



## **Topic 4.6. Phosphorus and its compounds.**

Name of  
instructor:M.Azhgaliev



# Outline

- ◆ **Introduction**
- ◆ **Main part**
  - ◆ 1. Phosphorus
  - ◆ 2. Phosphorus (V) oxide. Phosphine
  - ◆ 3. Phosphoric acid and its salts
- ◆ **Conclusion**
- ◆ **Literature**



Группа ↓ Период	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
Лантаноиды			57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
Актиноиды			89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	



# 1. Phosphorus

## Chemical element

**Phosphorus** is a chemical element number 15. It is located in the VA group of the Periodic Table.

**$P_{15} + 15) 2e) 8e) 5e$**

The outer layer of the phosphorus atom contains five valence electrons, three electrons are missing before it is completed. Therefore, in compounds with metals and hydrogen, phosphorus exhibits an oxidation state of **-3**, and when interacting with more electronegative elements: oxygen, fluorine and others, it exhibits a positive oxidation state of **+3** or **+5**.



# 1. Phosphorus

## Chemical element

The phosphorus atom has more electronic layers than the nitrogen atom, therefore its electronegativity, oxidizing and non-metallic properties are less pronounced.

In the earth's crust, phosphorus is in the form of phosphates. Calcium phosphate  $\text{Ca}_3(\text{PO}_4)_2$  is more common.

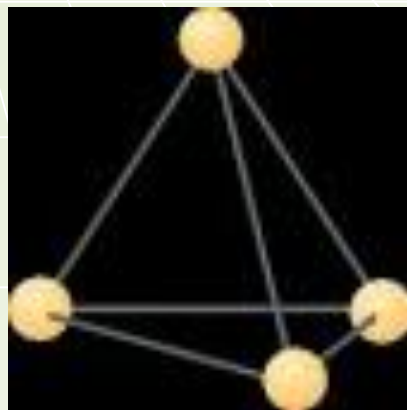
Phosphorus is a vital element. It is a part of **nucleic acids** and **ATP**, which are necessary for every cell of any living organism. Calcium phosphate is found in **bone** and gives it hardness.



## 1. Phosphorus

### Simple substances

The chemical element phosphorus is characterized by allotropy. It forms several simple substances that differ in structure. **White phosphorus** is composed of tetraatomic  $P_4$  molecules.



# 1. Phosphorus

## Simple substances

It is a white (with a yellow tinge), wax-like substance that glows in the dark due to oxidation by atmospheric oxygen.



Like all molecular compounds, white phosphorus is volatile. It has a garlic smell. Not soluble in water, but soluble in carbon disulfide. White phosphorus is highly toxic. In powder form, it can self-ignite. Store it under water.



# 1. Phosphorus

## Simple substances

Red phosphorus has an atomic crystal lattice



Red phosphorus is a powder and differs sharply from white in its properties. It is odorless, insoluble in water and carbon disulfide. Non-poisonous. The activity of red phosphorus is lower than that of white phosphorus.

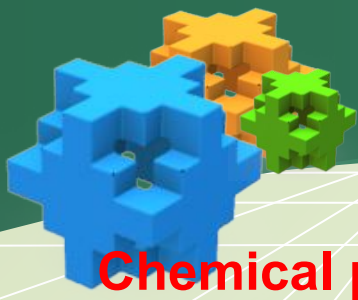




# 1. Phosphorus

## Simple substances

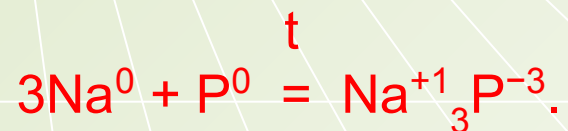
Allotropic modifications of phosphorus are **interconvertible**. White phosphorus turns to red in the light or upon prolonged heating without air access. Red phosphorus turns into white when the vapor is strongly heated and cooled.



## Chemical properties

The chemical properties of different allotropic phosphorus modifications are similar. White phosphorus is **more active** and reacts more easily.

Phosphorus exhibits **oxidizing properties** in reactions with **active metals**:



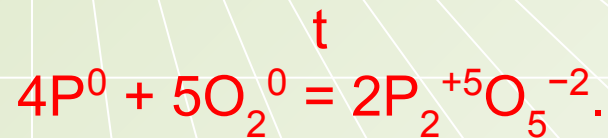
The resulting compounds are called **phosphides** (**Na<sub>3</sub>P** - sodium phosphide).

Unlike nitrogen, phosphorus does **not combine** with hydrogen.



## Chemical properties

Phosphorus exhibits **reducing properties** in reaction with oxygen. White phosphorus ignites spontaneously in air, and red lights up when heated. This produces a thick white smoke of **phosphorus (V) oxide** :

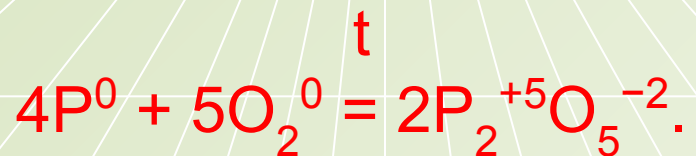


Red phosphorus is used in the manufacture of **matches**.



## Phosphorus (V) oxide

Phosphorus (V) oxide  $P_2O_5$  is formed during the combustion of phosphorus:



$P_2O_5$  is a white crystalline substance with a **molecular** structure.





## Phosphorus (V) oxide

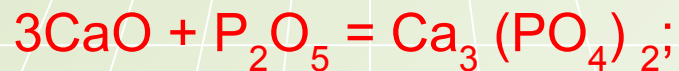
Phosphorus (V) oxide is **very hygroscopic**. It actively joins water, therefore it is used for **drying gases**. It is a typical acidic oxide.

Phosphorus (V) oxide reacts:

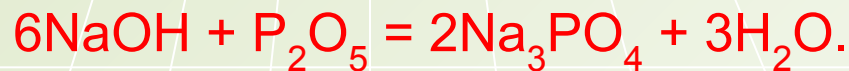
with water:



with basic oxides to form a phosphoric acid salt:



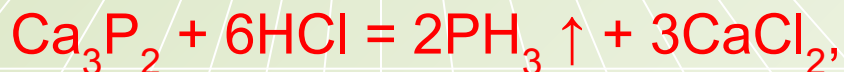
with alkalis to form salt and water:





## Phosphine

The hydrogen phosphorus compound **phosphine**  $\text{PH}_3$  can be obtained from phosphides:



Phosphine is a **poisonous gas** with an **unpleasant odor** that **ignites spontaneously** in air. It is released during the decomposition of organic matter. The formation and oxidation of phosphine is associated with such a natural phenomenon as wandering bog fires.



## Phosphoric acid

Phosphoric (orthophosphoric) acid  $\text{H}_3\text{PO}_4$  is a solid transparent crystalline substance.



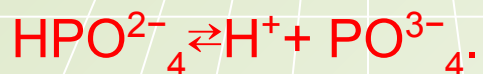
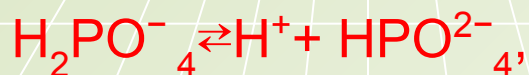
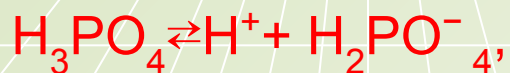
*Solid phosphoric acid*

It is very soluble in water (miscible in any ratio) and is usually used in the form of solutions.



## Phosphoric acid

In aqueous solutions, phosphoric acid dissociates in steps:



Dissociation at each next stage is weaker than at the previous one. Phosphoric acid does not completely decompose into ions and belongs to acids of medium strength. It is less active in chemical reactions compared to sulfuric, nitric, hydrochloric acids.





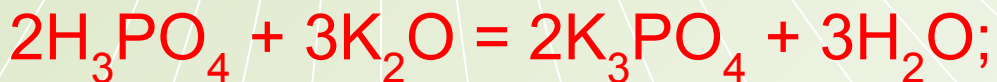
## Phosphoric acid

Phosphoric acid reacts:

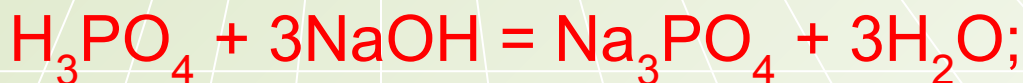
with metals located in the line of activity before hydrogen:



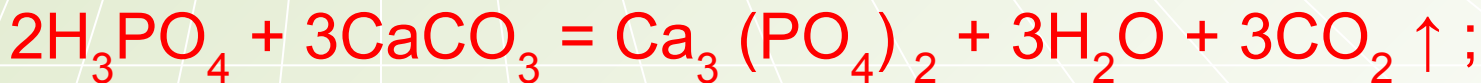
with basic oxides:



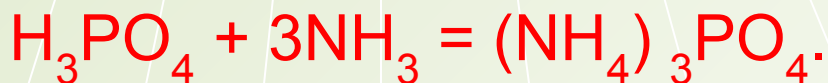
with bases:



with salts, if gas or sediment is released:



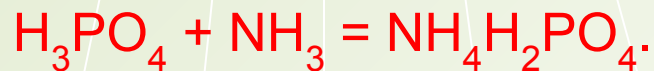
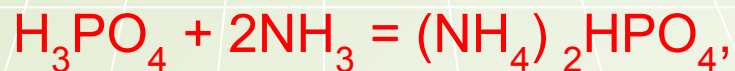
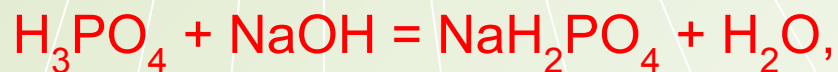
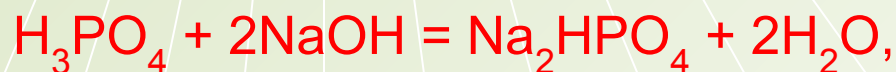
with ammonia:





## Phosphoric acid

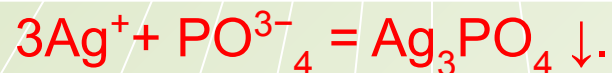
The reactions can form not only normal **phosphate** salts with an acidic residue  $\text{PO}_4^{3-}$ , but also acidic ones: **hydrophosphates** ( $\text{HPO}_4^{2-}$ ) and **dihydrogen phosphates** ( $\text{H}_2\text{PO}_4^-$ ). In the names of acidic salts, the prefix hydro- denotes a hydrogen atom, and dihydro- - two hydrogen atoms. The composition of the salt depends on the molar ratios of the acid and the substance that reacts with it:





## Phosphoric acid salts

Medium salts of phosphoric acid phosphates (eg  $\text{Ca}_3(\text{PO}_4)_2$ ) are insoluble in water, except for alkali metal phosphates. Silver phosphate has a characteristic yellow color. This property is used for the qualitative determination of soluble phosphates. When a silver nitrate solution is added to them, a yellow precipitate, soluble in nitric acid, forms:



Most dihydrogen phosphates ( $\text{CaH}_2\text{PO}_4$ , etc.) dissolve well in water. Hydrophosphates ( $\text{Ca}(\text{HPO}_4)_2$ , etc.) dissolve better than phosphates, but worse than dihydrogen phosphates.



## Application

Phosphoric acid is used:

- for the production of mineral fertilizers,
- as a food additive in beverages,
- in the production of synthetic detergents,
- in the production of feed additives for animals.
- Phosphoric acid salts are used as mineral fertilizers.



## Question for selfcontrol:

### 1. Select the characteristic of red phosphorus:

- A) a molecule consists of four atoms
- B) occurs naturally in free form
- C) reacts with oxygen only when ignited

### 2. Choose the property of phosphoric acid:

- A) strong oxidizing agent due to acid residue
- C) forms three rows of salts
- B) on decomposition forms a solid oxide and water
- A) is a solution of gas in water

### 3. Choose hydrogen phosphate formula:

- A)  $\text{KH}_2\text{PO}_4$
- B)  $\text{Ag}_3\text{PO}_4$
- C)  $(\text{NH}_4)_2\text{HPO}_4$



**4. A compound of the composition  $\text{Ba}(\text{H}_2\text{PO}_4)_2$  is called:**

- A) barium phosphate
- B) barium phosphide
- C) barium hydrogen phosphate
- D) barium dihydrogen phosphate

**5. White and red phosphorus differ in the type of crystal lattice.**

- A) True
- D) False

**6. White and red phosphorus are similar in color.**

- A) True
- D) False

**7. Phosphorus (V) oxide reacts with substances:**

- A)  $\text{BaSO}_4$
- B)  $\text{Na}_2\text{O}$
- C)  $\text{NaOH}$
- D)  $\text{CO}_2$



**8. Phosphoric acid reacts with substances:**

- A) KOH
- B)  $\text{Na}_2\text{O}$
- C)  $\text{H}_2\text{SO}_3$
- D) NaCl

**9. Phosphoric acid does not react with the substance:**

- A)  $\text{CO}_2$
- B) ZnO
- C)  $\text{AgNO}_3$
- D)  $\text{Mg}(\text{OH})_2$



## 10. Establish an accordance between a substance and its characteristics.

1 - white phosphorus; 2 - red phosphorus; 3 - phosphoric acid;  
4 - phosphorus (V) oxide; 5 - phosphine.

- a - used for the production of mineral fertilizers;
- b - forms acid when interacting with water;
- c - consists of tetraatomic molecules;
- d - can turn into white phosphorus;
- e - formed by the action of water on phosphides.





## Literature

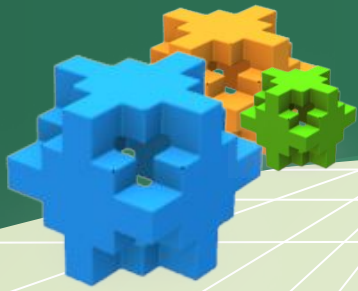
### 1. Basic literature :

1. Jenkins, Chemistry, ISBN 978-0-17-628930-0
2. Alberta Learning, Chemistry data booklet 2010, product №755115, ISBN 10645246
3. М.К.Оспанова, К.С.Аухадиева, Т.Г. Белоусова Химия: Учебник 1,2 часть для 10 класса естественно-математического направления общеобразовательных школ Алматы: Мектеп, 2019г.
4. М.К.Оспанова, К.С.Аухадиева, Т.Г. Белоусова Химия: Учебник 1,2 часть для 11 класса естественно-математического направления общеобразовательных школ Алматы: Мектеп, 2020 г.
5. М.Оспанова, К.Аухадиева, Т.Белоусова Химия. Дәрислик. 1, 2-қисим Алматы: Мектеп, 2019
6. М.Успанова, К.Аухадиева, Т. Белоусова Химия. Дарслик. 1, 2 - қисм Алматы: Мектеп, 2019
7. Т.Г.Белоусова, К.С. Аухадиева Химия: Методическое руководство 1, 2 часть естественно-математического направления общеобразовательных школ Алматы: Мектеп, 2019 г.
8. Темирбулатова А., Сагимбекова Н., Алимжанова С.,Химия. Сборник задач и упражнений Алматы: Мектеп, 2019 г.



## 2. Additional literature :

1. Б.А. Мансуров «Химия» 10-11 кл., Атамура 2015 г
2. Б. Мансуров., Н. Торшина «Методика преподавания органической химии» Атамура 2015г.
3. А.Е. Темирбулатова, Н.Н. Нурахметов, Р.Н. Жумадилова, С.К. Алимжанова Химия: Учебник для 11 класса естественно-математического направления общеобразовательной школы Алматы: Мектеп, 2015г. -344 стр.
4. Г. Джексембина «Методическое руководство» Алматы: Мектеп, 2015г
5. А. Темирболатова., А. Казымова., Ж. Сагымбекова «Книга для чтения» Мектеп 2015г.
6. Торгаева Э., Шуленбаева Ж. и др Химия. Электронный учебник. 10-класс. 2016 Национальный центр информатизации
7. Жакирова Н., Жандосова И. и др Химия. Электронный учебник. 11-класс. 2016 Национальный центр информатизации
8. Электронные ресурсы с [www.bilimland.kz](http://www.bilimland.kz)



**Do you have any questions?**

