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**CHEMISTRY (PRINCIPAL)**

**9791/01**

Paper 1 Multiple Choice

**May/June 2017**

**1 hour**

Additional Materials:      Multiple Choice Answer Sheet  
   Soft clean eraser  
   Soft pencil (type B or HB is recommended)  
   Data Booklet



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**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.

Do not use staples, paper clips, 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.

**DO NOT WRITE IN ANY BARCODES.**

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.

Electronic calculators may be used.

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The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **12** printed pages.

- 1 What are the coordination numbers of each type of ion in the fluorite (calcium fluoride) lattice?

	calcium ion	fluoride ion
<b>A</b>	4	4
<b>B</b>	4	8
<b>C</b>	8	4
<b>D</b>	8	8

- 2 The first five successive ionisation energies for element Q are shown.

$$738 \text{ kJ mol}^{-1}$$

$$1451 \text{ kJ mol}^{-1}$$

$$7733 \text{ kJ mol}^{-1}$$

$$10541 \text{ kJ mol}^{-1}$$

$$13629 \text{ kJ mol}^{-1}$$

In which group of the Periodic Table is Q?

- A** 1                      **B** 2                      **C** 13                      **D** 14

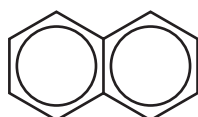
- 3 What is the approximate change in the HCH bond angle in ethene when it reacts with hydrogen?

- A** 30°                      **B** 15°                      **C** 10°                      **D** 0°

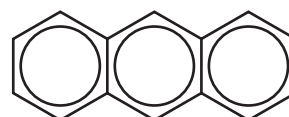
- 4 Polyaromatics can contain two or more fused benzene rings.



benzene



naphthalene



anthracene

For the polyaromatics shown, how does the addition of each fused ring change the number of carbon and hydrogen atoms?

	increase in number of carbon atoms	increase in number of hydrogen atoms
<b>A</b>	4	2
<b>B</b>	4	4
<b>C</b>	6	2
<b>D</b>	6	4

- 5 The compound  $\text{Mn}_3(\text{PO}_4)_2$  contains the phosphate ion in which phosphorus has an oxidation state of +5.

What is the electronic configuration of the manganese ion in  $\text{Mn}_3(\text{PO}_4)_2$ ?

- A  $[\text{Ar}] 3d^4$       B  $[\text{Ar}] 3d^5$       C  $[\text{Ar}] 3d^3 4s^2$       D  $[\text{Ar}] 3d^5 4s^2$

- 6 Magnesium is extracted by the electrolysis of molten magnesium chloride.

Which statement about the extraction of magnesium is correct?

- A Magnesium ions travel to the anode and are oxidised to magnesium metal.  
B Magnesium ions travel to the anode and are reduced to magnesium metal.  
C Magnesium ions travel to the cathode and are oxidised to magnesium metal.  
D Magnesium ions travel to the cathode and are reduced to magnesium metal.

- 7 Dimethylsulfide,  $(\text{CH}_3)_2\text{S}$ , is produced by plankton in oceans. It is oxidised by oxygen gas in the atmosphere to produce carbon dioxide, water and sulfuric acid only.

How many moles of gaseous oxygen molecules are needed to oxidise 1 mole of dimethylsulfide molecules?

- A 2.5      B 3.5      C 5      D 10

- 8 When two hydrogen atoms form a hydrogen molecule, the two 1s atomic orbitals combine to form two molecular orbitals.

Which statement correctly describes the bonding in a hydrogen molecule?

- A There are two electrons in an anti-bonding molecular orbital forming a  $\pi$  bond.  
B There is one electron in each of a bonding and an anti-bonding molecular orbital forming a  $\sigma$  bond.  
C There are two electrons in a bonding molecular orbital forming a  $\pi$  bond.  
D There are two electrons in a bonding molecular orbital forming a  $\sigma$  bond.

9 Four compounds of Period 3 elements are listed.



Water is added to separate samples of each of the four compounds.

Pairs of the resulting solutions are mixed together.

From which pair is it possible to get a solution with a pH of 7?

- A  $\text{NaCl}$  and  $\text{Na}_2\text{O}$
- B  $\text{NaCl}$  and  $\text{SO}_2$
- C  $\text{Na}_2\text{O}$  and  $\text{SiCl}_4$
- D  $\text{SiCl}_4$  and  $\text{SO}_2$

10 Which statement about the structures of nitrogen and white phosphorus is correct?

- A Both elements have a simple molecular structure consisting of molecules made up of two atoms.
- B Both elements have a simple molecular structure consisting of molecules made up of four atoms.
- C In both structures, each atom forms only three covalent bonds.
- D Nitrogen has a simple molecular structure whereas white phosphorus has a giant molecular structure.

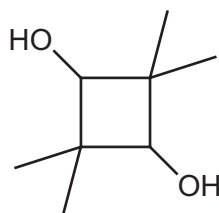
11 Which statement describes a part of the  $\text{S}_{\text{N}}1$  mechanism?

- A A bond is broken before a new bond is formed.
- B The leaving group is repelled by a positive charge on a carbon atom.
- C The nucleophile accepts a pair of electrons.
- D The transition state has a five-coordinate carbon atom.

12 Which reaction produces a species containing a halogen with a positive oxidation number?

- A  $\text{F}_2(\text{g}) + \text{H}_2(\text{g})$
- B  $\text{NaI}(\text{s}) + \text{conc. H}_2\text{SO}_4(\text{l})$
- C  $\text{NaBr}(\text{aq}) + \text{AgNO}_3(\text{aq})$
- D  $\text{Cl}_2(\text{aq}) + \text{cold NaOH}(\text{aq})$

13 The structure of 2,2,4,4-tetramethyl-1,3-cyclobutanediol is shown.



How many chiral carbons are there in this molecule and what is its empirical formula?

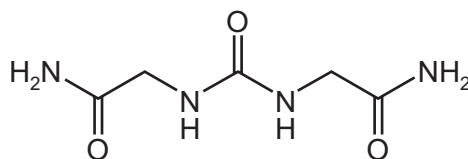
	number of chiral carbons	empirical formula
<b>A</b>	0	C <sub>4</sub> H <sub>7</sub> O
<b>B</b>	0	C <sub>4</sub> H <sub>8</sub> O
<b>C</b>	2	C <sub>4</sub> H <sub>7</sub> O
<b>D</b>	2	C <sub>4</sub> H <sub>8</sub> O

14 Deuterium, D, is the <sup>2</sup>H isotope of hydrogen.

Which reaction gives an organic product that does **not** have any chiral carbon atoms?

- A** CH<sub>3</sub>CH=CHCH<sub>3</sub> + D<sub>2</sub>  
**B** CH<sub>3</sub>CH=CHCH<sub>3</sub> + DBr  
**C** CH<sub>3</sub>CHO + NaBD<sub>4</sub>/D<sub>2</sub>O  
**D** CH<sub>3</sub>COCH<sub>3</sub> + DCN/NaCN in D<sub>2</sub>O

15 The diagram shows a molecule.



Which functional group level of carbon is **not** found in this molecule?

- A** 1 (alcohol)  
**B** 2 (carbonyl)  
**C** 3 (carboxylic acid)  
**D** 4 (carbon dioxide)

16 Which reaction **must** have an atom economy of 100%?

- A an addition reaction
- B a neutralisation reaction
- C a redox reaction
- D a substitution reaction

17 Aldehydes react with HCN in a reaction catalysed by NaCN.

Which statement about this reaction mechanism is **not** correct?

- A A new carbon-carbon bond is formed.
- B Homolytic fission of a bond occurs.
- C In the intermediate, an oxygen atom has a negative charge.
- D The final stage involves the formation of an oxygen-hydrogen bond.

18 Which statement about the intermediate  $[\text{C}_6\text{H}_6\text{NO}_2]^+$ , formed during the mononitration of benzene, is correct?

- A It contains a chiral centre.
- B It contains only one tetrahedrally bonded carbon atom.
- C It has geometrical isomers.
- D It is planar.

19 Which row is correct when the molecules given undergo a substitution reaction?

	molecule	position of substitution	relative reactivity compared to benzene
A	methylbenzene	3,5	more reactive
B	nitrobenzene	3,5	less reactive
C	phenol	2,4	less reactive
D	phenylamine	3,5	more reactive

- 20 A white crystalline material is dissolved in water and the following tests are carried out on the solution.

test	observation
addition of NaOH(aq)	a white precipitate which dissolves in an excess of NaOH(aq)
addition of NH <sub>3</sub> (aq)	a white precipitate which dissolves in an excess of NH <sub>3</sub> (aq)
addition of Ba(NO <sub>3</sub> ) <sub>2</sub> (aq)	a white precipitate which does not dissolve in HNO <sub>3</sub> (aq)

What is the white crystalline material?

- A** aluminium sulfate  
**B** magnesium nitrate  
**C** zinc chloride  
**D** zinc sulfate
- 21 An aqueous solution contains a mixture of chloride, bromide and iodide ions. AgNO<sub>3</sub>(aq) is added to this solution followed by excess dilute NH<sub>3</sub>(aq). The resulting mixture is filtered.

Which compounds could be present in the residue after filtration?

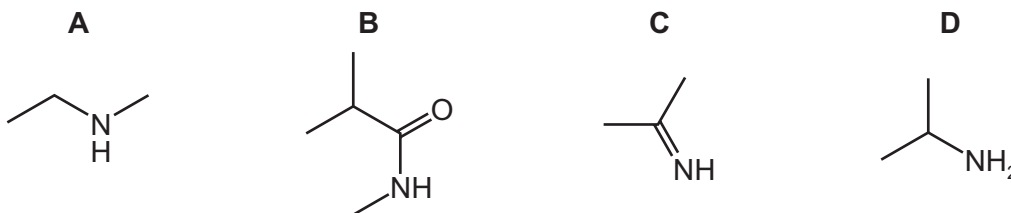
- A** AgBr and AgI  
**B** AgCl and AgBr  
**C** AgBr only  
**D** AgCl only
- 22 A major peak appears in the mass spectrum of propanal but not in the mass spectrum of propanone.

What is the m/z value of this peak?

- A** 15                      **B** 29                      **C** 43                      **D** 58
- 23 Why does the atomic absorption spectrum of hydrogen contain discrete lines?
- A** Only certain energy levels in atoms are allowed.  
**B** There is only one electron.  
**C** There is only one proton.  
**D** The spectra are recorded at low temperature.
- 24 In the reaction between iodine and thiosulfate ions, which sulfur-containing species is produced?

- A** SO<sub>4</sub><sup>2-</sup>                      **B** S<sub>2</sub>O<sub>3</sub><sup>2-</sup>                      **C** S<sub>2</sub>O<sub>8</sub><sup>2-</sup>                      **D** S<sub>4</sub>O<sub>6</sub><sup>2-</sup>

25 Which compound is a secondary amine?

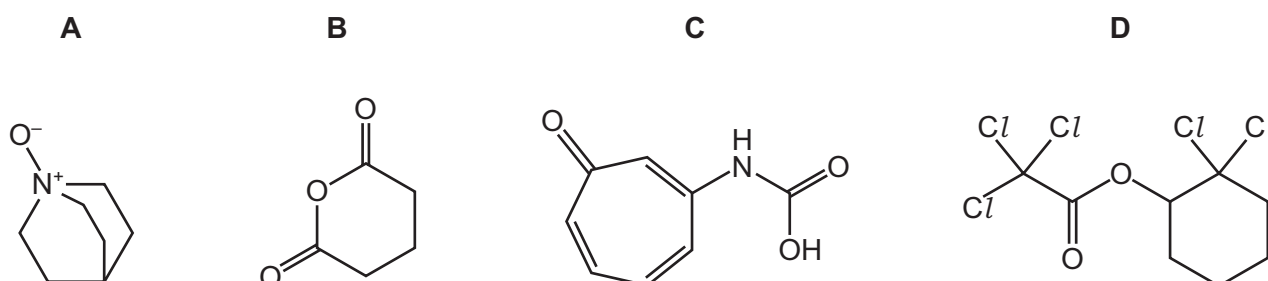


26 The ester  $\text{CH}_3\text{CO}_2\text{CH}_2(\text{CH}_2)_6\text{CH}_3$  is hydrolysed by aqueous sodium hydroxide.

What is the molecular formula of one of the products of this hydrolysis?

- A**  $\text{C}_2\text{H}_4\text{O}_2$       **B**  $\text{C}_2\text{H}_3\text{O}_2\text{Na}$       **C**  $\text{C}_8\text{H}_{16}\text{O}$       **D**  $\text{C}_8\text{H}_{17}\text{O}_2\text{Na}$

27 Which compound will release carbon dioxide on complete hydrolysis?



28 **X** is a compound of Q and R. It has a structure based on ions of Q in a face-centred cubic lattice with ions of R occupying half of the tetrahedral holes.

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

- A** QR      **B**  $\text{QR}_2$       **C**  $\text{Q}_2\text{R}$       **D**  $\text{Q}_4\text{R}$

29 A solution of  $\text{Sn}^{2+}$  ions reduces  $\text{MnO}_4^-$  ions in acidic solution to form  $\text{Mn}^{2+}$  ions. The  $\text{Sn}^{2+}$  ions are oxidised to  $\text{Sn}^{4+}$  ions.

Which amount of  $\text{Mn}^{2+}$  is produced when 0.10 mol of  $\text{SnCl}_2$  is added to excess acidified  $\text{KMnO}_4$ ?

- A** 0.02 mol      **B** 0.04 mol      **C** 0.10 mol      **D** 0.25 mol

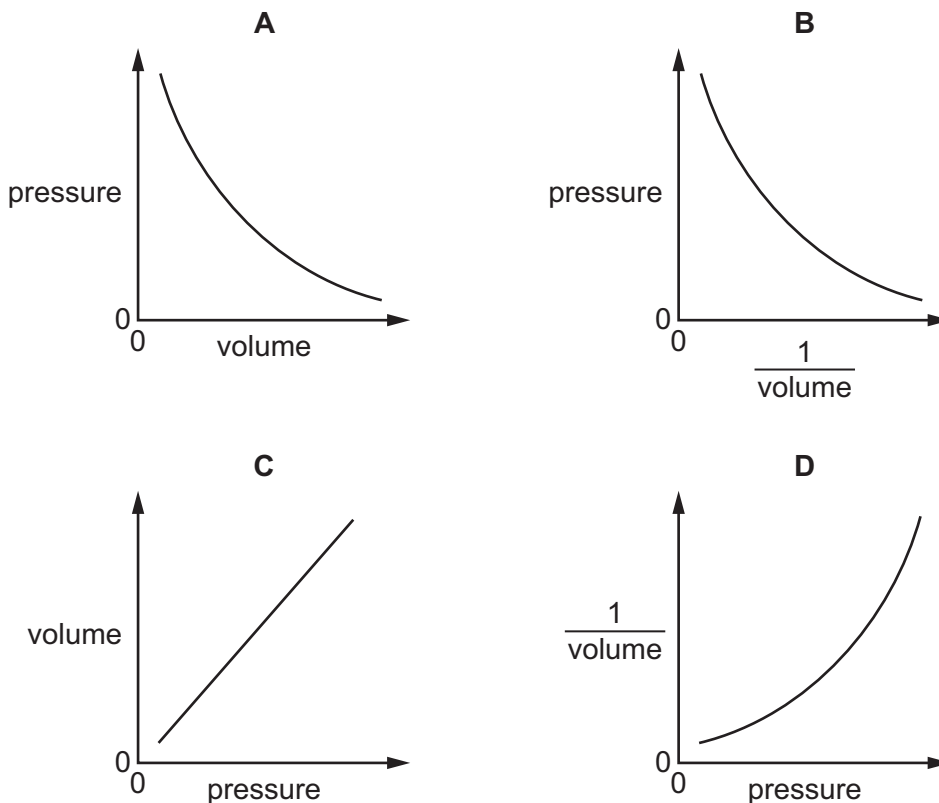
30 The complex  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$  was first prepared by Michele Peyrone in 1844.

Which statement about  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$  is correct?

- A** It is a square planar complex with no isomers.  
**B** It is a square planar complex with two isomers.  
**C** It is a tetrahedral complex with no isomers.  
**D** It is a tetrahedral complex with two isomers.



31 Which graph correctly represents Boyle's law?



32 As the carbon chain length increases from methanol,  $\text{CH}_3\text{OH}$ , to pentan-1-ol,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ , which property **decreases** for straight chain alcohols?

- A boiling point
- B energy released per mole on combustion
- C number of peaks in the  $^{13}\text{C}$  NMR spectrum
- D solubility in water

33  $12.5\text{ cm}^3$  of  $0.0500\text{ mol dm}^{-3}$  sodium hydroxide is added to  $25.0\text{ cm}^3$  of  $0.100\text{ mol dm}^{-3}$  hydrochloric acid.

Which concentration of hydrochloric acid remains in the reaction mixture?

- A  $0.0019\text{ mol dm}^{-3}$
- B  $0.0333\text{ mol dm}^{-3}$
- C  $0.0500\text{ mol dm}^{-3}$
- D  $0.0750\text{ mol dm}^{-3}$

34 Transition elements are often used as heterogeneous catalysts.

Which statement describes an aspect of heterogeneous catalysis?

- A Adsorption occurs at the catalyst surface.
- B Enzymes only take part in heterogeneous catalysis.
- C Ionic bonds link molecules to the catalyst surface.
- D The reactants and catalyst are in the same phase.

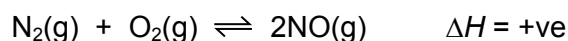
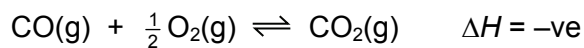
35 The value for the ionic product for water,  $K_w$ , varies with temperature.

temperature / °C	value of $K_w$
25	$1.00 \times 10^{-14}$
30	$1.47 \times 10^{-14}$

Which is correct for pure water at 30 °C?

- A  $[H^+] > [OH^-]$
- B  $[H^+] = 1.47 \times 10^{-14} \text{ mol dm}^{-3}$
- C  $\text{pH} < 7$
- D  $\text{pH} = 7$

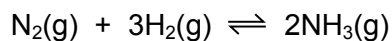
36 The reversible reactions shown occur in car engines.



Assuming that these equilibria are established, which condition would decrease the amount of CO without altering the amount of NO in the exhaust gases?

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

37 Ammonia can be made by reacting nitrogen with hydrogen.



The standard entropies,  $S^\ominus$ , of the reactants and product are shown.

molecule	$S^\ominus/\text{JK}^{-1}\text{mol}^{-1}$
$\text{N}_2(\text{g})$	191.5
$\text{H}_2(\text{g})$	130.6
$\text{NH}_3(\text{g})$	192.3

What is the standard entropy change,  $\Delta S^\ominus$ , of the forward reaction?

- A  $-198.7\text{JK}^{-1}\text{mol}^{-1}$
- B  $-129.8\text{JK}^{-1}\text{mol}^{-1}$
- C  $+129.8\text{JK}^{-1}\text{mol}^{-1}$
- D  $+198.7\text{JK}^{-1}\text{mol}^{-1}$

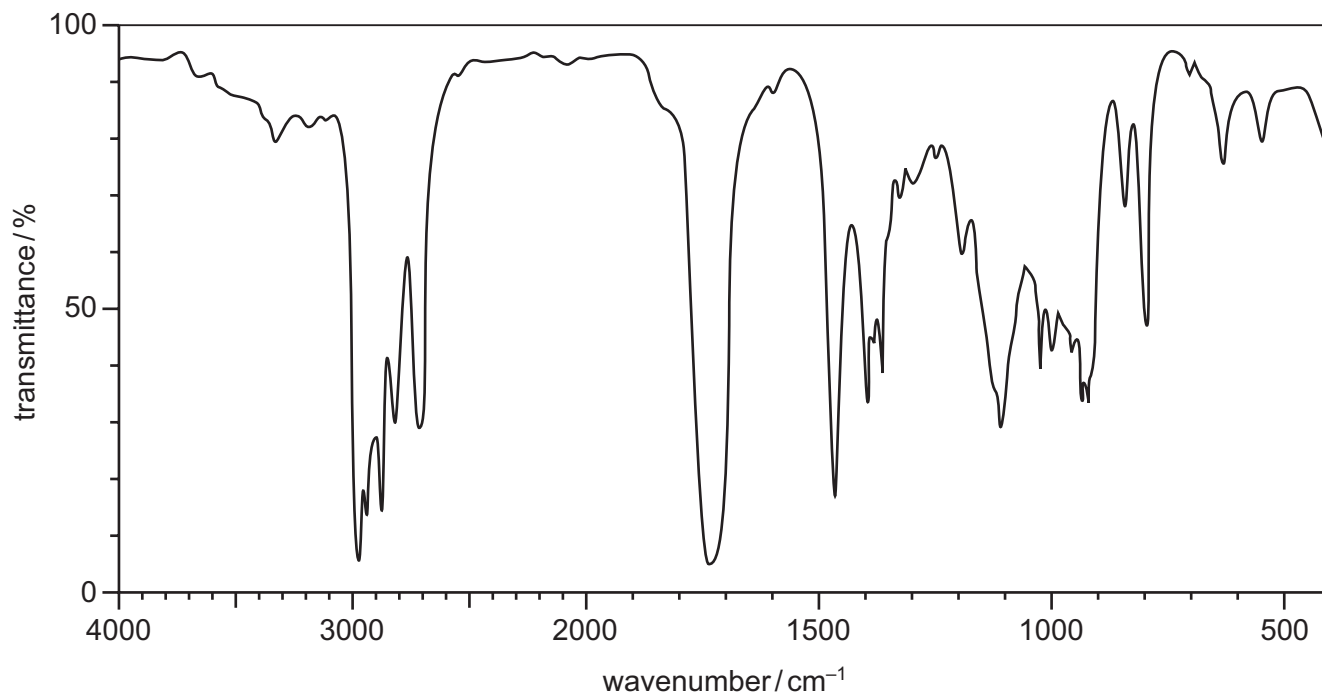
38 Hand warmers, when activated, generate their warmth by the spontaneous crystallisation of sodium ethanoate from a supersaturated solution.

Which row describes the entropy changes involved?

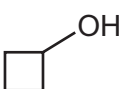
	$\Delta S_{\text{system}}$	$\Delta S_{\text{surroundings}}$	$\Delta S_{\text{total}}$
<b>A</b>	decrease	decrease	decrease
<b>B</b>	decrease	increase	increase
<b>C</b>	increase	decrease	increase
<b>D</b>	increase	increase	decrease

39 A compound has the molecular formula  $C_4H_8O$ .

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



What is the structural formula of this compound?

- A** 
- B**  $CH_2CHOCH_2CH_3$
- C**  $CH_2C(CH_3)CH_2OH$
- D**  $(CH_3)_2CHCHO$

40 The high-resolution  $^1H$  NMR spectrum of 2,2-dichloropropanal shows two signals.

Which splitting patterns would you expect to see in these two signals?

- A** a singlet and a doublet
- B** a singlet and a triplet
- C** a doublet and a quartet
- D** two singlets

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