agent and removes the undesirable colours from the fruit used in the jam.
 - B It is a preservative that destroys unwanted bacteria and enzymes.
 - C It is a reducing agent and removes the acids that give the jam a sharp taste.
 - D It is an acidic gas and maintains the pH of the jam at a suitable value to give it a sharp taste.
- 19 Which property of beryllium and its compounds is typical of the elements below it in Group II?
- A Be does not react with hot water.
 - B BeCl_2 is covalent.
 - C $\text{Be}(\text{NO}_3)_2$ produces BeO on thermal decomposition.
 - D BeO dissolves in alkalis.
- 20 One of the characteristics of addition polymerisation is that the empirical formulae of the polymer and of its monomer are the same. The absorbent material in babies' disposable nappies is made from the addition polymer shown.



From which monomer could this addition polymer be obtained?

- A $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$
- B $\text{HOCH}_2\text{CH}_2\text{CO}_2\text{H}$
- C $\text{H}_2\text{C}=\text{CHCO}_2\text{H}$
- D $\text{HO}_2\text{CCH}=\text{CHCO}_2\text{H}$

- 21 Compound X reacts with ethanoic acid in the presence of an H^+ catalyst to produce the compound below.



What is the molecular formula of compound X?

- A** $\text{C}_2\text{H}_6\text{O}_2$ **B** $\text{C}_2\text{H}_6\text{O}_3$ **C** $\text{C}_4\text{H}_8\text{O}$ **D** $\text{C}_4\text{H}_8\text{O}_2$

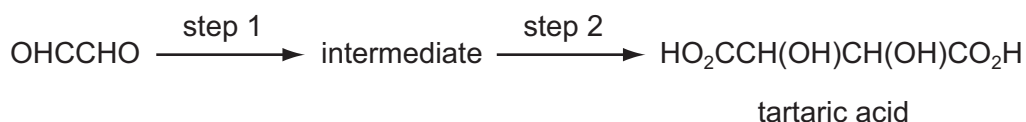
- 22 A compound Y has all of the properties below.

- It is a liquid at 25°C .
- It mixes completely with water.
- It reacts with aqueous sodium hydroxide.

What could Y be?

- A** ethanoic acid
B ethanol
C ethene
D ethyl ethanoate

- 23 Tartaric acid is present in some wines. It may be synthesised in the laboratory in two steps.



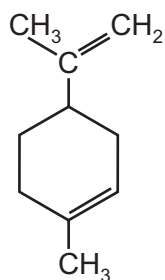
Which reagents could be used for this synthesis?

	step 1	step 2
A	HCl(aq)	HCN(g)
B	$\text{HCN, NaCN(aq/alcoholic)}$	$\text{H}_2\text{SO}_4\text{(aq)}$
C	$\text{H}_2\text{SO}_4\text{(aq)}$	$\text{K}_2\text{Cr}_2\text{O}_7 / \text{H}_2\text{SO}_4\text{(aq)}$
D	KCN(aq/alcoholic)	$\text{K}_2\text{Cr}_2\text{O}_7 / \text{H}_2\text{SO}_4\text{(aq)}$

24 Which alcohol gives only **one** possible oxidation product when warmed with dilute acidified potassium dichromate(VI)?

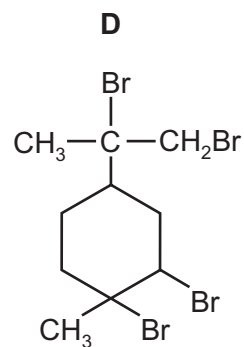
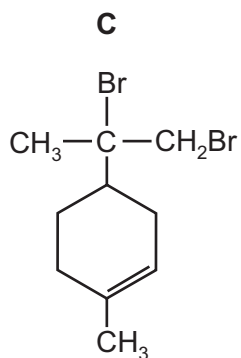
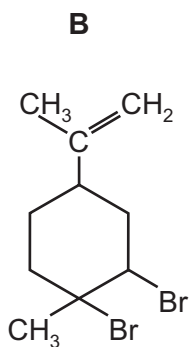
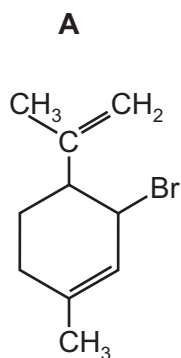
- A butan-1-ol
- B butan-2-ol
- C 2-methylpropan-1-ol
- D 2-methylpropan-2-ol

25 Limonene is an oil formed in the peel of citrus fruits.

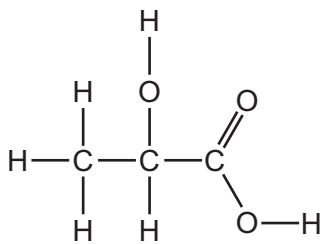


limonene

Which product is formed when an excess of bromine, $\text{Br}_2(\text{l})$, reacts with limonene at room temperature in the dark?



- 26 Lactic acid occurs naturally, for example in sour milk.

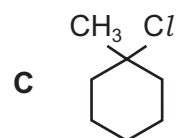


lactic acid

What is a property of lactic acid?

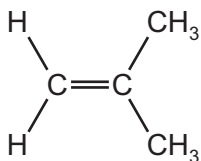
- A It decolourises aqueous bromine rapidly.
 - B It is insoluble in water.
 - C It reduces Fehling's reagent.
 - D Two molecules react with each other in the presence of a strong acid.
- 27 Which compound would undergo nucleophilic addition?
- A bromoethane, $\text{C}_2\text{H}_5\text{Br}$
 - B ethanal, CH_3CHO
 - C ethane, C_2H_6
 - D ethene, C_2H_4
- 28 Which compound undergoes an $\text{S}_{\text{N}}1$ substitution reaction?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$
- B $(\text{CH}_3)_3\text{CCH}_2\text{I}$



- D $\text{CH}_2=\text{CHCl}$

- 29 The compound 2-methylpropene, C_4H_8 , is a monomer used in the production of synthetic rubber.



In addition to 2-methylpropene there are x other isomers of C_4H_8 , structural or otherwise, which contain a double bond.

What is the value of x ?

- A** 1 **B** 2 **C** 3 **D** 4
- 30 Which environmental problem is **not** made worse by the release of oxides of nitrogen from car engines?
- A** acidification of lakes
B corrosion of buildings
C photochemical smog
D the hole in the ozone layer

Section B

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

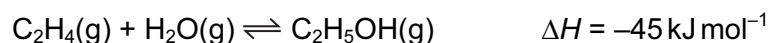
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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** Ethanol is manufactured by reacting ethene gas and steam in the presence of phosphoric(V) acid.



The reaction is carried out at 570 K and 60 atm.

What would be the consequences of carrying out the reaction at the same temperature but at a pressure of 200 atm?

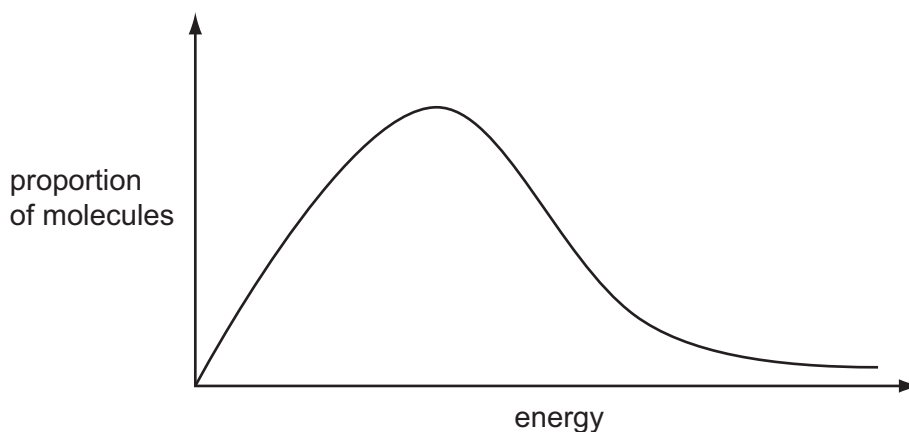
- 1** The manufacturing costs would increase.
- 2** The maximum yield at equilibrium would be higher.
- 3** The reaction would proceed at a faster rate.

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

A	B	C	D
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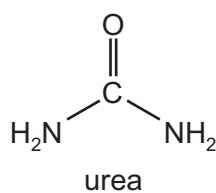
32 The diagram represents the Boltzmann distribution of molecular energies at a given temperature.



Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

- 1 increasing the concentration of reactants
- 2 increasing the temperature
- 3 the addition of a catalyst

33 Which types of intermolecular forces can exist between adjacent urea molecules?



- 1 hydrogen bonding
- 2 permanent dipole-dipole forces
- 3 temporary induced dipole-dipole forces

- 34 Samples of calcium and barium are separately added to beakers of cold water containing a few drops of litmus solution.

Which observations will be made with **only** the calcium and **not** with the barium?

- 1 A white suspension appears in the water.
- 2 The solution turns blue.
- 3 A gas is evolved.

- 35 Disproportionation is the term used to describe a reaction in which a reactant is simultaneously both oxidised and reduced.

To which incomplete equations does the term disproportionation apply?

- 1 $\text{Cl}_2(\text{g}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{Cl}^-(\text{aq}) + \dots\dots$
- 2 $3\text{Cl}_2(\text{g}) + 6\text{OH}^-(\text{aq}) \rightarrow 3\text{H}_2\text{O}(\text{l}) + \text{ClO}_3^-(\text{aq}) + \dots\dots$
- 3 $2\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{HNO}_3(\text{aq}) + \dots\dots$

- 36 Element X is a solid. It occurs as a contaminant of carbonaceous fuels.

Its oxide Y is formed in car engines.

Further oxidation of Y to Z can occur in the atmosphere.

Which statements about Y and Z are correct?

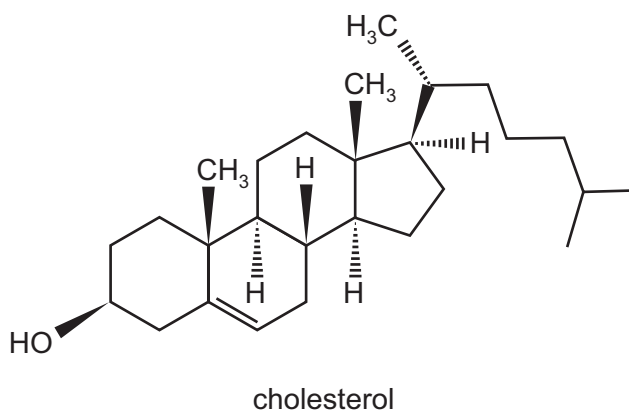
- 1 Molecule Y has lone pairs of electrons.
- 2 The atmospheric oxidation of Y to Z is a catalysed reaction.
- 3 Y is a colourless gas.

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

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

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

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



Which statements about cholesterol are correct?

- 1 The molecule contains a secondary alcohol group.
- 2 The molecule contains two π bonds.
- 3 All carbon atoms in the four rings lie in the same plane.

38 Glyceraldehyde, $\text{HOCH}_2\text{CH}(\text{OH})\text{CHO}$, is formed during photosynthesis, and contains a chiral carbon atom.

Which reagents will react with glyceraldehyde to produce an organic product **without** a chiral carbon atom?

- 1 warmed acidified $\text{K}_2\text{Cr}_2\text{O}_7$
- 2 NaBH_4
- 3 Tollens' reagent

- 39** An organic compound decolourises aqueous bromine and reacts with sodium to produce hydrogen.

Which molecular formula could represent this compound?

- 1** $\text{C}_3\text{H}_6\text{O}$
- 2** $\text{C}_3\text{H}_4\text{O}_2$
- 3** $\text{C}_3\text{H}_8\text{O}$

- 40** Textiles for use in aircraft are treated with a finish containing a halogenoalkane.

What is the reason for this?

- 1** The textile burns less easily, improving safety.
- 2** The fabric forms hydrogen bonds to water more readily, making the fabric easier to wash.
- 3** The halogenoalkane undergoes addition polymerisation, stiffening the fabric.

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CHEMISTRY

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Section A

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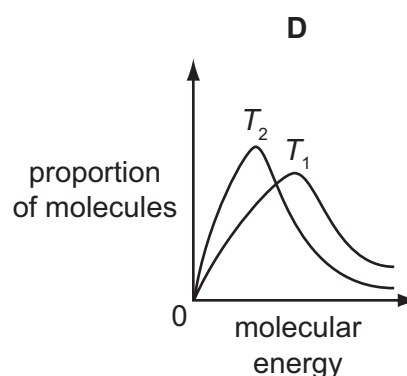
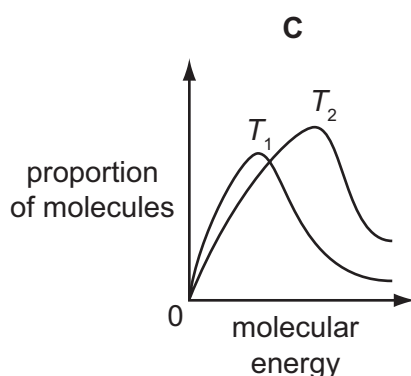
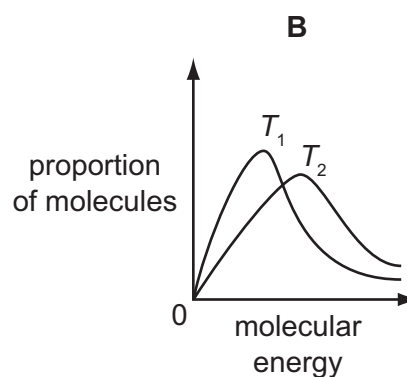
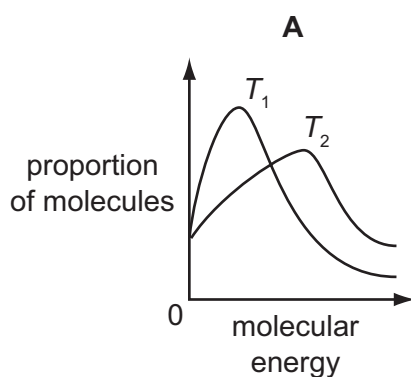
- 1 The ability of an atom in a covalent bond to attract electrons to itself is called its electronegativity.

The greater the difference between the electronegativities of the two atoms in the bond, the more polar is the bond.

Which pair will form the most polar covalent bond between the atoms?

- A** chlorine and bromine
- B** chlorine and iodine
- C** fluorine and chlorine
- D** fluorine and iodine

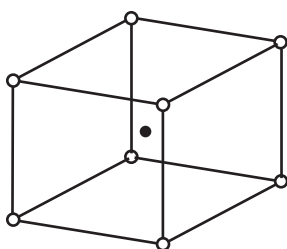
- 2 Which diagram correctly represents the Boltzmann distribution of molecular energies at two temperatures T_1 and T_2 , where $T_1 = 300\text{ K}$ and $T_2 = 310\text{ K}$?



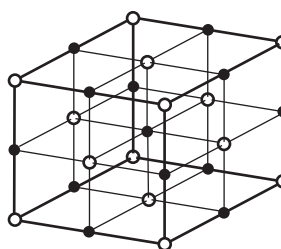
3 The table gives the radii, in pm, of some ions. [$1\text{ pm} = 10^{-12}\text{ m}$]

ion	radii
Na^+	102
Mg^{2+}	72
Cs^+	167
Cl^-	181
O^{2-}	140

Caesium chloride, CsCl , has a different lattice structure from both sodium chloride, NaCl , and magnesium oxide, MgO .



CsCl lattice

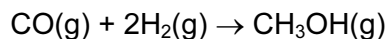


NaCl and MgO lattice

Which factor appears to determine the type of lattice for these three compounds?

- A** the charge on the cation
- B** the ratio of the ionic charges
- C** the ratio of the ionic radii
- D** the sum of the ionic charges

- 4 Methanol may be prepared by the reaction between carbon monoxide and hydrogen.



The relevant average bond energies are given below.

$$E(\text{C}\equiv\text{O}) \quad 1077 \text{ kJ mol}^{-1}$$

$$E(\text{C}-\text{O}) \quad 360 \text{ kJ mol}^{-1}$$

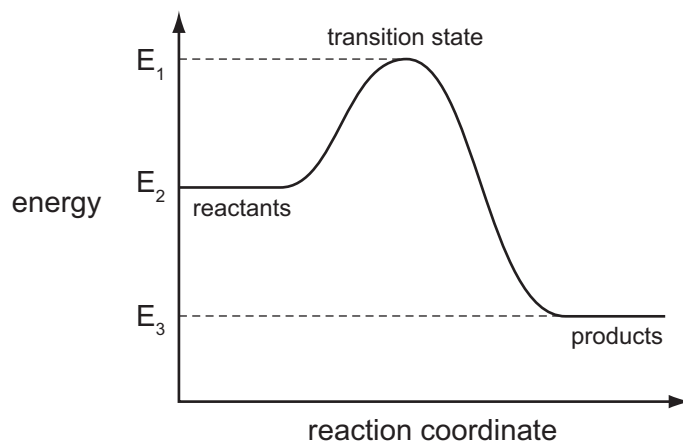
$$E(\text{C}-\text{H}) \quad 410 \text{ kJ mol}^{-1}$$

$$E(\text{H}-\text{H}) \quad 436 \text{ kJ mol}^{-1}$$

$$E(\text{O}-\text{H}) \quad 460 \text{ kJ mol}^{-1}$$

What is the enthalpy change of this reaction?

- A** -537 kJ mol^{-1}
B -101 kJ mol^{-1}
C $+101 \text{ kJ mol}^{-1}$
D $+537 \text{ kJ mol}^{-1}$
- 5 Which solid has a simple molecular lattice?
- A** calcium fluoride
B nickel
C silicon(IV) oxide
D sulfur
- 6 The reaction pathway diagram below illustrates the energies of reactants, products and the transition state of a reaction.



Which expression represents the activation energy of the forward reaction?

- A** $E_1 - E_2$ **B** $E_1 - E_3$ **C** $E_2 - E_3$ **D** $(E_1 - E_2) - (E_2 - E_3)$

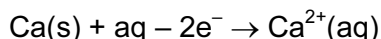
- 7 Flask X contains 5 dm³ of helium at 12 kPa pressure and flask Y contains 10 dm³ of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

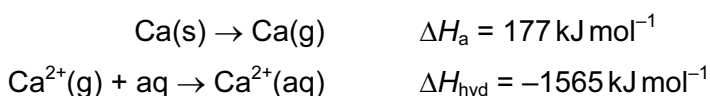
- A 8 kPa B 9 kPa C 10 kPa D 11 kPa

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

The enthalpy change of formation, ΔH_f , of hydrated calcium ions is the enthalpy change of the following reaction.



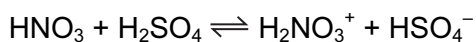
The following enthalpy changes are **not** quoted in the *Data Booklet*.



What is the enthalpy change of formation of hydrated calcium ions?

- A $-1388 \text{ kJ mol}^{-1}$
B -798 kJ mol^{-1}
C -238 kJ mol^{-1}
D $+352 \text{ kJ mol}^{-1}$

- 9 The following equilibrium is set up in a mixture of concentrated nitric and sulfuric acids.

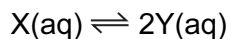


Which row correctly describes the behaviour of each substance in the equilibrium mixture?

	HNO ₃	H ₂ SO ₄	H ₂ NO ₃ ⁺	HSO ₄ ⁻
A	acid	acid	base	base
B	acid	base	base	acid
C	base	acid	acid	base
D	base	acid	base	acid

- 10 Which molecule or structure does **not** contain three atoms bonded at an angle between 109° and 110°?
- A ethanoic acid
B graphite
C propane
D silicon(IV) oxide

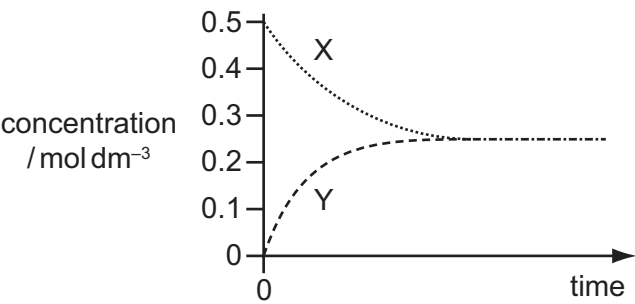
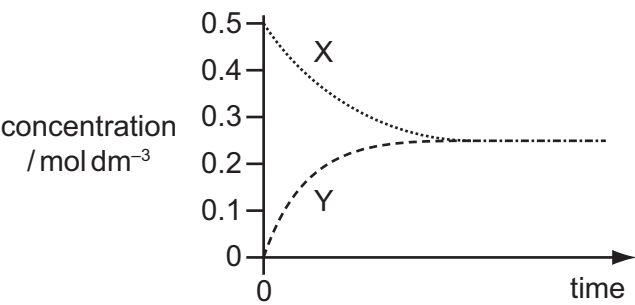
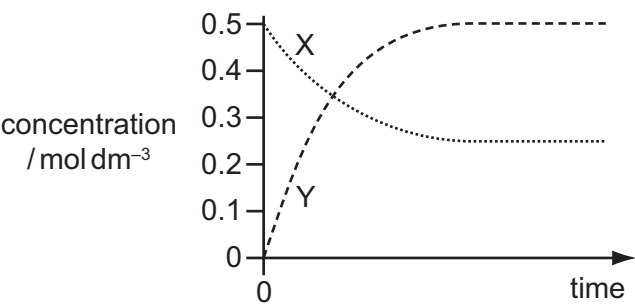
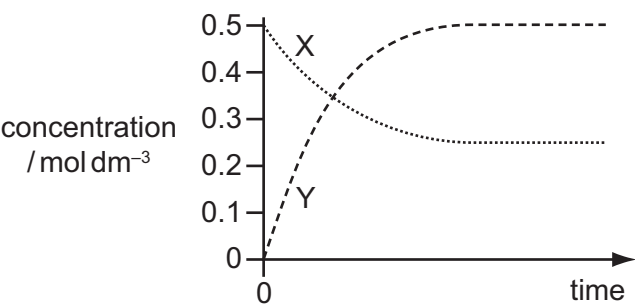
- 11 A dimer, X, is stable when solid but a dynamic equilibrium is set up in solution.



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

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

Which graph and value for K_c are correct?

	graph	$K_c / \text{mol dm}^{-3}$
A		1
B		2
C		1
D		2

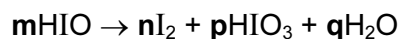
- 12 Equimolar quantities of magnesium carbonate and strontium carbonate are separately heated to bring about complete thermal decomposition. The minimum temperature for this to occur is called T_d .

The cold residues are separately added to equal volumes of water and the change in pH is measured. The change in pH is called ΔpH .

Which metal has the higher value of T_d , and the greater value of ΔpH ?

	T_d	ΔpH
A	Mg	Mg
B	Mg	Sr
C	Sr	Mg
D	Sr	Sr

- 13 In aqueous solution, the acid HIO disproportionates according to the following equation where **m**, **n**, **p** and **q** are simple whole numbers in their lowest ratios.



This equation can be balanced using oxidation numbers.

What are the values for **n** and **p**?

	n	p
A	1	2
B	2	1
C	4	1
D	4	2

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

Which mass of solid residue can be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

- A** 0.70g **B** 1.00g **C** 1.40g **D** 2.25g

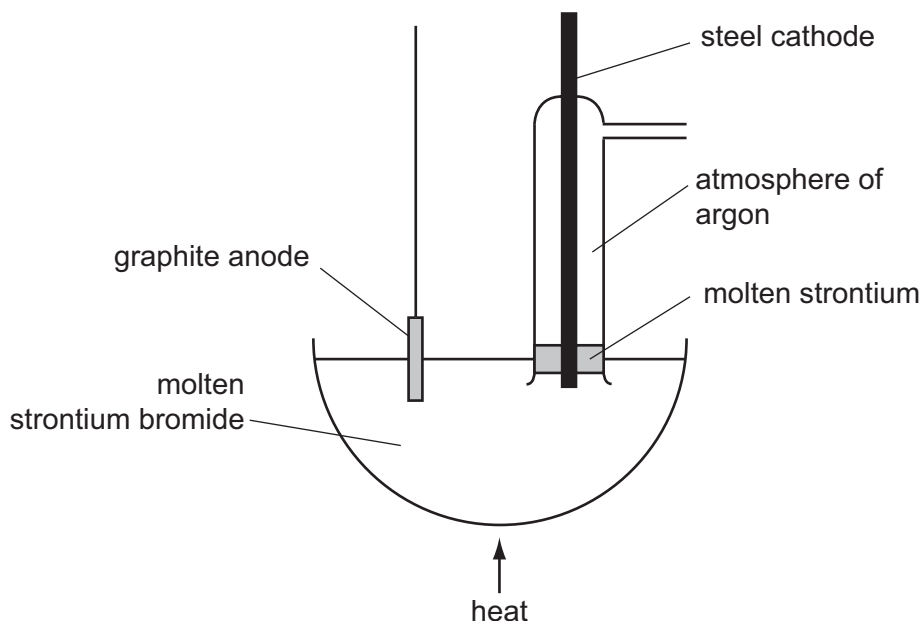
- 15 Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

- A** The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+ .
B NH_4Cl dissociates less fully than NaCl .
C The Na^+ and Mg^{2+} ions are isoelectronic (have the same number of electrons).
D The NH_4^+ ion can donate a proton.

16 What happens when chlorine is bubbled through aqueous potassium iodide?

- A Chlorine is oxidised to chlorate(V) ions.
- B Chlorine is oxidised to chloride ions.
- C Iodide ions are oxidised to iodine.
- D There is no observable reaction.

17 Strontium metal can be obtained by the electrolysis of molten strontium bromide, SrBr_2 , using the apparatus shown in the diagram.



Why is an atmosphere of argon used around the cathode?

- A A thin film of a compound of strontium and argon forms on the surface protecting the freshly formed metal.
- B The argon keeps the strontium molten.
- C The argon stops the molten strontium rising too high in the tube.
- D Without the argon, strontium oxide would form in the air.

18 Which statement about bromine is correct?

- A Bromine is insoluble in non-polar solvents.
- B Bromine vapour is more dense than air.
- C Bromine will not vapourise significantly under normal conditions.
- D Gaseous bromine is purple.

- 19 Concentrated sulfuric acid reacts with both solid sodium chloride at room temperature and with solid sodium iodide at room temperature.

Which row correctly describes how concentrated sulfuric acid behaves in each of these reactions?

	with sodium chloride	with sodium iodide
A	as an oxidising agent only	as an oxidising agent only
B	as a strong acid and as an oxidising agent	as a strong acid only
C	as a strong acid only	as a strong acid and as an oxidising agent
D	as a strong acid only	as a strong acid only

- 20 How many structural isomers are there of trichloropropane, $C_3H_5Cl_3$?

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

- 21 Nine compounds have molecular formula $C_4H_8Br_2$.

Which compound may be synthesised from an alkene by an addition reaction?

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

- 22 When ethanal, CH_3CHO , reacts with HCN and the organic product is hydrolysed by aqueous acid, organic compound Y is formed.

When propanal, C_2H_5CHO , is heated under reflux with acidified potassium dichromate(VI), organic compound Z is formed.

What is the difference in relative molecular mass of compounds Y and Z?

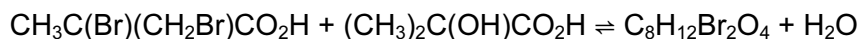
A 12 **B** 14 **C** 16 **D** 17

- 23 Which sequence of reagents may be used in the laboratory to convert propan-1-ol into 2-bromopropane?

- A** concentrated sulfuric acid, followed by bromine
B concentrated sulfuric acid, followed by hydrogen bromide
C ethanolic sodium hydroxide, followed by bromine
D ethanolic sodium hydroxide, followed by hydrogen bromide

- 24** Esters are frequently used as solvents and as flavouring agents in fruit drinks and confectionery.

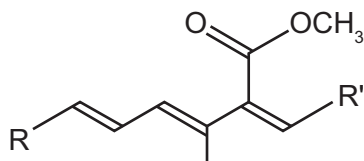
An ester $C_8H_{12}Br_2O_4$ can be prepared in low yield by the reaction shown.



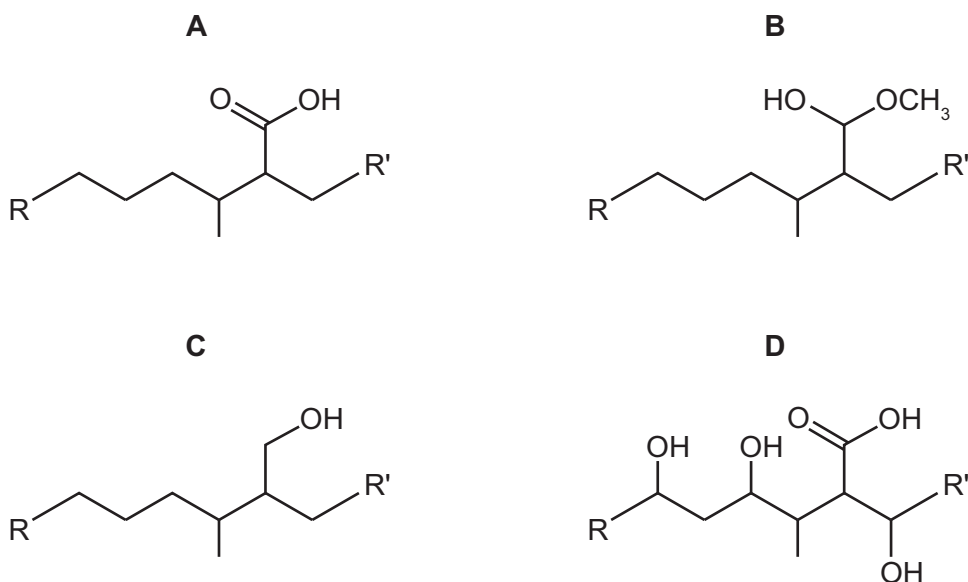
What is the structural formula of the ester $C_8H_{12}Br_2O_4$?

- A** $CH_3C(Br)(CH_2Br)CO_2C(CH_3)_2CO_2H$
- B** $CH_3C(Br)(CH_2Br)CO_2C(OH)(CH_3)CO_2CH_3$
- C** $CH_3C(Br)(CH_3)CO_2C(CH_3)_2CO_2CH_2Br$
- D** $(CH_3)_2C(Br)C(CO_2H)(CH_2Br)CO_2CH_3$
- 25** Many, but not all, organic reactions need to be heated before reaction occurs.
- Which reaction occurs at a good rate at room temperature (20 °C)?
- A** $C_{10}H_{22} \rightarrow C_8H_{18} + C_2H_4$
- B** $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$
- C** $CH_3CH_2OH + KBr \rightarrow CH_3CH_2Br + KOH$
- D** $(CH_3)_2CO + H_2NNHC_6H_3(NO_2)_2 \rightarrow (CH_3)_2C=NNHC_6H_3(NO_2)_2 + H_2O$
- 26** Which pair of reagents will take part in a redox reaction?
- A** $CH_3CH_2OH + \text{concentrated } H_2SO_4$
- B** $CH_3CHO + \text{Tollens' reagent}$
- C** $CH_3CO_2C_2H_5 + \text{dilute } H_2SO_4$
- D** $CH_3COCH_3 + \text{Fehling's solution}$

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

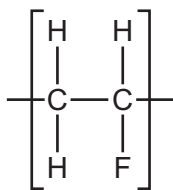


If strobilurin is first warmed with aqueous sulfuric acid, and its product then treated with hydrogen in the presence of a palladium catalyst, what could be the structure of the final product?



28 Fluoroalkenes are used to make polymers such as poly(vinyl)fluoride (PVF).

PVF is used to make non-flammable interiors for aircraft. The diagram shows the repeat unit of the polymer PVF.



What is the skeletal formula of the monomer of PVF?

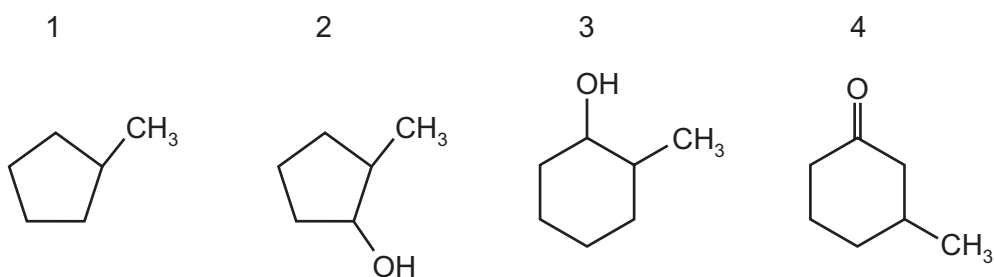


29 $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$ reacts with hydrogen cyanide to form a cyanohydrin.

Which feature applies to the product?

- A It has one chiral centre.
- B It is formed by electrophilic addition.
- C It is formed via a C–OH intermediate.
- D Its formation requires the use of cyanide ions as a catalyst.

30 Which of the compounds shown have chiral carbon atoms?



- A 1, 2, 3 and 4
- B 1 and 4 only
- C 2 and 3 only
- D 2, 3 and 4 only

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.

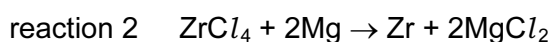
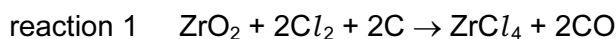
- 31** When ammonia, NH_3 , is produced in a school or college laboratory, it is usually dried before being collected.

Which drying agents may be used to dry ammonia?

- 1** calcium oxide, CaO
- 2** phosphorus(V) oxide, P_4O_{10}
- 3** concentrated sulfuric acid, H_2SO_4

- 32** Zirconium, Zr, proton number 40, is a metal which is used in corrosion-resistant alloys.

Zirconium metal is extracted from the oxide ZrO_2 by the following sequence of reactions.



Which statements about this extraction process are correct?

- 1** Carbon in reaction 1 behaves as a reducing agent.
- 2** Magnesium in reaction 2 behaves as a reducing agent.
- 3** Chlorine in reaction 1 behaves as a reducing agent.

- 33** Which statements about covalent bonds are correct?

- 1** A triple bond consists of one π bond and two σ bonds.
- 2** The electron density in a σ bond is highest along the axis between the two bonded atoms.
- 3** A π bond restricts rotation about the σ bond axis.

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

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

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

- 34** A student puts 10 cm^3 of 0.100 mol dm^{-3} sulfuric acid into one test-tube and 10 cm^3 of 0.100 mol dm^{-3} ethanoic acid into another test-tube. He then adds 1.0 g (an excess) of magnesium ribbon to each test-tube and takes suitable measurements. Both acids have the same starting temperature.

Neither reaction is complete after 2 minutes, but both are complete after 20 minutes.

Which statements are correct?

- 1** After 2 minutes, the sulfuric acid is at a higher temperature than the ethanoic acid.
- 2** After 2 minutes, the sulfuric acid has produced more gas than the ethanoic acid.
- 3** After 20 minutes, the sulfuric acid has produced more gas than the ethanoic acid.

- 35** In which ways are the main reactions in the Haber and Contact processes similar?

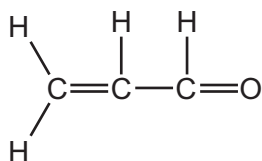
- 1** A higher yield is favoured by higher pressures.
- 2** The reaction is a redox process.
- 3** The forward reaction is exothermic.

- 36** A car burning lead-free fuel has a catalytic converter fitted to its exhaust. On analysis its exhaust gases are shown to contain small quantities of nitrogen oxides.

Which modifications would result in lower exhaust concentrations of nitrogen oxides?

- 1** an increase in the surface area of the catalyst in the converter
- 2** an increase in the rate of flow of the exhaust gases through the converter
- 3** a much higher temperature of combustion in the engine

37 The diagram shows a compound present in smoke from burning garden waste.



Which reagents would undergo a colour change on reaction with this compound?

- 1 aqueous bromine
- 2 Fehling's reagent
- 3 warm acidified $\text{K}_2\text{Cr}_2\text{O}_7$

38 Organic acids and alcohols react together to form esters.

Which pairs of compounds could produce a product of molecular formula $\text{C}_4\text{H}_6\text{O}_4$?

- 1 $\text{CH}_3\text{CO}_2\text{H}$ and $\text{C}_2\text{H}_5\text{OH}$
- 2 HCO_2H and $\text{HOCH}_2\text{CH}_2\text{OH}$
- 3 $\text{HO}_2\text{CCO}_2\text{H}$ and CH_3OH

39 *Use of the Data Booklet is relevant for this question.*

In an organic synthesis, a 62 % yield of product is achieved.

Which of these conversions are consistent with this information?

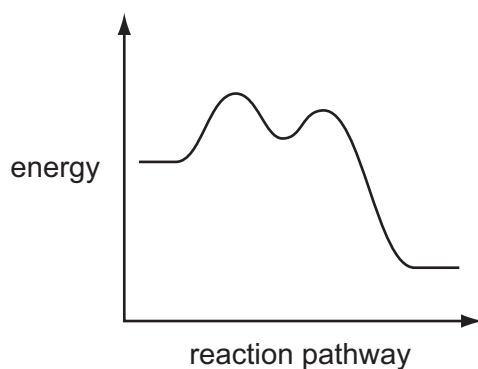
- 1 74.00g of butan-2-ol $\rightarrow$ 44.64 g of butanone
- 2 74.00g of butan-1-ol $\rightarrow$ 54.56 g of butanoic acid
- 3 74.00g of 2-methylpropan-1-ol $\rightarrow$ 54.56 g of 2-methylpropanoic acid

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.

40 A reaction pathway diagram is shown.



Which reactions would have such a profile?

- 1** $(\text{CH}_3)_3\text{CBr} + \text{NaOH} \rightarrow (\text{CH}_3)_3\text{COH} + \text{NaBr}$
- 2** $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaBr}$
- 3** $(\text{CH}_3)_3\text{CCH}_2\text{CH}_2\text{Cl} + 2\text{NH}_3 \rightarrow (\text{CH}_3)_3\text{CCH}_2\text{CH}_2\text{NH}_2 + \text{NH}_4\text{Cl}$



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

CHEMISTRY

9701/13

Paper 1 Multiple Choice

October/November 2010

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 **13** printed pages and **3** blank pages.



Section A

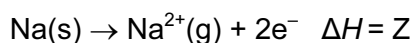
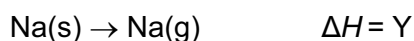
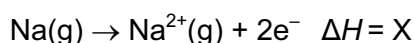
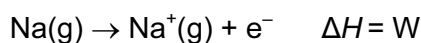
For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 A simple ion X^+ contains eight protons.

What is the electronic configuration of X^+ ?

- A** $1s^2 \quad 2s^1 \quad 2p^6$
B $1s^2 \quad 2s^2 \quad 2p^3$
C $1s^2 \quad 2s^2 \quad 2p^5$
D $1s^2 \quad 2s^2 \quad 2p^7$

- 2 Equations involving four enthalpy changes are shown.



What is the second ionisation energy of sodium?

- A** $2W$ **B** $X - W$ **C** $Y - W$ **D** $Z - Y$

- 3 Which ion has more electrons than protons and more protons than neutrons?

$[\text{H} = {}^1_1\text{H} ; \text{D} = {}^2_1\text{H} ; \text{O} = {}^{16}_8\text{O}]$

- A** D^- **B** H_3O^+ **C** OD^- **D** OH^-

- 4 Sulfur dioxide, SO_2 , is added to wines to prevent oxidation of ethanol by air. To determine the amount of SO_2 , a sample of wine is titrated with iodine, I_2 . In this reaction, **one** mole of SO_2 is oxidised by **one** mole of I_2 .

What is the change in oxidation number of sulfur in this reaction?

- A** +2 to +4 **B** +2 to +6 **C** +4 to +5 **D** +4 to +6

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

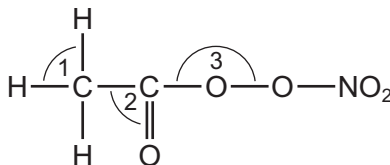
Nickel makes up 20 % of the total mass of a coin. The coin has a mass of 10.0 g.

How many nickel atoms are in the coin?

- A** 2.05×10^{22} **B** 4.30×10^{22} **C** 1.03×10^{23} **D** 1.20×10^{24}

- 6 Organic nitrates in photochemical smog can cause breathing difficulties.

The diagram shows an example of an organic nitrate molecule.



What is the correct order of the bond angles shown in ascending order (smallest first)?

- A** $1 \rightarrow 2 \rightarrow 3$ **B** $2 \rightarrow 1 \rightarrow 3$ **C** $3 \rightarrow 1 \rightarrow 2$ **D** $3 \rightarrow 2 \rightarrow 1$

- 7 Every year millions of tonnes each of chlorine and sodium hydroxide are manufactured by the electrolysis of brine using a 'diaphragm cell'.

What is the purpose of the diaphragm in such a cell?

- A** to prevent chlorine gas escaping into the factory
B to prevent the build up of pressure in the electrolysis cell
C to provide a large surface area of electrode
D to stop the products of electrolysis from reacting together

- 8 Which statement describes the halogens chlorine, bromine and iodine?

- A** Their bond energies decrease with increasing proton number.
B Their first ionisation energies increase with increasing proton number.
C They are all coloured gases at room temperature.
D They are all good reducing agents.

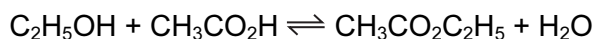
- 9 Chile saltpetre, NaNO_3 , contains sodium iodide as an impurity.

Aqueous silver nitrate is added to an aqueous solution of Chile saltpetre. Concentrated aqueous ammonia is then added.

Which observations are made?

	with acidified silver nitrate	with concentrated aqueous ammonia
A	no precipitate	no further reaction
B	no precipitate	precipitate forms
C	precipitate forms	precipitate dissolves
D	precipitate forms	precipitate remains

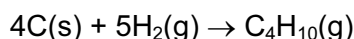
- 10 The value of the equilibrium constant, K_c , for the reaction to form ethyl ethanoate from ethanol and ethanoic acid is 4.0 at 60 °C.



When 1.0 mol of ethanol and 1.0 mol of ethanoic acid are allowed to reach equilibrium at 60 °C, what is the number of moles of ethyl ethanoate formed?

- A $\frac{1}{3}$ B $\frac{2}{3}$ C $\frac{1}{4}$ D $\frac{3}{4}$

- 11 Enthalpy changes of combustion can be used to determine enthalpy changes of formation. The following equation represents the enthalpy change of formation of butane.



By using the following standard enthalpy of combustion data, what is the value of the standard enthalpy change of formation, ΔH_f° , for this reaction?

compound	$\Delta H_c^\circ / \text{kJ mol}^{-1}$
carbon	−394
hydrogen	−286
butane	−2877

- A −5883 kJ mol^{−1}
 B −129 kJ mol^{−1}
 C +129 kJ mol^{−1}
 D +2197 kJ mol^{−1}
- 12 In a calorimetric experiment 1.60 g of a fuel is burnt. 45 % of the energy released is absorbed by 200 g of water whose temperature rises from 18 °C to 66 °C. The specific heat capacity of water is 4.2 J g^{−1} K^{−1}.
- What is the total energy released per gram of fuel burnt?
- A 25 200 J B 56 000 J C 89 600 J D 143 360 J
- 13 Which equation represents the change corresponding to the enthalpy change of atomisation of iodine?

- A $\frac{1}{2} \text{I}_2(\text{g}) \rightarrow \text{I}(\text{g})$
 B $\text{I}_2(\text{g}) \rightarrow 2\text{I}(\text{g})$
 C $\frac{1}{2} \text{I}_2(\text{s}) \rightarrow \text{I}(\text{g})$
 D $\text{I}_2(\text{s}) \rightarrow 2\text{I}(\text{g})$

- 14 Camphor is a white solid which was used to make the early plastic celluloid. Camphor contains the same percentage by mass of hydrogen and oxygen.

What is the molecular formula of camphor?

- A $C_{10}H_6O_6$ B $C_{10}H_8O$ C $C_{10}H_{16}O$ D $C_{10}H_{10}O_2$

- 15 Ammonium sulfate in nitrogenous fertilisers in the soil can be slowly oxidised by air producing sulfuric acid, nitric acid and water.

How many moles of oxygen gas are needed to oxidise completely one mole of ammonium sulfate?

- A 1 B 2 C 3 D 4

- 16 Why is the first ionisation energy of phosphorus greater than the first ionisation energy of silicon?

- A A phosphorus atom has one more proton in its nucleus.
B The atomic radius of a phosphorus atom is greater.
C The outer electron in a phosphorus atom is more shielded.
D The outer electron in a phosphorus atom is paired.

- 17 When magnesium nitrate, $Mg(NO_3)_2 \cdot 7H_2O$, is heated, which three gases are given off?

- A dinitrogen oxide, oxygen, water vapour
B hydrogen, nitrogen, oxygen
C hydrogen, nitrogen dioxide, oxygen
D nitrogen dioxide, oxygen, water vapour

- 18 Sulfur dioxide is used to bleach wood pulp in the production of paper. It is also used as an additive in the production of jam and marmalade, often in the form of sulfite compounds. When it is present in quantities greater than 10 mg / kg it is required to be listed as an ingredient of the jam.

Why is sulfur dioxide added to jam?

- A It is a bleaching agent and removes the undesirable colours from the fruit used in the jam.
B It is a preservative that destroys unwanted bacteria and enzymes.
C It is a reducing agent and removes the acids that give the jam a sharp taste.
D It is an acidic gas and maintains the pH of the jam at a suitable value to give it a sharp taste.

19 Which property of beryllium and its compounds is typical of the elements below it in Group II?

- A Be does not react with hot water.
- B BeCl_2 is covalent.
- C $\text{Be}(\text{NO}_3)_2$ produces BeO on thermal decomposition.
- D BeO dissolves in alkalis.

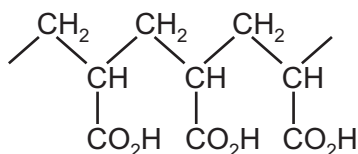
20 A compound Y has all of the properties below.

- It is a liquid at 25°C .
- It mixes completely with water.
- It reacts with aqueous sodium hydroxide.

What could Y be?

- A ethanoic acid
- B ethanol
- C ethene
- D ethyl ethanoate

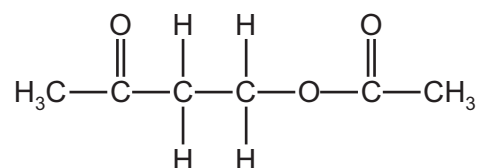
21 One of the characteristics of addition polymerisation is that the empirical formulae of the polymer and of its monomer are the same. The absorbent material in babies' disposable nappies is made from the addition polymer shown.



From which monomer could this addition polymer be obtained?

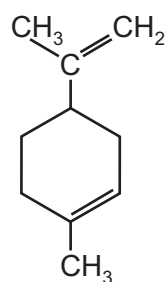
- A $\text{CH}_3\text{CH}(\text{OH})\text{CO}_2\text{H}$
- B $\text{HOCH}_2\text{CH}_2\text{CO}_2\text{H}$
- C $\text{H}_2\text{C}=\text{CHCO}_2\text{H}$
- D $\text{HO}_2\text{CCH}=\text{CHCO}_2\text{H}$

- 22 Compound X reacts with ethanoic acid in the presence of an H^+ catalyst to produce the compound below.



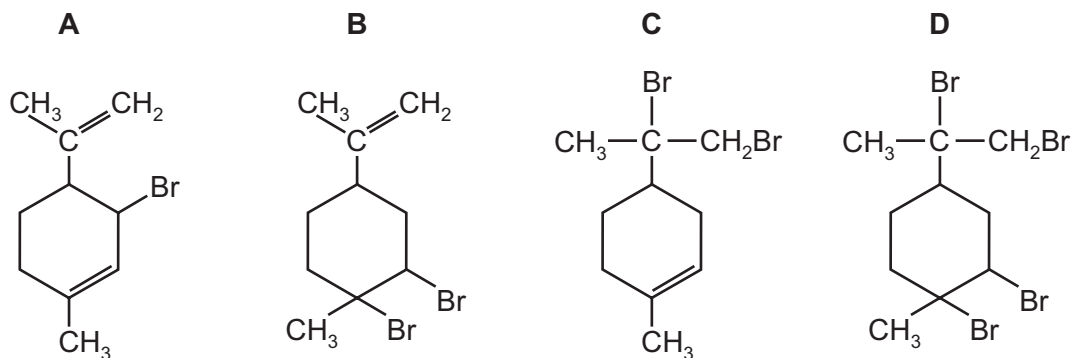
What is the molecular formula of compound X?

- A $\text{C}_2\text{H}_6\text{O}_2$ B $\text{C}_2\text{H}_6\text{O}_3$ C $\text{C}_4\text{H}_8\text{O}$ D $\text{C}_4\text{H}_8\text{O}_2$
- 23 Limonene is an oil formed in the peel of citrus fruits.

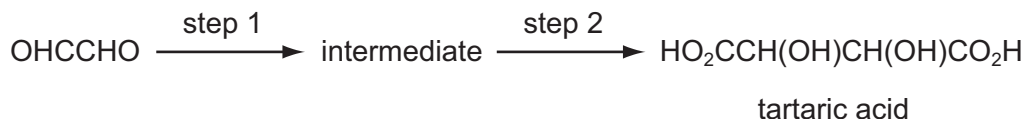


limonene

Which product is formed when an excess of bromine, $\text{Br}_2(\text{l})$, reacts with limonene at room temperature in the dark?



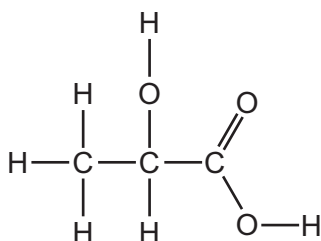
- 24 Tartaric acid is present in some wines. It may be synthesised in the laboratory in two steps.



Which reagents could be used for this synthesis?

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

- 25 Which alcohol gives only **one** possible oxidation product when warmed with dilute acidified potassium dichromate(VI)?
- A** butan-1-ol
- B** butan-2-ol
- C** 2-methylpropan-1-ol
- D** 2-methylpropan-2-ol
- 26 Lactic acid occurs naturally, for example in sour milk.



lactic acid

What is a property of lactic acid?

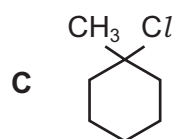
- A** It decolourises aqueous bromine rapidly.
- B** It is insoluble in water.
- C** It reduces Fehling's reagent.
- D** Two molecules react with each other in the presence of a strong acid.

27 Which compound would undergo nucleophilic addition?

- A bromoethane, $\text{C}_2\text{H}_5\text{Br}$
- B ethanal, CH_3CHO
- C ethane, C_2H_6
- D ethene, C_2H_4

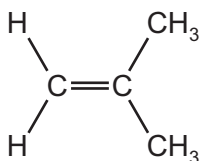
28 Which compound undergoes an $\text{S}_{\text{N}}1$ substitution reaction?

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$
- B $(\text{CH}_3)_3\text{CCH}_2\text{I}$



- D $\text{CH}_2=\text{CHCl}$

29 The compound 2-methylpropene, C_4H_8 , is a monomer used in the production of synthetic rubber.



In addition to 2-methylpropene there are x other isomers of C_4H_8 , structural or otherwise, which contain a double bond.

What is the value of x?

- A 1
- B 2
- C 3
- D 4

30 Which environmental problem is **not** made worse by the release of oxides of nitrogen from car engines?

- A acidification of lakes
- B corrosion of buildings
- C photochemical smog
- D the hole in the ozone layer

Section B

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

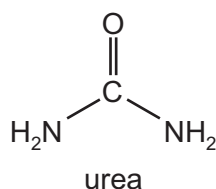
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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 types of intermolecular forces can exist between adjacent urea molecules?



- 1** hydrogen bonding
- 2** permanent dipole-dipole forces
- 3** temporary induced dipole-dipole forces

32 Ethanol is manufactured by reacting ethene gas and steam in the presence of phosphoric(V) acid.

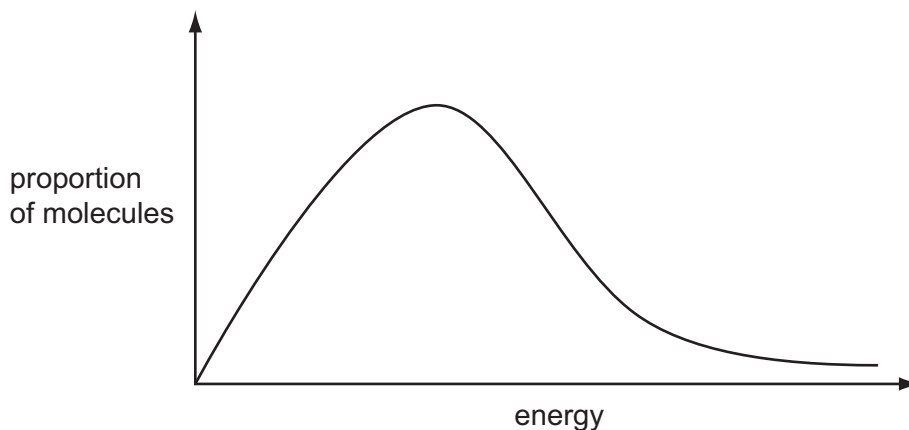


The reaction is carried out at 570 K and 60 atm.

What would be the consequences of carrying out the reaction at the same temperature but at a pressure of 200 atm?

- 1** The manufacturing costs would increase.
- 2** The maximum yield at equilibrium would be higher.
- 3** The reaction would proceed at a faster rate.

- 33 The diagram represents the Boltzmann distribution of molecular energies at a given temperature.



Which of the factors that affect the rate of a reaction can be explained using such a Boltzmann distribution?

- 1 increasing the concentration of reactants
 - 2 increasing the temperature
 - 3 the addition of a catalyst
- 34 Disproportionation is the term used to describe a reaction in which a reactant is simultaneously both oxidised and reduced.

To which incomplete equations does the term disproportionation apply?

- 1 $\text{Cl}_2(\text{g}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{Cl}^-(\text{aq}) + \dots\dots$
 - 2 $3\text{Cl}_2(\text{g}) + 6\text{OH}^-(\text{aq}) \rightarrow 3\text{H}_2\text{O}(\text{l}) + \text{ClO}_3^-(\text{aq}) + \dots\dots$
 - 3 $2\text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{HNO}_3(\text{aq}) + \dots\dots$
- 35 Samples of calcium and barium are separately added to beakers of cold water containing a few drops of litmus solution.

Which observations will be made with **only** the calcium and **not** with the barium?

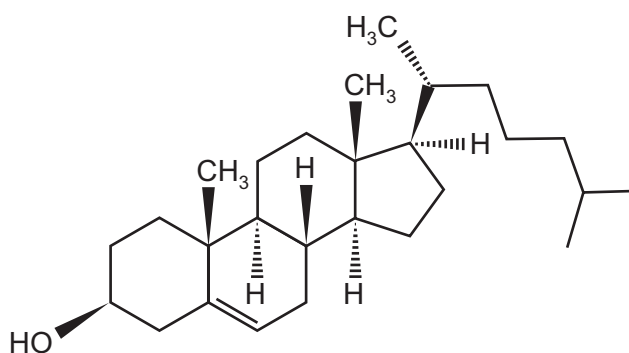
- 1 A white suspension appears in the water.
- 2 The solution turns blue.
- 3 A gas is evolved.

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.

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



cholesterol

Which statements about cholesterol are correct?

- 1** The molecule contains a secondary alcohol group.
- 2** The molecule contains two π bonds.
- 3** All carbon atoms in the four rings lie in the same plane.

37 Element X is a solid. It occurs as a contaminant of carbonaceous fuels.

Its oxide Y is formed in car engines.

Further oxidation of Y to Z can occur in the atmosphere.

Which statements about Y and Z are correct?

- 1** Molecule Y has lone pairs of electrons.
- 2** The atmospheric oxidation of Y to Z is a catalysed reaction.
- 3** Y is a colourless gas.

- 38 An organic compound decolourises aqueous bromine and reacts with sodium to produce hydrogen.

Which molecular formula could represent this compound?

- 1 $\text{C}_3\text{H}_6\text{O}$
- 2 $\text{C}_3\text{H}_4\text{O}_2$
- 3 $\text{C}_3\text{H}_8\text{O}$

- 39 Textiles for use in aircraft are treated with a finish containing a halogenoalkane.

What is the reason for this?

- 1 The textile burns less easily, improving safety.
- 2 The fabric forms hydrogen bonds to water more readily, making the fabric easier to wash.
- 3 The halogenoalkane undergoes addition polymerisation, stiffening the fabric.

- 40 Glyceraldehyde, $\text{HOCH}_2\text{CH}(\text{OH})\text{CHO}$, is formed during photosynthesis, and contains a chiral carbon atom.

Which reagents will react with glyceraldehyde to produce an organic product **without** a chiral carbon atom?

- 1 warmed acidified $\text{K}_2\text{Cr}_2\text{O}_7$
- 2 NaBH_4
- 3 Tollens' reagent

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