

# Inorganic Chemistry

## Question Paper

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Inorganic Chemistry
Booklet	Question Paper

**Time Allowed:** 58 minutes

**Score:** /48

**Percentage:** /100

**Grade Boundaries:**

## Periodic Table

- 1 The first seven successive ionisation energies of an element are 1010, 1900, 2900, 5000, 6300, 21300 and 25400 kJ mol<sup>-1</sup> respectively. In which group of the Periodic Table is this element found?

**A** 1                      **B** 13                      **C** 15                      **D** 17

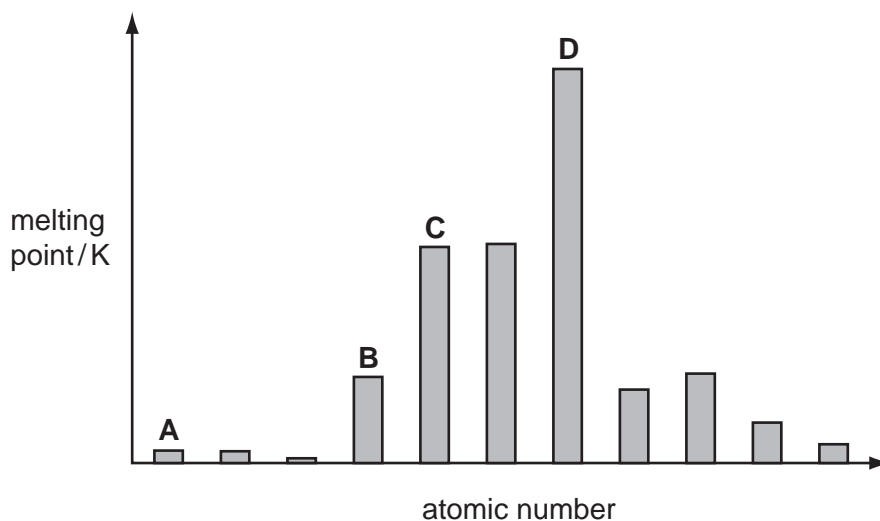
2. The oxide and chloride of an element **Z** are separately mixed with water. The two resulting solutions have the same effect on litmus.

What is element **Z**?

- A** sodium  
**B** magnesium  
**C** aluminium  
**D** phosphorus

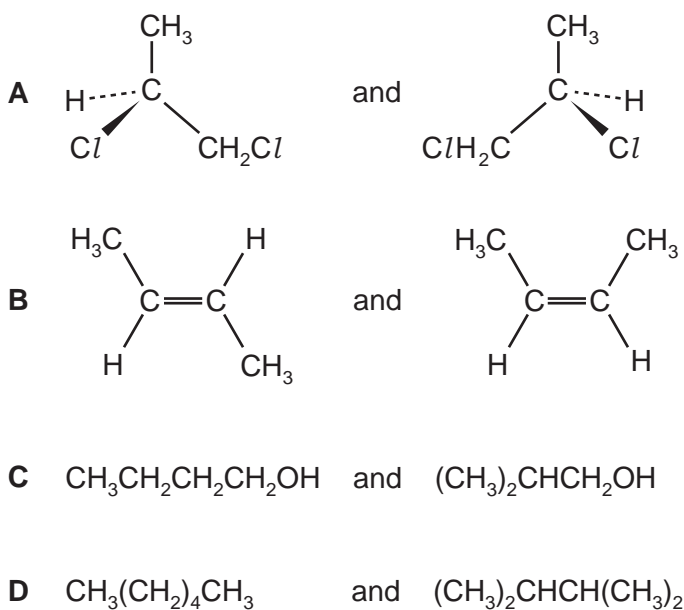
3. The bar chart shows the melting points of a series of consecutive elements arranged in order of increasing atomic number. The elements sodium to chlorine form part of this series.

Which bar represents sodium?



- 4 What is the pattern of the increase in metallic character in the Periodic Table?
- A** ascending groups and left to right across periods  
**B** ascending groups and right to left across periods  
**C** descending groups and left to right across periods  
**D** descending groups and right to left across periods
5. Why does magnesium have a greater electrical conductivity than sodium?
- A** A magnesium atom has more protons than a sodium atom.  
**B** Magnesium is more electronegative than sodium.  
**C** Magnesium has a higher relative atomic mass than sodium.  
**D** One mole of magnesium has more delocalised electrons than one mole of sodium.

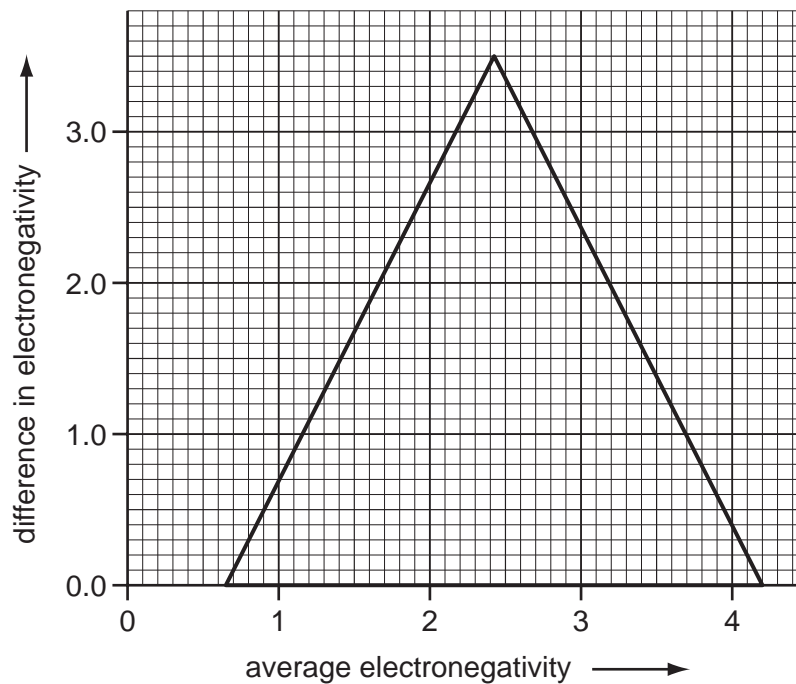
6. In which pair do the isomers have identical boiling points?



7. Which statement about an element in the Periodic Table is correct?
- A** Magnesium is a metalloid, has a giant structure and is a good conductor of electricity.  
**B** Silicon is a metalloid, has a simple molecular structure and is a semi-conductor of electricity.  
**C** Sodium is a metal, has a giant structure and is a good conductor of electricity.  
**D** Sulfur is a non-metal, has a giant structure and is a poor conductor of electricity.

8. Recent research has investigated ferrosilicon, FeSi, whose unusual electronic behaviour can be switched on and off with magnets.

element	electronegativity
Fe	1.8
Si	1.9



Using the van Arkel triangle and electronegativity values, which type of bonding is present in ferrosilicon?

- A covalent
  - B ionic
  - C metallic
  - D semi-metallic
9. 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  $\text{H}_2\text{SiO}_3$
  - C  $\text{H}_3\text{PO}_4$
  - D  $\text{H}_2\text{SO}_3$

10. Molecule **X** is made up from two elements from period 3 of the Periodic Table. One of the elements has the highest **melting** point and the other element has the lowest **melting** point (excluding argon) in the period.

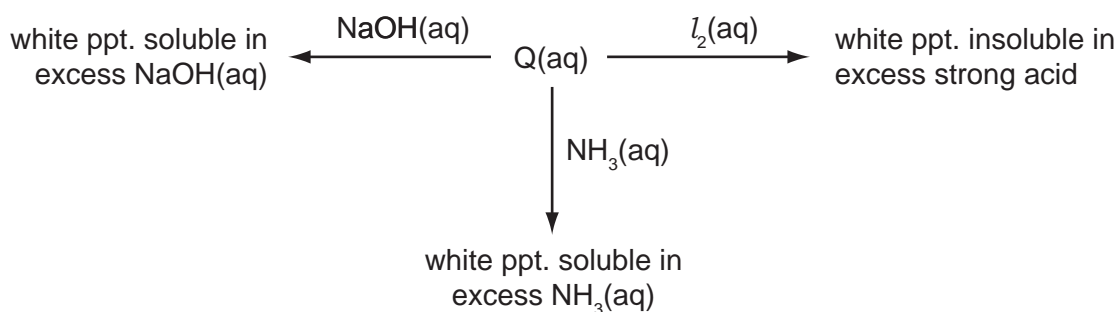
What is the formula of molecule **X**?

- A**  $AlCl_3$       **B**  $Al_2S_3$       **C**  $SiCl_4$       **D**  $SiS_2$

11. Which statement about an element in the Periodic Table is correct?

- A** Magnesium is a metalloid, has a giant structure and is a good conductor of electricity.  
**B** Silicon is a metalloid, has a simple molecular structure and is a semi-conductor of electricity.  
**C** Sodium is a metal, has a giant structure and is a good conductor of electricity.  
**D** Sulfur is a non-metal, has a giant structure and is a poor conductor of electricity.

12. The diagram shows some reactions of salt Q.



What is the identity of Q?

- A**  $Al_2(SO_4)_3$       **B**  $PbSO_4$       **C**  $ZnSO_3$       **D**  $ZnSO_4$

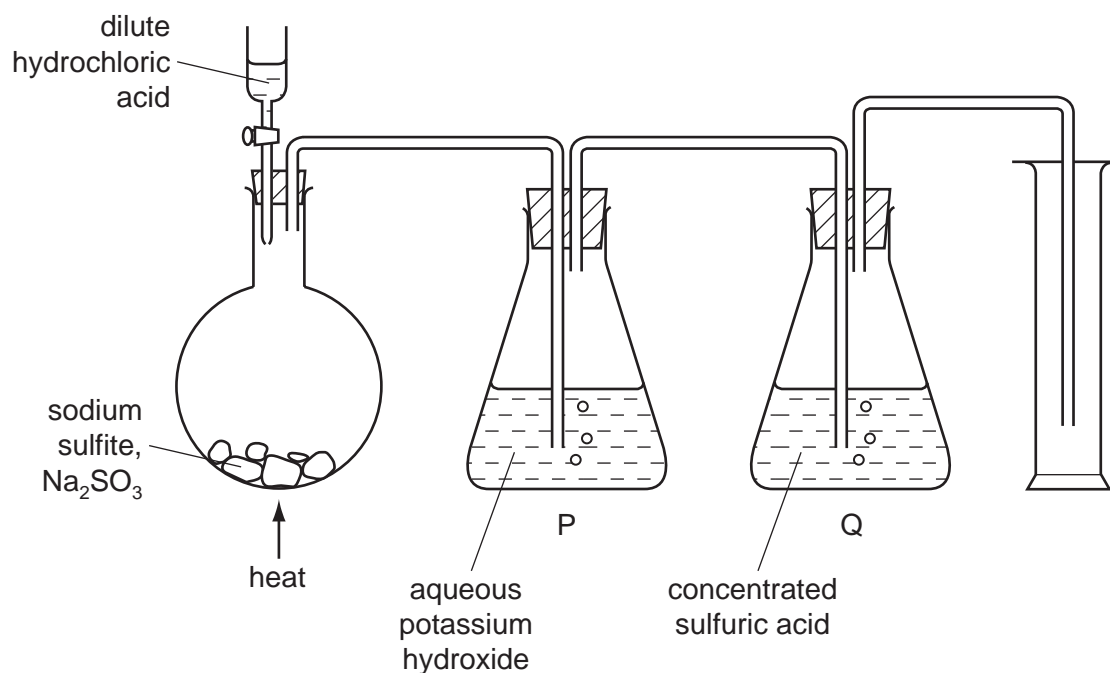
## Oxygen and Sulfur

13. The emissions from a power station contain about 14 tonnes of  $\text{SO}_2$  per hour from the oxidation of  $\text{FeS}_2$  contained in the coal.

What is the most practical way of preventing the  $\text{SO}_2$  from being released into the atmosphere?

- A Cool the gases and the  $\text{SO}_2$  will liquefy and can be removed.
- B Dissolve the ionic  $\text{FeS}_2$  in hexane.
- C Pass the emissions through a bed of calcium oxide.
- D Pass the gases through concentrated sulfuric acid to dissolve the  $\text{SO}_2$ .

14. The apparatus shows an unsuccessful attempt to prepare and collect dry sulfur dioxide.



Which change would make the experiment successful?

- A omitting flask P
- B omitting flask Q
- C using dilute nitric acid instead of dilute hydrochloric acid
- D using sodium sulfate instead of sodium sulfite

15. An element **X** in Period 3 is a metalloid and semiconductor and has a chloride which reacts with water to form an acidic solution.

An element **Y** has an atomic number one **less** than element **X**.

What is a property of the oxide of element **Y**?

- A** It is a gas at room temperature.
  - B** It is amphoteric.
  - C** It is covalent.
  - D** Its formula is  $YO_2$ .
16. Desulfurisation plants remove  $SO_2$  from power station emission gases by washing the gases with calcium hydroxide solution.

What is the main product **initially** formed in the reaction that occurs?

- A** CaS
  - B**  $CaSO_3$
  - C**  $CaSO_4$
  - D**  $Ca(HSO_4)_2$
17. The oxide and chloride of an element **R** are separately mixed with water. The two resulting solutions have the same effect on litmus paper.

What is element **R**?

- A** aluminium
- B** magnesium
- C** phosphorus
- D** sodium

## Nitrogen, Phosphorus, Amonia

18. Silicon and phosphorus are elements in Period 3.

Which statement about silicon and white phosphorus is correct?

- A They both can act as semi-conductors.
- B They both form chlorides that react with water.
- C They both form dioxides readily in oxygen.
- D They both have melting points below 200 °C.

19. At 900 °C,  $\text{CaCO}_3$  decomposes producing  $\text{CO}_2$  and the metal oxide.  
At 1100 °C,  $\text{CaSO}_4$  decomposes producing  $\text{SO}_3$  and the metal oxide.

Which statement explains the greater thermal stability of  $\text{CaSO}_4$ ?

- A  $\text{CaCO}_3$  has a higher lattice energy than  $\text{CaSO}_4$ .
- B  $\text{CO}_3^{2-}$  ions are more easily polarised than  $\text{SO}_4^{2-}$ .
- C The charge density of  $\text{CO}_3^{2-}$  is greater than that of  $\text{SO}_4^{2-}$ .
- D The  $\text{CO}_2$  molecule is smaller than  $\text{SO}_3$ .

20. A solid salt dissolved on being warmed with an excess of aqueous sodium hydroxide without any gas being evolved.

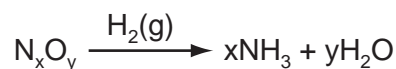
A colourless solution was produced.

What is the salt?

- A ammonium nitrate
- B chromium(III) nitrate
- C magnesium nitrate
- D zinc nitrate



21. In the analysis of an oxide of nitrogen, 0.10 mol of the oxide were reacted with excess hydrogen under suitable conditions.

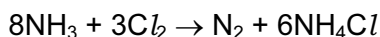


3.6 g of water were formed in this reaction, while the ammonia produced required 100 cm<sup>3</sup> of 1.0 mol dm<sup>-3</sup> HCl(aq) for neutralisation.

What is the formula of the oxide of nitrogen analysed?

- A** N<sub>2</sub>O                      **B** NO                      **C** NO<sub>2</sub>                      **D** N<sub>2</sub>O<sub>5</sub>
22. Which statement about the element astatine (atomic number 85) is **not** correct and is **not** consistent with its position 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.

23. In the gas phase, ammonia reacts with chlorine.



Which row indicates the correct combination of statements about this reaction?

	ammonia acts as a reducing agent	ammonia acts as a base	a dative bond is formed
<b>A</b>	✓	✓	✓
<b>B</b>	✓	x	x
<b>C</b>	x	✓	✓
<b>D</b>	x	x	✓

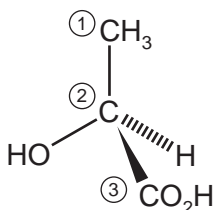
## Carbonates

24. Buckminsterfullerene is the most commonly occurring fullerene molecule, found in small quantities in soot.

Which statement about buckminsterfullerene is **incorrect**?

- A Its mass spectrum has a prominent peak at  $m/z$  value of 720.
- B The carbon atoms in the molecule are each bonded to four neighbours.
- C The molecule is composed of hexagons and pentagons of carbon atoms.
- D Van der Waals forces occur between molecules in the solid.

25. The diagram shows the structure of lactic acid.



What are the functional group levels of the carbon atoms in lactic acid?

[0 = hydrocarbon, 1 = alcohol, 2 = carbonyl, 3 = carboxylic acid, 4 = carbon dioxide level]

	carbon atom ①	carbon atom ②	carbon atom ③
<b>A</b>	0	1	3
<b>B</b>	1	0	3
<b>C</b>	0	1	4
<b>D</b>	1	0	4

26. 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.

27. In Group 2, what are the trends in charge density of the metal cations and thermal stability of the metal carbonates as the atomic number of the metal increases?

	charge density	thermal stability
<b>A</b>	decreases	decreases
<b>B</b>	decreases	increases
<b>C</b>	increases	decreases
<b>D</b>	increases	increases

## Halogens

28. For which halogen is the colour and state at room temperature correct?

	halogen	colour	state
<b>A</b>	bromine	brown	gas
<b>B</b>	chlorine	green	liquid
<b>C</b>	fluorine	green	gas
<b>D</b>	iodine	grey-black	solid

29. Concentrated sulfuric acid reacts with solid potassium bromide at room temperature.

Which substance is **not** formed in this reaction?

- A** bromine
  - B** hydrogen sulfide
  - C** sulfur dioxide
  - D** water
30.  $\text{Br}_2$  is a liquid but  $\text{F}_2$  is a gas at room temperature and pressure.

What is a valid explanation for the difference in state?

- A** Br–Br bonds are stronger than F–F bonds.
  - B**  $\text{Br}_2$  is less reactive than  $\text{F}_2$ .
  - C** Br is more electronegative than F.
  - D**  $\text{Br}_2$  is more polarisable than  $\text{F}_2$ .
31. A mixture of solids is treated with an excess of dilute hydrochloric acid.

A colourless gas is evolved and a white precipitate forms.

What are the solids in the mixture?

- A** calcium carbonate and magnesium hydroxide
- B** calcium carbonate and magnesium nitrate
- C** lead nitrate and calcium hydroxide
- D** lead nitrate and magnesium carbonate

32. Fluorine has anomalous properties in Group 17.

Which statement is correct?

- A Fluorine is intensely coloured.
- B HF is a strong acid.
- C The F–F bond is unusually weak.
- D The melting point of fluorine is high.

33. Addition of warm concentrated sulfuric acid,  $\text{H}_2\text{SO}_4$ , to crystals of sodium halides gives the following observations.

halide	observ
NaF	evolution of a colourless gas which etches a damp glass rod
NaCl	evolution of a choking colourless gas which produces a white cloud in contact with ammonia vapour
NaBr	evolution of a brown vapour and of pungent fumes which turn potassium dichromate(VI) paper green
NaI	evolution of a purple vapour and a gas smelling of rotten eggs

Which statements are consistent with the observations?

	hydrogen halide is produced in all four reactions	sulfuric acid is acting as a reducing agent in all four reactions	sulfur dioxide and hydrogen sulfide are reduction products of sulfuric acid
<b>A</b>	✓	x	✓
<b>B</b>	✓	✓	x
<b>C</b>	x	x	✓
<b>D</b>	x	✓	x

key

✓ = true

x = false

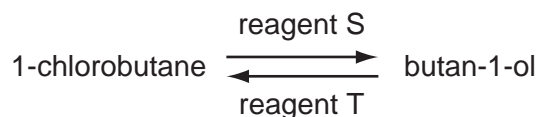
34. A powder was known to be either a single sodium halide or a mixture of two sodium halides.

A sample of the powder was dissolved in water and aqueous silver nitrate added. A precipitate was formed, which, on addition of excess aqueous ammonia, partly dissolved leaving a yellow solid.

What did the powder consist of?

- A NaBr only
- B NaI only
- C a mixture of NaCl and NaBr
- D a mixture of NaCl and NaI

35. Which quantity is greater for fluorine than for chlorine?
- A bond energy
  - B bond length
  - C melting point
  - D oxidising power
36. Halogenoalkanes and alcohols can be synthesised from each other using the appropriate reagents, as shown.

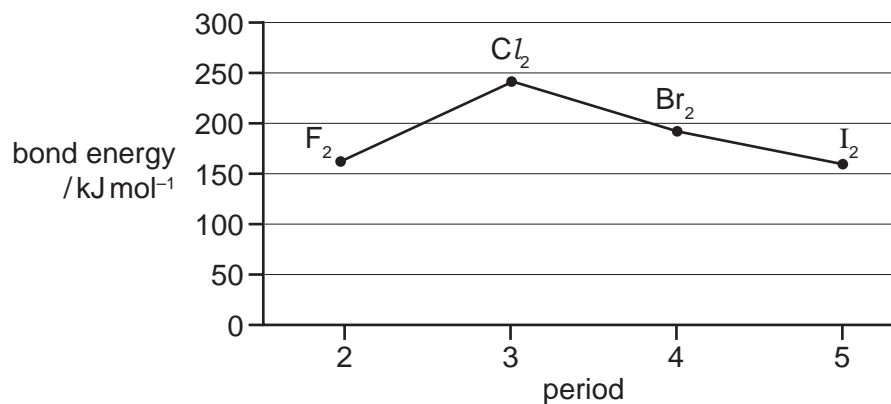


What is the correct combination of reagents for the conversions?

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

37. The great reactivity of fluorine is largely due to the low energy of the F–F bond. Which statement best accounts for the weak F–F bond?
- A The F–F bond is weak because of repulsion between the non-bonding electrons.
  - B The F–F bond is weak because of the short length of the bond.
  - C The F–F bond is weak because of the small nuclear charge of the fluorine atom.
  - D The F–F bond is weak because of the small size of the fluorine atom.
38. Sulfur is converted to SF<sub>6</sub> by fluorine, to SCl<sub>2</sub> by chlorine and to S<sub>2</sub>Br<sub>2</sub> by bromine. Which trend does this information best provide evidence for?
- A the trend in bond energy: F<sub>2</sub> < Cl<sub>2</sub> > Br<sub>2</sub>
  - B the trend in electronegativity: F > Cl > Br
  - C the trend in first ionisation energy: F > Cl > Br
  - D the trend in oxidising ability: F<sub>2</sub> > Cl<sub>2</sub> > Br<sub>2</sub>

39. The diagram shows bond energies in halogen molecules.



Why does the value for fluorine **not** follow the trend shown by chlorine, bromine and iodine?

- A** Fluorine is more electronegative than the other halogens.
- B** Lone electron pairs in fluorine repel more strongly than those in the other halogens.
- C** The bonds in fluorine are more polar than those in the other halogens.
- D** The bonds in fluorine have some  $\pi$ -character.

## Transition Elements

40. The  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}(\text{aq})$  ion is blue whereas the  $[\text{CuCl}_4]^{2-}(\text{aq})$  ion is yellow.

Which row best explains the difference in colour of these two ions?

	number of d electrons around copper	energy gap between the d orbitals
<b>A</b>	different	different
<b>B</b>	different	the same
<b>C</b>	the same	different
<b>D</b>	the same	the same

41. When a colourless solution of compound **J** is added to an acidified solution of a chromium compound, the solution changes colour from green to orange.

What type of reagent is **J**?

- A** a homogeneous catalyst
  - B** an alkali
  - C** an oxidising agent
  - D** a reducing agent
42. Three statements about the myoglobin molecule are given.

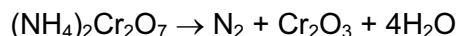
- 1 Its iron(II) ion can be 6 co-ordinated.
- 2 It contains alpha helices.
- 3 It transports oxygen in the blood stream.

Which statements are correct?

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



43. 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.
44. 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.

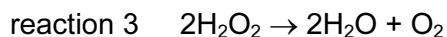
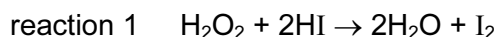
How does the sulfuric acid behave in this reaction?

- 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
45. Chemists studying the nitrogen cycle in the ocean need to consider  $\text{N}_2$ ,  $\text{NH}_4^+$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}_3^-$  and  $\text{NO}_2^-$ .

What is the order of increasing oxidation number of nitrogen for these species?

- A  $\text{NH}_4^+ \rightarrow \text{NO}_3^- \rightarrow \text{NO}_2^- \rightarrow \text{N}_2\text{O} \rightarrow \text{N}_2$
- B  $\text{NH}_4^+ \rightarrow \text{N}_2 \rightarrow \text{N}_2\text{O} \rightarrow \text{NO}_2^- \rightarrow \text{NO}_3^-$
- C  $\text{NO}_3^- \rightarrow \text{NO}_2^- \rightarrow \text{N}_2\text{O} \rightarrow \text{N}_2 \rightarrow \text{NH}_4^+$
- D  $\text{N}_2 \rightarrow \text{N}_2\text{O} \rightarrow \text{NO}_2^- \rightarrow \text{NO}_3^- \rightarrow \text{NH}_4^+$

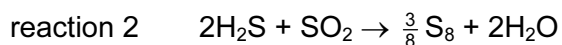
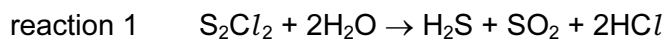
46. Three chemical reactions involving hydrogen peroxide,  $\text{H}_2\text{O}_2$ , are listed.



Which row identifies the reaction in which the oxygen of hydrogen peroxide is oxidised, is reduced and disproportionates?

	oxidised	reduced	disproportionates
<b>A</b>	reaction 1	reaction 2	reaction 3
<b>B</b>	reaction 2	reaction 1	reaction 3
<b>C</b>	reaction 2	reaction 3	reaction 1
<b>D</b>	reaction 3	reaction 1	reaction 2

47. The hydrolysis of  $\text{S}_2\text{Cl}_2$  proceeds by two reactions.



Which row correctly describes the two reactions?

	reaction 1	reaction 2
<b>A</b>	acidic solution formed	disproportionation
<b>B</b>	acidic solution formed	reverse disproportionation
<b>C</b>	neutral solution formed	disproportionation
<b>D</b>	neutral solution formed	reverse disproportionation

## Crystal Properties

48. The polyoxometallate  $W_{72}Mn_{12}Si_7O_{268}^{40-}$  was recently identified in a crystal garden.

Which row gives oxidation states of tungsten and manganese that are consistent with this formula?

	oxidation state of tungsten	oxidation state of manganese
<b>A</b>	+3	+2
<b>B</b>	+3	+3
<b>C</b>	+6	+2
<b>D</b>	+6	+3