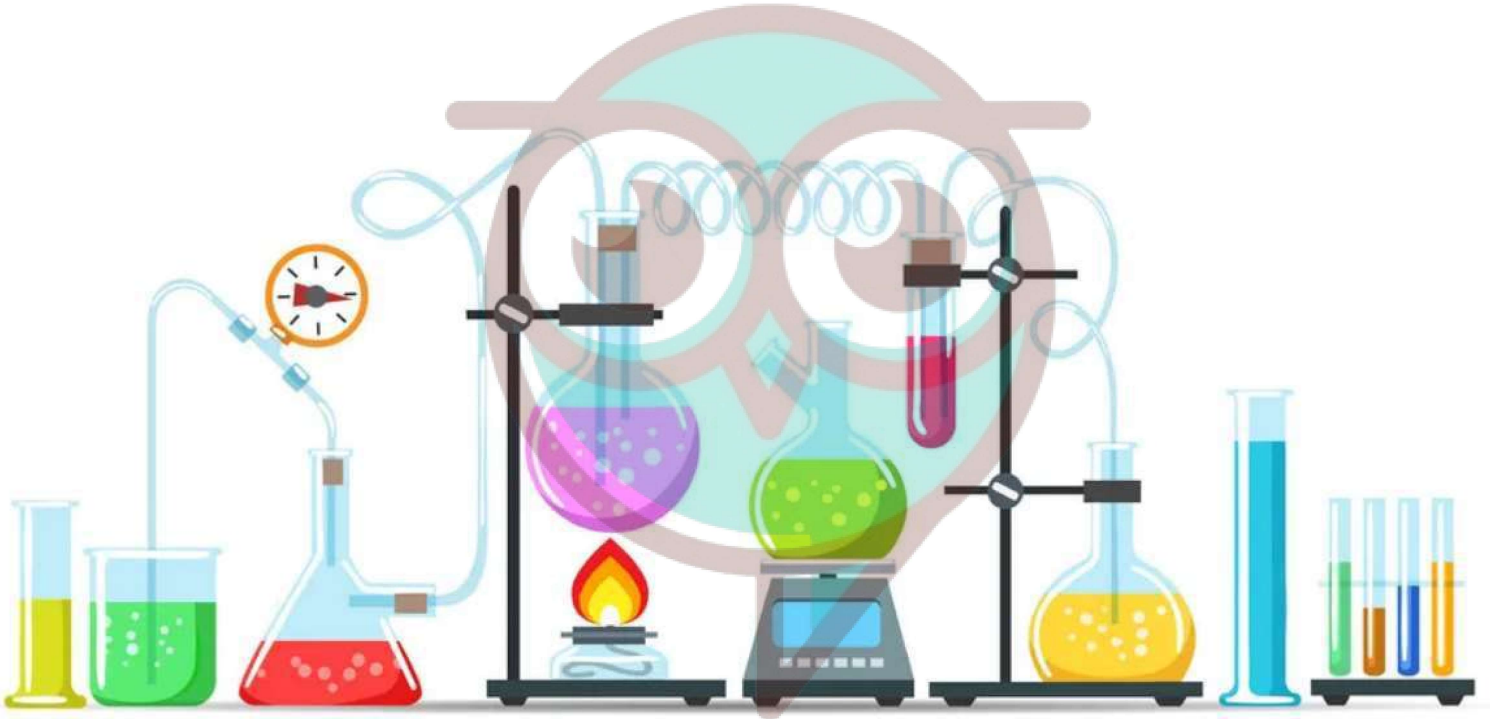
CHEMISTRY



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Important Questions

Multiple Choice questions-

1. H_2S is more acidic than H_2O because
(a) oxygen is more electronegative than sulphur.
(b) atomic number of sulphur is higher than oxygen.
(c) H — S bond dissociation energy is less as compared to H — O bond.
(d) H — O bond dissociation energy is less also compared to H — S bond.

2. The boiling points of hydrides of group 16 are in the order
(a) $H_2O > H_2Te > H_2S > H_2Se$
(b) $H_2O > H_2S > H_2Se > H_2Te$
(c) $H_2O > H_2Te > H_2Se > H_2S$
(d) None of these

3. In the manufacture of sulphuric acid by contact process Tyndall box is used to
(a) convert SO_2 and SO_3
(b) test the presence of dust particles
(c) filter dust particles
(d) remove impurities

4. Fluorine differs from rest of the halogens in some of its properties. This is due to
(a) its smaller size and high electronegativity.
(b) lack of d-orbitals.
(c) low bond dissociation energy.
(d) All of the these.

5. The set with correct order of acidity is
(a) $HClO < HClO_2 < HClO_3 < HClO_4$
(b) $HClO_4 < HClO_3 < HClO_2 < HClO$
(c) $HClO < HClO_4 < HClO_3 < HClO_2$
(d) $HClO_4 < HClO_2 < HClO_3 < HClO$

6. When chlorine reacts with cold and dilute solution of sodium hydroxide, it forms
(a) Cl^- and ClO^-
(b) Cl^- and ClO_2^-
(c) Cl^- and ClO_3^-
(d) Cl^- and ClO_4^-

7. The formation of $O_2^+ [PtF_6]^-$ is the basis for the formation of first xenon compound. This is because
(a) O_2 and Xe have different sizes.
(b) both O_2 and Xe are gases.
(c) O_2 and Xe have comparable electro-negativities.
(d) O_2 and Xe have comparable ionisation enthalpies.

8. Partial hydrolysis of XeF_4 gives
(a) XeO_3
(b) $XeOF_2$
(c) $XeOF_4$
(d) XeF_2

9. Helium is preferred to be used in balloons instead of hydrogen because it is
(a) incombustible
(b) lighter than hydrogen
(c) more abundant than hydrogen
(d) non polarizable

10. The increasing order of reducing power of the halogen acids is
(a) HF < HCl < HBr < HI
(b) HI < HBr < HCl < HF
(c) HBr < HCl < HF < HI
(d) HCl < HBr < HF < HI

Very Short Questions-

1. Write the elements of group 15?
2. Write chemical name & formulae of
a) Chile saltpetre
b) Indian saltpetre
3. What is special about the valence configuration of Group 15?
4. The atomic radii increases considerably from N to P but very little increase is observed from As to Bi. why?
5. Give reason for the following- the first ionization enthalpy of 15th group elements is higher than 16th group elements?
6. How does metallic character vary down the 15 group & why?
7. What are the common oxidation states of this group?
8. What is the maximum covalence shown by N?
9. Bi (v) is a stronger oxidizing agent than Bi (III). Why?
10. Give an example showing disproportionation of oxidation state of nitrogen?

Short Questions-

1. Write the various steps for preparation of sulphuric acid by contact process?
2. Name different sulphates formed by sulphuric acid?
3. Why are pentahalides more covalent than trihalides?
4. Why is BiH_3 the strongest reducing agent amongst all the hydrides of Group 15 elements?
5. Why is N_2 less reactive at room temperature?
6. How does ammonia react with a solution of Cu^{2+}?
7. What is the covalence of nitrogen in N_2O_5?
8. What happens when white phosphorus is heated with concentrated NaOH solution in an inert atmosphere of CO_2?
9. Write a balanced equation for the hydrolytic reaction of PCl_5 in heavy water.
10. What happens when PCl_5 is heated?

Long Questions-

1. Give reasons: -

(a) Oxygen molecule is diatomic whereas sulphur molecule is polyatomic.

(b) The most common oxidation state of oxygen is -2.

(c) H_2O is liquid whereas H_2S is gas at room temperature.

(d) The increasing order of acidic character in 16th group hydrides is $H_2O < H_2Se < H_2Te$.

(e) SF_6 is exceptionally stable, SH_6 does not exist.

2. Discuss the different types of oxides.
3. Bond angle in PH_4^+ is higher than that in PH_3. Why?
4. Comment on the nature of two S-O bonds formed in SO_2 molecule. Are the two S-O bonds in this molecule equal?
5. Discuss the general characteristics of Group 15 elements with reference to their electronic configuration, oxidation state, atomic size, ionisation enthalpy and electronegativity.
6. Discuss the trends in chemical reactivity of group 15 elements.
7. Write main differences between the properties of white phosphorus and red phosphorus.
9. Describe the manufacture of H_2SO_4 by contact process?
10. How is SO_2 an air pollutant?

Assertion and Reason Questions-

1. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c) Assertion is correct statement but reason is wrong statement.
d) Assertion is wrong statement but reason is correct statement.

Assertion: Caro's acid has S atom in +6 oxidation state.

Reason: Caro's acid contains one peroxo O_2^{2} – group.

2. In these questions, a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

a) Assertion and reason both are correct statements and reason is correct explanation for assertion.
b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.
c) Assertion is correct statement but reason is wrong statement.
d) Assertion is wrong statement but reason is correct statement.

Assertion: HOF bond angle in HFO is higher than HOCl bond angle in HClO.

Reason: Oxygen is more electronegative than all halogens except fluorine.

Case Study Questions-

1. Read the passage given below and answer the following questions:

Chlorine is a greenish yellow gas with pungent and suffocating odour. With dry slaked lime, it gives bleaching powder. Bleaching powder is a mixture of calcium hypochlorite and basic calcium chloride:

$[Ca(OCl)_2 \cdot CaCl_2 \cdot Ca(OH)_2 \cdot 2H_2O]$.

The amount of chlorine obtained from a sample of bleaching powder by the treatment with excess of dilute acids or CO_2 is called available chlorine. Chlorine is a powerful bleaching agent. Bleaching effect of chlorine is permanent.

The following questions are multiple choice questions. Choose the most appropriate answer:

(i) Chlorine gas reacts with _____ to form bleaching powder.

a) $Ca(OH)_2$
b) $CaCl_2$

c) $CaSO_4$
d) dry CaO

(ii) Chlorine reacts with cold and dilute alkali to form:

a) Chloride
b) Hypochlorite
c) Chlorate
d) Both (a) and (b)

(iii) Which of the following is produced on the reaction of bleaching powder with a few drops of cone. HCl?

a) Hypochlorous acid
b) Oxygen
c) Chlorine
d) Calcium oxide

(iv) Chlorine is used as a bleaching agent. The bleaching action is due to.

a) Oxidation
b) Chlorination
c) Hydrogenation
d) Reduction

(v) Bleaching powder contains a salt of an oxoacid as one of its components. The anhydride of that oxoacid is:

a) Cl_2O
b) Cl_2O_7
c) ClO_2
d) Cl_2O_6

2. Read the passage given below and answer the following questions:

Noble gases are inert gases with general electronic configuration of ns^2np^6. These are monoatomic, colourless, odourless and tasteless gases. The first compound of noble gases was obtained by the reaction of Xe with PtF_6. A large number of compounds of Xe and fluorine have been prepared till now. The structure of these compounds can be explained on the basis of VSEPR theory as well as concept of hybridisation. The compounds of krypton are fewer. Only the diftuoride of krypton (KrF_2) has been studied in detail. Compounds of radon have not isolated but only identified by radio tracer technique. However, no true compounds of helium, neon or argon are yet known.

The following questions are multiple choice questions. Choose the most appropriate answer:

(i) The formula of the compound when Xe and PtF_6 are mixed, is:

a) XeF_6
b) XeF_4
c) Xe_2PtF_6
d) $Xe^+[PtF_6]^-$

(ii) The shape and hybridisation of some xenon oxy-fluoride and fluoride compounds are given below. Find the incorrect one.

a) $XeOF_2$ - T-shape - sy^3d
b) $XeOF_4$ - square pyramidal - sp^3d^2
c) XeF_2 - linear - sp^3d
d) XeF_6 - square planar - dsp^2

(iii) Which of the following is not formed by Xe?

a) XeF_5
b) XeF
c) XeF_3
d) All of these.

(iv) The number oflone pairs and bond pairs of electrons around Xe in $XeOF_4$ respectively are,

a) 0 and 5
b) 1 and 5
c) 1 and 4
d) 2 and 3

(v) Which of the following compounds has more than one lone pair of electrons around central atom?

a) XeO_3
b) XeF_2
c) $XeOF_4$
d) XeO_2F_2

MCQ Answers-

1. Answer: b

2. Answer: b
3. Answer: b
4. Answer: b
5. Answer: b
6. Answer: a
7. Answer: d
8. Answer: b
9. Answer: a
10. Answer: a

Very Short Answers-

1. **Ans.** The elements of group 15 are Nitrogen (N), Phosphorous (P) , Arsenic (As) , Antimony (Sb) and Bismuth (Bi).

2. **Ans. (**a) Chile saltpetre – Sodium nitrate – $NaNO_3$
(b) Indian saltpetre – Potassium nitrate – KNO_3

3. **Ans.** The valence configuration of 15 group is ns^2np^3 the s-orbital is completely filled, and p-orbital is half filled. This half-filled orbital gives extra stability to elements of this group.

4. **Ans.** There is a considerable increase in size from N to P as expected but due to the presence of completely filled d- orbitals which have very poor shielding effects, the increase in size is very little from As to Bi.

5. **Ans.** Due to extra stability of half-filled configuration, the first Ionisation enthalpy of 15^{th} group elements is higher than 16^{th} group configuration ns^2np^3

6. **Ans.** The metallic character increases down the group due to decrease in ionization

enthalpy and increase in size of atom.

7. **Ans.** The common oxidation states of the group are -3, +3 & +5.

8. **Ans.** Nitrogen shows a maximum covalence of +4 because only four orbitals, one S and three P- orbitals are available for bonding in Nitrogen.

9. **Ans.** Bi is more stable in +3 oxidation state in comparison to +5 due to inert pair effect therefore Bi (v) has a strong tendency to act as oxidizing agent.

10. **Ans.**

$$\underset{+3}{3HNO_2} \rightarrow \underset{+5}{HNO_3} + H_2O + \underset{+2}{2NO}$$

Here Nitrogen is getting oxidized to a higher oxidation state as well as reduced to a lower oxidation state.

Short Answers-

Ans 1. Contact process for sulphuric acid: -

Step 1: Burning of sulphur in air to give SO_2.

$$S + O_2 SO_2$$

Step 2: Conversion of SO_2 to SO_3 by reacting it with oxygen in presence of V_2O_5.

$$2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3$$

Step 3: Absorption of SO_3 in H_2SO_4 to give of oleum $(H_2S_2O_7)$

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7\,(oleum)$$

Step 4: Dilution of oleum with water to get H_2SO_4 of desired concentration

$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

Ans 2. The two type of sulphates are –

(i) Normal sulphate eg. Na_2SO_4, $CuSO_4$

(ii) acid sulphate eg. $NaHSO_4$.

Ans 3. In pentahalides, the oxidation state is +5 and in trihalides, the oxidation state is +3. Since the metal ion with a high charge has more polarizing power, pentahalides are more covalent than trihalides.

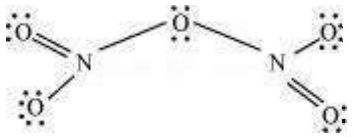
Ans 4. As we move down a group, the atomic size increases and the stability of the hydrides of group 15 elements decreases. Since the stability of hydrides decreases on moving from NH_3 to BiH_3, the reducing character of the hydrides increases on moving from NH_3 to BiH_3.

Ans 5. The two N atoms in N_2 are bonded to each other by very strong triple covalent bonds. The bond dissociation energy of this bond is very high. As a result, N_2 is less reactive at room temperature.

Ans 6. NH_3 acts as a Lewis base. It donates its electron pair and forms a linkage with metal ion.

$$\underset{\text{Blue}}{Cu^{2+}_{(aq)}} + 4NH_{3(aq)} \leftrightarrow \underset{\text{Deep Blue}}{\left[Cu(NH_3)_4\right]^{2+}_{(aq)}}$$

Ans 7.



From the structure of N_2O_5, it is evident that the covalence of nitrogen is 4.

Ans 8. White phosphorous dissolves in boiling NaOH solution (in a CO_2 atmosphere) to give phosphine, PH_3.

$$PH_3.P_4 + 3NaOH + 3H_2O \rightarrow \underset{\text{Phosphine}}{PH_3} + \underset{\text{Sodium hypophosphite}}{3NaH_2PO_2}$$

Ans 9. All the bonds that are present in PCl_5 are not similar. It has three equatorial and two axial bonds. The equatorial bonds are stronger are stronger than the axial ones. Therefore, when PCl_5 is heated strongly, it decomposes to form PCl_3.

Ans 10.

$PCl_5 + D_2O \rightarrow POCl_3 + 2DCl_2$

$POCl_3 + 3D_2O \rightarrow D_3PO_4 + 3DCl$

Therefore, the net reaction can be written as

$PCl_5 + 4D_2O \rightarrow D_3PO_4 + 5DCl$

Long Answers-

Ans 1. (a) Oxygen being small in size forms effective and strong P π-P π bonds with other oxygen atom. Therefore, oxygen molecule is diatomic and discrete whereas Sulphur due to its larger size, its orbitals cannot overlap effectively to form P π-P π bonds & completes valency by forming σ bonds with many sulphur, atom. Therefore, sulphur molecule is polyatomic solid.

(b) Since oxygen is highly electronegative, it has little tendency to give electrons. Therefore, its most common oxidation state is -2.

(c) H_2O is liquid at room temperature due to presence of intermolecular Hydrogen bonding which is absent in H_2S.

(d) As we move down the group, the size of atom increases this make the bond of the element with hydrogen weak. Due to weaker bonds, the bond dissociation enthalpy decreases making the molecule more acidic. Therefore, the order of acidic strength is.

$H_2O < H_2S < H_2Se < H_2Te$

(e) SF_6 is exceptionally stable due to steric reasons. Hydrogen being electropositive or less electronegative than fluorine cannot make the s- electrons of sulphur to participate in bonding. Therefore SF_6 does not exist.

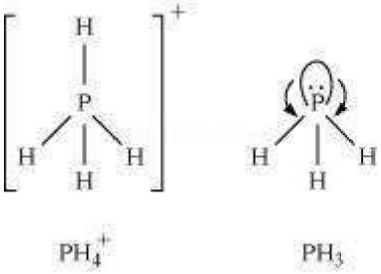
Ans 2. A binary compound of oxygen with another element is called oxide. Oxides can be simple or mixed. Simple oxides can be classified as acidic, basic Amphoteric or neutral.
An oxide that combines with water to give an acid is termed acidic oxide e.g. CO_2, SO_2 etc.

An oxide that combines with water to give a base is called basic oxide e.g. Na_2O, CaO, BaO etc.

An **oxide** that shows characteristics of both acids and bases is Amphoteric oxide e.g. Al_2O_3.

An oxide that shows characteristic of neither acid nor base is called neutral oxide e.g. CO, NO and N_2O.

Ans 3. In PH_3, P is sp_3 hybridized. Three orbitals are involved in bonding with three hydrogen atoms and the fourth one contains a lone pair. As lone pair-bond pair repulsion is stronger than bond pair-bond pair repulsion, the tetrahedral shape associated with *sp*3bonding is changed to pyramidal. PH_3 combines with a proton to form PH_4^+ in which the lone pair is absent. Due to the absence of lone pair in PH_4^+, there is no lone pair-bond pair repulsion. Hence, the bond angle in PH_4^+ is higher than the bond angle in PH_3.



PH_4^+ PH_3

Concept insite: the long pair-bond pair repulsion is more than bond pair-bond pair repulsion.

Ans 4. The electronic configuration of S is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$.

During the formation of

SO_2, one electron from 3*p* orbital goes to the 3*d* orbital and S undergoes sp^2 hybridization. Two of these orbitals form sigma bonds with two oxygen atoms and the third contains a lone pair. *p*-orbital and *d*-orbital contain an unpaired electron each. One of these electrons forms $p\pi - p\pi$ bond with one oxygen atom and the other forms $p\pi : p\pi$ bond with the other oxygen. This is the reason SO_2 has a bent structure. Also, it is a resonance hybrid of structures I and II. Both S-O bonds are equal in length (143 pm) and have a multiple bond character.

Ans 5. General trends in group15 elements

(i) Electronic configuration: All the elements in group 15 have 5 valence electrons. Their general electronic configuration is $ns^2\ np^3$.

(ii) Oxidation states: All these elements have 5 valence electrons and require three more electrons to complete their octets. However, gaining electrons is very difficult as the nucleus will have to attract three more electrons. This can take place only with nitrogen as it is the smallest in size and the distance between the nucleus and the valence shell is relatively small. The remaining elements of this group show a formal oxidation state of -3 in their covalent compounds. In addition to the -3 state, N and P also show -1 and -2 oxidation states.
All the elements present in this group show +3 and +5 oxidation states. However, the stability of +5 oxidation state decreases down a group, whereas the stability of +3 oxidation state increases. This happens because of the inert pair effect.

(iii) Ionization energy and electronegativity
First ionization decreases on moving down a group. This is because of increasing atomic sizes. As we move down a group, electronegativity decreases, owing to an increase in size.

(iv) Atomic size: On moving down a group, the atomic size increases. This increase in the atomic size is attributed to an increase in the number of shells.

Ans 6. General trends in chemical properties of group – 15

(i) Reactivity towards hydrogen:

The elements of group 15 react with hydrogen to form hydrides of type EH_3, where E = N, P, As, Sb, or Bi. The stability of hydrides decreases on moving down from NH_3 to BiH_3.

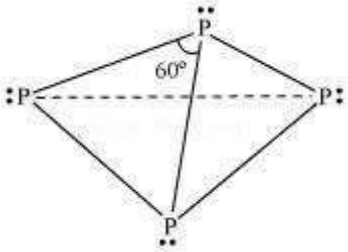
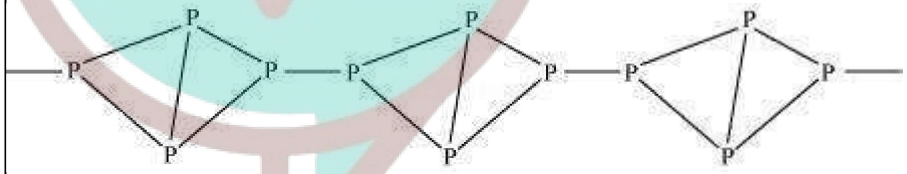
(ii) Reactivity towards oxygen:

The elements of group 15 form two types of oxides: E_2O_3 and E_2O_5, where E = N, P, As, Sb, or Bi. The oxide with the element in the higher oxidation state is more acidic than the other. However, the acidic character decreases on moving down a group.

(iii) Reactivity towards halogens: The group 15 elements react with halogens to form two series of salts: EX_3 and EX_5. However, nitrogen does not form NX_5 as it lacks the *d*-orbital. All trihalides (except NX_3) are stable.

(iv) Reactivity towards metals: The group 15 elements react with metals to form binary compounds in which metals exhibit -3 oxidation states.

Ans 7.

White phosphorus	Red Phosphorus
It is a soft and waxy solid. It possesses a garlic smell.	It is a hard and crystalline solid, without any smell.
It is poisonous.	It is non-poisonous.
It is insoluble in water but soluble in carbon disulphide.	It is insoluble in both water and carbon disulphide.
It undergoes spontaneous combustion in air.	It is relatively less reactive.
In both solid and vapour states, it exists as a P4 molecule. 	It exists as a chain of tetrahedral P4 units. 

8. Justify the placement of O, S, Se, Te and Po in the same group of the periodic table in terms of electronic configuration, oxidation state and hydride formation.

Ans 8. The elements of group 16 are collectively called chalcogens.

(i) Elements of group 16 have six valence electrons each. The general electronic configuration of these elements is $ns^2 np^4$, where n varies from 2 to 6.

(ii) Oxidation state:

As these elements have six valence electrons $(ns^2 np^4)$, they should display an oxidation state of -2. However, only oxygen predominantly shows the oxidation state of -2 owing to its high electronegativity. It also exhibits the oxidation state of -1 (H_2O_2), zero (O_2), and +2 (OF_2).

However, the stability of the -2 oxidation state decreases on moving down a group due to a decrease in the electronegativity of the elements. The heavier elements of the group show an oxidation state of +2, +4, and +6 due to the availability of *d*-orbitals.

(iii) Formation of hydrides:

These elements form hydrides of formula H_2E, where E = O, S, Se, Te, PO. Oxygen and sulphur also form hydrides of type H_2E_2. These hydrides are quite volatile in nature.

Ans 9. Sulphuric acid is manufactured by the contact process. It involves the following steps:

Step (i): Sulphur or sulphide ores are burnt in air to form SO_2.

Step (ii): By a reaction with oxygen, SO_2 is converted into SO_3 in the presence of V_2O_5 as a catalyst.

$$2SO_{2(g)} + O_2 \xrightarrow{V_2O_5} 2SO_{3(g)}$$

Step (iii): SO_3 produced is absorbed on H_2SO_4 to give $H_2S_2O_7$ (oleum).

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$

This oleum is then diluted to obtain H_2SO_4 of the desired concentration.
In practice, the plant is operated at 2 bar (pressure) and 720 K (temperature). The sulphuric acid thus obtained is 96-98% pure.

Ans 10. Sulphur dioxide causes harm to the environment in many ways:

1. It combines with water vapour present in the atmosphere to form sulphuric acid. This causes acid rain. Acid rain damages soil, plants, and buildings, especially those made of marble.

2. Even in very low concentrations, SO_2 causes irritation in the respiratory tract. It causes throat and eye irritation and can also affect the larynx to cause breathlessness.

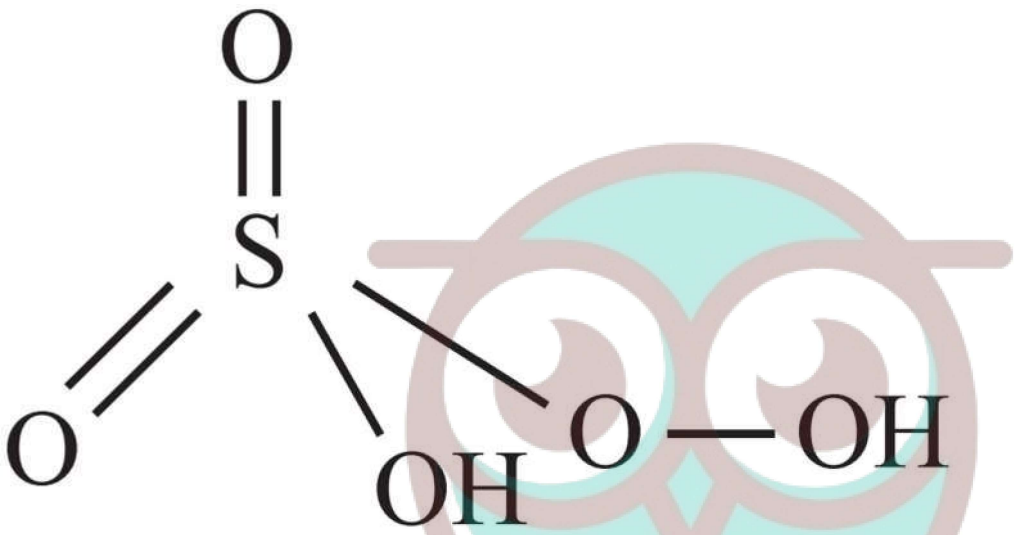
3. It is extremely harmful to plants. Plants exposed to sulphur dioxide for a long time lose colour from their leaves. This condition is known as chlorosis. This happens because the formation of chlorophyll is affected by the presence of sulphur dioxide.

Assertion and Reason Answers-

1. (a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

Explanation:

This can be explained through structure of caro's acid (peroxomonosulphuric acid).



Oxidation no. of S = x, oxidation no. of H = +1,

Oxidation no. of O in peroxo linkage = -1 (each),

Oxidation no. of other oxygen atoms = -2 (each).

2 + x - 6 - 2 = 0 or x = +6.

2. (d) Assertion is wrong statement but reason is correct statement.

Explanation:

HOF bond angle in HFO is lesser than that of HOCl bond angle in HClO. Oxygen is more electronegative than all halogens except fluorine.

Case Study Answers-

1. Answer :

(i) (a) $Ca(OH)_2$

(ii) (d) Both (a) and (b)

Explanation:

In cold, chlorine reacts with dilute alkalies to form chlorides and hypochlorites.

(iii) (c) Chlorine

(iv) (a) Oxidation

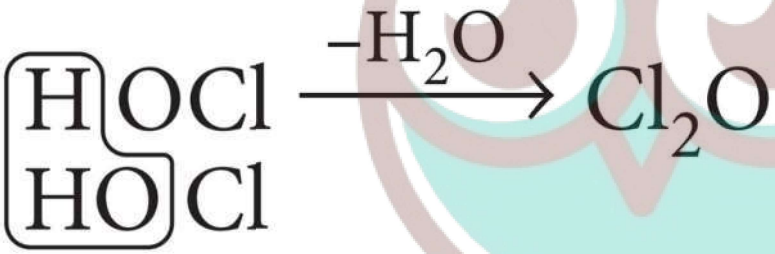
Explanation:

$Cl_2 + H_2O \rightarrow 2HCl + [O]$

(v) (a) Cl_2O

Explanation:

Bleaching powder contains OCl^- ion, hence the oxoacid is HOCl. Anhydride of HOCl is Cl_2O.



2. Answer :

(i) (d) $Xe^+[PtF_6]^-$

(ii) (d) XeF_6 - square planar - dsp^2

Explanation:

XeF_6 has sp^3d^3 hybridisation and distorted octahedral shape.

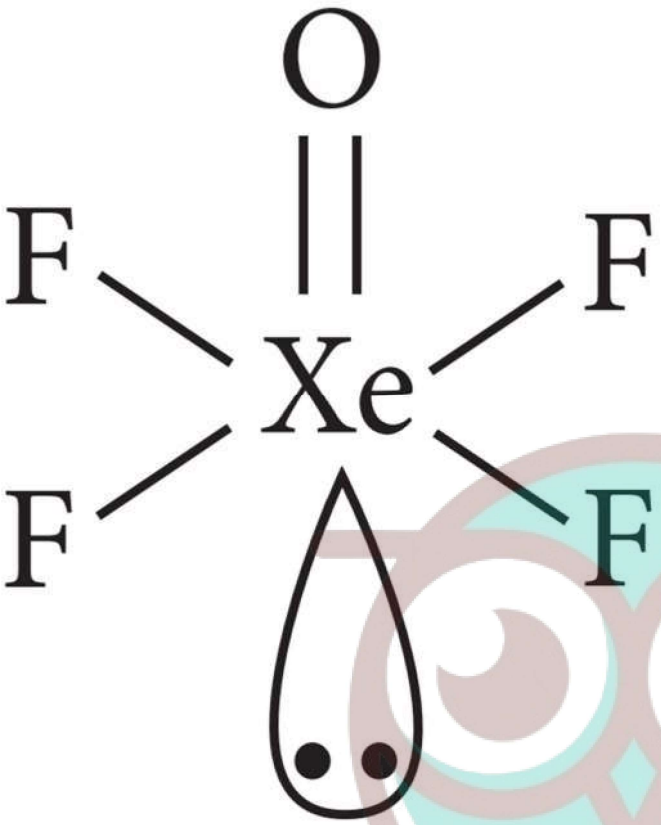
(iii) (d) All of these.

Explanation:

Xe has completely filled 5p-orbital. As a result, when it undergoes bonding with an odd number (1, 3 or 5) of fluorine atoms, it leaves behind one unpaired electron. This causes the molecule to become unstable. As a result, XeF, XeF_3 and XeF_5 do not exist.

(iv) (b) 1 and 5

Explanation:



(v) (b) XeF_2

Explanation:

XeF_2 has 3 lone pairs on Xe atom.