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# PERIOD 3 OXIDES

# IONIC OXIDES – Structure



Ionic bonding gets stronger (but more covalent character)



*lattice enthalpy of dissociation (kJ/mol)*

414

3795

15421

*melting points*

1132 °C

2852 °C

2072 °C

*solubility in water*

very soluble

slightly soluble

insoluble

# IONIC OXIDES – Reaction with water

$O^{2-}$  (if it dissolves) reacts with water:  $O^{2-} + H_2O \rightarrow 2OH^-$



Oxide gets less soluble so less alkaline solution formed

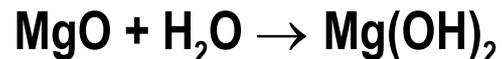
very soluble

slightly soluble

insoluble



pH 14



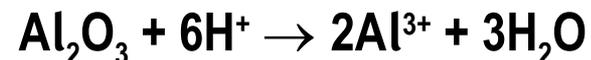
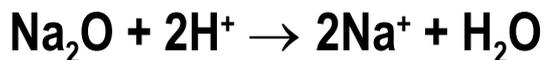
pH 10

no reaction

pH 7

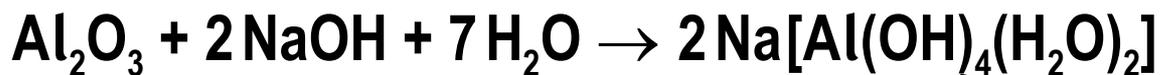
# IONIC OXIDES – Reaction with acid

$O^{2-}$  reacts with acid:  $O^{2-} + 2H^+ \rightarrow H_2O$



# IONIC OXIDES – Reaction with alkali

- ionic oxides do not react with OH<sup>-</sup>
- however, covalent oxides do react with OH<sup>-</sup>
- as Al<sub>2</sub>O<sub>3</sub> has some covalent character, it does also react with OH<sup>-</sup>
- when Al(+3) species react with OH<sup>-</sup>(aq): Al(OH)<sub>4</sub>(H<sub>2</sub>O)<sub>2</sub><sup>-</sup> is formed



## TIP to BALANCE

- Start with the product and there must be 2 as there are 2 Al in Al<sub>2</sub>O<sub>3</sub>
- If there are 2 of these on the right, we need 2 NaOH to give 2 Na
- There are 12 O on the right, so if we have 3 from Al<sub>2</sub>O<sub>3</sub> and 2 from 2NaOH then we need 7 more, so 7H<sub>2</sub>O

# IONIC OXIDES – Acid-base character



ionic

basic



ionic

basic



ionic with covalent character

amphoteric

nature	what is means
acidic	reacts with bases
basic	reacts with acids
amphoteric	reacts with acids & bases

# COVALENT OXIDES – Structure



giant covalent

1710 °C



simple molecular

340 °C



simple molecular

-72 °C

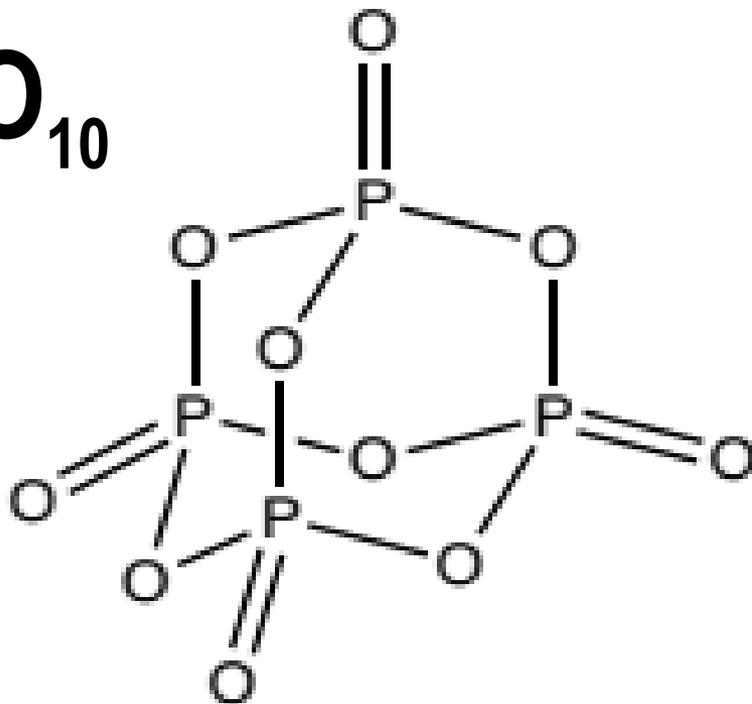


simple molecular

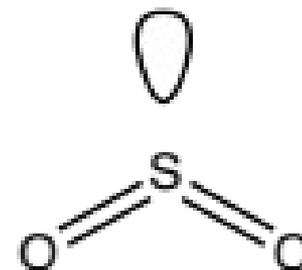
17 °C

*melting points*

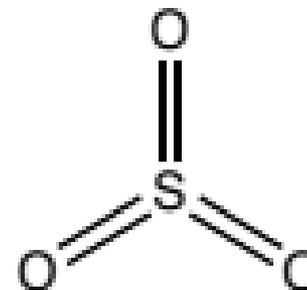
# COVALENT OXIDES (Molecular) – Structure



tetrahedral around each P



bent 118°



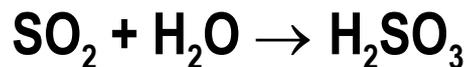
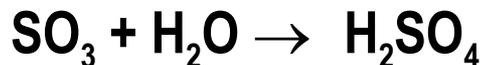
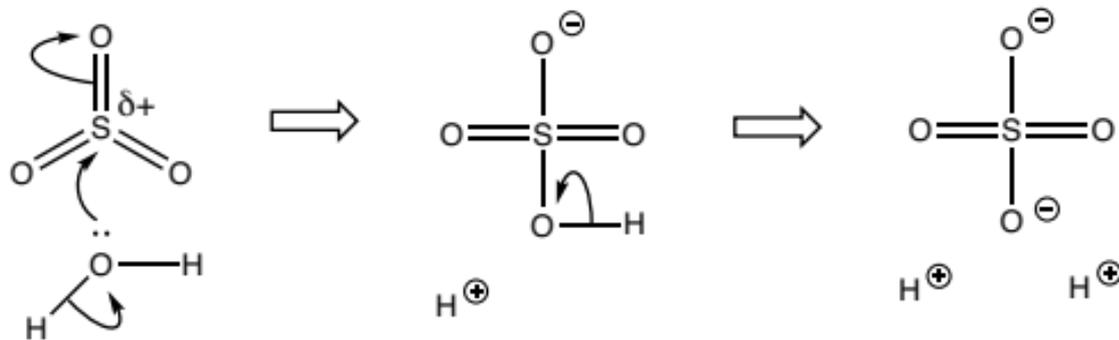
trigonal planar 120°

# COVALENT OXIDES (Molecular)

## Reaction with water

- the P/S atom in each molecule is  $\delta+$
- the lone pair on the O of  $\text{H}_2\text{O}$  attacks the  $\delta+$  O atom
- this releases  $\text{H}^+$  ions (from the  $\text{H}_2\text{O}$ ) plus  $\text{SO}_3^{2-}$  (from  $\text{SO}_2$ ) /  $\text{SO}_4^{2-}$  (from  $\text{SO}_3$ ) /  $\text{PO}_4^{3-}$  from  $\text{P}_4\text{O}_{10}$

*Simplified mechanism  
for reference – you do  
not need to know this*

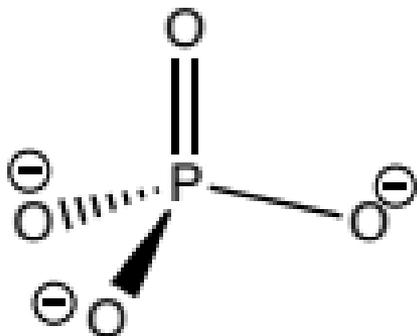


# COVALENT OXIDES (Molecular)

## Reaction with water – structure of anions formed



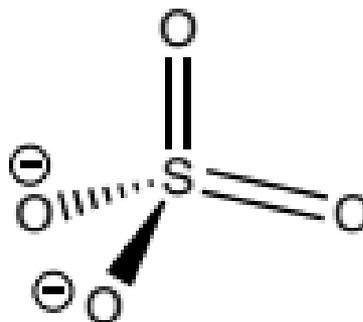
phosphate(V)



tetrahedral



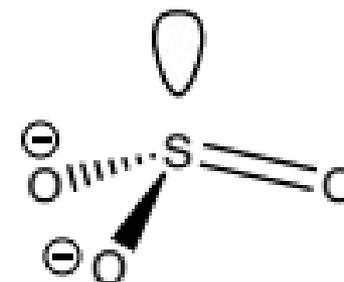
sulfate(VI)



tetrahedral



sulfate(IV)



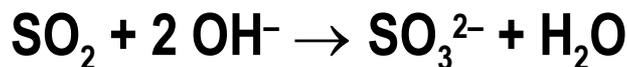
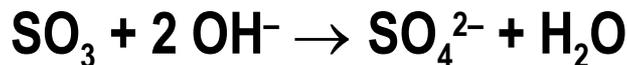
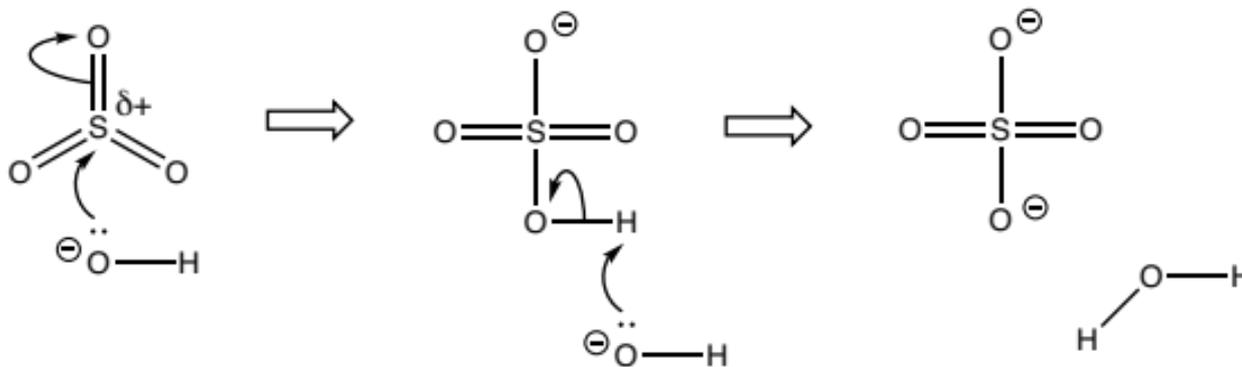
trigonal pyramidal

# COVALENT OXIDES (Molecular)

## Reaction with alkali

- the P/S atom in each molecule is  $\delta+$
- the lone pair on the O of  $\text{OH}^-$  attacks the  $\delta+$  S/P atom
- this releases  $\text{H}_2\text{O}$  plus  $\text{SO}_3^{2-}$  (from  $\text{SO}_2$ ) /  $\text{SO}_4^{2-}$  (from  $\text{SO}_3$ ) /  $\text{PO}_4^{3-}$  from  $\text{P}_4\text{O}_{10}$

*Simplified mechanism  
for reference – you do  
not need to know this*



### TIP to BALANCE

- 4 x  $\text{PO}_4^{3-}$  formed from the 4Ps in  $\text{P}_4\text{O}_{10}$
- 4 x  $\text{PO}_4^{3-}$  have 12- charge and so need 12  $\text{OH}^-$
- which has 12H on left to give 6 $\text{H}_2\text{O}$  on right

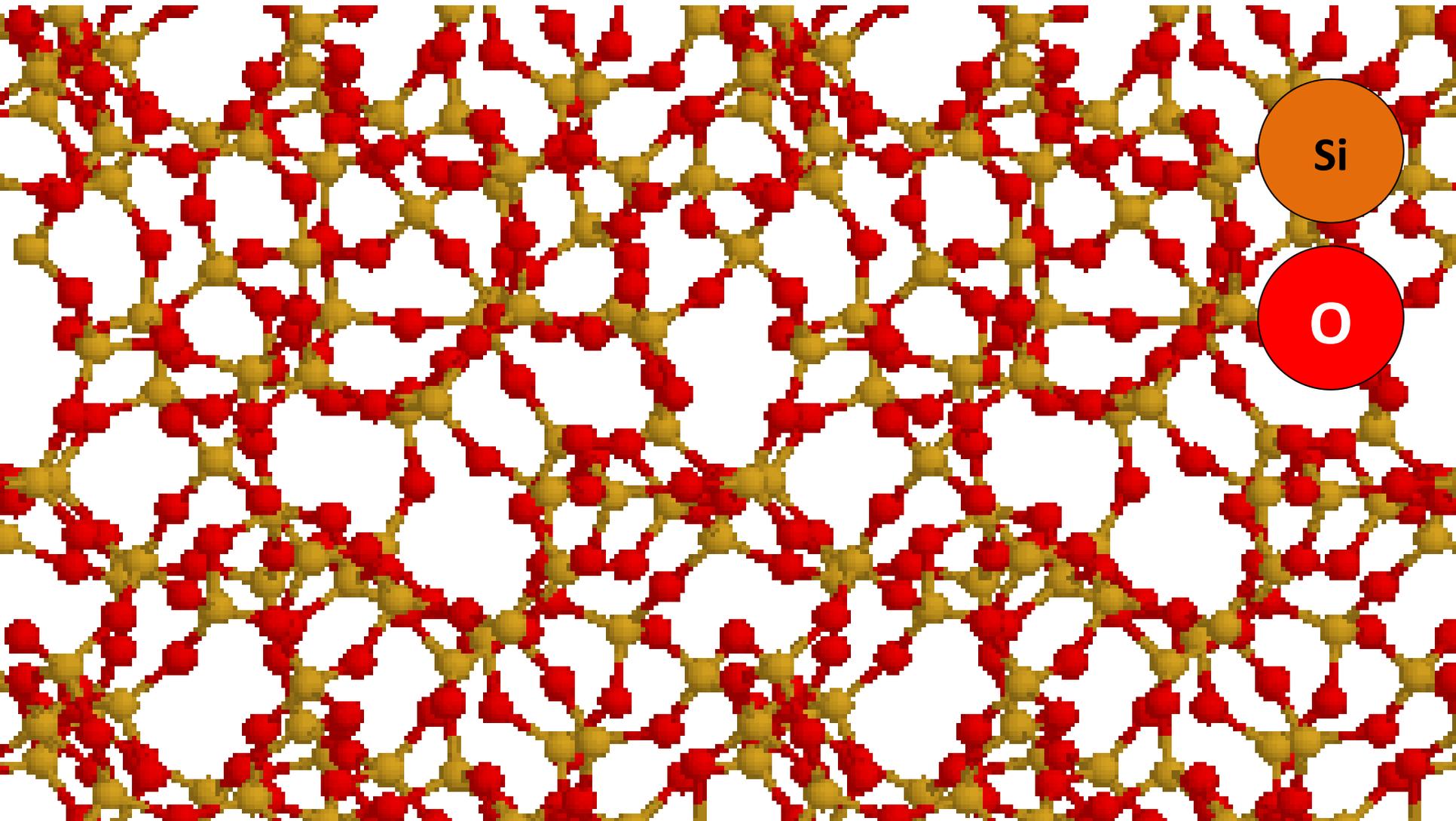
# COVALENT OXIDES (Molecular)

## Reaction with acid

- Covalent oxides do not react with acids

# COVALENT OXIDES ( $\text{SiO}_2$ ) – Structure

$\text{SiO}_2$



# COVALENT OXIDES ( $\text{SiO}_2$ )

## Reaction with water

### $\text{SiO}_2$ + water

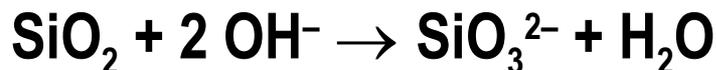
- $\text{SiO}_2$  is completely insoluble in water as it is giant covalent
- no reaction with water

# COVALENT OXIDES (SiO<sub>2</sub>)

## Reaction with alkali

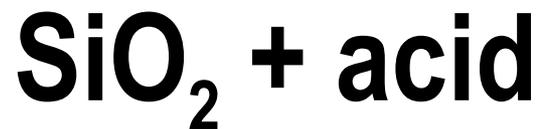
### SiO<sub>2</sub> + alkali (hot, conc)

- the Si atom is δ+
- the lone pair on the O of OH<sup>-</sup> attacks the δ+ Si atom
- this releases H<sub>2</sub>O plus SiO<sub>3</sub><sup>2-</sup>



# COVALENT OXIDES ( $\text{SiO}_2$ )

## Reaction with alkali



- Covalent oxides do not react with acids

# OVERVIEW

oxide	structure	water	acid	alkali	nature
Na <sub>2</sub> O	ionic	soluble <b>pH 14</b> O <sup>2-</sup> reacts to form OH <sup>-</sup> (O <sup>2-</sup> + H <sub>2</sub> O → 2OH <sup>-</sup> )	O <sup>2-</sup> reacts to form H <sub>2</sub> O (O <sup>2-</sup> + 2H <sup>+</sup> → H <sub>2</sub> O)	no reaction	basic
MgO	ionic	slightly soluble <b>pH 10</b> O <sup>2-</sup> reacts to form OH <sup>-</sup> (O <sup>2-</sup> + H <sub>2</sub> O → 2OH <sup>-</sup> )	O <sup>2-</sup> reacts to form H <sub>2</sub> O (O <sup>2-</sup> + 2H <sup>+</sup> → H <sub>2</sub> O)	no reaction	basic
Al <sub>2</sub> O <sub>3</sub>	ionic with covalent character	insoluble	O <sup>2-</sup> reacts to form H <sub>2</sub> O (O <sup>2-</sup> + 2H <sup>+</sup> → H <sub>2</sub> O)	reacts to form Al(H <sub>2</sub> O) <sub>4</sub> (OH) <sub>2</sub> <sup>-</sup>	amphoteric
SiO <sub>2</sub>	covalent (giant)	insoluble	no reaction	reacts to form SiO <sub>3</sub> <sup>2-</sup>	acidic
P <sub>4</sub> O <sub>10</sub>	covalent (molecular)	soluble <b>pH 0</b> H <sub>2</sub> O attacks δ+ P to form H <sup>+</sup> and PO <sub>4</sub> <sup>3-</sup> (H <sub>3</sub> PO <sub>4</sub> strong acid)	no reaction	reacts to form PO <sub>4</sub> <sup>3-</sup>	acidic
SO <sub>2</sub>	covalent (molecular)	soluble <b>pH 3</b> H <sub>2</sub> O attacks δ+ S to form H <sup>+</sup> and SO <sub>3</sub> <sup>2-</sup> (H <sub>2</sub> SO <sub>3</sub> weak acid)	no reaction	reacts to form SO <sub>3</sub> <sup>2-</sup>	acidic
SO <sub>3</sub>	covalent (molecular)	soluble <b>pH 0</b> H <sub>2</sub> O attacks δ+ S to form H <sup>+</sup> and SO <sub>4</sub> <sup>2-</sup> (H <sub>2</sub> SO <sub>4</sub> strong acid)	no reaction	reacts to form SO <sub>4</sub> <sup>2-</sup>	acidic