



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

CHEMISTRY

9701/11

Paper 1 Multiple Choice

October/November 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 Three elements, **X**, **Y** and **Z**, have the physical properties shown in the table.

element	melting point / °C	boiling point / °C	density / g cm ⁻³
X	-7	59	3.12
Y	98	883	0.97
Z	649	1107	1.74

What could be the identities of **X**, **Y** and **Z**?

	X	Y	Z
A	Br ₂	Al	Si
B	Br ₂	Na	Mg
C	I ₂	Mg	Na
D	I ₂	Si	K

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

Lead(IV) chloride will oxidise bromide ions to bromine. The Pb⁴⁺ ions are reduced to Pb²⁺ ions in this reaction.

If 6.980 g of lead(IV) chloride is added to an excess of sodium bromide solution, what mass of bromine would be produced?

- A** 0.799 g **B** 1.598 g **C** 3.196 g **D** 6.392 g

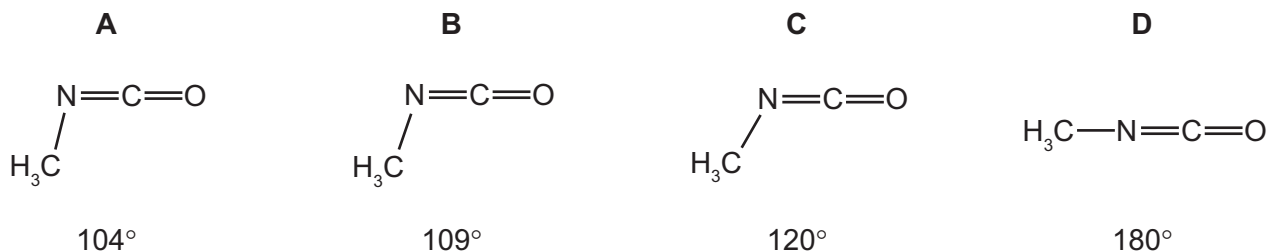
- 3 Which element has an equal number of electron pairs and of unpaired electrons within orbitals of principal quantum number 2?

- A** beryllium
B carbon
C nitrogen
D oxygen

- 4 Methyl isocyanate, CH_3NCO , is a toxic liquid which is used in the manufacture of some pesticides.

In the methyl isocyanate molecule, the sequence of atoms is $\text{H}_3\text{C}-\text{N}=\text{C}=\text{O}$.

What is the approximate angle between the bonds formed by the N atom?

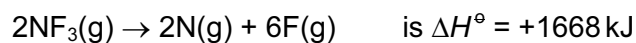


- 5 At room temperature and pressure chlorine does not behave as an ideal gas.

At which temperature and pressure would the behaviour of chlorine become more ideal?

	pressure /kPa	temperature /K
A	50	200
B	50	400
C	200	200
D	200	400

- 6 The standard enthalpy change for the reaction



What is the bond energy of the N-F bond?

- A** -556 kJ mol^{-1}
B -278 kJ mol^{-1}
C $+278 \text{ kJ mol}^{-1}$
D $+556 \text{ kJ mol}^{-1}$

- 7 When chlorine and aqueous sodium hydroxide are heated together the following overall reaction occurs.

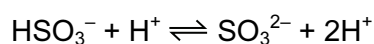
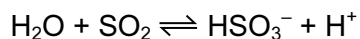


What are the oxidation numbers for chlorine in each of the following species?

	Cl_2	NaCl	NaClO_3
A	0	+1	-5
B	+2	-1	+3
C	0	-1	+5
D	-2	+1	-3

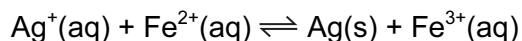
- 8 Sulfur dioxide is used as a preservative in wine making.

The following equations describe how sulfur dioxide dissolves.



Which statement about these two reactions is correct?

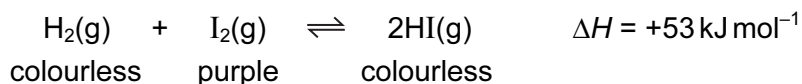
- A** HSO_3^- acts as a base.
B SO_2 acts as an oxidising agent.
C SO_3^{2-} acts as an acid.
D SO_3^{2-} acts as a reducing agent.
- 9 An aqueous solution was prepared containing 1.0 mol of AgNO_3 and 1.0 mol of FeSO_4 in 1.00 dm^3 of water. When equilibrium was established, there was 0.44 mol of $\text{Ag}^+(\text{aq})$ in the mixture.



What is the numerical value of K_c ?

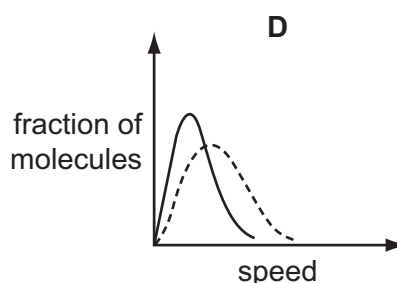
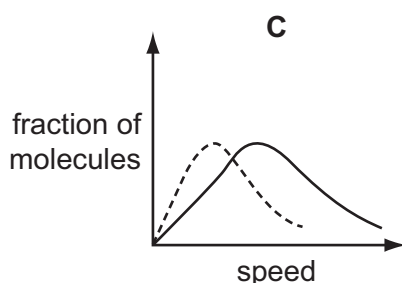
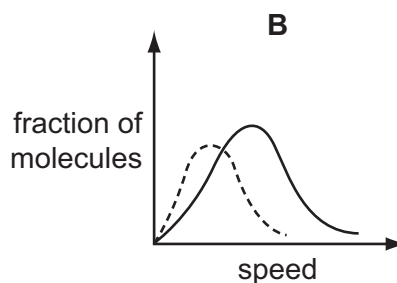
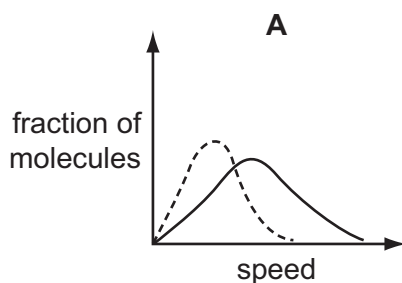
- A** 0.35 **B** 0.62 **C** 1.62 **D** 2.89

- 10 When gaseous iodine is heated with hydrogen at 450 °C, an equilibrium is established.



Which change of conditions will cause the purple colour of the equilibrium mixture to become paler?

- A decrease in pressure
 B decrease in temperature
 C increase in pressure
 D increase in temperature
- 11 Which solid-line curve most accurately represents the distribution of molecular speeds in a gas at 500 K if the dotted-line curve represents the corresponding distribution for the same gas at 300 K?



- 12 Butanedioate ions can be dehydrogenated to form *trans*-butenedioate ions. The enzyme fumarase speeds up this reaction.

Why does fumarase speed up this reaction?

- A Fumarase is a protein.
 B Fumarase is effective at body temperature.
 C Fumarase lowers the activation energy of the dehydrogenation reaction.
 D The enzyme fumarase is specific for this dehydrogenation reaction.

13 Which element shows the greatest tendency to form some covalent compounds?

- A** aluminium
- B** magnesium
- C** neon
- D** potassium

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

A significant contribution to atmospheric carbon dioxide levels comes from the thermal decomposition of limestone, in the manufacture of cement and of lime for agricultural purposes.

Cement works roast 1000 million tonnes of limestone per year and a further 200 million tonnes is roasted in kilns to make lime.

What is the total annual mass output of carbon dioxide (in million tonnes) from these two processes?

- A** 440 **B** 527 **C** 660 **D** 880

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

A 5.00 g sample of an anhydrous Group II metal nitrate loses 3.29 g in mass when heated strongly.

Which metal is present?

- A** magnesium
- B** calcium
- C** strontium
- D** barium

16 Aqueous sodium chloride (brine) is electrolysed by using inert electrodes in a cell which is stirred so that products of electrolysis react with each other. The cell is kept cold.

Which pair of substances is among the major products?

- A** hydrogen and chlorine
- B** hydrogen and sodium chlorate(I)
- C** hydrogen and sodium chlorate(V)
- D** sodium hydroxide and chlorine

17 Why do the halogens become less volatile as Group VII is descended?

- A The halogen-halogen bond energy decreases.
- B The halogen-halogen bond length increases.
- C The number of electrons in each molecule increases.
- D The van der Waals' forces between molecules become weaker.

18 Total removal of the pollutant sulfur dioxide, SO_2 , is difficult, both for economic and technical reasons. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are scrubbed (washed) with calcium hydroxide to remove the SO_2 .

What is the main product formed **initially**?

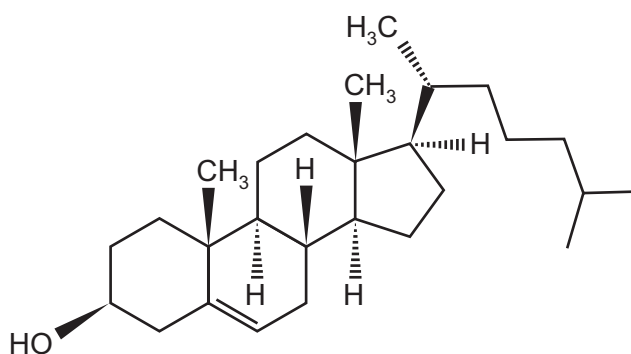
- A $\text{Ca}(\text{HSO}_4)_2$ B CaS C CaSO_3 D CaSO_4

19 Which reaction is endothermic?

- A $2\text{HBr} \rightarrow \text{H}_2 + \text{Br}_2$
- B $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
- C $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$
- D $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$

- 20 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

Separate oxidation reactions are carried out using different conditions.

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

Which statements about the **products** formed are correct?

	cold, dilute acidified KMnO_4 : number of hydroxy groups present	hot, concentrated acidified KMnO_4 : number of 6-membered rings remaining
A	1	2
B	1	3
C	3	2
D	3	3

- 21 Many different compounds have been used in aerosol sprays, refrigerators and in making foamed plastics.

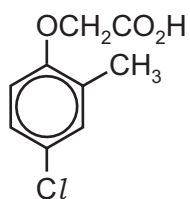
Which compound will cause the **most** ozone depletion?

- A** CCl_3F
- B** CH_2FCHClF
- C** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
- D** N_2O

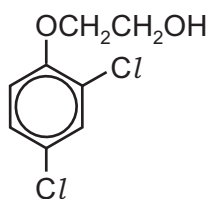
22 In the general formula of which class of compound, is the ratio of hydrogen atoms to carbon atoms the highest?

- A alcohols
- B aldehydes
- C carboxylic acids
- D halogenoalkanes

23 Y and Z are two widely-used selective weed killers.



Y



Z

Which reagent will distinguish Y from Z?

- A acidified $\text{AgNO}_3(\text{aq})$
- B Fehling's solution
- C Na
- D $\text{Na}_2\text{CO}_3(\text{aq})$

24 What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 1-bromobutane?

- A attack by a nucleophile on a carbon atom with a partial positive charge
- B heterolytic bond fission and attack by a nucleophile on a carbocation
- C homolytic bond fission and attack by an electrophile on a carbanion
- D homolytic bond fission and attack by a nucleophile on a carbocation

25 Use of the Data Booklet is relevant to this question.

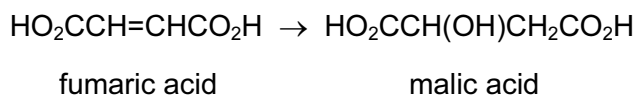
2.76 g of ethanol were mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The organic product was then collected by distillation.

The yield of product was 75.0 %.

What mass of product was collected?

- A 1.98 g
- B 2.07 g
- C 2.70 g
- D 4.80 g

- 26 Energy is released in the human body by the oxidation of glucose in a complex sequence of reactions. Part of this sequence is the Krebs cycle. One reaction in the Krebs cycle is the conversion of fumaric acid into malic acid.



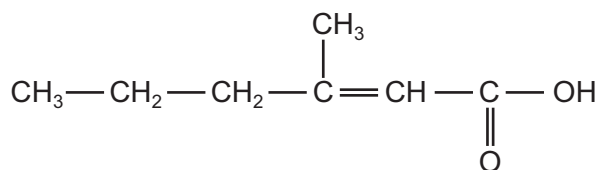
Which reagents could achieve this transformation in the laboratory?

- A** acidified KMnO_4
B $\text{Br}_2(\text{aq})$ followed by hot $\text{NaOH}(\text{aq})$
C H_2O with Pt catalyst
D steam with H_2SO_4
- 27 A reaction between chlorine and propane in ultraviolet light produces two isomeric monochloropropanes, $\text{C}_3\text{H}_7\text{Cl}$, as products.

Which information about this reaction is correct?

	type of bond fission in initiation step	expected ratio of 1-chloropropane to 2-chloropropane produced
A	heterolytic	1 : 1
B	heterolytic	3 : 1
C	homolytic	1 : 1
D	homolytic	3 : 1

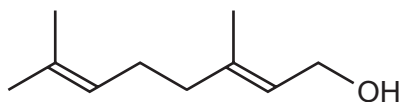
- 28 An unpleasant smelling chemical produced in the human armpit is 3-methylhex-2-enoic acid.



If this compound is reacted with a cold, dilute, acidified solution of potassium manganate(VII), how many chiral centres will be produced?

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

29 Geraniol is a constituent of some perfumes.



geraniol

Which statement about geraniol is **not** correct?

- A Geraniol causes hot acidified potassium dichromate(VI) to change colour from orange to green.
 - B Geraniol decolourises bromine water.
 - C There are three methyl groups and three methylene (CH_2) groups in geraniol.
 - D There are two pairs of *cis-trans* isomers of geraniol.
- 30 Which pair of substances could react to give the ester $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$?
- A ethanol and ethanoic acid
 - B methanol and ethanoic acid
 - C methanol and propanoic acid
 - D propan-1-ol and methanoic acid

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 The definitions of many chemical terms can be illustrated by chemical equations.

Which terms can be illustrated by an equation that shows the formation of a positive ion?

- 1** first ionisation energy
- 2** heterolytic fission
- 3** enthalpy change of atomisation

32 Why does aluminium chloride, Al_2Cl_6 , sublime at the relatively low temperature of 180°C ?

- 1** The intermolecular forces between the Al_2Cl_6 molecules are weak.
- 2** The co-ordinate bonds between aluminium and chlorine are weak.
- 3** The covalent bonds between aluminium and chlorine are weak.

33 The three statements that follow are all true.

Which of these can be explained, at least in part, by reference to hydrogen bonding?

- 1** At 0°C ice floats on water.
- 2** The boiling point of propan-2-ol is 82°C . The boiling point of propanone is 56°C .
- 3** At 20°C propanone and propanal mix completely.

- 34 A farmer spreads lime on land which has already been treated with an ammonium nitrate fertiliser.

Which reactions will occur in the treated soil?

- 1 $\text{Ca(OH)}_2 + 2\text{NH}_4^+(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{NH}_3 + 2\text{H}_2\text{O}$
- 2 $\text{Ca(OH)}_2 + 2\text{H}^+(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{H}_2\text{O}$
- 3 $\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$

- 35 Which of the halide ions, chloride, bromide or iodide, acts as a reducing agent when its sodium salt reacts with concentrated sulfuric acid?

- 1 at least one of Cl^- , Br^- and I^-
- 2 at least two of Cl^- , Br^- and I^-
- 3 all three of Cl^- , Br^- and I^-

- 36 In a car engine, non-metallic element X forms a pollutant oxide Y.

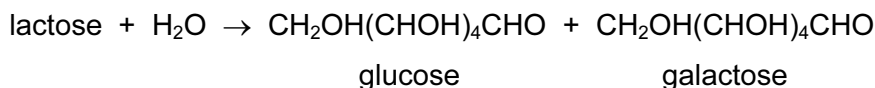
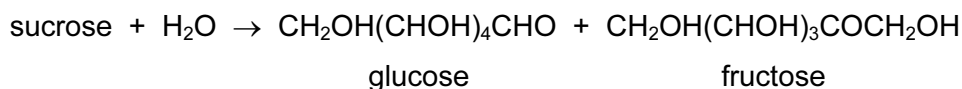
Further oxidation of Y to Z occurs spontaneously in the atmosphere. In this further oxidation, 1 mol of Y reacts with 0.5 mol of gaseous oxygen.

Which statements about X, Y and Z are correct?

- 1 X forms a basic hydride.
- 2 Y is a diatomic molecule.
- 3 Z is a polar molecule.

- 37 Disaccharides, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, are important in the human diet. For example, sucrose is found in pastries and lactose occurs in milk products.

Both of these compounds can be hydrolysed.



Which statements about these hydrolysis products are correct?

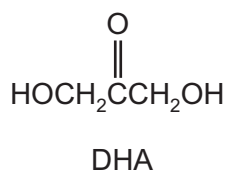
- 1 Glucose and fructose have structural isomers.
- 2 Glucose and galactose are optical isomers.
- 3 Glucose and galactose are ketones.

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** DHA is a colourless liquid which reacts with protein in skin to cause it to darken. It has the structure shown.



Which observations would be made when testing this substance?

- 1** Hydrogen is produced when sodium is added.
 - 2** A coloured precipitate is produced when 2,4-dinitrophenylhydrazine reagent is added.
 - 3** A silver precipitate is produced when Tollens' reagent is added.
- 39** On acid hydrolysis, which compounds produce propanoic acid?
- 1** $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$
 - 2** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$
 - 3** $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$
- 40** **X** is an organic compound. **X** gives a precipitate with aqueous silver nitrate. Some or all of this precipitate remains undissolved when an excess of dilute aqueous ammonia is added.

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

- 1** 2-chlorobutane
- 2** 2-bromobutane
- 3** iodomethane

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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 In the Haber process for the manufacture of ammonia, why is the heterogeneous catalyst iron in a finely divided state?

A to increase its surface area
B to produce the maximum reduction in the activation energy
C to reduce its loss during the reaction
D to reduce its surface area

- 2 The following equations the letters **W**, **X**, **Y** and **Z** all represent whole numbers.

When correctly balanced, which equation requires one of letters **W**, **X**, **Y** or **Z** to be 5?

A $\text{WC}_3\text{H}_7\text{COOH} + \text{XO}_2 \rightarrow \text{YCO}_2 + \text{ZH}_2\text{O}$
B $\text{WC}_4\text{H}_8 + \text{XO}_2 \rightarrow \text{YCO}_2 + \text{ZH}_2\text{O}$
C $\text{WH}_3\text{PO}_4 + \text{XNaOH} \rightarrow \text{YNa}_2\text{HPO}_4 + \text{ZH}_2\text{O}$
D $\text{WNH}_3 + \text{XO}_2 \rightarrow \text{YN}_2 + \text{ZH}_2\text{O}$

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

From which particle is the removal of an electron the most difficult?

A $\text{Cl}^-(\text{g})$ **B** $\text{F}^-(\text{g})$ **C** $\text{K}^+(\text{g})$ **D** $\text{Na}^+(\text{g})$

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

560 kg of nitrogen and 120 kg of hydrogen are pressurised, heated and passed over an iron catalyst. When the mixture of gases reaches equilibrium, it contains 96 kg of hydrogen.

Which mass of ammonia does it contain?

A 24 kg **B** 68 kg **C** 136 kg **D** 680 kg

- 5 The presence of dipoles helps to explain why the element Br_2 and the compound CHCl_3 exist as liquids at room temperature.

Which types of dipole are involved?

	Br_2	CHCl_3
A	induced dipoles and permanent dipoles	induced dipoles and permanent dipoles
B	induced dipoles and permanent dipoles	induced dipoles only
C	induced dipoles only	induced dipoles and permanent dipoles
D	induced dipoles only	induced dipoles only

- 6 Three compounds have the physical properties shown in the table.

compound	P	Q	R
melting point/ $^{\circ}\text{C}$	2852	993	-119
boiling point/ $^{\circ}\text{C}$	3600	1695	39
conductivity (solid)	poor	poor	poor
conductivity (liquid)	good	good	poor
conductivity (aqueous)	insoluble	good	insoluble

What might be the identities of **P**, **Q** and **R**?

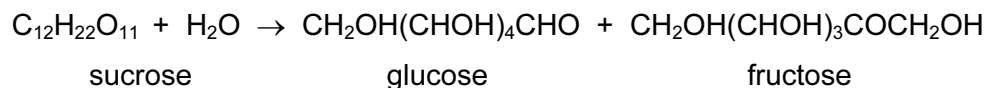
	P	Q	R
A	MgO	KCl	NH_3
B	MgO	NaF	$\text{C}_2\text{H}_5\text{Br}$
C	SiO_2	KCl	$\text{C}_2\text{H}_5\text{Br}$
D	SiO_2	NaF	HCl

- 7 For the equilibrium $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$, what will change the value of K_p ?
- A** adding a catalyst
B adding more O_2
C increasing the pressure
D increasing the temperature
- 8 Which pollutant, present in the exhaust fumes of an internal combustion engine, has an element in the +2 oxidation state and an odd number of electrons in one molecule of the pollutant?
- A** CO **B** H_2S **C** NO **D** NO_2

- 9 The use of sucrose in food processing depends in part on osmotic pressure, symbol Π .

In dilute solution, Π varies with concentration in a similar way to gas behaviour. The equation $\Pi V = nRT$ can be used, where n is the number of moles of solute molecules contained in volume V at temperature T . The number of moles of solvent molecules should be ignored.

Under aqueous acidic conditions sucrose is hydrolysed.



What can be deduced from this hydrolysis equation?

	the osmotic pressure	glucose and fructose are
A	decreases	optical isomers
B	decreases	structural isomers
C	increases	optical isomers
D	increases	structural isomers

- 10 Hess's Law can be used to calculate the average C-H bond energy in methane.

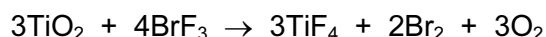
$\Delta H_{\text{at}}^\ominus$ = standard enthalpy change of atomisation

$\Delta H_{\text{f}}^\ominus$ = standard enthalpy change of formation

$\Delta H_{\text{c}}^\ominus$ = standard enthalpy change of combustion

Which data values are needed in order to perform the calculation?

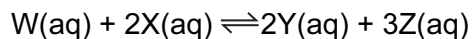
- A** $\Delta H_{\text{at}}^\ominus (\text{C})$, $\Delta H_{\text{at}}^\ominus (\text{H})$, $\Delta H_{\text{f}}^\ominus (\text{CH}_4)$
- B** $\Delta H_{\text{c}}^\ominus (\text{C})$, $\Delta H_{\text{c}}^\ominus (\text{H}_2)$, $\Delta H_{\text{c}}^\ominus (\text{CH}_4)$
- C** $\Delta H_{\text{c}}^\ominus (\text{C})$, $\Delta H_{\text{c}}^\ominus (\text{H}_2)$, $\Delta H_{\text{f}}^\ominus (\text{CH}_4)$
- D** $\Delta H_{\text{f}}^\ominus (\text{CH}_4)$ only, as $\Delta H_{\text{f}}^\ominus (\text{C})$, and $\Delta H_{\text{f}}^\ominus (\text{H}_2)$, are defined as zero
- 11 The amount of titanium dioxide in an ore can be determined by using the following reaction.



Which element increases in oxidation number in this reaction?

- A** bromine
- B** fluorine
- C** oxygen
- D** titanium

12 For the reaction



what are the correct units for the equilibrium constant K_c ?

- A** mol dm^{-3} **B** $\text{mol}^2 \text{dm}^{-6}$ **C** $\text{mol}^{-1} \text{dm}^3$ **D** $\text{mol}^{-2} \text{dm}^6$

13 Methyl mercaptan, CH_3SH , has a foul smell and is often used to impart a smell to natural gas.

What will be formed when CH_3SH is burned in an excess of air?

- A** CO H_2O SO_2
B CO_2 H_2O H_2S
C CO_2 H_2O SO_2
D CO_2 H_2O SO_3

14 Nitrogenous fertilisers are used extensively in modern farming. If rainwater washes excess fertiliser into a nearby lake, a process called eutrophication may occur.

Three of the stages of eutrophication are described below.

- P** Water plants growing on the lake bed die due to lack of sunlight.
Q An excessive growth of algae occurs.
R Excessive bacterial activity causes a reduction in oxygen levels.

In which order do these three stages occur?

- A** $P \rightarrow Q \rightarrow R$
B $P \rightarrow R \rightarrow Q$
C $Q \rightarrow P \rightarrow R$
D $Q \rightarrow R \rightarrow P$

15 Chlorine can be manufactured from brine in a diaphragm cell.

Which row represents the correct electrodes?

	nature of anode	nature of cathode
A	graphite	titanium
B	steel	titanium
C	titanium	graphite
D	titanium	steel

- 16 Sodium iodide reacts with concentrated sulfuric acid. The equation which represents one of the reactions that takes place is shown.



Which species has been oxidised in this reaction?

- A H^+ B I^- C Na^+ D SO_4^{2-}

- 17 The standard enthalpy changes of formation of HCl and HI are -92 kJ mol^{-1} and $+26 \text{ kJ mol}^{-1}$ respectively.

Which statement is **most** important in explaining this difference?

- A Chlorine is more electronegative than iodine.
 B The activation energy for the $\text{H}_2 + \text{Cl}_2$ reaction is much less than that for the $\text{H}_2 + \text{I}_2$ reaction.
 C The bond energy of HI is smaller than the bond energy of HCl .
 D The bond energy of I_2 is smaller than the bond energy of Cl_2 .

- 18 Lime mortar is made from quicklime, water and sand. Over a period of time, lime mortar changes into a much harder form. Both fresh and old lime mortar react with aqueous hydrochloric acid but only the old lime mortar effervesces during the reaction.

Which equation describes the change from fresh to old lime mortar?

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

- 19 Ar , Ca^{2+} and K^+ , contain the same number of electrons.

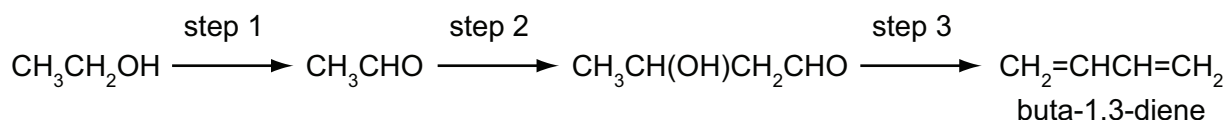
In which order do their radii increase?

	smallest radius	—————→	largest radius
A	Ar	K^+	Ca^{2+}
B	Ca^{2+}	Ar	K^+
C	Ca^{2+}	K^+	Ar
D	K^+	Ar	Ca^{2+}

- 20 Bromine and propene undergo an addition reaction.

Which is a property of the product?

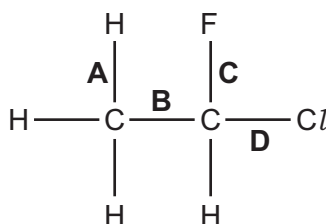
- A It exists in *cis-trans* isomers.
 - B It is more volatile than propene.
 - C It possesses a chiral centre.
 - D It possesses hydrogen bonding.
- 21 Buta-1,3-diene is currently obtained from fossil fuel sources. In future it may be obtained from ethanol, which can be produced from non-food agricultural crops. The sequence of reactions is as follows.



Which term could be used to describe step 1?

- A condensation
 - B dehydration
 - C dehydrogenation
 - D hydrogenation
- 22 Use of the Data Booklet is relevant to this question.

Which bond in the structure below has the lowest bond energy?



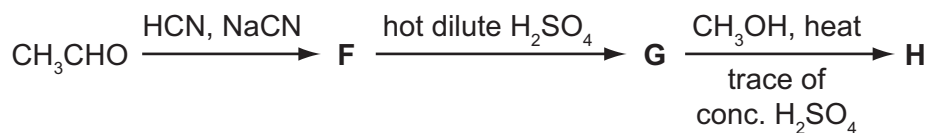
- 23 Ethanal, CH_3CHO , can be reduced using NaBH_4 in aqueous ethanol.

This is a nucleophilic addition reaction.

What could be the first step of this mechanism?

- A attack of an H^- ion at the carbon atom of the carbonyl group
- B attack of an H^- ion at the oxygen atom of the carbonyl group
- C attack of an H^+ ion at the carbon atom of the carbonyl group
- D attack of an H^+ ion at the oxygen atom of the carbonyl group

- 24 In a sequence of reactions, ethanal is converted into a compound **H**.



What could **H** be?

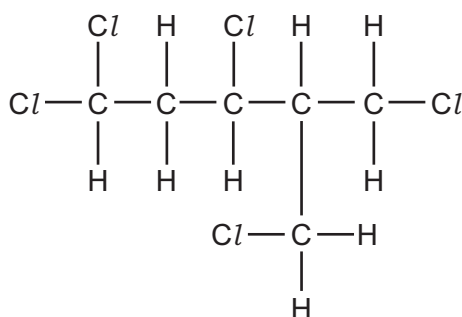
- A** $\text{CH}_3\text{CH}_2\text{COOCH}_3$
B $\text{CH}_3\text{CH}(\text{OH})\text{COOCH}_3$
C $\text{CH}_3\text{CH}(\text{OH})\text{OCOCH}_3$
D $\text{CH}_3\text{CH}(\text{OCH}_3)\text{COOH}$
- 25 What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 2-bromo-2-methylbutane?
- A** heterolytic bond fission, attack by an electrophile on a carbanion
B heterolytic bond fission, attack by a nucleophile on a carbocation
C homolytic bond fission, attack by an electrophile on a carbanion
D homolytic bond fission, attack by a nucleophile on a carbocation
- 26 *Use of the Data Booklet is relevant to this question.*

2.30 g of ethanol were mixed with aqueous acidified potassium dichromate(VI). The desired product was collected by immediate distillation under gentle warming.

The yield of product was 70.0 %.

What mass of product was collected?

- A** 1.54 g **B** 1.61 g **C** 2.10 g **D** 3.14 g
- 27 The molecule shown is optically active.



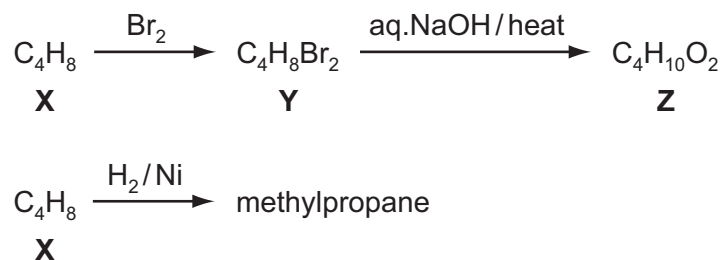
How many chiral carbon atoms are present in this molecule?

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

28 Which reagent could best be used to distinguish between cyclohexene and cyclohexanol?

- A $\text{Ag}(\text{NH}_3)_2^+$ in H_2O
- B Br_2 in CCl_4
- C 2,4-dinitrophenylhydrazine in CH_3OH
- D NaBH_4 in CH_3OH

29 Compound X, molecular formula C_4H_8 , undergoes the following reactions.



What is the formula of compound Z?

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

30 How many of the isomeric alcohols with the formula $\text{C}_4\text{H}_9\text{OH}$ will produce an alkene that has cis and trans isomers, on treatment with conc. H_2SO_4 ?

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

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

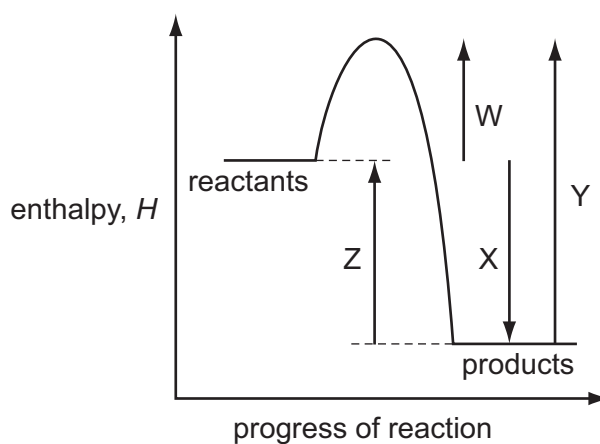
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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

31 Which statements about bond angles are correct?

- 1** The bond angle in SO_2 is smaller than the bond angle in CO_2 .
- 2** The bond angle in H_2O is smaller than the bond angle in CH_4 .
- 3** The bond angle in NH_3 is smaller than the bond angle in BF_3 .

32 An energy profile diagram is shown.



What do the labels on the diagram represent?

- 1** $W = \Delta H$ of the forward reaction, $Y = E_a$ of the backward reaction
- 2** $Z = \Delta H$ of the backward reaction, $Y = E_a$ of the backward reaction
- 3** $X = \Delta H$ of the forward reaction, $W = E_a$ of the forward reaction

33 Which are assumptions of the kinetic theory of gases and hence of the ideal gas equation, $PV = nRT$?

- 1 Molecules move without interacting with one another except for collisions.
- 2 Intermolecular forces are negligible.
- 3 Intermolecular distances are much greater than the molecular size.

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

Which properties would be expected for radium, ${}_{88}\text{Ra}$, or its compounds?

- 1 Radium carbonate would not decompose at the temperature of a Bunsen flame.
- 2 Radium hydroxide is very insoluble.
- 3 Radium does not react with cold water.

35 When a firework is lit, a fuel and an oxidising agent react together.

In one such firework, magnesium is the fuel and barium nitrate is the oxidising agent.

Which solids are produced when the firework is lit?

- 1 BaO
- 2 MgO
- 3 $\text{Mg}(\text{NO}_3)_2$

36 In a car engine, non-metallic element **X** forms a pollutant oxide **Y**.

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

Which statements about **X**, **Y** and **Z** are correct?

- 1 The oxidation number of **X** increases by 2 from **Y** to **Z**.
- 2 The molecule of **Y** has no unpaired electrons.
- 3 The molecule of **Z** contains three oxygen atoms.

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** Compound **X** has molecular formula $C_4H_{10}O$. Separate samples of **X** are tested with three different reagents.

Which results could **not** be obtained?

	Tollens' reagent	2,4-dinitrophenylhydrazine reagent	warm acidified potassium dichromate(VI) solution
1	silver mirror forms	orange precipitate forms	colour changes from orange to green
2	no change	no change	no change
3	no change	no change	colour changes from orange to green

- 38** **Y** is an organic compound. **Y** gives a precipitate with aqueous silver nitrate. All of this precipitate dissolves when concentrated aqueous ammonia is added.

What is a possible identity for **Y**?

- 1** 1-bromopropane
 - 2** chloroethane
 - 3** 2-iodo-2-methylpropane
- 39** Which compounds will produce ethanoic acid when boiled under reflux with dilute alkali followed by acidification?
- 1** CH_3CH_2Cl
 - 2** $CH_3CO_2CH_3$
 - 3** CH_3CN

40 Which pairs of homologous series have the same C:H ratio in their general formulae?

- 1** aldehydes and ketones
- 2** carboxylic acids and esters
- 3** alkenes and ketones

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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

October/November 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 **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 *Use of the Data Booklet is relevant to this question.*

Lead(IV) chloride will oxidise bromide ions to bromine. The Pb^{4+} ions are reduced to Pb^{2+} ions in this reaction.

If 6.980 g of lead(IV) chloride is added to an excess of sodium bromide solution, what mass of bromine would be produced?

- A** 0.799 g **B** 1.598 g **C** 3.196 g **D** 6.392 g

- 2 Which element has an equal number of electron pairs and of unpaired electrons within orbitals of principal quantum number 2?

- A** beryllium
B carbon
C nitrogen
D oxygen

- 3 Three elements, **X**, **Y** and **Z**, have the physical properties shown in the table.

element	melting point / °C	boiling point / °C	density / g cm ⁻³
X	-7	59	3.12
Y	98	883	0.97
Z	649	1107	1.74

What could be the identities of **X**, **Y** and **Z**?

	X	Y	Z
A	Br_2	Al	Si
B	Br_2	Na	Mg
C	I_2	Mg	Na
D	I_2	Si	K

- 4 At room temperature and pressure chlorine does not behave as an ideal gas.

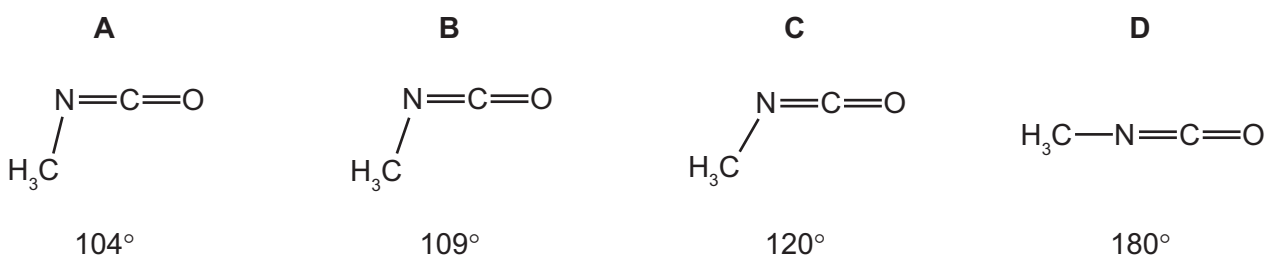
At which temperature and pressure would the behaviour of chlorine become more ideal?

	pressure /kPa	temperature /K
A	50	200
B	50	400
C	200	200
D	200	400

- 5 Methyl isocyanate, CH_3NCO , is a toxic liquid which is used in the manufacture of some pesticides.

In the methyl isocyanate molecule, the sequence of atoms is $\text{H}_3\text{C}-\text{N}=\text{C}=\text{O}$.

What is the approximate angle between the bonds formed by the N atom?



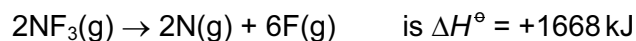
- 6 When chlorine and aqueous sodium hydroxide are heated together the following overall reaction occurs.



What are the oxidation numbers for chlorine in each of the following species?

	Cl_2	NaCl	NaClO_3
A	0	+1	-5
B	+2	-1	+3
C	0	-1	+5
D	-2	+1	-3

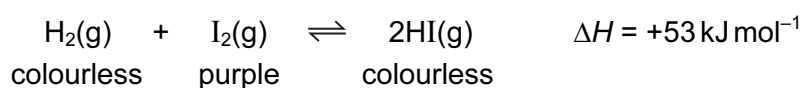
- 7 The standard enthalpy change for the reaction



What is the bond energy of the N–F bond?

- A -556 kJ mol^{-1}
- B -278 kJ mol^{-1}
- C $+278 \text{ kJ mol}^{-1}$
- D $+556 \text{ kJ mol}^{-1}$

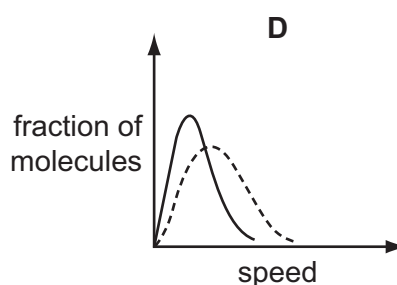
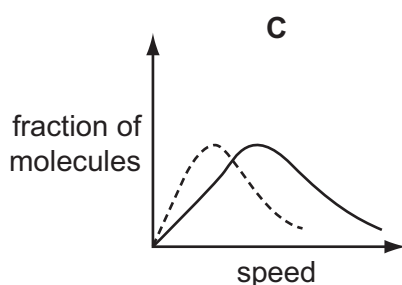
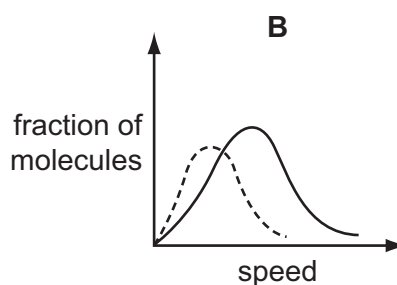
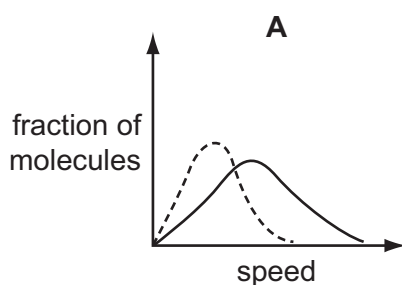
- 8 When gaseous iodine is heated with hydrogen at 450°C , an equilibrium is established.



Which change of conditions will cause the purple colour of the equilibrium mixture to become paler?

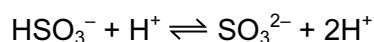
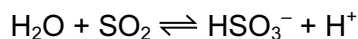
- A decrease in pressure
- B decrease in temperature
- C increase in pressure
- D increase in temperature

- 9 Which solid-line curve most accurately represents the distribution of molecular speeds in a gas at 500 K if the dotted-line curve represents the corresponding distribution for the same gas at 300 K ?



- 10 Sulfur dioxide is used as a preservative in wine making.

The following equations describe how sulfur dioxide dissolves.

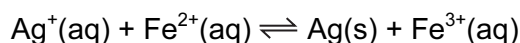


Which statement about these two reactions is correct?

- A HSO_3^- acts as a base.
 - B SO_2 acts as an oxidising agent.
 - C SO_3^{2-} acts as an acid.
 - D SO_3^{2-} acts as a reducing agent.
- 11 Butanedioate ions can be dehydrogenated to form *trans*-butenedioate ions. The enzyme fumarase speeds up this reaction.

Why does fumarase speed up this reaction?

- A Fumarase is a protein.
 - B Fumarase is effective at body temperature.
 - C Fumarase lowers the activation energy of the dehydrogenation reaction.
 - D The enzyme fumarase is specific for this dehydrogenation reaction.
- 12 An aqueous solution was prepared containing 1.0 mol of AgNO_3 and 1.0 mol of FeSO_4 in 1.00 dm^3 of water. When equilibrium was established, there was 0.44 mol of $\text{Ag}^+(\text{aq})$ in the mixture.



What is the numerical value of K_c ?

- A 0.35 B 0.62 C 1.62 D 2.89
- 13 Which element shows the greatest tendency to form some covalent compounds?
- A aluminium
 - B magnesium
 - C neon
 - D potassium

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

A 5.00 g sample of an anhydrous Group II metal nitrate loses 3.29 g in mass when heated strongly.

Which metal is present?

- A** magnesium
- B** calcium
- C** strontium
- D** barium

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

A significant contribution to atmospheric carbon dioxide levels comes from the thermal decomposition of limestone, in the manufacture of cement and of lime for agricultural purposes.

Cement works roast 1000 million tonnes of limestone per year and a further 200 million tonnes is roasted in kilns to make lime.

What is the total annual mass output of carbon dioxide (in million tonnes) from these two processes?

- A** 440 **B** 527 **C** 660 **D** 880

16 Why do the halogens become less volatile as Group VII is descended?

- A** The halogen-halogen bond energy decreases.
- B** The halogen-halogen bond length increases.
- C** The number of electrons in each molecule increases.
- D** The van der Waals' forces between molecules become weaker.

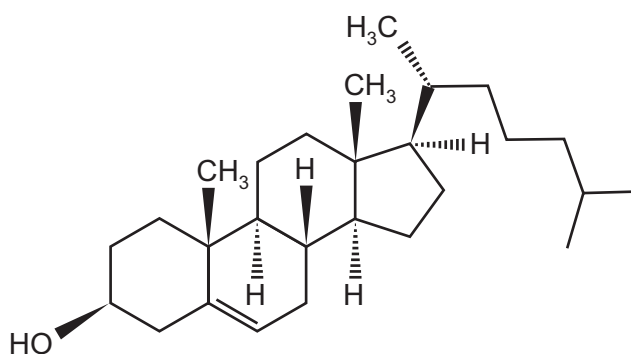
17 Aqueous sodium chloride (brine) is electrolysed by using inert electrodes in a cell which is stirred so that products of electrolysis react with each other. The cell is kept cold.

Which pair of substances is among the major products?

- A** hydrogen and chlorine
- B** hydrogen and sodium chlorate(I)
- C** hydrogen and sodium chlorate(V)
- D** sodium hydroxide and chlorine

- 18 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

Separate oxidation reactions are carried out using different conditions.

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

Which statements about the **products** formed are correct?

	cold, dilute acidified KMnO_4 : number of hydroxy groups present	hot, concentrated acidified KMnO_4 : number of 6-membered rings remaining
A	1	2
B	1	3
C	3	2
D	3	3

- 19 Which reaction is endothermic?

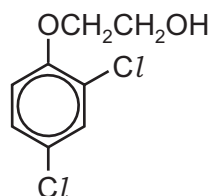
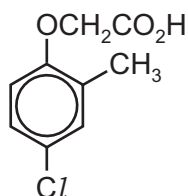
- A** $2\text{HBr} \rightarrow \text{H}_2 + \text{Br}_2$
- B** $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$
- C** $2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{SO}_3$
- D** $\text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4$

- 20 Total removal of the pollutant sulfur dioxide, SO_2 , is difficult, both for economic and technical reasons. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are scrubbed (washed) with calcium hydroxide to remove the SO_2 .

What is the main product formed **initially**?

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

- 21 **Y** and **Z** are two widely-used selective weed killers.



Which reagent will distinguish **Y** from **Z**?

- A** acidified $\text{AgNO}_3(\text{aq})$
B Fehling's solution
C Na
D $\text{Na}_2\text{CO}_3(\text{aq})$
- 22 What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 1-bromobutane?
- A** attack by a nucleophile on a carbon atom with a partial positive charge
B heterolytic bond fission and attack by a nucleophile on a carbocation
C homolytic bond fission and attack by an electrophile on a carbanion
D homolytic bond fission and attack by a nucleophile on a carbocation
- 23 In the general formula of which class of compound, is the ratio of hydrogen atoms to carbon atoms the highest?
- A** alcohols
B aldehydes
C carboxylic acids
D halogenoalkanes

- 24 Many different compounds have been used in aerosol sprays, refrigerators and in making foamed plastics.

Which compound will cause the **most** ozone depletion?

- A CCl_3F
 B CH_2FCHClF
 C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
 D N_2O

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

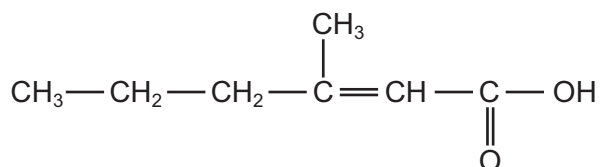
2.76 g of ethanol were mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The organic product was then collected by distillation.

The yield of product was 75.0 %.

What mass of product was collected?

- A 1.98 g B 2.07 g C 2.70 g D 4.80 g

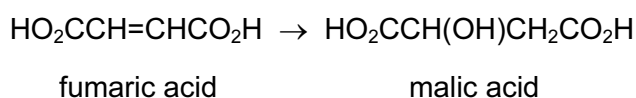
- 26 An unpleasant smelling chemical produced in the human armpit is 3-methylhex-2-enoic acid.



If this compound is reacted with a cold, dilute, acidified solution of potassium manganate(VII), how many chiral centres will be produced?

- A 0 B 1 C 2 D 3

- 27 Energy is released in the human body by the oxidation of glucose in a complex sequence of reactions. Part of this sequence is the Krebs cycle. One reaction in the Krebs cycle is the conversion of fumaric acid into malic acid.



Which reagents could achieve this transformation in the laboratory?

- A acidified KMnO_4
 B $\text{Br}_2(\text{aq})$ followed by hot $\text{NaOH}(\text{aq})$
 C H_2O with Pt catalyst
 D steam with H_2SO_4

- 28 A reaction between chlorine and propane in ultraviolet light produces two isomeric monochloropropanes, C_3H_7Cl , as products.

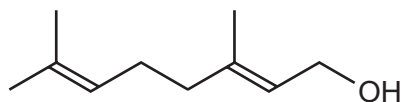
Which information about this reaction is correct?

	type of bond fission in initiation step	expected ratio of 1-chloropropane to 2-chloropropane produced
A	heterolytic	1 : 1
B	heterolytic	3 : 1
C	homolytic	1 : 1
D	homolytic	3 : 1

- 29 Which pair of substances could react to give the ester $CH_3CH_2CO_2CH_3$?

- A** ethanol and ethanoic acid
- B** methanol and ethanoic acid
- C** methanol and propanoic acid
- D** propan-1-ol and methanoic acid

- 30 Geraniol is a constituent of some perfumes.



geraniol

Which statement about geraniol is **not** correct?

- A** Geraniol causes hot acidified potassium dichromate(VI) to change colour from orange to green.
- B** Geraniol decolourises bromine water.
- C** There are three methyl groups and three methylene (CH_2) groups in geraniol.
- D** There are two pairs of *cis-trans* isomers of geraniol.

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 The definitions of many chemical terms can be illustrated by chemical equations.

Which terms can be illustrated by an equation that shows the formation of a positive ion?

- 1** first ionisation energy
- 2** heterolytic fission
- 3** enthalpy change of atomisation

32 The three statements that follow are all true.

Which of these can be explained, at least in part, by reference to hydrogen bonding?

- 1** At 0 °C ice floats on water.
- 2** The boiling point of propan-2-ol is 82 °C. The boiling point of propanone is 56 °C.
- 3** At 20 °C propanone and propanal mix completely.

33 Which of the halide ions, chloride, bromide or iodide, acts as a reducing agent when its sodium salt reacts with concentrated sulfuric acid?

- 1** at least one of Cl^- , Br^- and I^-
- 2** at least two of Cl^- , Br^- and I^-
- 3** all three of Cl^- , Br^- and I^-

34 Why does aluminium chloride, Al_2Cl_6 , sublime at the relatively low temperature of 180 °C?

- 1** The intermolecular forces between the Al_2Cl_6 molecules are weak.
- 2** The co-ordinate bonds between aluminium and chlorine are weak.
- 3** The covalent bonds between aluminium and chlorine are weak.

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.

- 35** A farmer spreads lime on land which has already been treated with an ammonium nitrate fertiliser.

Which reactions will occur in the treated soil?

- 1** $\text{Ca(OH)}_2 + 2\text{NH}_4^+(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{NH}_3 + 2\text{H}_2\text{O}$
- 2** $\text{Ca(OH)}_2 + 2\text{H}^+(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{H}_2\text{O}$
- 3** $\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$

- 36** In a car engine, non-metallic element X forms a pollutant oxide Y.

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

Which statements about X, Y and Z are correct?

- 1** X forms a basic hydride.
- 2** Y is a diatomic molecule.
- 3** Z is a polar molecule.

- 37** **X** is an organic compound. **X** gives a precipitate with aqueous silver nitrate. Some or all of this precipitate remains undissolved when an excess of dilute aqueous ammonia is added.

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

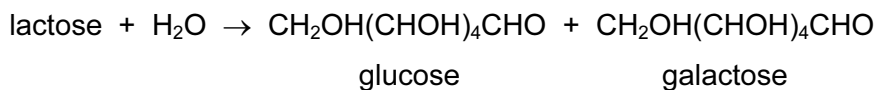
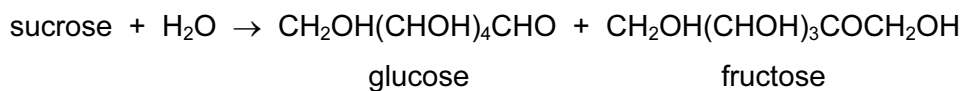
- 1** 2-chlorobutane
- 2** 2-bromobutane
- 3** iodomethane

- 38** On acid hydrolysis, which compounds produce propanoic acid?

- 1** $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$
- 2** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$
- 3** $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$

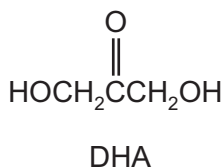
- 39 Disaccharides, $C_{12}H_{22}O_{11}$, are important in the human diet. For example, sucrose is found in pastries and lactose occurs in milk products.

Both of these compounds can be hydrolysed.



Which statements about these hydrolysis products are correct?

- 1 Glucose and fructose have structural isomers.
 - 2 Glucose and galactose are optical isomers.
 - 3 Glucose and galactose are ketones.
- 40 DHA is a colourless liquid which reacts with protein in skin to cause it to darken. It has the structure shown.



Which observations would be made when testing this substance?

- 1 Hydrogen is produced when sodium is added.
- 2 A coloured precipitate is produced when 2,4-dinitrophenylhydrazine reagent is added.
- 3 A silver precipitate is produced when Tollens' reagent is added.

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