



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

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CHEMISTRY

9791/01

Paper 1 Part A Multiple Choice

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 working should be done in this booklet.

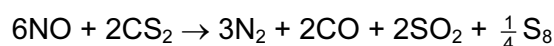
This document consists of **14** printed pages and **2** blank pages.



1 Which element in period 3 is **not** correctly described?

	element	bonding	structure
A	chlorine	covalent	simple
B	magnesium	metallic	giant
C	phosphorus	covalent	simple
D	silicon	covalent	simple

2 An exciting chemical demonstration is the 'barking dog'. An equation which describes the reaction is shown.



Carbon disulfide, CS_2 , is a liquid with a density of 1.26 g cm^{-3} .

Which mass of sulfur would be formed from 5.00 cm^3 of CS_2 if the reaction proceeded with 100% yield?

- A** 0.330g **B** 1.67g **C** 2.65g **D** 5.31g

3 An ion of manganese has an electronic configuration of $[\text{Ar}]3d^4$.

Which compound contains this ion?

- A** MnCl_2 **B** MnO **C** Mn_2O_3 **D** MnO_2

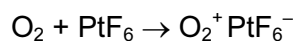
4 An ionic compound Q

- has an empirical formula NH_2O ,
- reacts with $\text{NaOH}(\text{aq})$ to produce ammonia gas.

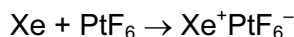
How many electrons are present in the anion of Q?

- A** 23 **B** 24 **C** 31 **D** 32

- 5 Oxygen reacts with platinum(VI) fluoride, PtF_6 , as shown.



When the first noble gas compound was produced in 1962, it was suggested that xenon should react similarly.



What is the most likely reason for this suggestion being made?

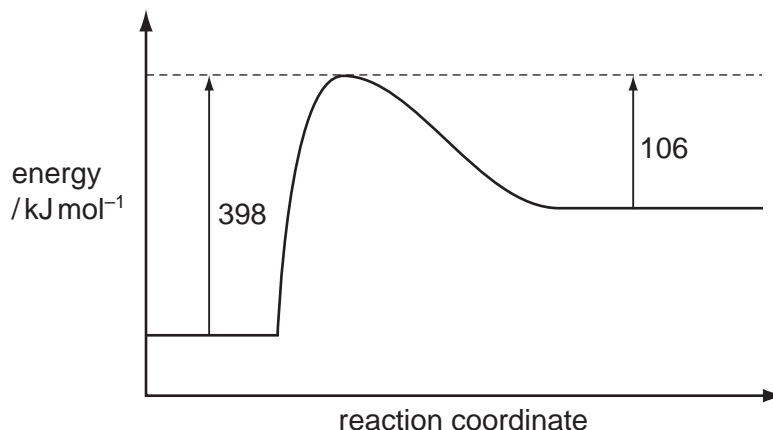
- A** O and Xe have similar electron affinities.
- B** O and Xe have similar ionic radii.
- C** O_2 and Xe have similar electron configurations.
- D** O_2 and Xe have similar first ionisation energies.
- 6 Which statement about antibonding is **not** correct?
- A** Filling an antibonding orbital lowers the bond order of a molecule by 1.
- B** For a given orbital overlap, the antibonding orbital is always higher in energy than the bonding orbital.
- C** Stable molecules cannot have any electrons in antibonding orbitals.
- D** The antibonding orbitals are found outside the region of space between the two bonding nuclei.
- 7 The shape of the PCl_5 molecule in the gas phase is trigonal bipyramidal.

The chlorine atoms can be replaced one at a time by fluorine atoms, the axial chlorine atoms being replaced first, then the equatorial atoms.

Which molecule does **not** have a dipole moment?

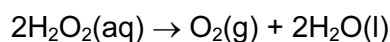
- A** PClF_4 **B** PCl_2F_3 **C** PCl_3F_2 **D** PCl_4F

- 8 The diagram shows the energy profile for a simple reaction.



Which statement about the reaction is correct?

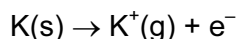
- A** The reaction is endothermic and the enthalpy change of reaction ($\Delta_r H$) is $+292 \text{ kJ mol}^{-1}$.
- B** The reaction is endothermic and the enthalpy change of reaction ($\Delta_r H$) is $+504 \text{ kJ mol}^{-1}$.
- C** The reaction is exothermic and the enthalpy change of reaction ($\Delta_r H$) is -292 kJ mol^{-1} .
- D** The reaction is exothermic and the enthalpy change of reaction ($\Delta_r H$) is -504 kJ mol^{-1} .
- 9 At room temperature, hydrogen peroxide decomposes slowly according to the equation.



Which statement correctly explains the result of carrying out this decomposition in the presence of a catalyst such as MnO_2 ?

- A** The reaction rate increases because the collision frequency increases due to a decrease in the activation energy.
- B** The reaction rate increases because the collision frequency increases due to an increase in the average energy of the molecules.
- C** The reaction rate increases because the proportion of successful collisions increases due to a decrease in the activation energy.
- D** The reaction rate increases because the proportion of successful collisions increases due to an increase in the average energy of the molecules.

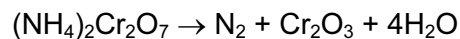
- 10 An energy change accompanies the reaction shown.



What is equal to the value of this energy change?

- A** the enthalpy change of vaporisation of potassium
B the first ionisation energy of potassium
C the sum of the enthalpy change of atomisation and the electron affinity of potassium
D the sum of the enthalpy change of atomisation and the first ionisation energy of potassium
- 11 Hot concentrated nitric acid, HNO_3 , is a powerful oxidising agent.
In its reaction with carbon, the oxidation number of carbon increases by 4 and the oxidation number of nitrogen decreases by 1.
How many moles of nitric acid are needed to oxidise one mole of carbon in this reaction?
A 1 **B** 2 **C** 3 **D** 4
- 12 Which compound is **not** a product of the reaction between an oxide of a period 3 element and water?
A $\text{Mg}(\text{OH})_2$ **B** H_2SiO_3 **C** H_3PO_4 **D** H_2SO_3
- 13 When anhydrous sodium carbonate, a white solid, is heated in a roaring Bunsen flame, it turns into a colourless liquid.
Which statement explains this change?
A It has absorbed water from the atmosphere.
B It has melted to form liquid sodium carbonate.
C It has reacted with the air, with water as one of the products.
D It has thermally decomposed to sodium oxide.

- 14 The famous 'volcano' chemical demonstration involves ammonium dichromate and can be summarised by the equation.



In this reaction, the ammonium ion acts as

- A an acid.
 - B a base.
 - C an oxidising agent.
 - D a reducing agent.
- 15 Which quantity is greater for fluorine than for chlorine?
- A bond energy
 - B bond length
 - C melting point
 - D oxidising power
- 16 Iodine pentoxide, I_2O_5 , is a colourless crystalline solid. Carbon monoxide, CO, is a reducing agent.

When an excess of CO is reacted with I_2O_5 , there is no change in gaseous volume after cooling to the original temperature. A grey-black solid is produced. When this solid is heated separately, it produces a purple vapour.

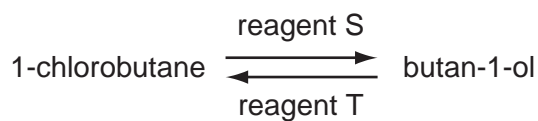
In which molar ratio do CO and I_2O_5 react?

- A 1:1
 - B 2:5
 - C 5:1
 - D 5:2
- 17 When sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, is mixed with concentrated sulfuric acid under suitable conditions, a violent reaction occurs producing a black solid and one other product.

How does the sulfuric acid behave in this reaction?

- A as a dehydrating agent
- B as a dehydrating agent and an oxidising agent
- C as a strong involatile acid
- D as an oxidising agent

- 18 Halogenoalkanes and alcohols can be synthesised from each other using the appropriate reagents, as shown.



What is the correct combination of reagents for the conversions?

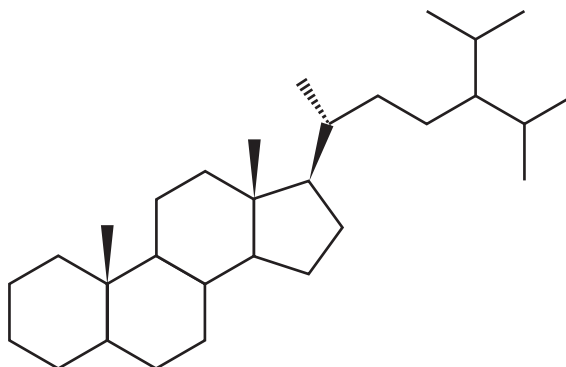
	reagent S	reagent T
A	NaOH(aq)	NH ₄ Cl(aq)
B	NaOH(aq)	PCl ₅
C	NaOH/ethanol	NH ₄ Cl(aq)
D	NH ₃ /ethanol	PCl ₅

- 19 Which statements about the reaction of butan-2-ol heated under reflux with acidified potassium dichromate(VI) are correct?

- 1 The organic product contains a π -bond in its molecule.
- 2 The organic product contains a chiral carbon atom in its molecule.
- 3 One carbon atom in butan-2-ol increases its functional group level by one.

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

- 20 The molecule 24-isopropylcholestane, which has been isolated from a class of sponge, can serve as a biomarker and has determined the first evolutionary appearances of some species.



Carbon atoms in a molecule are classified as primary, secondary, tertiary or quaternary, depending on whether they are directly bonded to one, two, three or four other carbon atoms.

How many tertiary carbons and how many chiral carbons are there in this molecule?

	tertiary carbons	chiral carbons
A	9	4
B	9	8
C	11	4
D	11	8

- 21 A compound of formula $C_5H_6Cl_2O$ has the following features.

- geometric isomers
- no optical isomers
- two carbon atoms at the carbonyl functional group level

What is the compound?

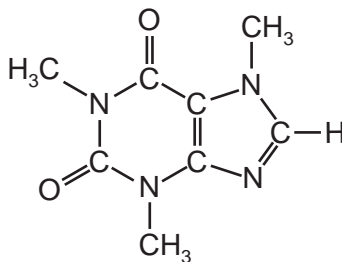
- A** $CHCl_2COCH=CHCH_3$
- B** $CH_2ClCOCH=CHCH_2Cl$
- C** $CH_3CHClCCl=CHCHO$
- D** $CH_3CH_2COCH=CCl_2$
- 22 A **straight chain** organic compound X, $C_4H_8Br_2$, undergoes hydrolysis with aqueous sodium hydroxide to produce a compound which reacts with Tollens' reagent to form a silver mirror.

In X, the bromine atoms are joined to carbon atoms numbered

- A** 1,1. **B** 1,2. **C** 1,4. **D** 2,2.

23 Caffeine is the stimulant found in tea and coffee.

The structure of caffeine is shown.



How many of its eight carbon atoms are at each of the functional group levels shown?

	alcohol	carbonyl	carboxylic acid	carbon dioxide
A	3	1	4	0
B	3	3	2	0
C	4	2	1	1
D	4	1	2	1

24 A non-cyclic compound has the molecular formula $C_4H_9O_2N$.

Which pair of functional groups could **not** both be present in this molecule?

- A** amide and alcohol
- B** amine and carboxylic acid
- C** amine and ester
- D** carboxylic acid and nitrile

25 Which isomer of bromobutanol, C_4H_9OBr , reacts with aqueous sodium hydroxide to give an organic product that has only two peaks in its ^{13}C NMR spectrum?

- A** 1-bromobutan-1-ol
- B** 3-bromobutan-1-ol
- C** 2-bromobutan-2-ol
- D** 3-bromobutan-2-ol

26 X is $\text{HOCH}_2\text{CH}(\text{OH})\text{CHO}$

Y is $\text{HOCH}_2\text{COCH}_2\text{OH}$

Which statement about X and Y is correct?

- A X can be directly oxidised to Y.
- B X and Y have different empirical formulae.
- C X and Y both react with Tollens' reagent.
- D X and Y can both be reduced to $\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$.

27 Grignard reagents react with compounds containing the carbonyl functional group.

Which compound would react with Grignard reagent $\text{CH}_3\text{CH}_2\text{MgBr}$ to produce an organic product with a chiral carbon atom?

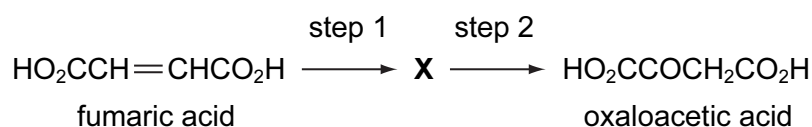
- A ethanal
- B methanal
- C propanal
- D propanone

28 Elimination occurs when 2,4-dibromoheptane reacts with hot alcoholic sodium hydroxide, producing a mixture of dienes with the molecular formula C_7H_{12} .

Which diene would **not** be produced in this reaction?

- A $\text{CH}_2=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}_3$
- B $\text{CH}_2=\text{CHCH}=\text{CHCH}_2\text{CH}_2\text{CH}_3$
- C $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_3$
- D $\text{CH}_3\text{CH}=\text{CHCH}=\text{CHCH}_2\text{CH}_3$

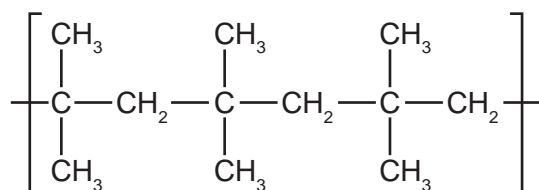
29 In the Krebs cycle, fumaric acid is converted to oxaloacetic acid by a two step process involving an intermediate compound **X**.



What is the identity of **X**?

- A $\text{HO}_2\text{CCH}_2\text{CH}_2\text{CO}_2\text{H}$
- B $\text{HO}_2\text{CCHBrCH}_2\text{CO}_2\text{H}$
- C $\text{HO}_2\text{CCH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$
- D $\text{HO}_2\text{CCH}(\text{OH})\text{CH}(\text{OH})\text{CO}_2\text{H}$

- 30 Patches used to administer drugs contain pressure-sensitive adhesives that stick to the skin. The diagram shows part of the structure of one such adhesive.



Which monomer could be used to make this polymer?

- A $\text{CH}_3\text{CH}=\text{CHCH}_3$
 B $(\text{CH}_3)_2\text{C}=\text{CHC}(\text{CH}_3)_3$
 C $(\text{CH}_3)_2\text{C}=\text{CH}_2$
 D $(\text{CH}_3)_2\text{CHC}(\text{CH}_3)_2\text{CH}_2\text{CH}_3$
- 31 Which type of reaction must have the greatest atom economy?
- A addition
 B condensation
 C elimination
 D substitution
- 32 A gravimetric analysis of a sample of an iron ore was carried out.

0.5873 g of ore was dissolved in perchloric acid to oxidise the iron to Fe^{3+} . The resultant solution was filtered to remove solid impurities and made basic to precipitate the Fe^{3+} as a hydrated hydroxide. The precipitate was filtered and heated to produce 0.3174 g of Fe_2O_3 .

Which percentage of iron did the ore contain?

- A 18.90% B 37.80% C 54.04% D 64.71%
- 33 A large excess of aqueous silver nitrate is added to aqueous barium chloride and the precipitate removed by filtration.
- What are the most abundant ions in the filtrate?
- A Ag^+ , Ba^{2+} and NO_3^-
 B Ag^+ and NO_3^- only
 C Ba^{2+} , NO_3^- and Cl^-
 D Ba^{2+} and NO_3^- only

34 A chemist has samples of solutions of aluminium nitrate and lead(II) nitrate.

Which reagent will **not** be able to distinguish clearly between these two substances? (All reagents are soluble in water.)

- A HCl B KI C NaOH D Na₂SO₄

35 In a time-of-flight mass spectrometer, in which order do the fragments arrive at the detector?

	1st	2nd	3rd
A	CO ₂ ⁺	CH ₃ CO ⁺	CH ₃ CH ₂ NH ₃ ⁺
B	CH ₃ CO ⁺	CO ₂ ⁺	CH ₃ CH ₂ NH ₃ ⁺
C	CH ₃ CH ₂ NH ₃ ⁺	CH ₃ CO ⁺	CO ₂ ⁺
D	CH ₃ CH ₂ NH ₃ ⁺	CO ₂ ⁺	CH ₃ CO ⁺

36 Which molecule gives large peaks in its mass spectrum at $m/z = 29$ and $m/z = 43$?

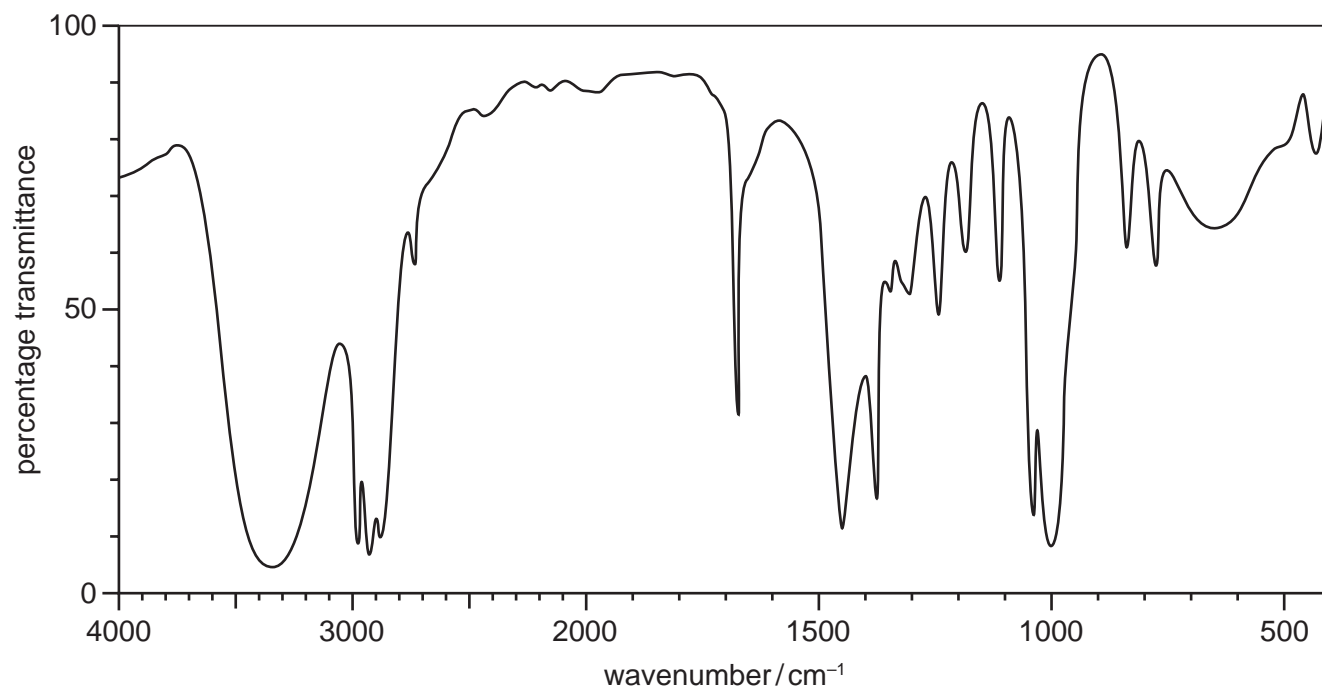
- A CH₂CHCH(CH₃)₂
 B CH₃CH₂CH(CH₃)₂
 C CH₃CH₂COOCH₂CH₃
 D CH₃COOCH₃

37 Which statement about electronic spectroscopy is **not** correct?

- A Higher electron shells in hydrogen become closer together in energy.
 B In the atomic emission line spectrum for hydrogen, the convergence limit represents the electron breaking free from the hydrogen atom.
 C The energy of a transition is inversely proportional to the frequency of the photon that is absorbed or emitted.
 D In the hydrogen atom, the subshells within each quantum shell all have the same energy.

38 A compound has the molecular formula $C_5H_{10}O$.

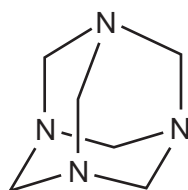
The diagram shows the infra-red spectrum of the compound.



What is the structural formula of the compound?

- A $(CH_3)_2CHOCHCH_2$
- B $CH_3CH_2CH_2CH_2CHO$
- C $CH_3CH_2CH_2COCH_3$
- D $CH_3C(CH_3)CHCH_2OH$

39 Hexamine is a crystalline white solid that is used as an antibiotic and as solid fuel by campers.



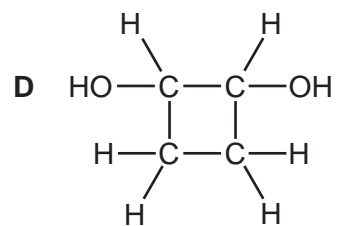
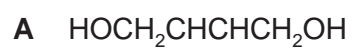
The four nitrogen atoms lie at the corners of a tetrahedron.

How many signals are there in the ^{13}C NMR spectrum of hexamine?

- A 1
- B 2
- C 4
- D 6

- 40 The ^{13}C NMR spectrum of a compound with formula $\text{C}_4\text{H}_8\text{O}_2$ shows peaks at 15 ppm, 20 ppm, 60 ppm and 175 ppm.

What is the structure of the compound?



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