



CHEMISTRY (PRINCIPAL)

9791/01

Paper 1 Multiple Choice

May/June 2018

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, 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.

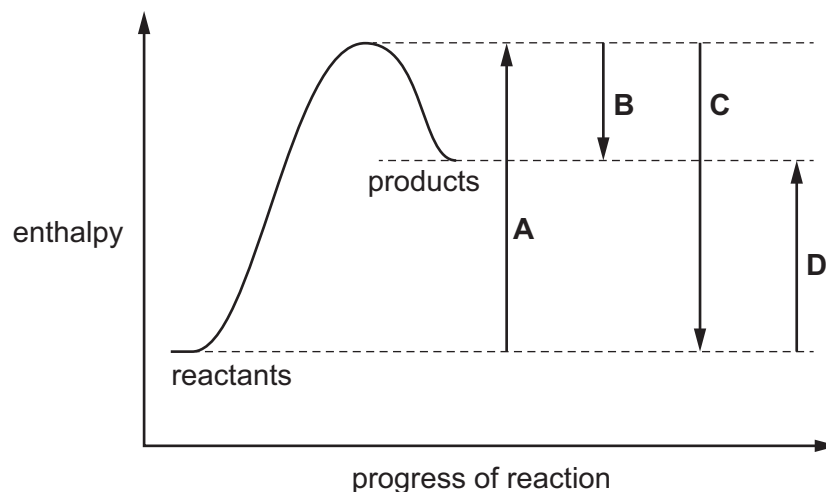
Any working should be done in this booklet.

Electronic calculators may be used.

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

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

- 1 Which arrow on the reaction profile diagram shows the enthalpy change of reaction?



- 2 Which row shows the coordination number for the anions in sodium chloride and in calcium fluoride?

| | anion in sodium chloride | anion in calcium fluoride |
|----------|--------------------------|---------------------------|
| A | 4 | 4 |
| B | 6 | 4 |
| C | 6 | 8 |
| D | 8 | 8 |

- 3 The compound $\text{YBa}_2\text{Cu}_3\text{O}_7$ is a semi-conductor.

In this compound, the oxidation number of yttrium is +3, barium is +2 and oxygen is -2.

What could be the oxidation numbers of the three copper atoms?

- A** 0 +2 +3
B +1 +2 +3
C +2 +2 +3
D +3 +3 +3
- 4 Neon exists as three isotopes ^{20}Ne , ^{21}Ne and ^{22}Ne .

How many neutrons are present in a neon atom of the most abundant isotope?

- A** 9 **B** 10 **C** 11 **D** 12

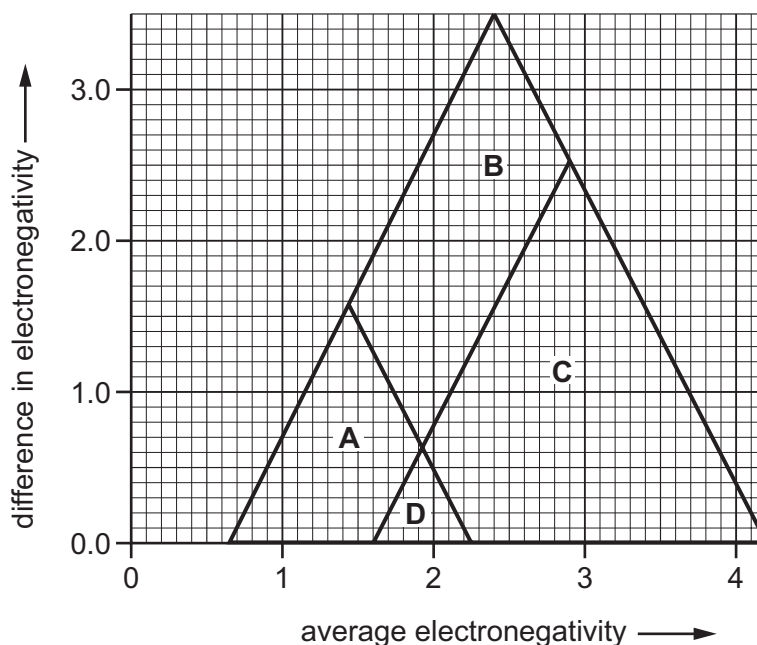
- 5 Which row represents a species that can be discharged at the cathode during the electrolysis of a suitable molten salt?

| | atomic number | electronic configuration |
|----------|---------------|--------------------------|
| A | 3 | [He] |
| B | 11 | [Ne]3s ¹ |
| C | 17 | [Ar] |
| D | 18 | [Ar] |

- 6 The diagram shows a van Arkel triangle.

The electronegativity of antimony is 2.18 and that of chlorine is 3.16.

In which region of the diagram would SbCl₃ be found?

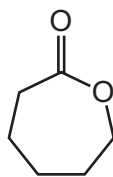


- 7 Urea has the formula (NH₂)₂CO.

Which statement about urea is correct?

- A** The molecule has a carbon atom at the carbonyl functional group level.
- B** The molecule has two π bonds.
- C** The molecule has three lone-pairs of electrons.
- D** The molecule produces carbon dioxide on hydrolysis.

- 8 Caprolactone is used in the manufacture of specialist polymers.



caprolactone

From which compound could caprolactone be made by a single reaction?

- A** $\text{HOCH}_2(\text{CH}_2)_3\text{CH}_2\text{OH}$
B $\text{HOCH}_2(\text{CH}_2)_3\text{COOH}$
C $\text{HOCH}_2(\text{CH}_2)_4\text{COOH}$
D $\text{HOOC}(\text{CH}_2)_4\text{COOH}$
- 9 To prepare dry samples of ammonia and sulfur dioxide in a school laboratory, each gas is passed through a drying agent.

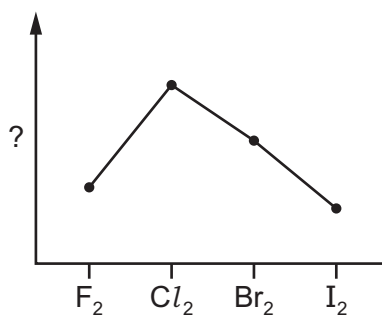
Which drying agent would be used for each of these gases?

| | for ammonia | for sulfur dioxide |
|----------|----------------------------|----------------------------|
| A | calcium oxide | calcium oxide |
| B | calcium oxide | concentrated sulfuric acid |
| C | concentrated sulfuric acid | calcium oxide |
| D | concentrated sulfuric acid | concentrated sulfuric acid |

- 10 Which substance has the most vigorous reaction with water?

- A** AlCl_3 **B** Cl_2 **C** P_4 **D** SiO_2

- 11 The sketch graph shows the variation in a property of halogen molecules.



What is the label of the y-axis of this graph?

- A bond energy
 B intensity of colour
 C oxidising power
 D volatility
- 12 When barium hydroxide and ammonium thiocyanate powders are stirred together with a thermometer, the chemical reaction between them can cause the temperature to drop from room temperature to below the freezing point of water.

Which row describes the entropy changes involved?

| | ΔS_{system} | $\Delta S_{\text{surroundings}}$ | ΔS_{total} |
|----------|----------------------------|----------------------------------|---------------------------|
| A | decrease | decrease | decrease |
| B | decrease | increase | increase |
| C | increase | decrease | increase |
| D | increase | increase | decrease |

- 13 Ammonium iodide decomposes according to the equation shown.



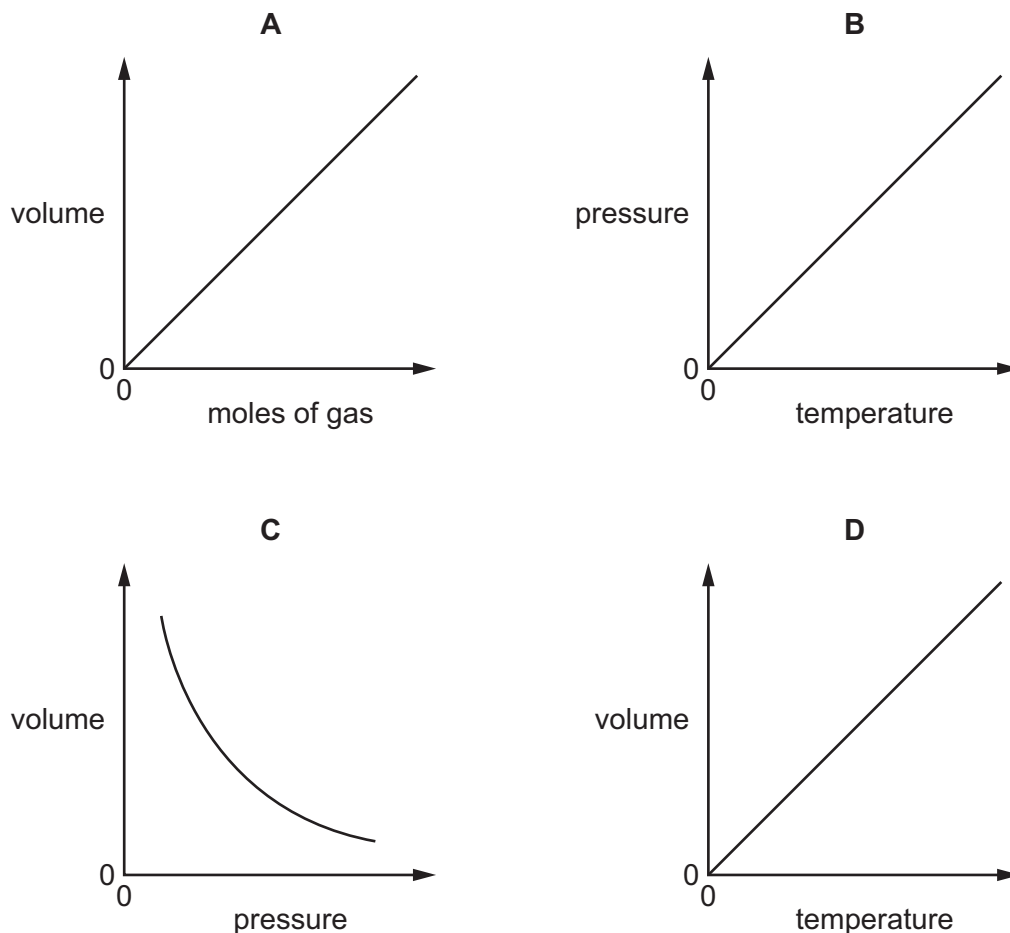
The standard enthalpy change for the reaction, $\Delta_r H^\ominus$, is $+181.8 \text{ kJ mol}^{-1}$.

The standard entropy change for the reaction, $\Delta_r S^\ominus$, is $+281.3 \text{ JK}^{-1} \text{ mol}^{-1}$.

What is the minimum temperature at which the reaction is feasible?

- A 0.646°C B 373°C C 646°C D 919°C

14 Which graph correctly depicts Charles's Law?



15 Hexanoic acid and 1,5-pentanediamine both smell foul. After they are mixed in a 2:1 mole ratio, very little smell can be detected.

Which statement explains this observation?

- A Each smell masks the smell of the other molecule.
- B The carboxylic acid hydrolyses the diamine.
- C The two reagents react to form a condensation polymer.
- D The two reagents react to form an involatile salt.

16 Glycol, $\text{HOCH}_2\text{CH}_2\text{OH}$, is used in anti-freeze. It forms a number of different oxidation products.

One of these products, **X**, has both carbon atoms at the same functional group level. **X** reacts with Tollens' reagent to form silver.

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

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

- 17 Calcium carbide is an ionic compound in which the oxidation number of carbon is -1 .

Calcium carbide reacts with water giving only two products.

What are the formulae of calcium carbide and the two products?

| | calcium carbide | products |
|----------|-----------------------|--|
| A | Ca_2C | $\text{CaO} + \text{C}_2\text{H}_4$ |
| B | Ca_2C | $\text{Ca(OH)}_2 + \text{C}_2\text{H}_2$ |
| C | CaC_2 | $\text{CaO} + \text{C}_2\text{H}_4$ |
| D | CaC_2 | $\text{Ca(OH)}_2 + \text{C}_2\text{H}_2$ |

- 18 Ethanoic acid forms a dimer (a double molecule) of molecular formula $\text{C}_4\text{H}_8\text{O}_4$.

This dimer contains an 8-membered ring. This ring contains two hydrogen bonds.

How many carbon, hydrogen and oxygen atoms are present in this ring?

| | C | H | O |
|----------|---|---|---|
| A | 2 | 2 | 4 |
| B | 2 | 4 | 2 |
| C | 4 | 0 | 4 |
| D | 4 | 2 | 2 |

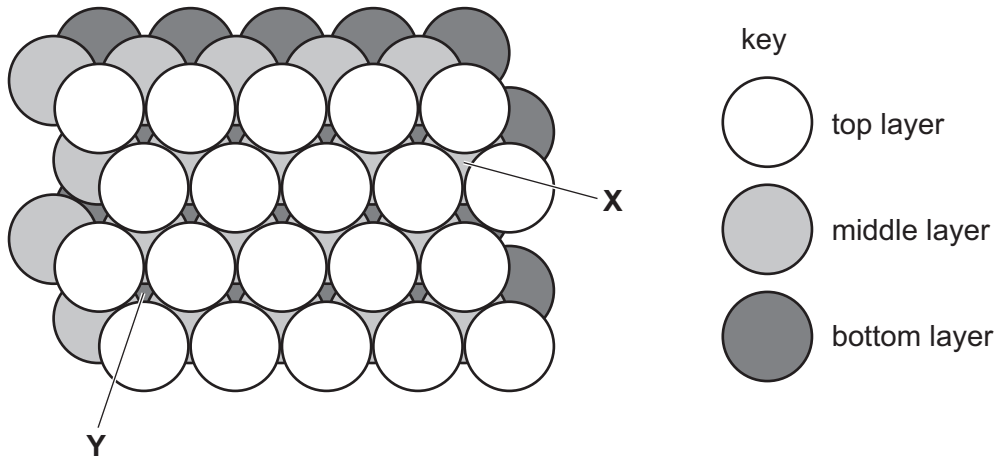
- 19 Which statement about antibonding is **not** correct?

- A** Filling an empty antibonding orbital lowers the bond order 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.

- 20 Which equation does **not** represent the standard enthalpy change stated?

| | enthalpy change of | equation |
|----------|--------------------------------------|--|
| A | atomisation of Cl | $\text{Cl}_2(\text{g}) \rightarrow 2\text{Cl}(\text{g})$ |
| B | combustion of H_2S | $\text{H}_2\text{S}(\text{g}) + 1.5\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{SO}_2(\text{g})$ |
| C | formation of H_2SO_4 | $\text{H}_2(\text{g}) + 2\text{O}_2(\text{g}) + \frac{1}{8}\text{S}_8(\text{s}) \rightarrow \text{H}_2\text{SO}_4(\text{l})$ |
| D | solution of K_2SO_4 | $\text{K}_2\text{SO}_4(\text{s}) + \text{aq} \rightarrow 2\text{K}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$ |

21 The diagram shows cubic close-packed spheres, with two holes labelled.



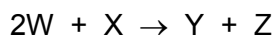
Hole **X** is between the top layer and the middle layer.

Hole **Y** is between the middle layer and the bottom layer.

Which shape is each hole?

| | X | Y |
|----------|-------------|-------------|
| A | octahedral | octahedral |
| B | octahedral | tetrahedral |
| C | tetrahedral | octahedral |
| D | tetrahedral | tetrahedral |

22 The kinetics of the reaction



were investigated.

The table shows the initial rate of reaction when the concentrations of W and X were changed.

| [W]/mol dm ⁻³ | [X]/mol dm ⁻³ | initial rate/mol dm ⁻³ s ⁻¹ |
|--------------------------|--------------------------|---|
| 0.015 | 0.010 | 5.10×10^{-4} |
| 0.030 | 0.020 | 4.08×10^{-3} |
| 0.045 | 0.010 | 1.53×10^{-3} |

What is the rate equation for this reaction?

- A rate = $k[W][X]$
- B rate = $k[W][X]^2$
- C rate = $k[W]^2[X]$
- D rate = $k[W]^2[X]^2$

- 23 When sulfuric acid is added to $\text{Cu}^{2+}(\text{aq})$, no colour change occurs, but when concentrated hydrochloric acid is added to $\text{Cu}^{2+}(\text{aq})$, the solution turns yellow-green. The solution returns to its original colour when the solution is diluted with water.

Which type of reaction is occurring between $\text{HCl}(\text{aq})$ and $\text{Cu}^{2+}(\text{aq})$?

- A acid/base
- B disproportionation
- C ligand exchange
- D redox

- 24 The lattice energy of silver chloride has been measured experimentally and found to be -905 kJ mol^{-1} . However, using the ionic model, its calculated value is -833 kJ mol^{-1} .

Which statement explains this discrepancy?

- A Silver chloride is insoluble in water and so the lattice does not fully break down.
- B The calculation for the ionic model ignores any repulsion between ions.
- C The experimental value was not obtained under standard conditions.
- D The ionic model cannot account for any covalency in a compound.

25 Which pair of reagents will react under appropriate conditions to produce the ester methyl propanoate?

- A $\text{CH}_3\text{COCl} + \text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
 B $\text{CH}_3\text{COCl} + \text{CH}_3\text{OH}$
 C $\text{C}_2\text{H}_5\text{COCl} + \text{C}_2\text{H}_5\text{OH}$
 D $\text{C}_2\text{H}_5\text{COCl} + \text{CH}_3\text{OH}$

26 A molten chloride of a Group 1 metal, QCl , and a molten chloride of a Group 2 metal, RCl_2 , are separately electrolysed using the same current for the same time.

Which statement about this experiment is correct?

- A An equal number of moles of Q and R is deposited.
 B Equal masses of Q and R are deposited.
 C The number of moles of Q deposited is twice the number of moles of R deposited.
 D QCl gives off half the volume of chlorine gas compared with RCl_2 , measured under the same conditions of temperature and pressure.

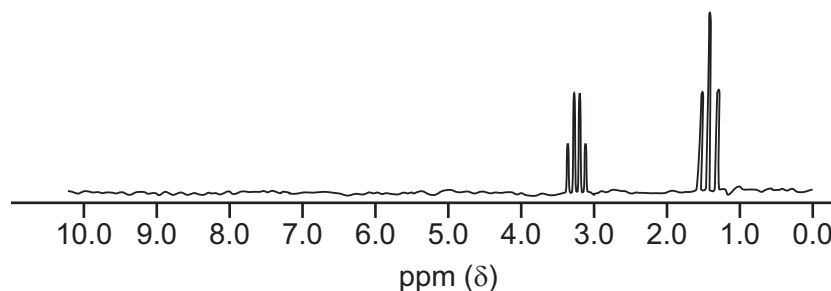
27 Solution X is added to a warm mixture of an organic compound Y and $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$.

A reaction occurs producing $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ ions.

What are X and Y?

| | X | Y |
|---|------------------------------------|---------------------------------|
| A | $\text{H}_2\text{SO}_4(\text{aq})$ | $\text{C}_2\text{H}_5\text{OH}$ |
| B | $\text{H}_2\text{SO}_4(\text{aq})$ | CH_3COOH |
| C | $\text{NaOH}(\text{aq})$ | $\text{C}_2\text{H}_5\text{OH}$ |
| D | $\text{NaOH}(\text{aq})$ | CH_3CHO |

28 The proton NMR spectrum of compound Z is shown.



What could Z be?

- A CH_3CHCl_2 B $\text{CH}_3\text{CH}_2\text{OH}$ C $\text{CH}_3\text{CH}_2\text{Br}$ D $\text{CH}_3\text{COCH}_2\text{Br}$

- 29 Dry carbon dioxide is bubbled through a solution of the Grignard reagent $\text{CH}_3\text{CH}_2\text{CH}_2\text{MgBr}$ in ethoxyethane. The product of this reaction then undergoes hydrolysis with dilute sulfuric acid to produce a carboxylic acid.

Which statement correctly describes the outcome of these two reactions?

- A One carbon atom in the Grignard reagent moves up three levels and butanoic acid is formed.
 - B One carbon atom in the Grignard reagent moves up three levels and propanoic acid is formed.
 - C The carbon atom in the carbon dioxide moves down a level and butanoic acid is formed.
 - D The carbon atom in the carbon dioxide moves down a level and propanoic acid is formed.
- 30 Nitrobenzene can be reduced to phenylamine using tin and hydrochloric acid. The final step of this process is addition of excess sodium hydroxide to the reaction mixture.

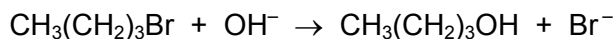
Why is the sodium hydroxide added?

- A to decompose any remaining starting material
 - B to dry the product
 - C to hydrolyse the intermediate
 - D to react with phenylammonium chloride
- 31 Alanine is an amino acid of formula $\text{H}_2\text{NCH}(\text{CH}_3)\text{COOH}$.

Which statement about alanine and its zwitterion is correct?

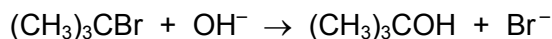
- A Both contain a dative covalent bond.
- B Both have one chiral carbon atom.
- C They have different numbers of lone pairs of electrons.
- D They have different percentages by mass of hydrogen.

32 The reaction



has an $\text{S}_{\text{N}}2$ mechanism.

The reaction



has an $\text{S}_{\text{N}}1$ mechanism.

Which statement is correct?

- A Both reactions involve homolytic fission.
 - B Both reactions involve hydroxide ions acting as electron pair donors.
 - C Both reactions involve the formation of a positively charged intermediate.
 - D Both reactions occur in a single step.
- 33 Which statement about the element astatine or its compounds is **not** correct as it is **not** consistent with the position of astatine in Group 17?
- A Astatine is a product of the reaction between sodium astatide and concentrated sulfuric acid.
 - B Astatine is a solid at room temperature and pressure.
 - C Silver astatide is soluble in aqueous ammonia.
 - D The bond energy of hydrogen astatide is less than that of hydrogen iodide.

34 Cyanogen, $(\text{CN})_2$, behaves like chlorine.

How would it react with cold, dilute KOH?

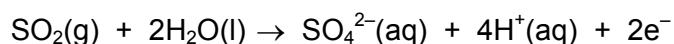
- A $2\text{KOH} + (\text{CN})_2 \rightarrow 2\text{KCN} + \text{H}_2\text{O}_2$
 - B $2\text{KOH} + (\text{CN})_2 \rightarrow \text{KCN} + \text{KCNO} + \text{H}_2\text{O}$
 - C $6\text{KOH} + 3(\text{CN})_2 \rightarrow 5\text{KCN} + \text{KCNO}_3 + 3\text{H}_2\text{O}$
 - D $\text{KOH} + (\text{CN})_2 \rightarrow \text{KCN} + \text{HCN} + \frac{1}{2}\text{O}_2$
- 35 Buckminsterfullerene, graphene and graphite are allotropes of carbon.

Which statements about these allotropes of carbon are correct?

- 1 Buckminsterfullerene has a simple molecular structure.
- 2 Each carbon in a buckminsterfullerene is bonded to four other carbon atoms.
- 3 Graphene and graphite have higher melting points than buckminsterfullerene.

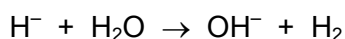
- A 1 and 2
- B 1 and 3
- C 2 and 3
- D 3 only

- 36 Sulfur dioxide gas is converted into sulfate ions when it is bubbled into a solution containing aqueous manganate(VII) ions.



How will the pH of the reaction mixture change as sulfur dioxide is bubbled at constant rate into a well-stirred solution of manganate(VII) ions until its colour just fades?

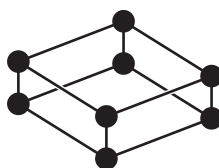
- A The pH will decrease.
 B The pH will decrease then increase.
 C The pH will increase.
 D The pH will increase then decrease.
- 37 Ionic metal hydrides react with water.



1.0g samples of ionic hydrides are separately added to an excess of water.

Which ionic hydride produces the greatest mass of hydrogen gas?

- A calcium hydride
 B magnesium hydride
 C potassium hydride
 D sodium hydride
- 38 An unusual form of oxygen has the formula O_8 . Its structure is shown.

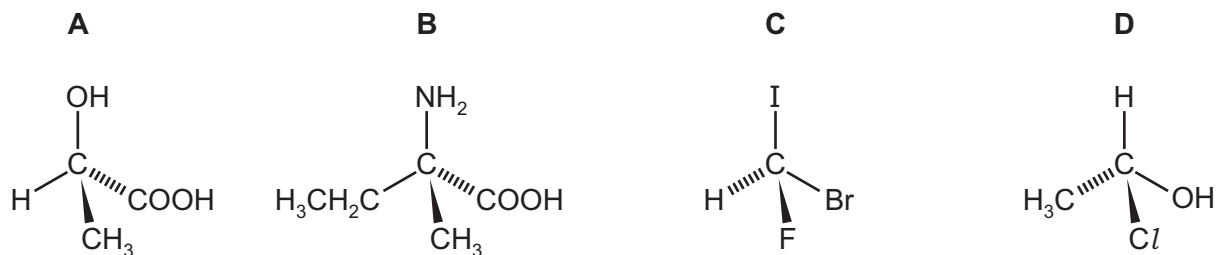


Which statement explains why this form of oxygen is uncommon, whereas S_8 is the common form of sulfur?

- A O_8 contains more bonds than S_8 .
 B O–O single bonds are much weaker than S–S single bonds.
 C Oxygen is more easily reduced than sulfur.
 D Oxygen is more electronegative than sulfur.

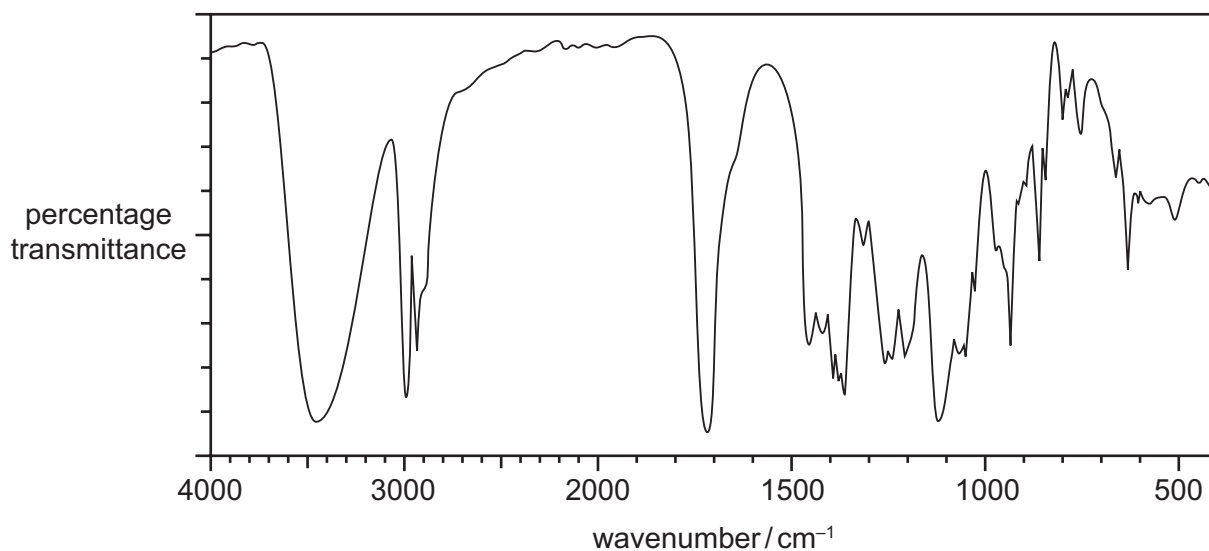
39 The Cahn-Ingold-Prelog priority rules are used to assign *R* or *S*.

Which chiral centre has *S* configuration?



40 An organic compound has the empirical formula C_2H_4O .

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



What is the structural formula of this compound?

- A** CH_3CHO
- B** C_3H_7COOH
- C** $HCOOC_2H_5$
- D** $CH_3COCH(OH)CH_3$

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