

SULFUR

17.1. Choose the correct statements:

- A. Sulfur is placed in the third period and in the sixth A group.
- B. Sulfur atom contains 32 electrons.
- C. The valence shell of a sulfur atom contains 6 electrons.
- D. There are two energy levels in the sulfur atoms.
- E. Sulfur is an oxidizing agent, and accepting two electrons.
- F. Superior oxidation state of sulfur is +4.
- G. The superior oxide of sulfur is SO_3 .
- H. Sulfur forms acid oxides and acids.
- I. The oxidation states of sulfur are -2, -4, and -6.

17.2. Choose the correct statements:

- A. Sulfur is a solid substance with a yellowish color.
- B. Sulfur possesses a high electrical conductivity.
- C. It melts easily.
- D. It forms S_8 molecule in free state.
- E. Plastic sulfur is formed by freezing of molten sulfur.
- F. It is found in nature only in pure state.
- G. The most abundant the natural sulfur ions are sulfate and sulfides.
- H. It can be dissolved in water.

17.3. Write down the formulas of the most well-known sulfur compounds and name them.

17.4. 112.8°C is the melting point of sulfur. Propose a method by which it could be separated from sand mixture.

17.5. Name the allotropic forms of oxygen, and write down their formulas. Explain the importance of these substances in nature.

17.6. Determine the oxidation states of sulfur in the following compounds:

- A. Al_2S_3
- B. Li_2S
- C. H_2S
- D. H_2SO_3
- E. SO_2
- F. Na_2SO_3
- G. SO_3
- H. K_2SO_4

In which oxidation states of sulfur is an oxidant, in which it is reductant, and in which both of them?

17.7. Determine the types of chemical bonds in the following compounds of sulfur:

- A. Hydrogen sulfide
- B. Sulfur dioxide
- C. Potassium sulfide

Draw the structures of molecules.

17.8. Compare the following elements in terms of periodic properties:

- A. Sulfur and oxygen
- B. Sulfur and chlorine

17.9. Write down the equations of sulfur reacting with the following substances:

- A. Zinc
- B. Aluminum
- C. Sodium
- D. Hydrogen
- E. Iron
- F. Oxygen

17.10. Write down the equations of the formation of following substances:

- A. Hydrogen sulfide
- B. Potassium sulfide
- C. Mercury (II) sulfide
- D. Copper (II) sulfide
- E. Silver sulfide
- F. Sulfur dioxide
- G. Sulfur tetrafluoride
- H) Aluminum sulfide

Explain the role of sulfur; oxidant or reductant, in the reactions.

17.11. Calculate the volume of sulfur dioxide that can be obtained by burning of 320 kg of 4% impure sulfur.

17.12. Calculate the mass of products obtained by heating in the following reactions:

- A. 2.5 mol zinc and 3 mol sulfur.
- B. 10 g zinc and 10 g sulfur.
- C. 10.26 g of 5 % impure technical zinc by mass and 10 g of 4 % impure sulfur.

17.13. Sulfur is considered as a component of an amino acid in the human organism - an active biological substance (0.15% of human's body). Calculate the mass of sulfur in human with a mass of 70 kg.

17.14. Sulfur is obtained in big quantities from hydrogen sulfide, which is found as an impurity in natural gases, oil and etc. What volume of hydrogen sulfide is necessary to obtain 1 ton of sulfur, which contains 1% impurity?

HYDROGEN SULFIDE and SULFIDES

18.1. Write down the equations of reactions by which hydrogen sulfide is obtained by using:

- A. combination reaction
- B. displacement reaction

How can hydrogen sulfide be collected: by using the water displacement or air substitution?

18.2. Explain by which processes hydrogen sulfide can be obtained in nature.

18.3. Choose the statements that characterize the hydrogen sulfide (A) and the hydrogen chloride (B):

- 1. is a volatile hydrogenated compound of a non-metal.
- 2. can be obtained by reaction of simple substances.
- 3. can be formed by decay of protein.
- 4. is contained in the gastric juice as a solution
- 5. has a sharp odor.
- 6. its relative density is 17 relatively to hydrogen.
- 7. is readily soluble in water.
- 8. is toxic and smells like rotten eggs.
- 9. forms a weak acid when dissolved in water.
- 10. forms a white precipitate when reacted with silver nitrate.
- 11. forms a strong acid when dissolved in water.
- 12. forms a black precipitate when reacted with lead (II)

nitrate.

18.4. Hydrogen sulfide burns in excess oxygen, so that sulfur dioxide and water are formed, whereas an insufficient of oxygen yields only sulfur and water.

A. Write down the reactions and balance them.

B. Calculate the volume of sulfur dioxide that can be obtained by complete burning of 1 m^3 of hydrogen sulfide having 20% impure by volume.

18.5. A paper soaked with lead nitrate or with lead (II) acetate becomes black. The presence of which gas in the laboratory cause this reaction happens? Explain why it is dangerous. Write down the equations by which sulfide is identified.

18.6. A 2.3 L of hydrogen sulfide is dissolved in 1 L of water. Calculate the mass of hydro sulfuric acid in the obtained solution.

18.7. Sulfuric acid is a strong acid, even though it shows the properties of both weak and strong acids. Write down the equations of reactions in both molecular and ionic form that characterize the properties of sulfuric acid.

18.8. Choose the substances that react with hydro sulfuric acid:

Mg, KOH, Cu, CO_2 , CuSO_4 , Na_2SO_4 , $\text{Pb}(\text{NO}_3)_2$, H_2SiO_3 , Na_2SO_4

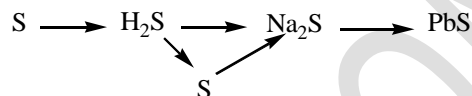
Write down the equations in both molecular and ionic form.

18.9. Write down the reactions for the following transformations:

A. $\text{FeS} \rightarrow \text{H}_2\text{S} \rightarrow \text{K}_2\text{S} \rightarrow \text{PbS}$

B. $\text{S} \rightarrow \text{FeS} \rightarrow \text{H}_2\text{S} \rightarrow \text{SO}_2$

C.



18.10. Calculate the volume of the hydrogen sulfide that can absorb:

A. 0.2 mol of lead (II) nitrate.

B. 3.3 g of lead (II).

C. 331 g of 5 % lead (II) nitrate by mass.

18.11. Calculate the volume of hydrogen sulfide that can be obtained from the reaction of:

A. hydrochloric acid with 8.8 g iron (II) sulfide.

B. hydrochloric acid with 20 g technical iron (II) sulfide having 3% impurities by mass.

C. 20 g of 10% hydrochloric acid solution with 2 g of 97 % iron (II) oxide sulfide by mass.

OXIDES OF SULFUR, SULFURIC ACID and THEIR SALTS

19.1. Write down the equations of reactions by which sulfur dioxide is obtained:

A. burning of sulfur or of hydrogen sulfide, H_2S .

B. burning of Zinc sulfide ZnS .

C. displacement reaction of sodium sulfite, Na_2SO_3 .

19.2. Explain the practical applications of sulfur dioxide.

19.3. Calculate the volume of 8 g of sulfur dioxide at STP.

19.4. Choose the statements that match with the following substances:

A. sulfur dioxide

B. sulfur trioxide

C. sulfuric acid

1. colorless viscous liquid.

2. acid oxide.

3. possesses bleaching and disinfecting properties.

4. cannot be directly obtained from sulfur.

5. heat is produced by mixing water with this substance.

6. unstable acid obtained when dissolved in water.

7. is formed through catalytic oxidations of sulfur trioxide.

8. dissolves in and react with water.

9. is used to dry the gases.

10. is transformed into a powerful acid when dissolved in water.

11. is obtained by burning of sulfur.

12. Diprotic strong acid.

19.5. Write down the reactions that characterize the chemical properties of following substances:

A. sulfur dioxide

B. sulfur trioxide

C. hydro sulfuric acid

D. sulfuric acid

19.6. Choose from the following: Zn, Ag, CO_2 , Li_2O , KOH, H_2O , Na_2S , K_2SO_3 , $\text{Ba}(\text{OH})_2$, $\text{Ba}(\text{NO}_3)_2$, Na_2CO_3 , O_2 substances that react with following substances:

A. SO_2

B. H_2SO_3

C. SO_3

D. H_2SO_4 (dil.)

Write them all in both molecular, and if possible, in ionic form.

19.7. Write down the equations in the molecular form, and if possible, in ionic form.

I
A. $\text{H}_2\text{SO}_4 + \text{Al} \rightarrow$

B. $\text{SO}_2 + \text{NaOH} \rightarrow$

C. $\text{SO}_3 + \text{CaCl}_2 \rightarrow$

D. $\text{H}_2\text{S} + \text{Cu} \rightarrow$

E. $\text{H}_2\text{SO}_3 + \text{Ca}(\text{OH})_2 \rightarrow$

F. $\text{Na}_2\text{SO}_4 + \text{Ba}(\text{NO}_3)_2 \rightarrow$

G. $\text{CaSO}_4 + \text{NaOH} \rightarrow$

H. $\text{SO}_3 + \text{H}_2\text{O} \rightarrow$

II

A. $\text{Na}_2\text{SO}_4 + \text{KNO}_3 \rightarrow$

B. $\text{CuSO}_4 + \text{BaCl}_2 \rightarrow$

C. $\text{Na}_2\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow$

D. $\text{KCl} + \text{H}_2\text{S} \rightarrow$

- E. $\text{Na}_2\text{CO}_3 + \text{H}_2\text{S} \rightarrow$
 F. $\text{Cu}(\text{OH})_2 + \text{H}_2\text{SO}_4 \rightarrow$
 G. $\text{Cu} + \text{H}_2\text{SO}_4(\text{dil.}) \rightarrow$
 H. $\text{SO}_3 + \text{BaO} \rightarrow$

III

- A. $\text{SO}_3 + \text{KOH} \rightarrow$
 B. $\text{SO}_2 + \text{SiO}_2 \rightarrow$
 C. $\text{H}_2\text{S} + \text{Cu}(\text{NO}_3)_2 \rightarrow$
 D. $\text{Na}_2\text{SO}_4 + \text{Al}(\text{OH})_3 \rightarrow$
 E. $\text{BaSO}_3 + \text{HCl} \rightarrow$
 F. $\text{SO}_3 + \text{O}_2 \rightarrow$
 G. $\text{H}_2\text{SO}_4 + \text{Fe}_2\text{O}_3 \rightarrow$
 H. $\text{H}_2\text{S} + \text{NaOH} \rightarrow$

19.8. Make a scheme of acid rain formation reactions and comment it.

19.9. Write down the equations of reactions by using zinc, copper, and barium sulfate with following substances as an initial substance (if possible):

- A. a metal
 B. a metallic oxide
 C. a metallic hydroxide
 D. a salt
 E. two salts

19.10. Write down equations of reaction for following transformations:



- A. $\text{S} \rightarrow \text{SO}_2 \rightarrow \text{Na}_2\text{SO}_3 \rightarrow \text{BaSO}_3 \rightarrow$
 B. $\text{S} \rightarrow \text{H}_2\text{S} \rightarrow \text{SO}_2 \rightarrow \text{CaSO}_3 \rightarrow \text{SO}_2$
 C. $\text{H}_2\text{S} \rightarrow \text{S} \rightarrow \text{SO}_2 \rightarrow \text{K}_2\text{SO}_3 \rightarrow \text{K}_2\text{SO}_4$
 D. $\text{ZnS} \rightarrow \text{SO}_2 \rightarrow \text{SO}_3 \rightarrow \text{H}_2\text{SO}_3 \rightarrow \text{BaSO}_4$
 E. $\text{FeS} \rightarrow \text{H}_2\text{S} \rightarrow \text{S} \rightarrow \text{SO}_2 \rightarrow \text{SO}_3 \rightarrow \text{Na}_2\text{SO}_4 \rightarrow \text{BaSO}_4$

19.11. Write down the equations of reactions in both molecular and ionic form for the following transformations:

- A. $\text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 \rightarrow \text{NaCl}$
 B. $\text{Zn} \rightarrow \text{ZnSO}_4 \rightarrow \text{ZnCl}_2$
 C. $\text{H}_2\text{SO}_4 \rightarrow \text{Al}_2(\text{SO}_4)_3 \rightarrow \text{Al}(\text{OH})_3$
 D. $\text{CuO} \rightarrow \text{CuSO}_4 \rightarrow \text{FeSO}_4$

19.12. Purpose a method by which each of three solutions can be identified:

- A. $\text{BaCl}_2, \text{H}_2\text{SO}_4, \text{H}_2\text{S}$
 B. $\text{Na}_2\text{SO}_4, \text{Na}_2\text{S}, \text{NaCl}$
 C. $\text{HCl}, \text{H}_2\text{SO}_4, \text{H}_2\text{S}$
 D. $\text{BaCl}_2, \text{Ba}(\text{SO}_4)_2, \text{Ba}(\text{NO}_3)_2$

Write down the method and related reactions.

19.13. A 53.2 g of sulfur trioxide was obtained from oxidation of 15.68 L of sulfur dioxide at STP. Calculate the mass of the product in the reaction.

19.14. Sulfur dioxide, which is obtained by burning of sulfur, is used in order to disinfect mushrooms, mold and etc. What is the mass of sulfur with 5% impurity necessary to disinfect a room with a volume of 75 m^3 , if the standard usage of sulfur dioxide is 1.6 g per cubic meter volume?

19.15. A neutral salt Na_2SO_4 or an acidic salt NaHSO_3 can be formed by reaction of sulfur dioxide with a base. Calculate the volume of sulfur oxide necessary to react with a 20 g of 10% sodium hydroxide solution, by mass, in order to obtain:

- A. a neutral salt
 B. an acidic salt

19.16. Calculate the mass of sulfur to be burned so that the reaction of sulfur dioxide obtained reacts with 2.8 g potassium hydroxide to obtain:

- A. potassium sulfite
 B. potassium hydrosulfite

19.17. Mass of 96% concentrated sulfuric acid, in an open jar, has increased in 24 hours by 180 g. Calculate the mass of sulfuric acid in the obtained solution, if the initial mass of the solution is 920 g.

19.18. Calculate the mass of precipitate formed as a result of the reaction:

- A. A 0.5 mol of barium nitrate solution with a 0.25 mol of sodium sulfate solution.
 B. A 20.8 g of barium chloride solution with a 14.7 g of sulfuric acid solution.
 C. A 85.5 g of 2% barium hydroxide solution with a 98 g of 5% sulfuric acid solution.

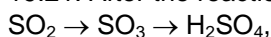
19.19. Calculate the mass of salt formed as a result of reaction of 10 g of 20 % impure copper (II) oxide with sulfuric acid solution which has:

- A. 0.15 mol sulfuric acid.
 B. 7.35 g of sulfuric acid.
 C. 20 g of 4.9% H_2SO_4 , by mass.

19.20. Calculate the mass of 10% sulfuric acid solution, by mass, necessary to:

- A. react completely with a 0.75 mol of zinc oxide.
 B. react completely with a 12 g of iron (III) oxide.
 C. obtain 8.96 L of hydrogen gas at STP, when reacted with zinc metal.
 D. react completely with a 160 g of 10% sodium hydroxide solution by mass.

19.21. After the reaction scheme known:



calculate the volume of sulfur dioxide necessary to obtain sulfuric acid with:

- A. 5 mol.
 B. 980 g.
 C. 980 g mass, if the yield of the reactions totally is 96 %.

19.22. At thermoelectric power plants one of the proposed

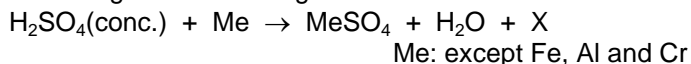
methods to eliminate sulfur (IV) oxide from natural gas is the reaction of sulfur dioxide with hydrogen sulfide. A residue of the reaction is elementarily sulfur.

A. Write down the equation of the reaction, and balance it. Indicate the oxidant and the reductant substances.

B. Calculate the volume of the hydrogen sulfide necessary to eliminate sulfur dioxide which is burned with 1- t coal, which contains 3.5% sulfur. What is the mass of sulfur contained? The efficiency is 100%.

19.23. 405 t of anhydrous sulfuric acid is obtained from 320 t of pyrite, FeS_2 , which contains 45% sulfur. Calculate the mass of sulfuric acid yield.

19.24. Concentrated sulfuric acid reacts with metals according to the following reaction:



where X: SO_2 , S or H_2S , with respect to Me activity and the concentration of the acid. Write down the oxidation-reduction reactions with:

- A. Cu, if X: SO_2
- B. Zn, if X: SO_2
- C. Zn, if X: S
- D. Zn, if X: H_2S

Balance the reactions; indicate the reductant and the oxidant.

19.25. Complete the reactions, and balance them.

- A. $\text{H}_2\text{SO}_4(\text{conc.}) + \text{Mg} \rightarrow ? + ? + \text{SO}_3\uparrow$
- B. $\text{H}_2\text{SO}_4(\text{conc.}) + \text{Mg} \rightarrow ? + ? + \text{S}\downarrow$
- C. $\text{H}_2\text{SO}_4(\text{conc.}) + \text{Mg} \rightarrow ? + ? + \text{H}_2\text{S}\uparrow$
- D. $\text{H}_2\text{SO}_4(\text{conc.}) + \text{Cu} \rightarrow ? + ? + \text{SO}_2\uparrow$

19.26. Write down the equations of reaction for the following transformations:

- A. $\text{H}_2\text{SO}_4(\text{conc.}) \rightarrow \text{S}$
- B. $\text{H}_2\text{SO}_4(\text{conc.}) \rightarrow \text{H}_2\text{S}\uparrow$
- C. $\text{H}_2\text{SO}_4(\text{conc.}) \rightarrow \text{SO}_2\uparrow$
- D. $\text{H}_2\text{SO}_4(\text{dil.}) \rightarrow \text{H}_2\uparrow$

Balance the reactions.