

9.8 SULPHUR

Symbol: S

Molecular formula: S₈

Atomic number: 16

Atomic mass: 32.07 amu

Electronegativity: 2.5

Electronic configuration: 1s² 2s² 2p⁶ 3s² 3p⁴

Position in the periodic table: group 16(VI A), 3rd period; p - block

Occurrence:

Sulphur is present in native form as well as in the form of sulphide, sulphite, and sulphate ores.

Allotropes of sulphur

1. Rhombic or octahedral sulphur (α -sulphur)
2. Monoclinical or prismatic sulphur (β sulphur)
3. Plastic sulphur (γ -sulphur)
4. Colloidal sulphur (δ -sulphur)
5. Milk of sulphur

Uses of sulphur

1. One of the essential constituents of the living cell.
2. To produce sulphuric acid.
3. To prepare gunpowder.
4. Sulphur is the most important constituent of sulpha drugs.
5. In the preparation of some organo-sulphur compounds which are used in pharmaceuticals and agrochemicals.

1. The molecular formula of sulphur is

a. S₄

b. S₆

c. S₈

d. S₂

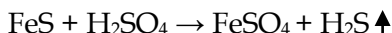
HYDROGEN SULPHIDE (H₂S)

1. Draw the Lewis structure of the H₂S molecule and explain its geometry on the basis of VSEPR theory.

3

Preparation of H₂S gas using Kipp's apparatus

H₂S gas is formed by the reaction of dilute sulphuric acid with iron sulphide.



Working Principle

- Kipp's apparatus consists of three bulbs bulb A, bulb B and bulb C.
- Bulb A communicates with bulb C with a long stem and bulb C communicates with bulb B with a narrow neck such that liquids can pass through them. Bulb B is fitted with a stop cock for the delivery of H₂S gas.
- Iron sulphide is kept in bulb B and H₂SO₄ is passed to bulb C by a long pipe such that the level of acid rises to bulb B.
- When the tap of bulb B is opened, H₂SO₄ reacts with FeS to give H₂S gas.
- But when the tap is closed, the H₂S gas produced exerts pressure, due to which the acid level drops until there is no contact between FeS and H₂SO₄

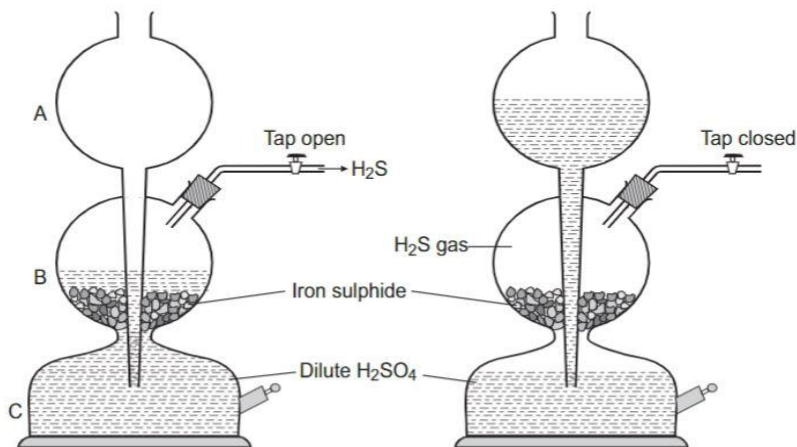


Figure: Working mechanism of Kipp's apparatus

2. Describe Kipp's apparatus method for the preparation of H₂S. 4
3. Why do chemists prefer to use Kipp's apparatus for the production of H₂S instead of using a simple hard glass tube fitted with cork and delivery tube? 2
2. H₂S can be prepared by reaction of FeS with

a. Conc. HCl

b. conc. H₂SO₄

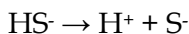
c. conc. HNO₃

d. none

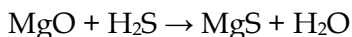
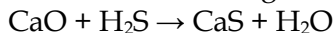
Properties of H₂S

- Colourless gas with a rotten egg smell.
- It is a water-soluble poisonous gas; causes nausea, dizziness and headache in low concentration, in high concentration its deadly.

1. Acidic nature: H₂S is a dibasic acid, so it gives off two series of salts



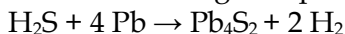
It combines with oxides to give salt.



4. How can you test for the acidic nature of hydrogen sulphide?

2

2. Action with metals: Some metals such as lead and silver can displace hydrogen from H₂S forming a sulphide coating in the metal.



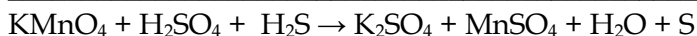
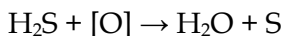
5. Write the action of H₂S gas on a) lead acetate paper b) silver powder
c) acidified potassium dichromate solution

3

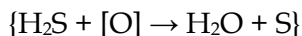
3. H₂S as a reducing agent

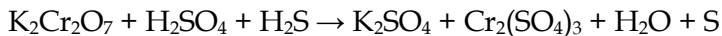
Since H₂S tends to get oxidized in a chemical reaction, it acts as a reducing agent.

- Action with acidified KMnO₄



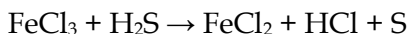
- Action with acidified K₂Cr₂O₇



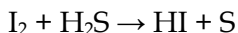
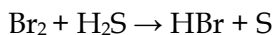
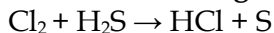


6. Give two reactions to show H_2S act as a reducing agent. 2
7. What happens when H_2S gas is passed through the acidified solution of potassium permanganate solution? 1

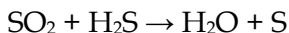
- **Action with ferric chloride:** H_2S reduces ferric chloride to ferrous chloride



- **Action with halogens:** H_2S reduces halogens into halides.

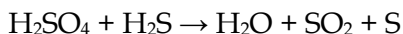


- **Action with SO_2 :** With SO_2 , it gives sulphur.

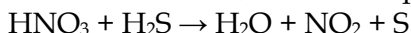


8. Write the action of H_2S on a) acidified $\text{K}_2\text{Cr}_2\text{O}_7$ b) FeCl_3 . 2
9. How does H_2S act upon a) SO_2 b) water 2
10. What happens when H_2S gas is passed through bromine water? 1

- **Action with conc. H_2SO_4 :** With conc. H_2SO_4 , it forms sulphur.



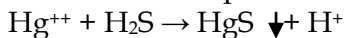
- **With conc. HNO_3 ,** it forms sulphur



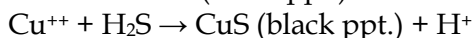
4. H_2S as an analytical reagent

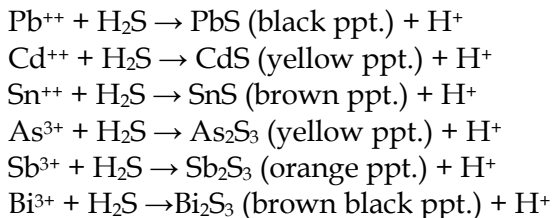
H_2S gas is used as an analytical agent to detect group (II) ions and group (IIIB) ions.

When H_2S gas is passed through the solution of group (II) ions in an acidic medium (presence of dil. HCl), the characteristic-coloured ppt. is formed. This shows the presence of metal ions in the given salt.

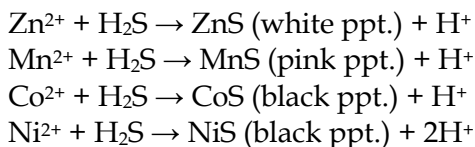


(black ppt.)

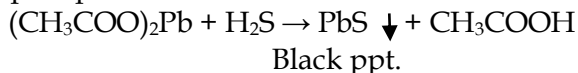




When H_2S is passed through the solution of the group (III B) metal salts in an alkaline medium (NH_4Cl and NH_4OH), then characteristic coloured ppt. is formed. This shows the presence of metal ions in the given salt.



Action with lead acetate: When H_2S gas is passed through lead acetate, a black precipitate is formed.



- | | |
|---|---|
| 11. Why is H_2S gas called an analytical reagent? | 2 |
| 12. Write the application of H_2S in salt analysis. | 4 |

Uses of H_2S

1. as a reducing agent
2. as an analytical reagent in the laboratory
3. To prepare metallic sulphide, which can be used as a pigment.

5. Which of the following chemicals is not used in Kipp's apparatus?

a. FeS	b. FeSO_4	c. dil. H_2SO_4	d. all of the above
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6. Which of the following statements is incorrect?
 - a. H_2S gas is fairly soluble in water.
 - b. H_2S gas is lighter than air.
 - c. Hydrogen sulphide is weakly dibasic.
 - d. Hydrogen sulphide is a reducing agent.
7. H_2S acts as

- a. Oxidising agent b. reducing agent c. both d. none
8. Black ppt of CuS is formed while passing H₂S gas through CuSO₄ in the presence of
 a. HCl b. water c. NH₄Cl/NH₄OH d. all
9. Which of these can change Lead acetate paper into black?
 a. SO₂ b. H₂S c. Cl₂ d. NH₃
10. H₂S gas is an important analytical reagent in qualitative analysis. It precipitates out metal ions as their sulfides, having characteristic colours. Which among the following is an incorrect match?
 a. ZnS – black b. HgS - black
 c. CuS – black d. PbS – black

SULPHUR DIOXIDE (SO₂)

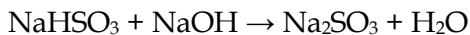
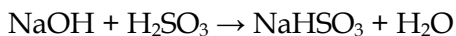
Properties of Sulphur dioxide:

SO₂ is a colourless gas with a choking smell, highly soluble in water.

1. Acidic nature: SO₂ dissolves in water to form a small amount of sulphurous acid.



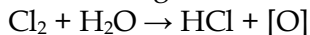
Sulphurous acid is a diprotic acid, therefore, it produces two series of salts if reacted with a base.

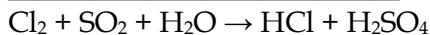


13. How is SO₂ responsible for acid rain? 1
11. SO₂ is an anhydride of
 a. H₂SO₄ b. H₂SO₃ c. H₂SO₅ d. H₂S₂O₈

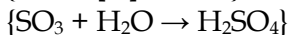
2. SO₂ as a reducing agent:

i. Action with halogens: With halogens, respective halides are formed.

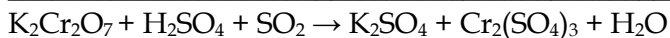
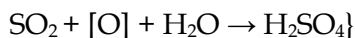
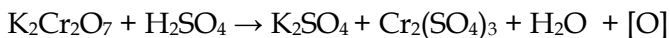




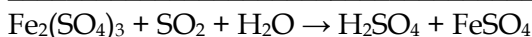
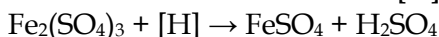
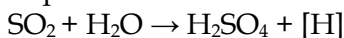
ii. Action with acidified KMnO_4 solution



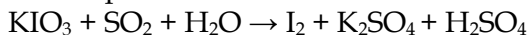
iii. Action with acidified $\text{K}_2\text{Cr}_2\text{O}_7$:



iv. With ferric sulphate



v. Action with potassium iodate:



14. What happens when SO_2 is passed through a potassium iodate solution?

15. What happens when SO_2 gas is passed through acidified KMnO_4 ? 1

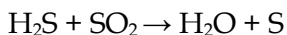
16. What happens when SO_2 is passed through the solution of acidified

$\text{K}_2\text{Cr}_2\text{O}_7$? 1

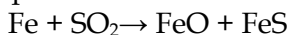
17. Give the action of SO_2 on chlorine water and acidified $\text{K}_2\text{Cr}_2\text{O}_7$. 2

3. SO_2 as an oxidizing agent: Sulphur dioxide acts both as oxidizing as well as reducing agent.

a) Action with H_2S : SO_2 oxidizes H_2S to Sulphur



b) Action with iron: Sulphur dioxide oxidizes the iron to ironoxide and iron sulphide.



18. Write the reactions to show that SO_2 acts both as an oxidising and reducing agent. 2
19. Explain why H_2S can only behave as a reducing agent, whereas SO_2 can act as both an oxidising and reducing agent. 2

4. SO_2 as a bleaching agent: The formation of a colourless product from a coloured reactant is called bleaching.

a) Bleaching action of SO_2 is due to:

- **Bleaching by Reduction:** In the presence of moisture, SO_2 produces nascent hydrogen, which bleaches the colouring matter.
$$\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 + [\text{H}]$$

Vegetable colouring matter + $[\text{H}] \rightarrow$ Colourless product.
- **Bleaching by addition reaction:** In some cases, the bleaching action of SO_2 is due to the formation of the addition product.

20. Write the bleaching action of SO_2 . 1
21. SO_2 acts as a bleaching agent. Explain. 1

Comparison of the bleaching action of SO_2 and Cl_2

Bleaching action of SO_2	Bleaching action of Cl_2
1. The bleaching action of SO_2 is due to the reduction or addition of product formation.	1. The bleaching action of Cl_2 is due to an oxidation reaction.
2. Action with moisture takes place as follows: $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 + [\text{H}]$ This nascent hydrogen reduces the colouring matter to colourless matter.	3. Action with moisture takes place as follows: $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{HCl} + [\text{O}]$ This nascent oxygen oxidises colouring matter to colourless matter.

4. The bleaching action of SO_2 is temporary.	5. The bleaching action of Cl_2 is permanent.
2. The original colour can be regained by adding dil. H_2SO_4 , if the colour change is due to the addition product.	3. The original colour cannot be regained by adding dil. H_2SO_4 .

22. Write any two differences between the bleaching action of SO_2 and Cl_2 .

23. Acidified KMnO_4 is a widely used oxidising agent in laboratories and many industries. Write its reaction with

- Nascent hydrogen
- Hydrogen sulphide
- Sulphur dioxide
- Hydrochloric acid

Balance the reaction in numbers (a) by hit and trial method; (b and (c) with the partial equation method and (d) with the oxidation number method. $1+1.5+1.5+2$

Uses

- In the manufacture of sulphuric and sulphurous acid
- Bleaching agent for delicate articles like wool, silk, straw, hair, etc
- As disinfectant for killing germs, fungi, moulds, etc.

12. The bleaching action of SO_2 is due to

- Oxidation
- Reduction
- Dehydration
- Polymerization

13. Which of the following bleaches by reduction?

- Cl_2
- SO_2
- CaOCl_2
- H_2O_2

14. $\text{SO}_2 + \text{H}_2\text{S} \rightarrow \text{S} + \text{H}_2\text{O}$; in this reaction ' SO_2 ' acts as

- Oxidizing agent
- Reducing agent
- Both
- None

15. Which of these can act as both oxidising agent as well as reducing agent?

- SO_2
- H_2S
- both
- none

16. SO_2 acts as

- Bleachant
- Reducing agent
- germicide
- all

17. SO_2 can reduce

- Acidified KMnO_4
- Alkaline KMnO_4
- alkaline KMnO_4
- all of them

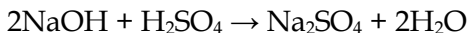
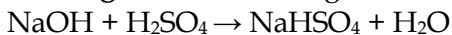
SULPHURIC ACID (H₂SO₄)

18. Which of the following is called *oil of vitriol*?
a. HCl b. HNO₃ c. CuSO₄ solution d. H₂SO₄
19. Which of the following chemicals is known as the *king of chemicals*?
a. HCl b. NaOH c. CaCO₃ d. H₂SO₄

Write the Lewis structure of sulphuric acid.

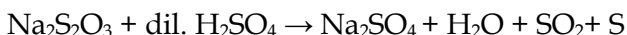
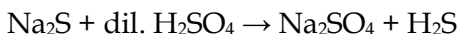
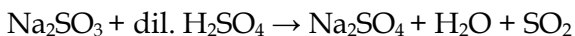
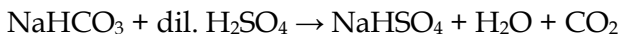
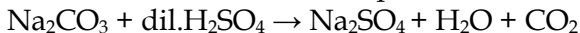
Chemical properties

1. **As a strong dibasic acid,** It gives a series of two salts

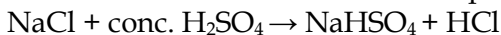


2. Action with salt:

- a) Action of salt with dilute sulphuric acid

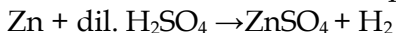


- b) Action of salt with concentrated sulphuric acid:

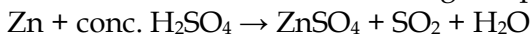


3. As an oxidising agent:

- i. Action with metals: Metals lying above hydrogen in electrochemical series can displace hydrogen from dilute acids

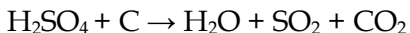
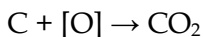


With conc. H₂SO₄, however, SO₂ gas is produced.

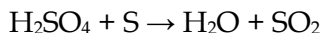
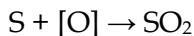


- ii. Action with non-metals:

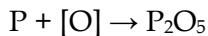
- a) Action with C: Sulphuric acid oxidises carbon to carbon dioxide and itself is reduced to sulphur dioxide.



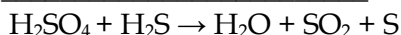
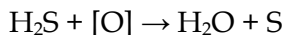
- b) Action with S



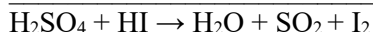
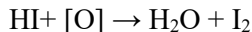
c) Action with P:



iii. Action with H_2S :



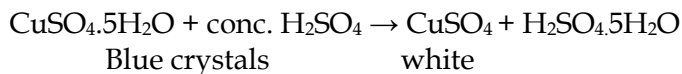
iv. Action with HI:



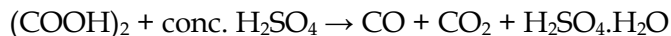
24. Write the reaction of conc. H_2SO_4 by i) Phosphorus and ii) oxalic acid iii) BaCl_2 solution. 3

4. Sulphuric acid as a dehydrating agent:

- a. Due to the high affinity of sulphuric acid towards water molecules, it absorbs water of crystallization from hydrated salts.



- b. Conc. H_2SO_4 dehydrates compounds such as formic acid and oxalic acid



- c. Concentrated sulphuric acid dehydrates glucose, sucrose, etc., strongly leaving behind only carbon

$$\text{C}_6\text{H}_{12}\text{O}_6 + \text{H}_2\text{SO}_4 \rightarrow \text{C} + \text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$$

$$\text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{H}_2\text{SO}_4 \rightarrow \text{C} + \text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$$
- d. Conc. H_2SO_4 dehydrates ethyl alcohol, whereby Ethene or ether is formed depending upon the applied temperature.

$$\text{C}_2\text{H}_5\text{OH} + \text{H}_2\text{SO}_4 \rightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$$

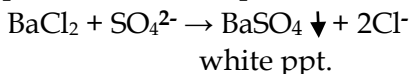
$$\text{C}_2\text{H}_5\text{OH} + \text{H}_2\text{SO}_4 \rightarrow \text{C}_2\text{H}_5\text{OC}_2\text{H}_5 + \text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$$
- e. Conc. H_2SO_4 dehydrates HNO_3 giving nitronium ion.

$$\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{NO}_2^+ + \text{H}_2\text{O} + \text{HSO}_4^-$$

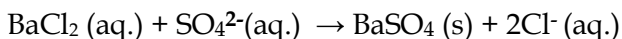
The nitronium ion is used to nitrate benzene into nitrobenzene. The nitronium ion is an electrophile.

25. Write the structures (condensed formula) and IUPAC names of formic acid, oxalic acid, ethyl alcohol, diethyl ether, and ethylene. 2
26. Identify a viscous liquid that converts sugar into a charred mass. Write the reaction involved.
27. How would you show that the H_2SO_4 acts as: a) an acid b) a dehydrating agent? 2
28. How does conc. H_2SO_4 reacts with i) sugar and ii) copper 2
29. Give the action of conc. H_2SO_4 on a) sucrose b) HI 2
30. Write two reactions each to show the dehydrating and oxidizing agent of conc. H_2SO_4 . 4
31. Identify a liquid that reacts with common table sugar ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$), giving a charred (black) mass. Provide the reaction involved. 2

5. Test of sulphuric acid: With barium chloride, it gives a white precipitate of barium sulphate, which is insoluble in dilute HCl.



or



This reaction is also used for the confirmatory test of sulphate ions (as acid radical) in salt solutions.

32. Write the test for the sulphate ion in its aqueous solution.

2

20. Which of the following reagents is used to precipitate out SO_4^{2-} ions

- a. CaCl_2 b. AgCl c. BaCl_2 d. AgNO_3

Uses of sulphuric acid:

1. In the manufacture of fertilizers
2. In petroleum refining
3. In the manufacture of lead-acid batteries
4. In chemical laboratories
 - as dehydrating agent
 - as an oxidising agent
 - as precipitant

21. Sulphuric acid is

- a. Monobasic acid d. Dibasic acid
b. Tribasic acid e. Organic acid
c. Weak acid

22. Dehydration of formic acid with conc. H_2SO_4 gives

- a. CO_2 b. SO_2 c. CO d. H_2O

23. Dehydration of oxalic acid with conc. H_2SO_4 gives

- a. CO b. CO_2 c. both d. none

24. Which of the following is incorrect about sulphuric acid?

- a. Reducing agent c. dehydrating agent
b. Sulphonating agent d. oxidising agent

33. Mention two important uses of sulphuric acid and hydrobromic acid each.

2

SODIUM THIOSULPHATE (hypo) ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$)

Uses of sodium thiosulfate

1. In medicine, as an antidote for cyanide poisoning
2. In the estimation of iodine.
3. In photography.

4. To remove excess chlorine in the bleaching industry (an antichlor).

34. Write the molecular formula of hypo.

0.5

25. $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ is commonly known as

- a. Hypo b. Sodalime c. Soda d. Fool's gold

26. Which of the following is used as an antichlor to remove residual Cl_2 ?

- a. Na_2SO_4 b. H_2SO_4 c. H_2S d. $\text{Na}_2\text{S}_2\text{O}_3$

*****This is not a complete note. It is just to guide you. It is recommended to study the prescribed textbooks along with this material. *****