Holiday Assignments

Section Name

Subject	**Grade**	**Medium**

Group 16 elements

Group trends

First element, oxygen of Group 16 shows different properties to the other elements in the group. Metallic nature increases going down the group. However, none of the Group 16 elements behaves as true metals. Both oxygen and sulphur are non-metals and other elements in the group show metallic and nonmetallic properties. Only oxygen exists as a gas, and other elements in the group are solids. Except for oxygen, other elements in the group can form even-numbered oxidation states from +6 to -2. Stability of +6 and -2 oxidation states decreases down the group whereas the stability of the +4 oxidation state increases.

Properties of group 16 elements.

	O	S	**Se	**Te	**Po
Ground state electronic configuration	$[He]2s^2 2p^4$	$[Ne]3s^2 3p^4$	$[Ar]3d^{10} 4s^2 4p^4$	$[Kr]4d^{10} 5s^2 5p^4$	$[Xe]4f^{14} 5d^{10} 6s^2 6p^4$
Ionic radius X^{2-}/ pm	140	184	198	221	-
Covalent radius/ pm	73	103	117	137	140
Melting point/ °C	-218	113(α)	217	450	254
Pauling electronegativity	3.4	2.6	2.6	2.1	2.0
1st electron gain enthalpy/ kJ mol^{-1} $X(g) + e \longrightarrow X^-(g)$	-141	-200	-195	-190	-183
2nd electron gain enthalpy/ kJ mol^{-1} $X^-(g) + e \longrightarrow X^{2-}(g)$	844	532	-	-	-

*** Not a part of the current G. C. E. (A/L) Chemistry syllabus*

Non metal (O, S) | metalloid (Se, Te) | radioactive metal (Po)

Hydrides of Group 16

Group 16 elements form simple hydrides with hydrogen. All of them are covalent hydrides. The variations of selected properties down the group, of hydrides are shown in below table.

	H_2O	H_2S	H_2Se	H_2Te
Melting point/ °C	0.0	-85.6	-65.7	-51
Boiling point / °C	100.0	-60.3	-41.3	-4
Bond length/ pm	96	134	146	169
Bond angle/ °	104.5	92.1	91	90

Q1; Revise boiling points of hydrides of group 14,15,16 and 17 (table given in unit 2) elements and give reason for the following.

a) Why elements of second period show higher boiling points than rest of elements in the group except methane.
b) What is the general pattern down the group and give reason.

Due to the extensive hydrogen bonding, H_2O shows abnormally high boiling and melting points than the other hydrides of the group. Water is the only non-poisonous hydride among all the other hydrides of the group.

The observed variation in bond length of covalent hydrides is due to the increase of size of the central atom. Therefore, bond length increases down the group.

The covalent bond angle decreases as you come down in the group due to the less repulsion of the bonding electrons as a result of electronegativity of the central atom decreases down the group. In H_2S, H_2Se and H_2Te the bond angles become close to 90°. This may also suggest that almost pure p orbitals on selenium and tellurium especially are used for bonding with hydrogen.

Q2;Predict bond angles of PH_3 and NH_3 and give reason.

ANS: In ammonia sp^3 hybridization occurs .So its bond angle should have been 109°28' . But due to the presence of lone pair it is slightly less. So it was expected that the angle in PH_3 will also be approximately same. But, it is around 90°. This fact is explained as:

- No Hybridisation occurs in PH_3.
- So according to VBT (Valence bond theory) the bond angle is the angle between the p-orbitals(Px , Py,Pz) ie. 90°.

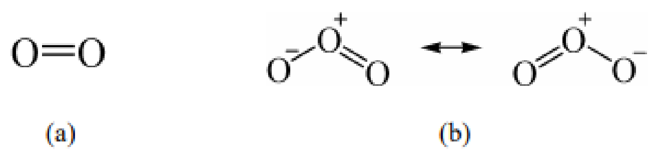
This is the case with all the hydrides of Nitrogen and Oxygen family. No hybridisation occurs in them. So the bond angle is way too small than expected. It is around 90°.

Oxygen

Oxygen has two allotropes, dioxygen (O_2) and trioxygen (ozone, O_3). Dioxygen is a colourless and an odourless gas which is slightly soluble in water. Ozone has a pungent odour. Ozone has a bond angle of 111.5°.

Q3; Draw structures of these two allotropes.

ANS: Structure of oxygen and ozone



Catalytic decomposition of potassium chlorate and hydrogen peroxide can be used to produce oxygen.

$2KClO_3(s) \longrightarrow 2KCl(s) + 3O_2(g)$, heating in the presence of MnO_2 or Pt eq:1

$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$, heating in the presence of MnO_2 eq:2

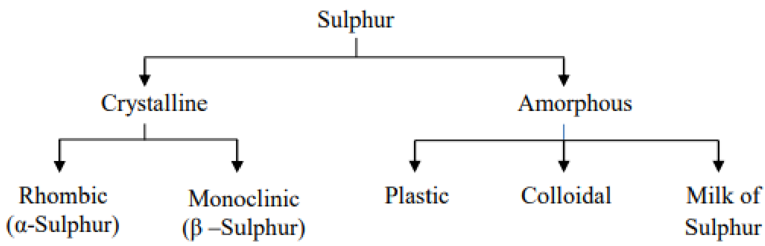
$2KNO_3$ KNO_2

Metals react with dioxygen to produce metal oxides. Ozone is a powerful oxidizing agent stronger than dioxygen. Ozone is used to disinfect water in many developed countries to kill pathogens. Unlike chlorine, ozone does not produce any harmful by-products in the disinfection process.

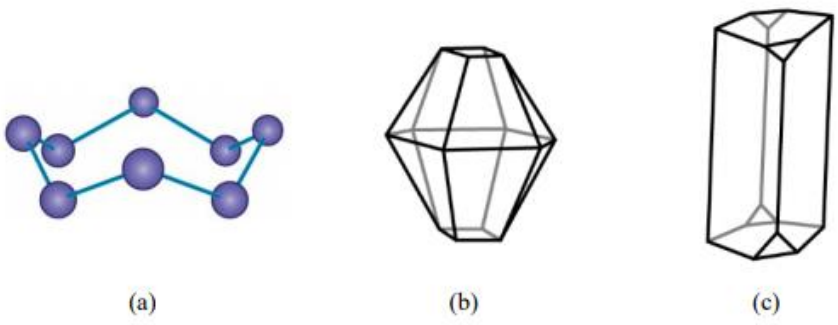
Q4; write balanced half equations (oxidation half and reduction half) to equations 1 and 2 above.

Sulphur

Sulphur can be classified as it is explained below.



Unlike oxygen, sulphur forms single bonds with itself rather than double bonds. The most commonly occurring allotrope is rhombic sulphur which is referred to as α-sulphur (α-S_8). It has a crown shape with eight-membered ring that has a cyclic zigzag arrangement as shown below. When heated above 93 °C, α-S_8 changes its packing arrangement to the other commonly found form of monoclinic sulphur, β-sulphur (β-S_8). These two forms are allotropes of each other.



a) Crown form of S_8 b) Rhombic sulphur c) Monoclinic sulphur

Crystalline form of rhombic and monoclinic sulphur consist of S_8 rings in the shape of crown. These can be packed together in two different ways to form rhombic crystals and to form needle shaped monoclinic crystals as shown above. Below 95 °C the rhombic form is the most stable allotropic form of sulphur.

Amorphous sulphur is an elastic form of sulphur which is obtained by pouring melted sulphur into water. Sudden cooling of molten sulphur with open chains converts liquid sulphur to amorphous sulphur with open chains. With time, amorphous sulphur converts to crystalline sulphur. The amorphous form of sulphur is malleable but it is unstable.