



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

CHEMISTRY

Paper 1 Multiple Choice

9701/11

May/June 2012

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 In which species does the underlined atom have an incomplete outer shell?

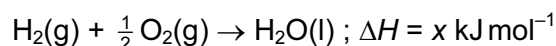
A $\underline{\text{B}}\text{F}_3$ **B** $\underline{\text{C}}\text{H}_3^-$ **C** $\text{F}_2\underline{\text{O}}$ **D** $\text{H}_3\underline{\text{O}}^+$

- 2 Ammonia is manufactured by the Haber Process, in an exothermic reaction.

Assuming that the amount of catalyst remains constant, which change will **not** bring about an increase in the rate of the forward reaction?

- A** decreasing the size of the catalyst pieces
B increasing the pressure
C increasing the temperature
D removing the ammonia as it is formed

- 3 The equation for a reaction is shown.



Which pair of descriptions is fully correct for this reaction?

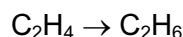
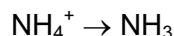
	type(s) of enthalpy change	value of x
A	formation only	positive
B	formation only	negative
C	combustion, formation	positive
D	combustion, formation	negative

- 4 The value of the second ionisation energy of calcium is 1150 kJ mol^{-1} .

Which equation correctly represents this statement?

- A** $\text{Ca}(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{e}^- ; \Delta H^\ominus = +1150 \text{ kJ mol}^{-1}$
B $\text{Ca}^+(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^- ; \Delta H^\ominus = +1150 \text{ kJ mol}^{-1}$
C $\text{Ca}^+(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^- ; \Delta H^\ominus = -1150 \text{ kJ mol}^{-1}$
D $\text{Ca}(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{e}^- ; \Delta H^\ominus = -1150 \text{ kJ mol}^{-1}$

- 5 Two conversions are outlined below.



What similar feature do these two conversions have?

- A** a lone pair of electrons in the product
 - B** change in oxidation state of an element
 - C** decrease in bond angle of the species involved
 - D** disappearance of a π bond
- 6 *Use of the Data Booklet is relevant to this question.*

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.56 g of ethene gas is contained in a vessel at a pressure of 102 kPa and a temperature of 30 °C.

What is the volume of the vessel?

- A** 49 cm³ **B** 494 cm³ **C** 48 900 cm³ **D** 494 000 cm³
- 7 Propanone has the molecular formula C₃H₆O.

The enthalpy change of combustion of hydrogen is –286 kJ mol^{–1}.

The enthalpy change of combustion of carbon is –394 kJ mol^{–1}.

The enthalpy change of combustion of propanone is –1786 kJ mol^{–1}.

Using this information, what is the enthalpy change of formation of propanone?

- A** –1106 kJ mol^{–1}
 - B** –540 kJ mol^{–1}
 - C** –254 kJ mol^{–1}
 - D** +1106 kJ mol^{–1}
- 8 Under which set of conditions is a gas most likely to behave ideally?

	temperature	pressure
A	high	high
B	high	low
C	low	high
D	low	low

- 9 Two moles of compound P were placed in a vessel. The compound P was partly decomposed by heating. A dynamic equilibrium between chemicals P, Q and R was established.

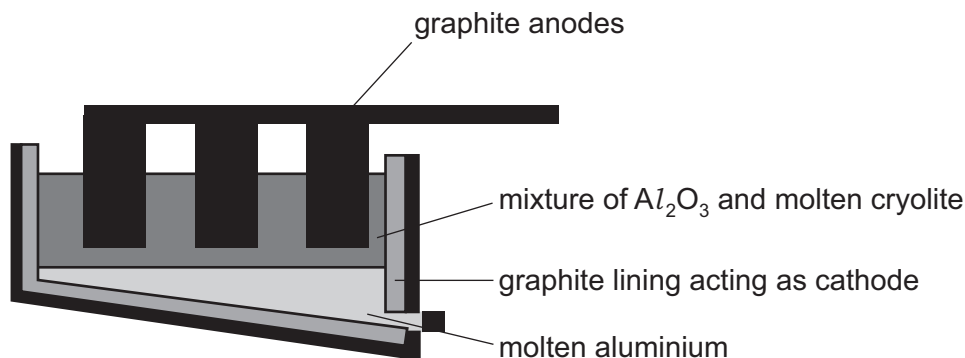
At equilibrium, x mol of R were present and the total number of moles present was (2 + x).

What is the equation for this equilibrium?

- A $P \rightleftharpoons 2Q + R$
 B $2P \rightleftharpoons 2Q + R$
 C $2P \rightleftharpoons Q + R$
 D $2P \rightleftharpoons Q + 2R$
- 10 The oxide of titanium, TiO_2 , is used as a 'whitener' in toothpaste. It is obtained from the ore iron(II) titanate, $FeTiO_3$.

What is the change, if any, in the oxidation number (oxidation state) of titanium in the reaction $FeTiO_3 \rightarrow TiO_2$?

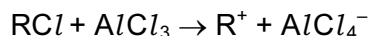
- A It is oxidised from +3 to +4.
 B It is reduced from +3 to +2.
 C It is reduced from +6 to +4.
 D There is no change in the oxidation number.
- 11 The diagram shows a cell for the manufacture of aluminium.



Which statement is **incorrect**?

- A Aluminium ions are oxidised in this process.
 B Aluminium is liberated at the cathode by the reaction $Al^{3+} + 3e^- \rightarrow Al$.
 C The cryolite acts as a solvent.
 D The graphite anode burns away.

- 12 Aluminium chloride catalyses certain reactions by forming carbocations with chloroalkanes as shown.



Which property makes this reaction possible?

- A $AlCl_3$ exists as the dimer Al_2Cl_6 in the vapour.
 - B $AlCl_3$ is a covalent molecule.
 - C The aluminium atom in $AlCl_3$ has an incomplete octet of electrons.
 - D The chlorine atom in RCl has a vacant p orbital.
- 13 *Use of the Data Booklet is relevant to this question.*

When a mineral was heated in a Bunsen flame to constant mass, a colourless gas that turned lime water milky was evolved. The remaining solid was cooled and then added to aqueous hydrochloric acid. Vigorous effervescence was seen.

What was the mineral?

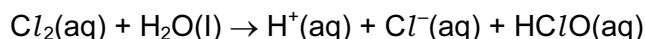
- A aragonite, $CaCO_3$
 - B artinite, $MgCO_3 \cdot Mg(OH)_2 \cdot 3H_2O$
 - C barytocalcite, $BaCO_3 \cdot CaCO_3$
 - D dolomite, $CaCO_3 \cdot MgCO_3$
- 14 *Use of the Data Booklet is relevant to this question.*

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The metal oxides and nitrogen are the only products.

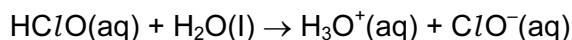
Which volume of nitrogen, measured under room conditions, is produced when 0.783 g of anhydrous barium nitrate reacts with an excess of aluminium?

- A 46.8 cm^3
 - B 72.0 cm^3
 - C 93.6 cm^3
 - D 144 cm^3
- 15 The oxides BaO , CaO , MgO and SrO all produce alkaline solutions when added to water.
- Which oxide produces the saturated solution with the highest pH?
- A $BaO(aq)$
 - B $CaO(aq)$
 - C $MgO(aq)$
 - D $SrO(aq)$

- 16 In the treatment of domestic water supplies, chlorine is added to the water to form HClO .



The HClO reacts further to give ClO^- ions.



Both HClO and ClO^- kill bacteria by oxidation.

What is the overall change in oxidation number of chlorine when forming the ClO^- ion from the aqueous chlorine?

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

- 17 What trend is observed on descending Group VII?

- A** The colours of the elements become lighter.
B The elements become more volatile.
C The hydrides of the elements become more thermally stable.
D The reactions of the elements with hydrogen become less vigorous.

- 18 The following two experiments are carried out with anhydrous potassium chloride and observations X and Y are made at the end of each experiment.

Concentrated sulfuric acid is added to the potassium chloride and the fumes produced are bubbled into aqueous potassium iodide solution - observation X.

The potassium chloride is dissolved in aqueous ammonia and this is then added to aqueous silver nitrate - observation Y.

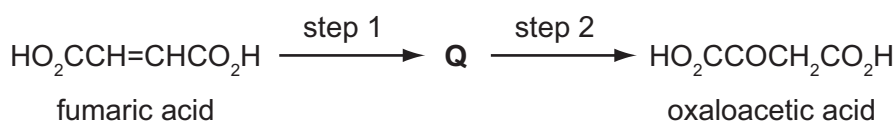
What are the observations X and Y?

	X	Y
A	brown solution	colourless solution
B	brown solution	white precipitate
C	colourless solution	colourless solution
D	colourless solution	white precipitate

- 19 Carbon monoxide, CO, nitrogen monoxide, NO, and sulfur dioxide, SO₂, may all be present in the exhaust fumes from a car engine.

Which reaction concerning these compounds occurs in the atmosphere?

- A CO is spontaneously oxidised to CO₂
 B NO₂ is reduced to NO by CO
 C NO₂ is reduced to NO by SO₂
 D SO₂ is oxidised to SO₃ by CO₂
- 20 Fumaric acid can be converted into oxaloacetic acid by a two-step process involving the intermediate **Q**.



Each of these steps can be achieved in the laboratory by a single reagent.

What could be the intermediate **Q** and the reagent for step 2?

	Q	reagent for step 2
A	HO ₂ CCHBrCH ₂ CO ₂ H	warm acidified KMnO ₄
B	HO ₂ CCHBrCH(OH)CO ₂ H	warm NaOH(aq)
C	HO ₂ CCH(OH)CH ₂ CO ₂ H	Fehling's solution
D	HO ₂ CCH(OH)CH ₂ CO ₂ H	warm acidified K ₂ Cr ₂ O ₇

- 21 An organic compound **J** reacts with sodium to produce an organic ion with a charge of –3. **J** reacts with NaOH(aq) to produce an organic ion with a charge of –1.

What could be the structural formula of **J**?

- A HO₂CCH(OH)CH₂CO₂H
 B HO₂CCH(OH)CH₂CHO
 C HOCH₂CH(OH)CH₂CO₂H
 D HOCH₂COCH₂CHO

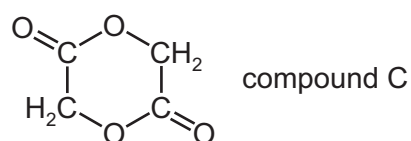
22 Use of the Data Booklet is relevant to this question.

A sample of ethyl propanoate is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed.

Out of the total mass of products obtained, what is the percentage by mass of each product?

- A** 32.4 % and 67.6 %
- B** 38.3 % and 61.7 %
- C** 42.3 % and 57.7 %
- D** 50.0 % and 50.0 %

23 Compound C is used in textile and leather processing.



Which starting material(s), on gentle heating with a few drops of concentrated sulfuric acid, generates compound C?

- A** CH_3COOH only
- B** HOCH_2COOH only
- C** $\text{CH}_3\text{COOCH}_2\text{COOH}$ only
- D** CH_3COOH mixed with HOCH_2COOH

24 How many isomeric esters have the molecular formula $\text{C}_4\text{H}_8\text{O}_2$?

- A** 2
- B** 3
- C** 4
- D** 5

25 Which compound, on reaction with hydrogen cyanide, produces a compound with a chiral centre?

- A** CH_3CHO
- B** $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$
- C** $\text{CH}_3\text{CO}_2\text{CH}_3$
- D** HCHO

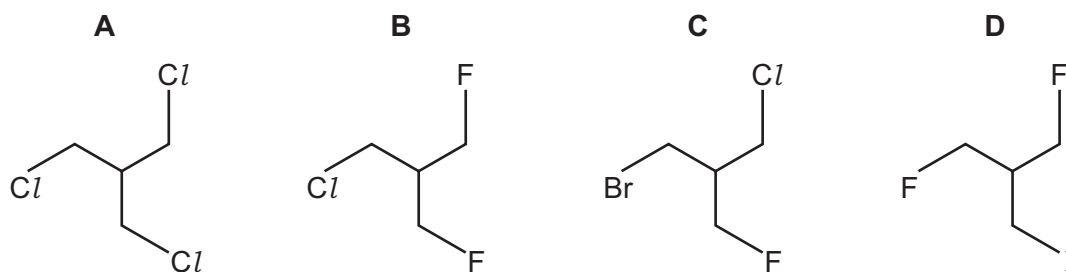
- 26**
- | | | | |
|--|--------------------------------------|---|---|
| $\text{CH}_3\text{COCH}_2\text{CH}_2\text{OH}$ | $\text{CH}_3\text{COCH}_2\text{CHO}$ | $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$ | $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ |
| <i>W</i> | <i>X</i> | <i>Y</i> | <i>Z</i> |

Which of these compounds can be oxidised by acidified dichromate(VI) solution and also gives a positive response to Tollens' reagent?

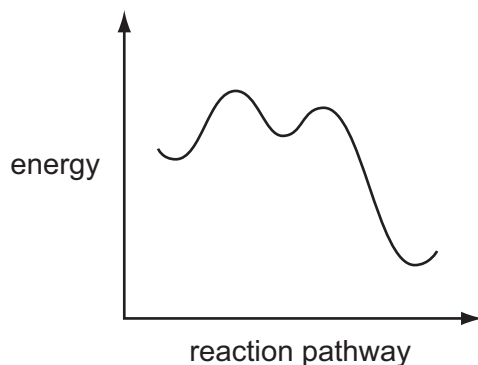
- A** *W* and *X* only
B *W* and *Y* only
C *X* and *Z* only
D *Y* and *Z* only

- 27** The presence of halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

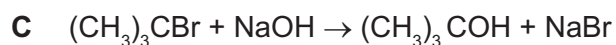
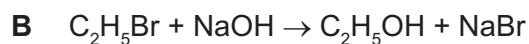
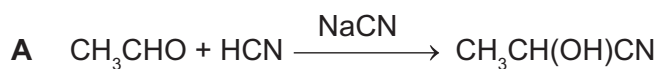
Which compound would produce a precipitate quickest?



28 A reaction pathway diagram is shown.



Which reaction does **not** have such a profile?



29 The depletion of the ozone layer in the upper atmosphere reduces the Earth's natural protection from harmful ultraviolet radiation.

Which compound would cause the most depletion of the ozone layer?



30 Which statement does **not** correctly describe the polymer PVC?

A Combustion of PVC waste produces a highly acidic gas.

B PVC molecules are saturated.

C The empirical formula of PVC is the same as the empirical formula of its monomer.

D The repeat unit of PVC is $-(\text{CHClCHCl})-$.

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 gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

where each symbol has its usual meaning.

Which statements are correct?

- 1** One mole of an ideal gas occupies the same volume under the same conditions of temperature and pressure.
- 2** The density of an ideal gas at constant pressure is inversely proportional to the temperature, T .
- 3** The volume of a given mass of an ideal gas is doubled if its temperature is raised from 25 °C to 50 °C at constant pressure.

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

In which pairs do both species have the same number of unpaired p electrons?

- 1** O and Cl^+
- 2** F^+ and Ga^-
- 3** P and Ne^+

Section B

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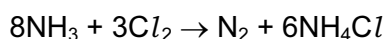
No other combination of statements is used as a correct response.

- 33** Nitrogen and phosphorus are both in Group V of the Periodic Table. Phosphorus forms a chloride with the formula PCl_5 .

Why is it **not** possible for nitrogen to form NCl_5 ?

- 1** Nitrogen's outer shell can only contain eight electrons.
- 2** Nitrogen cannot have oxidation state +5.
- 3** Nitrogen is almost inert.

- 34** Ammonia and chlorine react in the gas phase.



Which statements are correct?

- 1** Ammonia behaves as a reducing agent.
- 2** Ammonia behaves as a base.
- 3** The oxidation number of the hydrogen changes

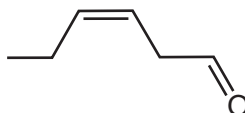
- 35** Which statements are correct for all three halogens, chlorine, bromine and iodine?

- 1** They all form hydrides that are strong acids in aqueous solution.
- 2** They all react with aqueous sodium hydroxide to form oxo-anions.
- 3** They all require one more electron to fill the p orbitals of their outer shells.

- 36 In the manufacture of sulfuric acid the reaction $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ usually takes place at $400\text{ }^\circ\text{C}$ and 1 atm pressure. In one industrial plant, it is decided to change the pressure to 20 atm.

What will be the consequences of this change?

- 1 increased running costs
 - 2 an increased percentage of sulfur trioxide in the equilibrium mixture
 - 3 the rate of the backward reaction increases
- 37 What is **always** involved in a carbon-carbon π bond?
- 1 a shared pair of electrons
 - 2 a sideways overlap of p orbitals
 - 3 delocalised electrons
- 38 A number of alcohols with the formula $\text{C}_4\text{H}_{10}\text{O}$ are separately oxidised. Using 70 g of the alcohols a 62 % yield of organic product is achieved.
- What mass of product could be obtained?
- 1 42.2 g of butanone
 - 2 51.6 g of butanoic acid
 - 3 51.6 g of 2-methyl propanoic acid
- 39 The compound *cis*-hex-3-enal is responsible for the characteristic smell of cut grass. The human nose is particularly sensitive to this compound, being able to detect 0.25 parts per billion in air.



cis-hex-3-enal

Which reagents will react with *cis*-hex-3-enal?

- 1 sodium
- 2 sodium borohydride
- 3 Fehling's reagent

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.

40 How can a good yield of ethylamine be made using bromoethane as starting material?

- 1** by heating bromoethane with an excess of ammonia gas in a sealed tube
- 2** by adding dilute aqueous ammonia to bromoethane at room temperature
- 3** by heating bromoethane under reflux with aqueous ammonium chloride

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CHEMISTRY

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9701/12

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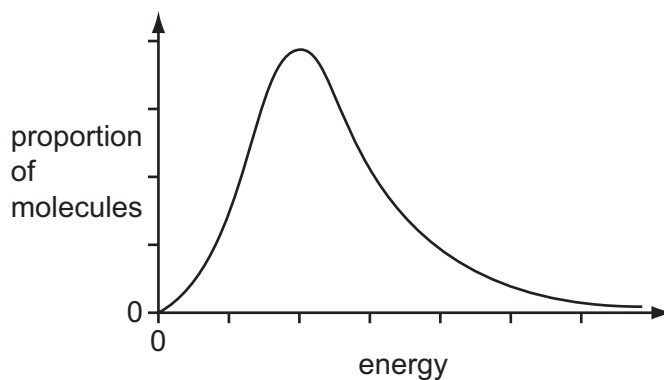
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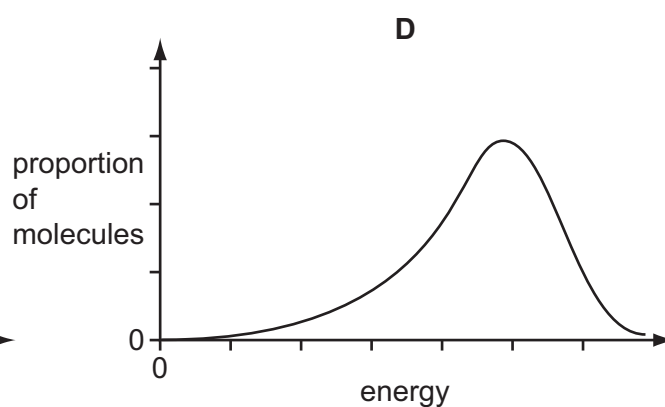
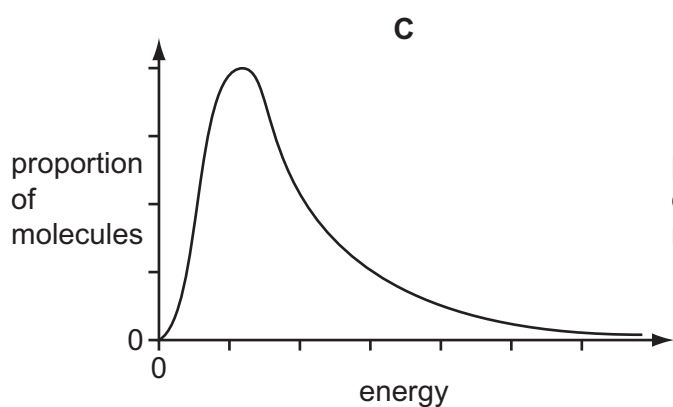
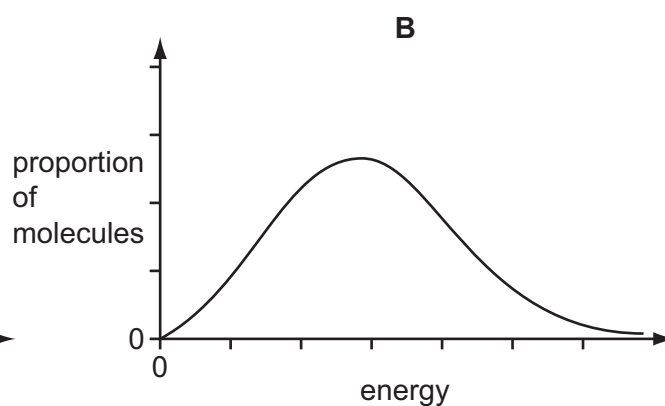
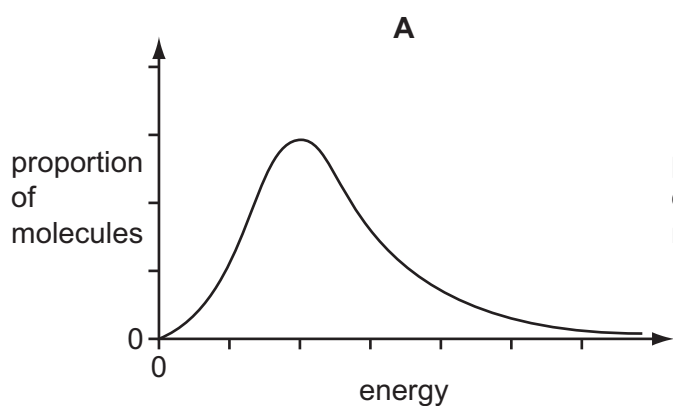
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For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

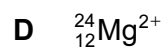
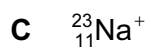
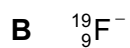
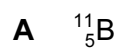
- 1 The molecular energy distribution curve represents the variation in energy of the molecules of a gas at room temperature.



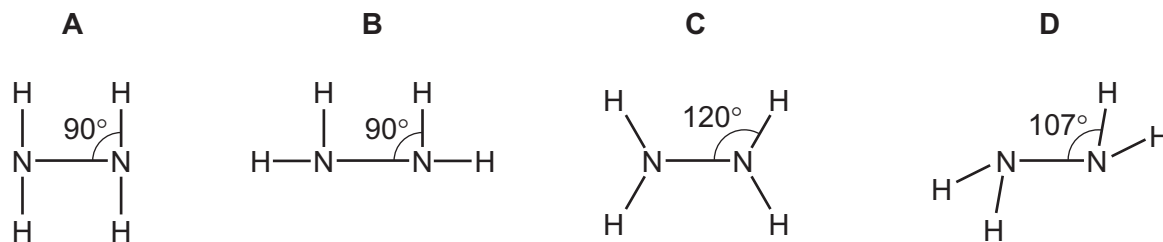
Which curve applies for the same gas at a lower temperature?



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



3 What is the **most** likely shape of a molecule of hydrazine, N_2H_4 ?



4 In which species does the underlined atom have an incomplete outer shell?

- A** $\underline{\text{Al}}_2\text{Cl}_6$

 B $\underline{\text{C}}\text{H}_3^+$

 C $\text{Cl}_2\underline{\text{O}}$

 D $\text{H}_2\underline{\text{Cl}}\text{C}\cdot$

5 Which solid contains more than one kind of bonding?

- A** iodine
B silicon dioxide
C sodium chloride
D zinc

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

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.96 g of oxygen gas is contained in a glass vessel of volume 7000 cm^3 at a temperature of 30°C .

What is the pressure in the vessel?

- A** 1.1 kPa

 B 2.1 kPa

 C 10.8 kPa

 D 21.6 kPa

7 Two moles of compound P were placed in a vessel. The vessel was heated and compound P was partly decomposed to produce Q and R. A dynamic equilibrium between chemicals P, Q and R was established.

At equilibrium x moles of R were present and the total number of moles present was $(2 + \frac{x}{2})$.

What is the equation for this equilibrium reaction?

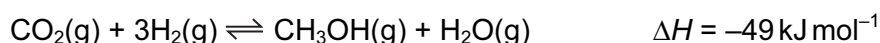
- A** $\text{P} \rightleftharpoons 2\text{Q} + \text{R}$
B $2\text{P} \rightleftharpoons 2\text{Q} + \text{R}$
C $2\text{P} \rightleftharpoons \text{Q} + \text{R}$
D $2\text{P} \rightleftharpoons \text{Q} + 2\text{R}$

- 8 The value of the third ionisation energy of aluminium is 2740 kJ mol^{-1} .

Which correctly represents this statement?

- A $\text{Al(g)} \rightarrow \text{Al}^{3+}(\text{g}) + 3\text{e}^- \quad \Delta H^\ominus = -2740 \text{ kJ mol}^{-1}$
 B $\text{Al}^{2+}(\text{g}) \rightarrow \text{Al}^{3+}(\text{g}) + \text{e}^- \quad \Delta H^\ominus = -2740 \text{ kJ mol}^{-1}$
 C $\text{Al(g)} \rightarrow \text{Al}^{3+}(\text{g}) + 3\text{e}^- \quad \Delta H^\ominus = +2740 \text{ kJ mol}^{-1}$
 D $\text{Al}^{2+}(\text{g}) \rightarrow \text{Al}^{3+}(\text{g}) + \text{e}^- \quad \Delta H^\ominus = +2740 \text{ kJ mol}^{-1}$

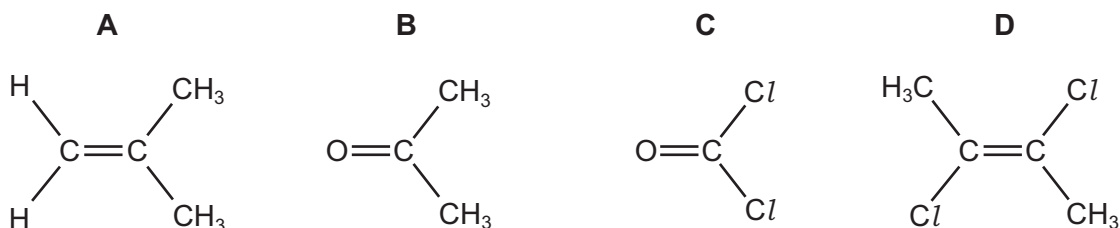
- 9 Methanol is manufactured by reacting carbon dioxide and hydrogen.



What would increase the equilibrium yield of methanol in this process?

- A adding a catalyst
 B adding an excess of steam
 C increasing the pressure
 D increasing the temperature

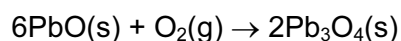
- 10 Which molecule has the largest overall dipole?



- 11 In which substance does nitrogen exhibit the highest oxidation state?

- A NO B N₂O C N₂O₄ D NaNO₂

- 12 Red lead oxide, Pb₃O₄, is used in metal priming paints. It can be made by heating PbO in air.



Which two values are needed to calculate the enthalpy change for this reaction?

- A enthalpy change of atomisation of O₂ and enthalpy change of formation of Pb₃O₄
 B enthalpy change of formation of O₂ and enthalpy change of formation of Pb₃O₄
 C enthalpy change of formation of PbO and enthalpy change of atomisation of O₂
 D enthalpy change of formation of PbO and enthalpy change of formation of Pb₃O₄

13 Which gas is present in the exhaust fumes of a car engine in a much greater amount than any other gas?

- A carbon dioxide
- B carbon monoxide
- C nitrogen
- D water vapour

14 Slaked lime, Ca(OH)_2 , may be made from limestone, CaCO_3 .

On heating in a lime kiln at 1000°C , limestone decomposes as follows.



Water is then reacted with calcium oxide, CaO , as follows.



What are the enthalpy changes of these reactions?

	reaction 1	reaction 2
A	endothermic	endothermic
B	endothermic	exothermic
C	exothermic	endothermic
D	exothermic	exothermic

15 The period 4 elements gallium (Ga), germanium (Ge), arsenic (As) and selenium (Se) are the elements below aluminium, silicon, phosphorus and sulfur in the Periodic Table, a portion of which is shown below.

period 3 elements	Al	Si	P	S
period 4 elements	Ga	Ge	As	Se

The properties of each period 4 element resemble those of the period 3 element directly above it.

Which period 4 elements form oxides that dissolve in water to give an acid solution?

- A As and Se
- B Ga and Ge
- C Ga and Se
- D Se only

- 16 Chlorine shows oxidation states ranging from -1 to $+7$ in its compounds.

What are the reagent(s) and conditions necessary for the oxidation of elemental chlorine into a compound containing chlorine in the $+5$ oxidation state?

- A $\text{AgNO}_3(\text{aq})$ followed by $\text{NH}_3(\text{aq})$ at room temperature
 B concentrated H_2SO_4 at room temperature
 C cold dilute $\text{NaOH}(\text{aq})$
 D hot concentrated $\text{NaOH}(\text{aq})$
- 17 What can be seen when a piece of magnesium ribbon is placed in cold water?
- A A vigorous effervescence occurs.
 B Bubbles of gas form slowly on the magnesium.
 C The magnesium floats on the surface of the water and reacts quickly.
 D The magnesium glows and a white solid is produced.
- 18 *Use of the Data Booklet is relevant to this question.*

Sodium and sulfur react together to form sodium sulfide, Na_2S .

How do the atomic radius and ionic radius of sodium compare with those of sulfur?

	atomic radius	ionic radius
A	sodium > sulfur	sodium > sulfur
B	sodium > sulfur	sodium < sulfur
C	sodium < sulfur	sodium > sulfur
D	sodium < sulfur	sodium < sulfur

- 19 Which substance does **not** produce a poisonous gas, when burnt in a limited amount of air?
- A hydrogen
 B methane
 C propene
 D sulfur

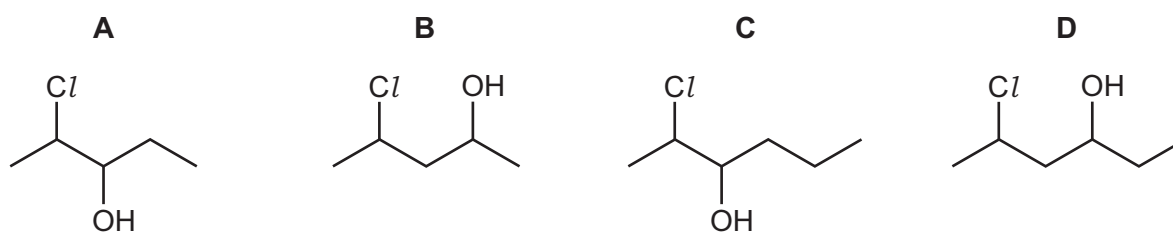
20 Use of the Data Booklet is relevant to this question.

A sample of propyl ethanoate is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed.

Out of the total mass of products obtained, what is the percentage by mass of each product?

- A 32.4 % and 67.6 %
- B 38.3 % and 61.7 %
- C 42.3 % and 57.7 %
- D 50.0 % and 50.0 %

21 Which diagram gives the skeletal formula of 2-chloropentan-3-ol?

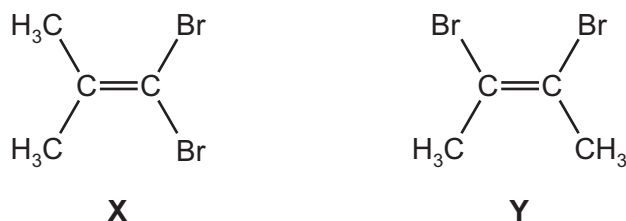


22 When 1-bromopropane is treated in succession with two reagents, X and Y, it produces propanoic acid.

What are reagents X and Y?

	X	Y
A	NaOH(aq)	$\text{H}^+ / \text{Cr}_2\text{O}_7^{2-}(\text{aq})$
B	NaOH(aq)	CO_2
C	KCN in ethanol	HCl(aq)
D	KCN in ethanol	NaOH(aq)

23 Isomers **X** and **Y** both react with HBr.



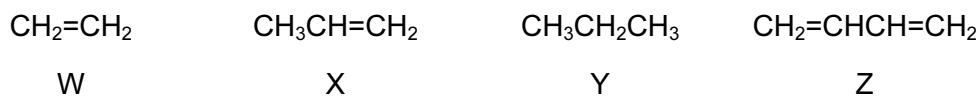
A mixture of **X** and **Y** is reacted with HBr.

Which three structures represent three **different** possible products of this reaction?

- | | | | |
|----------|-----------------------------------|---|--|
| A | $(\text{CH}_3)_2\text{CHCBr}_3$ | $(\text{CH}_3)_2\text{CBrCHBr}_2$ | $\text{CH}_3\text{CHBrCHBrCH}_3$ |
| B | $(\text{CH}_3)_2\text{CHCBr}_3$ | $(\text{CH}_3)_2\text{CBrCHBr}_2$ | $\text{CH}_3\text{CBr}_2\text{CHBrCH}_3$ |
| C | $(\text{CH}_3)_2\text{CBrCBr}_3$ | $(\text{CH}_3)_2\text{CHCBr}_3$ | $\text{CH}_3\text{CBr}_2\text{CHBrCH}_3$ |
| D | $(\text{CH}_3)_2\text{CBrCHBr}_2$ | $\text{CHBr}_2\text{CBr}(\text{CH}_3)\text{CH}_3$ | $\text{CH}_3\text{CHBrCBr}_2\text{CH}_3$ |

24 Oct-1-ene, $\text{CH}_3(\text{CH}_2)_5\text{CH}=\text{CH}_2$, is subjected to thermal cracking.

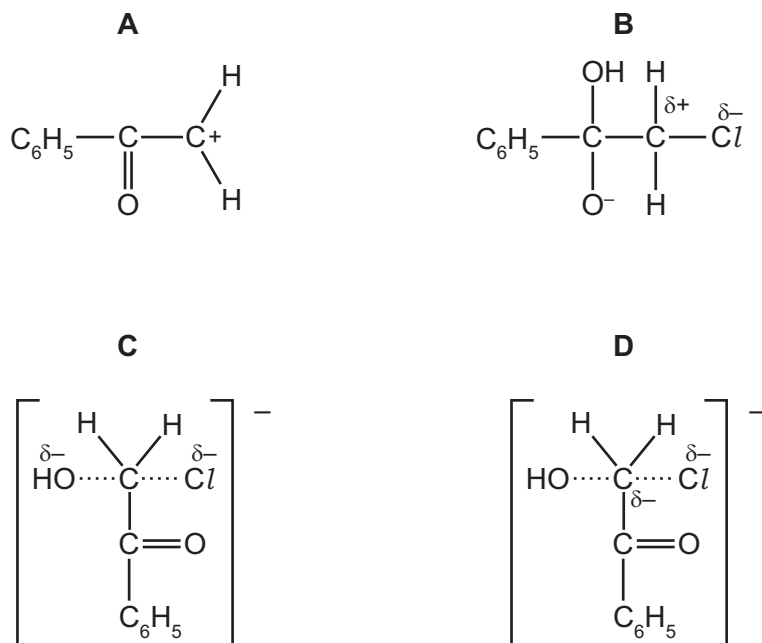
Which combination of compounds W, X, Y and Z can be obtained?



- A** W, X, Y and Z
- B** W, X and Y only
- C** W, X and Z only
- D** W and X only

- 25 When phenacyl chloride, $\text{C}_6\text{H}_5\text{COCH}_2\text{Cl}$, is reacted with aqueous NaOH , the substitution reaction follows an $\text{S}_{\text{N}}2$ mechanism.

Which structure represents a species formed during the reaction?



- 26 Complete combustion of compound X gives carbon dioxide and water only. A sample of X is mixed with aqueous potassium(V) dichromate and boiled under reflux for one hour. The mixture is then distilled and the only organic substance present is collected.

The organic substance collected reacts with sodium to give hydrogen, but does not react with 2,4-dinitrophenylhydrazine reagent and does not react with ethanol in the presence of concentrated sulfuric acid to give an ester.

What can be deduced from this information?

- A** X is a carboxylic acid.
- B** X is a ketone.
- C** X is an alcohol.
- D** X is an alkane.

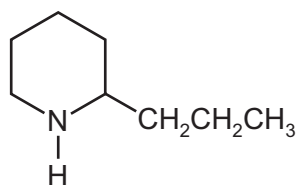
27 A compound **Y** has the following properties.

- It is a liquid at room temperature and atmospheric pressure.
- It does not mix completely with water.
- It does not give steamy fumes with PCl_5 .

What could **Y** be?

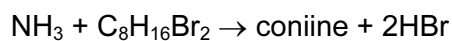
- A** ethane
- B** ethanoic acid
- C** ethanol
- D** ethyl ethanoate

28 Coniine is the major constituent of the poison 'oil of hemlock'.



coniine

Coniine can be synthesised by reacting ammonia with a dibromo compound, **X**.



X

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

- A** 1,1-dibromo-2-propylcyclopentane
- B** 1,2-dibromo-2-propylcyclopentane
- C** 1,4-dibromooctane
- D** 1,5-dibromooctane

29 A common industrial solvent is a mixture of propanone, CH_3COCH_3 , and pentyl ethanoate $\text{CH}_3\text{CO}_2(\text{CH}_2)_4\text{CH}_3$.

Which reagent would have **no** reaction with this industrial solvent?

- A** $\text{HCl}(\text{aq})$
- B** $\text{HCN}(\text{aq})$ with a little KCN
- C** $\text{Na}(\text{s})$
- D** NaBH_4

- 30** An organic compound will decolorise dilute acidified aqueous potassium manganate(VII) on warming, but will not decolorise bromine water.

What could the organic compound be?

- A** butane
- B** ethanol
- C** ethene
- D** ethanoic 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

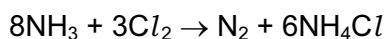
A	B	C	D
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

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

31 Which of the following molecules and ions have a regular trigonal planar shape?

- 1** BF_3
- 2** CH_3^+
- 3** AlCl_3

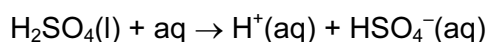
32 Ammonia and chlorine react in the gas phase.



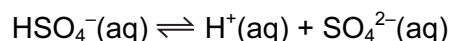
Which statements are correct?

- 1** Each nitrogen atom is oxidised.
- 2** Each chlorine atom is reduced.
- 3** Ammonia behaves as a base.

33 Concentrated sulfuric acid behaves as a strong acid when it reacts with water.



The HSO_4^- ion formed behaves as a weak acid.



Which statements are true for 1.0 mol dm^{-3} sulfuric acid?

- 1** $[\text{H}^+(\text{aq})]$ is high
- 2** $[\text{SO}_4^{2-}(\text{aq})]$ is high
- 3** $[\text{HSO}_4^-(\text{aq})] = [\text{SO}_4^{2-}(\text{aq})]$

34 Silver chloride dissolves in aqueous ammonia.

What happens in this process?

- 1 A co-ordinate bond is formed.
- 2 The oxidation number of nitrogen is unchanged.
- 3 Ammonia acts as a Brønsted-Lowry base.

35 Compared with the HCl molecule, the bond X..... of the HBr molecule is Y.....

Which pairs of words correctly complete the above sentence?

	X	Y
1	energy	less
2	polarity	less
3	length	greater

36 Which statements are true about the Haber process for the manufacture of ammonia?

- 1 At higher temperatures, the yield goes down but the rate of production of ammonia is faster.
- 2 At higher pressures, the yield goes down but the rate of production of ammonia is faster.
- 3 In the presence of a catalyst, the yield goes down but the rate of production of ammonia is faster.

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

- 1 $\text{CH}_2\text{OHCHOHCH}_3$
- 2 $\text{-(CH}_2\text{CH(CH}_3\text{))}_n\text{-}$
- 3 $\text{CH}_2\text{BrCH}_2\text{CH}_2\text{Br}$

38 What are the same for a pair of optical isomers?

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

39 Which statements about the photochemical chlorination of ethane are correct?

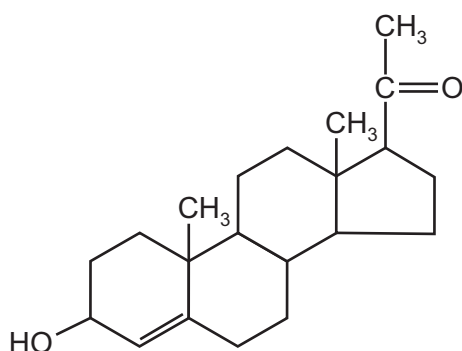
- 1 Hydrogen gas is one of the products.
- 2 A propagation step in the mechanism is $\text{C}_2\text{H}_6 + \text{Cl}\cdot \rightarrow \text{C}_2\text{H}_5\cdot + \text{HCl}$.
- 3 The initiation step is the homolytic fission of chlorine.

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 The compound shown is a hormone produced during pregnancy to suppress ovulation.



Which reagents would give positive results with this compound?

- 1** aqueous bromine
- 2** 2,4-dinitrophenylhydrazine
- 3** Fehling's reagent

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

CHEMISTRY

Paper 1 Multiple Choice

9701/13

May/June 2012

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 Ammonia is manufactured by the Haber Process, in an exothermic reaction.

Assuming that the amount of catalyst remains constant, which change will **not** bring about an increase in the rate of the forward reaction?

- A** decreasing the size of the catalyst pieces
- B** increasing the pressure
- C** increasing the temperature
- D** removing the ammonia as it is formed

- 2 In which species does the underlined atom have an incomplete outer shell?

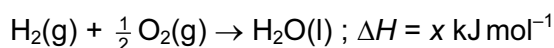
- A** $\underline{\text{B}}\text{F}_3$ **B** $\underline{\text{C}}\text{H}_3^-$ **C** $\text{F}_2\underline{\text{O}}$ **D** $\text{H}_3\underline{\text{O}}^+$

- 3 The value of the second ionisation energy of calcium is 1150 kJ mol^{-1} .

Which equation correctly represents this statement?

- A** $\text{Ca(g)} \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{e}^-$; $\Delta H^\ominus = +1150 \text{ kJ mol}^{-1}$
- B** $\text{Ca}^+(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^-$; $\Delta H^\ominus = +1150 \text{ kJ mol}^{-1}$
- C** $\text{Ca}^+(\text{g}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{e}^-$; $\Delta H^\ominus = -1150 \text{ kJ mol}^{-1}$
- D** $\text{Ca(g)} \rightarrow \text{Ca}^{2+}(\text{g}) + 2\text{e}^-$; $\Delta H^\ominus = -1150 \text{ kJ mol}^{-1}$

- 4 The equation for a reaction is shown.



Which pair of descriptions is fully correct for this reaction?

	type(s) of enthalpy change	value of x
A	formation only	positive
B	formation only	negative
C	combustion, formation	positive
D	combustion, formation	negative

- 5 Propanone has the molecular formula $\text{C}_3\text{H}_6\text{O}$.

The enthalpy change of combustion of hydrogen is -286 kJ mol^{-1} .

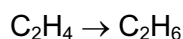
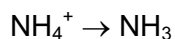
The enthalpy change of combustion of carbon is -394 kJ mol^{-1} .

The enthalpy change of combustion of propanone is $-1786 \text{ kJ mol}^{-1}$.

Using this information, what is the enthalpy change of formation of propanone?

- A $-1106 \text{ kJ mol}^{-1}$
- B -540 kJ mol^{-1}
- C -254 kJ mol^{-1}
- D $+1106 \text{ kJ mol}^{-1}$

- 6 Two conversions are outlined below.



What similar feature do these two conversions have?

- A a lone pair of electrons in the product
- B change in oxidation state of an element
- C decrease in bond angle of the species involved
- D disappearance of a π bond

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

The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

0.56 g of ethene gas is contained in a vessel at a pressure of 102 kPa and a temperature of 30°C .

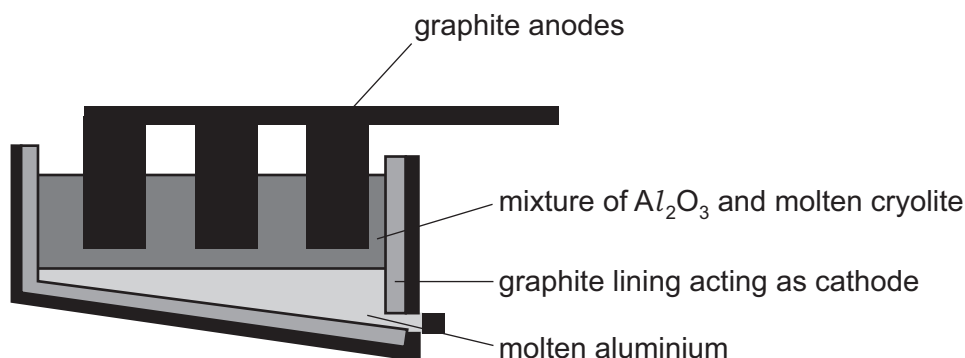
What is the volume of the vessel?

- A 49 cm^3
- B 494 cm^3
- C $48\,900 \text{ cm}^3$
- D $494\,000 \text{ cm}^3$

- 8 Under which set of conditions is a gas most likely to behave ideally?

	temperature	pressure
A	high	high
B	high	low
C	low	high
D	low	low

- 9 The diagram shows a cell for the manufacture of aluminium.



Which statement is **incorrect**?

- A Aluminium ions are oxidised in this process.
 - B Aluminium is liberated at the cathode by the reaction $Al^{3+} + 3e^{-} \rightarrow Al$.
 - C The cryolite acts as a solvent.
 - D The graphite anode burns away.
- 10 The oxide of titanium, TiO_2 , is used as a 'whitener' in toothpaste. It is obtained from the ore iron(II) titanate, $FeTiO_3$.
- What is the change, if any, in the oxidation number (oxidation state) of titanium in the reaction $FeTiO_3 \rightarrow TiO_2$?
- A It is oxidised from +3 to +4.
 - B It is reduced from +3 to +2.
 - C It is reduced from +6 to +4.
 - D There is no change in the oxidation number.
- 11 Two moles of compound P were placed in a vessel. The compound P was partly decomposed by heating. A dynamic equilibrium between chemicals P, Q and R was established.

At equilibrium, x mol of R were present and the total number of moles present was (2 + x).

What is the equation for this equilibrium?

- A $P \rightleftharpoons 2Q + R$
- B $2P \rightleftharpoons 2Q + R$
- C $2P \rightleftharpoons Q + R$
- D $2P \rightleftharpoons Q + 2R$

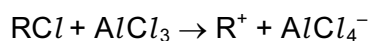
12 *Use of the Data Booklet is relevant to this question.*

When a mineral was heated in a Bunsen flame to constant mass, a colourless gas that turned lime water milky was evolved. The remaining solid was cooled and then added to aqueous hydrochloric acid. Vigorous effervescence was seen.

What was the mineral?

- A** aragonite, CaCO_3
- B** artinite, $\text{MgCO}_3 \cdot \text{Mg}(\text{OH})_2 \cdot 3\text{H}_2\text{O}$
- C** barytocalcite, $\text{BaCO}_3 \cdot \text{CaCO}_3$
- D** dolomite, $\text{CaCO}_3 \cdot \text{MgCO}_3$

13 Aluminium chloride catalyses certain reactions by forming carbocations with chloroalkanes as shown.



Which property makes this reaction possible?

- A** AlCl_3 exists as the dimer Al_2Cl_6 in the vapour.
- B** AlCl_3 is a covalent molecule.
- C** The aluminium atom in AlCl_3 has an incomplete octet of electrons.
- D** The chlorine atom in RCl has a vacant p orbital.

14 The oxides BaO , CaO , MgO and SrO all produce alkaline solutions when added to water.

Which oxide produces the saturated solution with the highest pH?

- A** $\text{BaO}(\text{aq})$
- B** $\text{CaO}(\text{aq})$
- C** $\text{MgO}(\text{aq})$
- D** $\text{SrO}(\text{aq})$

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

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The metal oxides and nitrogen are the only products.

Which volume of nitrogen, measured under room conditions, is produced when 0.783 g of anhydrous barium nitrate reacts with an excess of aluminium?

- A** 46.8 cm^3
- B** 72.0 cm^3
- C** 93.6 cm^3
- D** 144 cm^3

- 16** The following two experiments are carried out with anhydrous potassium chloride and observations X and Y are made at the end of each experiment.

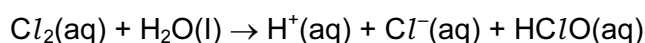
Concentrated sulfuric acid is added to the potassium chloride and the fumes produced are bubbled into aqueous potassium iodide solution - observation X.

The potassium chloride is dissolved in aqueous ammonia and this is then added to aqueous silver nitrate - observation Y.

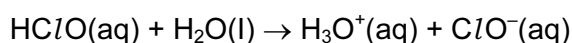
What are the observations X and Y?

	X	Y
A	brown solution	colourless solution
B	brown solution	white precipitate
C	colourless solution	colourless solution
D	colourless solution	white precipitate

- 17** In the treatment of domestic water supplies, chlorine is added to the water to form HClO .



The HClO reacts further to give ClO^- ions.



Both HClO and ClO^- kill bacteria by oxidation.

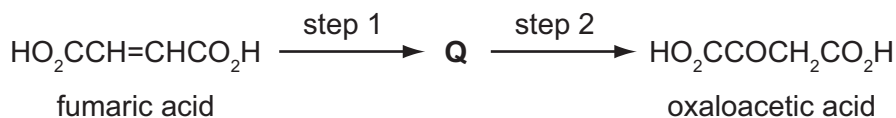
What is the overall change in oxidation number of chlorine when forming the ClO^- ion from the aqueous chlorine?

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

- 18** What trend is observed on descending Group VII?

- A** The colours of the elements become lighter.
B The elements become more volatile.
C The hydrides of the elements become more thermally stable.
D The reactions of the elements with hydrogen become less vigorous.

- 19 Fumaric acid can be converted into oxaloacetic acid by a two-step process involving the intermediate **Q**.



Each of these steps can be achieved in the laboratory by a single reagent.

What could be the intermediate **Q** and the reagent for step 2?

	Q	reagent for step 2
A	$\text{HO}_2\text{CCHBrCH}_2\text{CO}_2\text{H}$	warm acidified KMnO_4
B	$\text{HO}_2\text{CCHBrCH(OH)CO}_2\text{H}$	warm NaOH(aq)
C	$\text{HO}_2\text{CCH(OH)CH}_2\text{CO}_2\text{H}$	Fehling's solution
D	$\text{HO}_2\text{CCH(OH)CH}_2\text{CO}_2\text{H}$	warm acidified $\text{K}_2\text{Cr}_2\text{O}_7$

- 20 Carbon monoxide, CO , nitrogen monoxide, NO , and sulfur dioxide, SO_2 , may all be present in the exhaust fumes from a car engine.

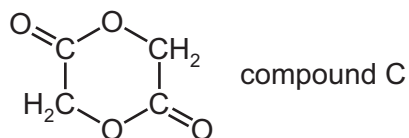
Which reaction concerning these compounds occurs in the atmosphere?

- A** CO is spontaneously oxidised to CO_2
- B** NO_2 is reduced to NO by CO
- C** NO_2 is reduced to NO by SO_2
- D** SO_2 is oxidised to SO_3 by CO_2
- 21 An organic compound **J** reacts with sodium to produce an organic ion with a charge of -3 . **J** reacts with NaOH(aq) to produce an organic ion with a charge of -1 .

What could be the structural formula of **J**?

- A** $\text{HO}_2\text{CCH(OH)CH}_2\text{CO}_2\text{H}$
- B** $\text{HO}_2\text{CCH(OH)CH}_2\text{CHO}$
- C** $\text{HOCH}_2\text{CH(OH)CH}_2\text{CO}_2\text{H}$
- D** $\text{HOCH}_2\text{COCH}_2\text{CHO}$

22 Compound C is used in textile and leather processing.



Which starting material(s), on gentle heating with a few drops of concentrated sulfuric acid, generates compound C?

- A** CH_3COOH only
- B** HOCH_2COOH only
- C** $\text{CH}_3\text{COOCH}_2\text{COOH}$ only
- D** CH_3COOH mixed with HOCH_2COOH

23 How many isomeric esters have the molecular formula $C_4H_8O_2$?

- A** 2 **B** 3 **C** 4 **D** 5

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

A sample of ethyl propanoate is hydrolysed by heating under reflux with aqueous sodium hydroxide. The two organic products of the hydrolysis are separated, purified and weighed.

Out of the total mass of products obtained, what is the percentage by mass of each product?

- A** 32.4 % and 67.6 %
B 38.3 % and 61.7 %
C 42.3 % and 57.7 %
D 50.0 % and 50.0 %

25

$\text{CH}_3\text{COCH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{COCH}_2\text{CHO}$	$\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
<i>W</i>	<i>X</i>	<i>Y</i>	<i>Z</i>

Which of these compounds can be oxidised by acidified dichromate(VI) solution and also gives a positive response to Tollens' reagent?

- A** *W* and *X* only
- B** *W* and *Y* only
- C** *X* and *Z* only
- D** *Y* and *Z* only

26 Which compound, on reaction with hydrogen cyanide, produces a compound with a chiral centre?

- A CH_3CHO
 B $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$
 C $\text{CH}_3\text{CO}_2\text{CH}_3$
 D HCHO

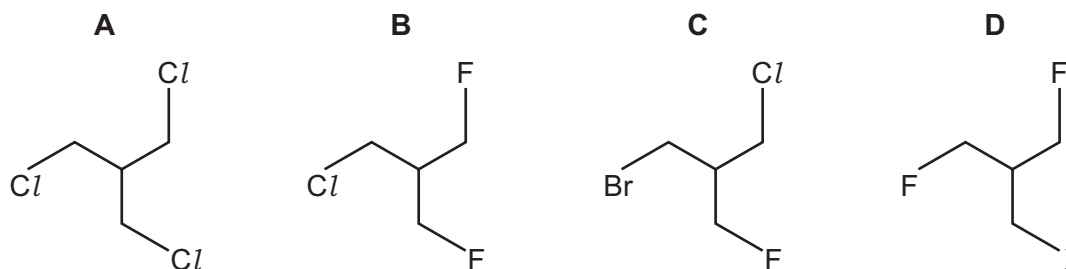
27 The depletion of the ozone layer in the upper atmosphere reduces the Earth's natural protection from harmful ultraviolet radiation.

Which compound would cause the most depletion of the ozone layer?

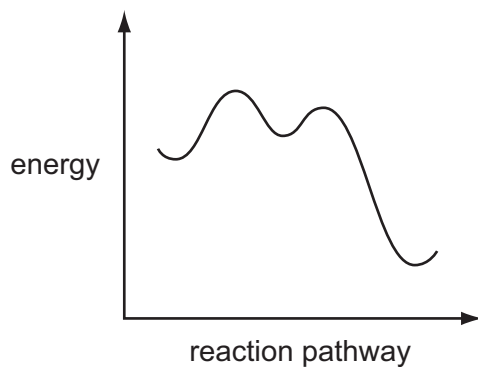
- A CCl_3F B CF_4 C CHClF_2 D CH_2F_2

28 The presence of halogen in an organic compound may be detected by warming the organic compound with aqueous silver nitrate.

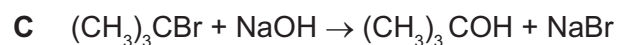
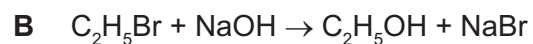
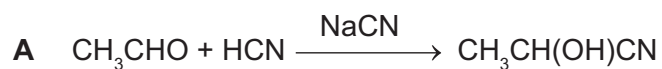
Which compound would produce a precipitate quickest?



29 A reaction pathway diagram is shown.



Which reaction does **not** have such a profile?



30 Which statement does **not** correctly describe the polymer PVC?

A Combustion of PVC waste produces a highly acidic gas.

B PVC molecules are saturated.

C The empirical formula of PVC is the same as the empirical formula of its monomer.

D The repeat unit of PVC is $-(\text{CHClCHCl})-$.

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** Nitrogen and phosphorus are both in Group V of the Periodic Table. Phosphorus forms a chloride with the formula PCl_5 .

Why is it **not** possible for nitrogen to form NCl_5 ?

- 1** Nitrogen's outer shell can only contain eight electrons.
- 2** Nitrogen cannot have oxidation state +5.
- 3** Nitrogen is almost inert.

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

In which pairs do both species have the same number of unpaired p electrons?

- 1** O and Cl^+
- 2** F^+ and Ga^-
- 3** P and Ne^+

Section B

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

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

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

33 The gas laws can be summarised in the ideal gas equation.

$$pV = nRT$$

where each symbol has its usual meaning.

Which statements are correct?

- 1** One mole of an ideal gas occupies the same volume under the same conditions of temperature and pressure.
- 2** The density of an ideal gas at constant pressure is inversely proportional to the temperature, T .
- 3** The volume of a given mass of an ideal gas is doubled if its temperature is raised from 25 °C to 50 °C at constant pressure.

34 Which statements are correct for all three halogens, chlorine, bromine and iodine?

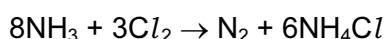
- 1** They all form hydrides that are strong acids in aqueous solution.
- 2** They all react with aqueous sodium hydroxide to form oxo-anions.
- 3** They all require one more electron to fill the p orbitals of their outer shells.

- 35 In the manufacture of sulfuric acid the reaction $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ usually takes place at 400 °C and 1 atm pressure. In one industrial plant, it is decided to change the pressure to 20 atm.

What will be the consequences of this change?

- 1 increased running costs
- 2 an increased percentage of sulfur trioxide in the equilibrium mixture
- 3 the rate of the backward reaction increases

- 36 Ammonia and chlorine react in the gas phase.



Which statements are correct?

- 1 Ammonia behaves as a reducing agent.
 - 2 Ammonia behaves as a base.
 - 3 The oxidation number of the hydrogen changes.
- 37 A number of alcohols with the formula $\text{C}_4\text{H}_{10}\text{O}$ are separately oxidised. Using 70 g of the alcohols a 62 % yield of organic product is achieved.

What mass of product could be obtained?

- 1 42.2 g of butanone
 - 2 51.6 g of butanoic acid
 - 3 51.6 g of 2-methyl propanoic acid
- 38 What is **always** involved in a carbon-carbon π bond?
- 1 a shared pair of electrons
 - 2 a sideways overlap of p orbitals
 - 3 delocalised electrons
- 39 How can a good yield of ethylamine be made using bromoethane as starting material?
- 1 by heating bromoethane with an excess of ammonia gas in a sealed tube
 - 2 by adding dilute aqueous ammonia to bromoethane at room temperature
 - 3 by heating bromoethane under reflux with aqueous ammonium chloride

Section B

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

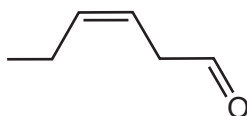
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

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.

- 40** The compound *cis*-hex-3-enal is responsible for the characteristic smell of cut grass. The human nose is particularly sensitive to this compound, being able to detect 0.25 parts per billion in air.



cis-hex-3-enal

Which reagents will react with *cis*-hex-3-enal?

- 1** sodium
- 2** sodium borohydride
- 3** Fehling's reagent

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