P-block Elements Group 15 Chemistry Questions with Solutions

Q-1: Illustrate with the help of an equation, why +5 oxidation state of Bi is less stable than +3 state.

Answer:
Bi shows +3 and +5 oxidation states in $BiCl_3$ and $BiCl_5$ respectively. But due to the inert pair effect, the +5 oxidation state is less stable than +3 oxidation state. This is evident from the observation that $BiCl_3$ even on prolonged heating with Cl_2 does not form $BiCl_5$.

The chemical reaction shown below does not proceed due to $BiCl_3$ being more stable than $BiCl_5$.

$BiCl_3 + Cl_2 \rightarrow BiCl_5$

Q-2: Which of the following is not known?

a) NCl_5
b) NCl_3
c) NI_3
d) $SbCl_3$

Answer: a) NCl_5
Explanation: N is from the second period. There is no d-orbital in the second subshell. As a result, arranging five pairs of bonding electrons around a nitrogen atom is impossible. As a result, NCl_5 does not exist.

Q-3: Which of the Group 15 elements does not exhibit allotropy?
a) Nitrogen
b) Phosphorous
c) Antimony
d) Bismuth

Answer: d) Bismuth

Explanation: Allotropy, also known as allotropes of the elements, is the property of some chemical elements to exist in two or more different forms in the same physical state.

Bismuth does not exhibit allotropy, but other elements do.

Nitrogen→ α-nitrogen and β-nitrogen (solid crystalline forms)
Phosphorus →White, Red and Black forms

Arsenic →Yellow and Grey forms
Antimony →White,Yellow and Black forms.

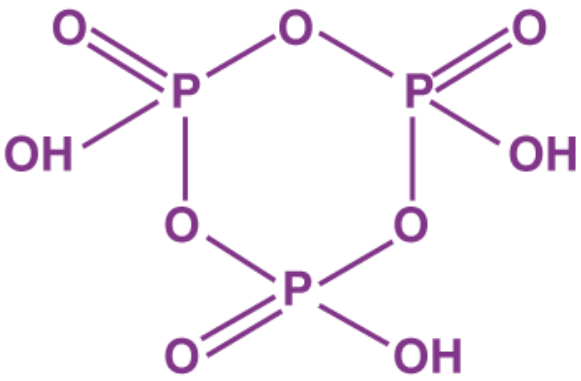
Q-4: The number of P-O-P bonds in cyclic tri metaphosphoric acid is

a) Zero
b) Two
c) Three
d) four

Answer: c) Three

Explanation: The general formula for cyclic metaphosphoric acid is $(HPO_3)_n$, where the value of 'n' gives the number of P-O-P bonds.
The formula of cyclic tri meta phosphoric acid is $(HPO_3)_3$.This shows 'n' is equal to 3. Hence, the number of P-O-P bonds are 3.

The structure for the cyclic tri metaphosphoric acid is shown below:



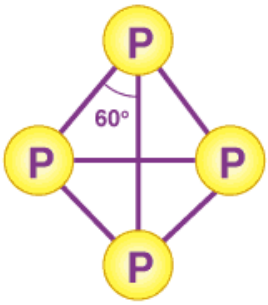
Q-5: Select the incorrect statement:

a) Black phosphorus has layered graphite like structure and is thermodynamically most stable.
b) White phosphorus is less reactive than red phosphorus.
c) Red phosphorus has a polymeric structure with P-P linkages.
d) Angle strain in red phosphorus is less than white phosphorus.

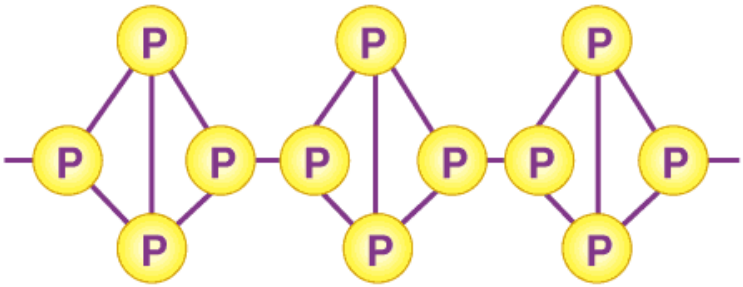
Answer: b) White phosphorus is less reactive than red phosphorus.

Explanation:

White phosphorus: The angles in the P_4 molecule are only 60 degrees, making it less stable and thus more reactive than the other solid phases under typical conditions. It easily catches fire in the air, producing dense white P_4O_{10} vapours. The structure of white phosphorous is shown below:

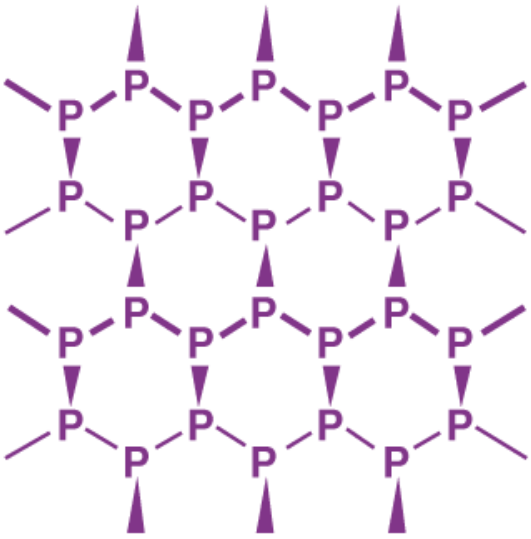


Red phosphorus It has an iron grey lustre. It has no odour, is non-poisonous, and is insoluble in both water and carbon disulphide. Red phosphorus is less reactive chemically than white phosphorus. It is not visible in the dark. It's polymeric, made up of chains of P_4 tetrahedra connected by P-P connections as shown below



Black phosphorus There are two types of black phosphorus: α-black phosphorus and β--black phosphorus. When red phosphorus is heated to 803K in a sealed tube, black phosphorus is created. At normal temperature and pressure, black phosphorus is thermodynamically stable. It has opaque monoclinic or rhombohedral crystals and can be sublimed in air. It does not oxidise when exposed to air. Black phosphorus creates layered structures just like graphene as shown in the below figure.White phosphorus is heated to 473 K under high pressure to produce black phosphorus. Up to 673 K, it does

not burn in air.



Q-6: Complete the following reactions:

i) $PbO_2 + HNO_3 \rightarrow$

ii) $NH_4NO_2 \xrightarrow{\Delta}$

Answer:

i) $PbO_2 + HNO_3 \rightarrow Pb(NO_3)_2 + H_2O + O_2$

ii) $NH_4NO_2 \xrightarrow{\Delta} N_2 + H_2O$

Q-7: What happens when

i) Solid XeF_2 reacts with AsF_5 in 1:1 ratio

ii) White phosphorus reacts with NaOH.

Answer:

i) Strong Lewis acids like AsF_5, SbF_5, IF_5, PtF_5 act as F^- acceptor with XeF_4 or XeF_2.

The following reaction takes place:

$XeF_2 + AsF_5 \rightarrow [XeF]^+ + [AsF_6]^-$

ii) Heating white phosphorus with concentrated NaOH solution in an inert atmosphere of CO_2 gives Phosphine (PH_3).

The reaction is shown below:

$P_4 + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$

Q-8: What are the Pseudohalogens and Pseudohalides? Give examples

Answer: A few ions are known consisting of two or more atoms of which at least one is N, that have properties similar to those of the halide ions. They are therefore called pseudohalides ions. These ions are univalent and form salts resembling the halide salts.

Table: The important pseudohalogens

Anion	Acid	Dimer
CN^- cyanide ion SCN^- thiocyanate ion $SeCN^-$ selenocyanate ion OCN^- cyanate ion ONC^- fulminate ion N_3^- azide ion	HCN hydrogen cyanide HSCN thiocyanic acid HOCN cyanic acid HONC fulminic acid HN_3 hydrogen azide	$(CN)_2$ cyanogen $(SCN)_2$ thiocyanogen $(SeCN)_2$ selenocyanogen

Q-9: $SbCl_3$ on hydrolysis produces a white turbidity due to the formation of

a) $Sb(OH)_3$
b) SbOCl
c) $SbCl_2(OH)$
d) $Sb(OH)_2Cl$

Answer: b) SbOCl

Explanation: The chemical breakdown of compounds by water is known as hydrolysis. So, in terms of science, hydrolysis entails demonstrating the separation of synthetic molecules by adding water. Water's reaction to the other chemical molecule results in the formation of at least two things.

Hydrolysis of $SbCl_3$ produces a white Antimony oxychloride precipitate.

The balanced chemical equation taking place is
$SbCl_3 + H_2O \rightarrow SbOCl + 2HCl$

Q-10: Ostwald's process generates nitric acid from ammonia via the formation of intermediate compounds

a) Nitric oxide and nitrogen dioxide
b) Nitrogen and nitric oxide
c) Nitric oxide and dinitrogen pentoxide
d) Nitrogen and nitrous oxide

Answer: a) Nitric oxide and nitrogen dioxide

Explanation: Ostwald's process is most commonly used to produce nitric acid.

Ostwald's process is a two-stage chemical reaction that converts ammonia to nitric acid.
Stage 1 involves the oxidation of ammonia to produce nitric oxide and nitric dioxide, followed by the dissolution of nitrogen dioxide in water and the formation of nitric acid.

The reactions involved are:

$4NH_3 + O_2 \rightarrow 4NO + 6H_2O$
$2NO + O_2 \rightarrow 2NO_2$
$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

Hence, we can clearly see that the intermediate compounds are nitric oxide(NO) and nitrogen dioxide(NO_2)

Q-11: The oxidation states of P atom in $POCl_3$,H_2PO_3 and $H_4P_2O_6$, respectively are

a) +5,+4,+4
b) +5,+5,+4
c) +4,+4,+4
d) +3,+4,+5

Answer: a) +5,+4,+4

Explanation: To determine the oxidation state of P, the oxidation states of each atom in a compound are added.

The sum of the oxidation numbers of the atoms in the compound is then made equal to zero for neutral compounds.

Let the oxidation state of P be x in each compound.

Compound	Formula	Oxidation state of P
$POCl_3$	x+(-2)+3(-1)=0	+5
H_2PO_3	2(+1)+x+3(-2)=0	+4
$H_4P_2O_6$	4(+1)+2(x)+6(-2)=0	+4

Q-12: Which of the following statements is wrong?

a) A single N-N bond is more powerful than a single P-P bond.
b) In the formation of a coordination compound with transition elements, PH_3 can act as a ligand.
c) NO_2 is paramagnetic in nature
d) Covalency of nitrogen in N_2O_5 is four

Answer: a) A single N-N bond is more powerful than a single P-P bond.

Explanation: A small size of N atom results in a shorter N-N bond length.As a result, the lone pair of electrons on both N atoms repel each other, causing the N-N bond to become unstable or weaken.On the other hand, due to the large size of P, there is no electronic repulsion between P atoms.

Q-13: Give the correct order of acidic character of following oxides.

Al_2O_3, MgO, SiO_2, P_4O_{10}

Answer:
Acidic strength is the tendency of a molecule/compound to liberate protons. In case of proton deficient compounds, acidic strength is governed by the positive oxidation state of the central atom. More is the value of positive oxidation state, more is the acidic strength.

The oxidation states of Al, Mg, Si and P are +3,+2,+4 and +5 respectively.

This makes the order of the acidic strength as:
$P_4O_{10} > SiO_2 > Al_2O_3 > MgO$

Q-14: N_2O_5 is an anhydride of

a) HNO_2
b) HNO_3
c) $H_2N_2O_2$
d) HNO_4

Answer: b) HNO_3

Explanation: The term anhydride literally means "without water." It is the chemical compound formed by removing water from another compound. Anhydride reacts with water to form a base or an acid.

Because anhydride is formed by removing water, adding water to N_2O_5 anhydride produces the corresponding acid/base.

$N_2O_5 + H_2O \rightarrow 2HNO_3$

We can clearly see that HNO_3 is obtained from the N_2O_5 anhydride which is an acid.

Q-15: N_2O is a laughing gas which is prepared by heating

a) NH_4Cl
b) $(NH_4)_2SO_4$
c) NH_4NO_3
d) $NH_4Cl + NaNO_3$

Answer: c) NH_4NO_3

Explanation: When ammonium nitrate (NH_4NO_3) is heated, the following reaction takes place resulting in the formation of laughing gas.

$NH_4NO_3 + \text{heat} \rightarrow N_2O + 2H_2O$

Practise Questions on P-block Elements Group 15

Q-1: Bond dissociation enthalpy of A-H (A=element)bond is given below. Which of the following compound will act as the weakest reducing agent

Compound	NH_3	PH_3	AsH_3	SbH_3
Bond dissociation enthalpy(KJ/mol)	389	322	297	255

Answer: A reducing agent is the one that causes reduction of other species but itself undergoes oxidation.(loss of H)

The compound that gives hydrogen easily is the strong reducing agent, while the compound that gives hydrogen less easily is the weaker one. The bond dissociation enthalpy can help in finding out this.

A higher bond dissociation enthalpy results in a weaker reducing agent, while a lower one results in the strongest reducing agent. Hence NH_3 is the weakest reducing agent.

Q-2: Match the compounds in column I with their boiling point in column II

Compound	**Boiling point (K)**
A) NH_3	i) 290
B) PH_3	ii) 211
C) AsH_3	iii) 186
D) SbH_3	iv) 240
E) BiH_3	v) 264

Answer: A)-iv, B)-iii), C)-ii ,D)-v), E)- i)

Explanation: The boiling point rises as the van der Waal forces increase.
As the van der Waal forces increase in the group, so does the boiling point. However, because of the presence of H-bonding, ammonia has a higher boiling point than PH_3 and AsH_3

So the boiling point trend is

$BiH_3 > SbH_3 > NH_3 > AsH_3 > PH_3$

Q-3: Among the following gases, which oxide of N is coloured?

a) Nitrous oxide
b) Nitrogen monoxide
c) Nitrogen dioxide
d) Dinitrogen pentoxide

Answer: Nitrogen dioxide

Explanation: Nitrogen dioxide(NO_2) is a reddish brown coloured gas.

Other oxides of nitrogen mentioned are colourless.

Q-4: Among the following, a sublimable substance is

a) NH_4Cl
b) $BaSO_4$
c) $CaHPO_3$
d) $CaCO_3$

Answer: a) NH_4Cl

Explanation: Sublimation occurs when a solid compound changes from a solid to a gaseous state without becoming a liquid.

Some of the sublimable substances are : NH_4Cl, camphor, I_2

Q-5: Write a chemical reaction between ammonia and cupric oxide.

Answer: Ammonia (NH_3) when heated with cupric oxide(CuO) reduces CuO to Cu. The following reaction take place:

$2NH_3 + 3CuO + heat \rightarrow 3Cu + N_2 + 3H_2O$