PHOSPHORUS AND ITS COMPOUNDS

23.1 Complete the statements:
A. In the periodic table phosphorus is placed ……..
B. In the nucleus of phosphorus atom there are …… protons and …… neutrons, and around nucleus there are ……. electrons.
C. In the outer most shell of phosphorus atom there are ……. electrons, therefore it gains …… , electrons minimum ……. oxidation state or displaying maximum …….. oxidation state.
D. Highest oxidation state of phosphorus' has ……. character and it corresponds ……
E. It is found in ……. Phosphates in Earth's crust and in the living organisms as ……..
F. It is found in nature in only …… form.
G. It has some allotropes ……., ……
H. The word "phosphorus" means ……
I. It is used to produce ……..

23.2 Compare:
A. Phosphorus with sulfur;
B. Phosphorus with nitrogen;
1. with respect to using atom structure;
2. with respect to bond character and their compound.

23.3 Explain, why phosphorus is found just in compounds in nature, but nitrogen in free state.

23.4 How does nonmetallic property change in periodic system from nitrogen to phosphorus?

23.5 What allotropic forms of phosphorus are there? Compare their chemical activity. (For example reactivity with oxygen). Which of them is the most dangerous?

23.6 Determine the oxidation state of phosphorus in the following compounds:
PH_3, Ba_3P_2, P_2O_5, HPO_3, H_3PO_4, PCl_5, P_2O_3, K_3PO_4.

23.7 Show the bond type in following substances:
P_4, PH_3, P_2O_5.

23.8 Complete the following reaction:
A. $P + ? \rightarrow P_2O_5$
B. $P + ? \rightarrow PF_5$
C. $P + ? \rightarrow Ca_3P_2$
D. $P + ? \rightarrow Na_3P$
E. $P + ? \rightarrow P_2O_3$
F. $P + ? \rightarrow K_3P$
G. $P + ? \rightarrow PCl_5$
H. $P + ? \rightarrow AlP$
In which one is phosphorus oxidant and reductant.

23.9 Explain the chemical properties of :
A. P_2O_5 B. H_3PO_4
by using general properties of inorganic substances.

23.10 Which of following substances can react with diphosphorus pentoxide? Write the reaction equation that can take place.
A. water
B. carbon dioxide
C. calcium oxide
D. potassium hydroxide
E. nitric acid
F. carbon

23.11 Propose a method to obtain orthophosphoric (phosphoric) acid, if initial substance is:
A. phosphorus;
B. diphosphorus pentoxide;
C. calcium phosphate.

23.12 Write the gradual dissociation of orthophosphoric acid. Explain, why hydrogen ion easily separates from H_3PO_4 molecule, but harder from $H_2PO_4^-$ and HPO_4^{-2}. Show the possible formulas of all sodium salts and calcium salts of ortophosphoric acid.

23.13 Complete the table with formulas of salts of ortophosphoric acid and write their names.

Cation	Radical acid ion (anion)		
	PO_4^{-3}	HPO_4^{-2}	$H_2PO_4^-$
Na^+			
K^+			
Ca^{+2}			
NH_4^+			
Al^{+3}			

23.14 Complete the following reactions, and write them in ionic form if possible.

I

A. $P_2O_5 + H_2O$ (temp.) $\rightarrow$

B. $P_2O_5 + ? \rightarrow HPO_3$
C. $HPO_3 + ?$ (temp.) $\rightarrow H_3PO_4$
D. $P_2O_5 + ? \rightarrow Na_3PO_4 + ?$
E. $P_2O_5 + K_2O \rightarrow$

F. $P_2O_5 + ? \rightarrow NaH_2PO_4 + H_2O$

G. $P_2O_5 + H_2O + ? \; NaH_2PO_4$

II

A. $H_3PO_4 + Mg \rightarrow ? + ?$
B. $H_3PO_4 + Na_2O \rightarrow ? + ?$
C. $H_3PO_4 + ? \rightarrow K_3PO_4 + H_2O$
D. $H_3PO_4 + ? \rightarrow K_2HPO_4 + H_2O$
E. $H_3PO_4 + ? \rightarrow KH_2PO_4 + ?$
F. $H_3PO_4 + Na_2CO_3 \rightarrow ? + ?$
G. $H_3PO_4 + K_2S \rightarrow ? + ?$

23.15 Choose which one of the substances reacts with
1. phosphoric acid
2. diphosphorus pentoxide
react with:
A. silver
B. sulfur trioxide
C. copper (II) chloride
D. calcium
E. potassium oxide
F. calcium hydroxide
G. water
H. barium sulfate
I. sulfuric acid
K. potassium hydroxide
Write possible the reaction equations, write them in ionic form if possible..

23.16 Write the molecular equations of the following ionic equations:
A. $3Ca^{+2} + 2PO_4^{-3} \rightarrow Ca_3(PO_4)_2\downarrow$
B. $3Ba^{+2} + 2PO_4^{-3} \rightarrow Ba_3(PO_4)_2\downarrow$
C. $P_2O_5 + 6OH^- \rightarrow 2PO_4^{-3} + 3H_2O\downarrow$
D. $3Ag^+ + PO_4^{-3} \rightarrow Ag_3(PO_4)_2\downarrow$
E. $H_3PO_4 + 2OH^- \rightarrow Ca_3(PO_4)_2\downarrow$
F. $Ca_3(PO_4)_2 + 4H^+ \rightarrow 3Ca^{+2} + 2H_2PO_4^-$

23.17 Write equations of reaction to obtain:
A. potassium phosphate;
B. potassium hydrogen phosphate
C. potassium dihydrogen phosphate;
D. ortophosphoric acid;
E. barium phosphate;
F. ammonium dihydrogen phosphate

23.18 Choose, which one of the substances react with
1. sodium phosphate
2. potassium phosphate
react with:
A. sulfuric acid
B.sodium nitrate
C. potassium hydroxide
D. ortophosphoric acid
E. copper (II) nitrate

23.19 Explain the properties of:
A. sodium phosphate
B. potassium phosphate
using bond character of inorganic substances.

23.20 Complete following reactions in ionic and molecular form:
A. $CaCl_2 + Na_3PO_4 \rightarrow$
B. $AgNO_3 + Na_3PO_4 \rightarrow$
C. $Ca_3(PO_4)_2 + H_2SO_4 \rightarrow$
D. $Ca_3(PO_4)_2 + H_3PO_4 \rightarrow$
E. $Na_3PO_4 + Ca(OH)_2 \rightarrow$
F. $K_3PO_4 + NaOH \rightarrow$
G. $Ba(NO_3)_2 + K_3PO_4 \rightarrow$
H. $NaCl + Ca_3(PO_4)_2 \rightarrow$
I. $Ca_3(PO_4)_2 + HCl \rightarrow$
K. $Na_3PO_4 + Cu(OH)_2 \rightarrow$
L. $HNO_3 + MgO \rightarrow$
M. $K_3PO_4 + Ba(OH)_2 \rightarrow$

23.21 Complete the possible reactions:

I

A. $P_2O_5 + O_2 \rightarrow$
B. $P_2O_5 + HCl \rightarrow$
C. $P_2O_5 + NaOH \rightarrow$
D. $P_2O_5 + H_2O \rightarrow$
E. $P_2O_5 + SO_2 \rightarrow$
F. $P_2O_5 + BaO \rightarrow$
G. $P_2O_5 + S \rightarrow$
H. $P_2O_5 + H_2O$ (temp.) $\rightarrow$

II

A. $H_3PO_4 + NH_3 \rightarrow$
B. $H_3PO_4 + 2NH_3 \rightarrow$
C. $H_3PO_4 + 3NH_3 \rightarrow$
D. $H_3PO_4 + CaO \rightarrow$
E. $H_3PO_4 + CO_2 \rightarrow$
F. $H_3PO_4 + 3NaOH \rightarrow$
G. $H_3PO_4 + 2NaOH \rightarrow$
H. $H_3PO_4 + NaOH \rightarrow$

III

A. $Ca_3(PO_4)_2 + K_2SO_4 \rightarrow$
B. $Ca_3(PO_4)_2 + KOH \rightarrow$
C. $Ca_3(PO_4)_2 + NaNO_3 \rightarrow$
D. $Ca_3(PO_4)_2 + H_2SO_4$ (conc.) $\rightarrow$
E. $Na_3PO_4 + FeCl_3 \rightarrow$
F. $K_3PO_4 + Al_2(SO_4)_3 \rightarrow$
G. $Ca_3(PO_4)_2 + Pb(NO_3)_2 \rightarrow$
H. $Zn_3(PO_4)_2 + KOH \rightarrow$

23.22 Write the formulas of the following substances and explain the application area of each of them:
A. red phosphorus;
E. calcium dihydrogen phosphate;
B. diphosphorus pentoxide;
F. calcium hydrogen phosphate;
C. ortophosphoric acid;
G. ammonium hydrogen phosphate;
D. calcium phosphate;
H. ammonium dihydrogen phosphate.

23.23 Complete the following transformations:

A. $P \rightarrow P_2O_5 \rightarrow HPO_3 \rightarrow H_3PO_4 \rightarrow Na_3PO_4 \rightarrow Ag_3PO_4$

$Ca_3P_2 \rightarrow PH_3$; $H_3PO_4 \rightarrow NaH_2PO_4$; $H_3PO_4 \rightarrow Na_2HPO_4$

B. $Ca_3(PO_4)_2 \rightarrow P \rightarrow P_2O_5 \rightarrow K_3PO_4 \rightarrow Ca_3(PO_4)_2$

$P_2O_5 \rightarrow Ca(H_2PO_4)_2$; $K_3PO_4 \rightarrow CaSO_4$

C. $H_3PO_4 \rightarrow NaH_2PO_4 \rightarrow Na_2HPO_4 \rightarrow Na_3PO_4 \rightarrow Ba_3(PO_4)_2$

$H_3PO_4 \rightarrow NH_4H_2PO_4$; $H_3PO_4 \rightarrow (NH_4)_2HPO_4$

D) $K_3PO_4 \rightarrow Ca_3(PO_4)_2 \rightarrow Ca(H_2PO_4)_2$

$P \rightarrow P_2O_5 \rightarrow H_3PO_4 \rightarrow Zn_3(PO_4)_2$

$AlPO_4 \rightarrow H_3PO_4$

23.24 Explain, what the superphosphate is and how it is obtained. Which one of these fertilizers:
phosphoric or double superphosphate fertilizers is better for soil?

23.25 Write the chemical formulas for the following mineral fertilizers: mono ammonium phosphate, diammonium phosphate, double superphosphate, ammonium nitrate, potassium nitrate, potassium chloride, ammonium sulfate. What nutrients do they contain? Give a classification method of mineral fertilizers.

23.26 Find the mass phosphorus which is found in human bones with 20 kg mass, if it is known that the mass percentage of calcium phosphate is 58 % in bones.

23.28 4 moles of diphosphorus pentoxide are put into excess boiling water. Find:
A. the mass of products;
B. the mass percentage of substance in 2.5 kg obtained solution.

23.29 The diphosphorus pentoxide obtained by burning of 15.5 phosphorus in oxygen, was dissolved by heating in 500 mL water. Find the mass percentage of ortophosphoric acid in obtained solution.

23.30 Technical zinc phosphide contains some metallic zinc impurities. After the reaction hydrochloric acid with 8.96 L, phosphine gas, PH_3 and 2.24 L hydrogen gas at STP are obtained. Find the mass percentage of technical zinc phosphide.

23.31 620 g of calcium phosphate were treated with boiling 60% sulfuric acid. Find:
a. the mass of product;
b. the mass of 60% sulfuric acid solution necessary for reaction.

23.32 14.2 g of diphosphorus pentoxide were dissolved in 500 mL of 28% phosphoric acid solution by mass. (d = 1.2 g/mL). Find the mass percentage of H_3PO_4 in obtained solution.

23.33 Calculate the mass of ortophosphoric acid which can be obtained by the reaction of 77.5 g of calcium phosphate with 23.52 g of sulfuric acid.

23.34 Calculate the mass of phosphorus in 65% $Ca_3(PO_4)_2$ which is necessary to obtain:
A. 124 kg of phosphorus, by the equation:
$Ca_3(PO_4)_2 + 5C + 3SiO_2 \rightarrow 3CaSiO_3 + 5CO\uparrow + 2P$;

B. 196 kg of phosphoric acid, by the equation:
$Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 2H_3PO_4 + 3CaSO_4$.

23.35 Find the percent yield of phosphorus, if 24.8 kg of phosphorus was obtained from 155 kg of calcium phosphate.

23.36 Find the salt that is obtained by the reaction of:
A. 0.5 mol phosphoric acid with 1 mol sodium hydroxide;
B. 9.8 g phosphoric acid with 4 g sodium hydroxide;
C. 98 g of 10% phosphoric acid solution by mass with 120 g of 10% sodium hydroxide solution by mass.
Calculate the mass of salt in each.

23.37 Calculate the mass of $NH_4H_2PO_4$ that is obtained by reaction of 224 L of ammonia with phosphoric acid, with 80% reaction yield.