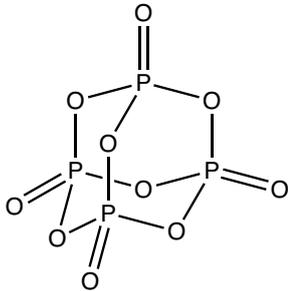
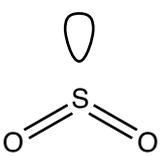
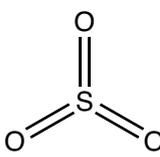
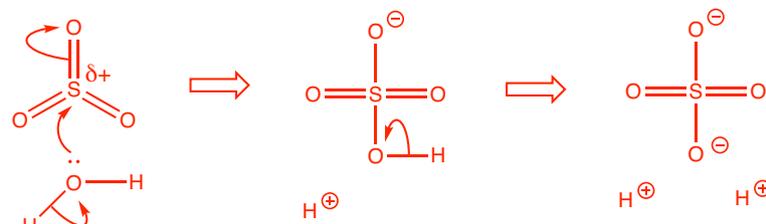
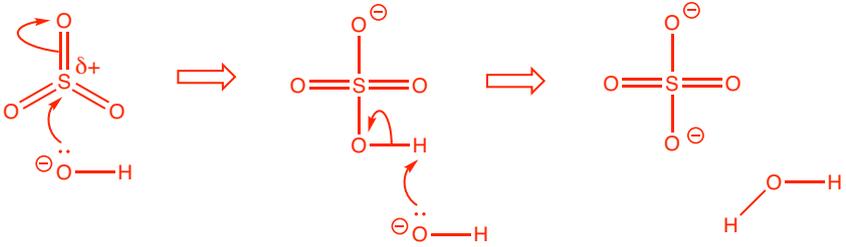


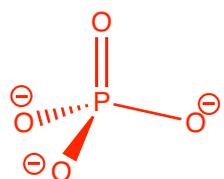
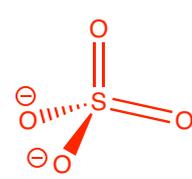
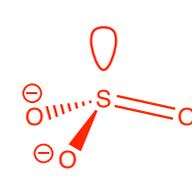


PERIOD 3 OXIDES

Ionic Oxides	
Which oxides are ionic?	Na ₂ O MgO Al ₂ O ₃
Comparing the strength of the ionic bonding (lattice enthalpies) and any covalent character	<p>From Na₂O to Al₂O₃</p> <ul style="list-style-type: none">the strength of ionic bonding increasesdue to the metal ions getting smaller and more positive (Na⁺, Mg²⁺, Al³⁺)so magnitude of lattice enthalpy increasesAl₂O₃ (while still ionic) has some covalent character due to the highly polarising nature of very small, highly charged Al³⁺
Comparing solubility	<p>Solubility decreases as the lattice enthalpy increases:</p> <p>Na₂O is very soluble MgO is slightly soluble Al₂O₃ is insoluble</p>
How ionic oxides react with water	<p>If the O²⁻ ion dissolves in water, it then reacts with water: O²⁻ + H₂O → 2 OH⁻</p> <p>Na₂O very soluble, so lots of NaOH formed with very alkaline pH 14-ish Na₂O + H₂O → 2 NaOH</p> <p>MgO slightly soluble, so little Mg(OH)₂ formed with slightly alkaline pH 10-ish MgO + H₂O → Mg(OH)₂</p> <p>Al₂O₃ insoluble</p>
How ionic oxides react with acid	<p>The O²⁻ ions are attacked by the H⁺: O²⁻ + 2 H⁺ → H₂O</p> <p>Na₂O Na₂O + 2 H⁺ → 2 Na⁺ + H₂O</p> <p>MgO MgO + 2 H⁺ → Mg²⁺ + H₂O</p> <p>Al₂O₃ Al₂O₃ + 6 H⁺ → 2 Al³⁺ + 3H₂O</p>
How ionic oxides react with alkali	<p>Ionic oxides do not normally react with alkali, but Al₂O₃ has some covalent character and covalent oxides do react with alkali.</p> <p>When Al³⁺ reacts with alkali, it forms [Al(H₂O)₄(OH)₂]⁻</p> <p>Al₂O₃ + 2 OH⁻ + 7 H₂O → 2 [Al(H₂O)₂(OH)₄]⁻</p>
Acid-base nature	<p>Na₂O & MgO react with acids, so basic</p> <p>Al₂O₃ react with acids and bases, so amphoteric (due to that covalent character)</p>
Example equations	<p>a) magnesium oxide + hydrochloric acid MgO + 2 HCl → MgCl₂ + H₂O</p> <p>b) aluminium oxide + nitric acid Al₂O₃ + 6 HNO₃ → 2 Al(NO₃)₃ + 3 H₂O</p> <p>c) aluminium oxide + potassium hydroxide Al₂O₃ + 2 KOH + 7 H₂O → 2 K[Al(H₂O)₂(OH)₄]</p> <p>d) sodium oxide + sulfuric acid Na₂O + H₂SO₄ → Na₂SO₄ + H₂O</p> <div style="border: 1px solid black; border-radius: 15px; padding: 10px; margin-top: 10px;"><p>TIP Start with the product - there must be 2 as there are 2 Al in Al₂O₃. If there are 2 of these on the right, we need 2 KOH to give 2 K There are 12 O on the right, so if we have 3 from Al₂O₃ and 2 from 2KOH then we need 7 more, so 7H₂O</p></div>

Covalent Oxides (simple molecular)

Which oxides are molecular?	P ₄ O ₁₀ phosphorus(V) oxide	SO ₂ sulfur(IV) oxide	SO ₃ sulfur(VI) oxide
	 <p style="text-align: center; color: red;">tetrahedral around each P</p>	 <p style="text-align: center; color: red;">bent (118°)</p>	 <p style="text-align: center; color: red;">trigonal planar (120°)</p>
How do molecular oxides react with water	<ul style="list-style-type: none"> • the P/S atom in each molecule is δ⁺ • the lone pair on the O of H₂O attacks the δ⁺ S/P atom • this releases H⁺ ions (from the H₂O) plus SO₃²⁻ (from SO₂) / SO₄²⁻ (from SO₃) / PO₄³⁻ from P₄O₁₀ <div style="text-align: center;">  <p style="text-align: center; color: red;"><i>simplified mechanism – you do not need to know this</i></p> <ul style="list-style-type: none"> ○ SO₂ + H₂O → H₂SO₃ (sulfuric(IV) acid – a weak acid, pH 3) ○ SO₃ + H₂O → H₂SO₄ (sulfuric(VI) acid – a strong acid, pH 0) ○ P₄O₁₀ + 6H₂O → 4H₃PO₄ (phosphoric acid – a strong acid, pH 0) </div>		
How do molecular oxides react with acids	<ul style="list-style-type: none"> • H⁺ does not attack these molecular oxides 		
How do molecular oxides react with alkalis	<ul style="list-style-type: none"> • the P/S atom in each molecule is δ⁺ • the lone pair on the O of OH⁻ attacks the δ⁺ S/P atom • this results in H₂O plus SO₃²⁻ (from SO₂) / SO₄²⁻ (from SO₃) / PO₄³⁻ from P₄O₁₀ <div style="text-align: center;">  <p style="text-align: center; color: red;"><i>simplified mechanism – you do not need to know this</i></p> <ul style="list-style-type: none"> ○ SO₂ + 2OH⁻ → SO₃²⁻ + H₂O ○ SO₃ + 2OH⁻ → SO₄²⁻ + H₂O ○ P₄O₁₀ + 12OH⁻ → 4PO₄³⁻ + 6H₂O <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-left: auto;"> <p style="margin: 0;">TIP 4 x PO₄³⁻ formed from the 4Ps in P₄O₁₀ 4 x PO₄³⁻ have 12- charge and so need 12 OH⁻; which has 12H to give 6H₂O</p> </div> </div>		

Structure of anions formed	PO ₄ ³⁻ phosphate(V)	SO ₃ ²⁻ sulfate(IV)	SO ₄ ²⁻ sulfate(VI)
	 <p>tetrahedral</p>	 <p>tetrahedral</p>	 <p>trigonal pyramidal</p>
Acid-base nature	Molecular oxides are acidic as they react with bases		
Example equations	<p>a) sulfur(VI) oxide + sodium hydroxide $SO_3 + 2 NaOH \rightarrow Na_2SO_4 + H_2O$</p> <p>b) phosphorus oxide + potassium hydroxide $P_4O_{10} + 12 KOH \rightarrow 4K_3PO_4 + 6 H_2O$</p> <p>c) sulfur(IV) oxide + barium hydroxide $SO_2 + Ba(OH)_2 \rightarrow BaSO_3 + H_2O$</p>		

Covalent Oxides (giant covalent)

Which oxides are giant covalent?	SiO ₂
How does it react with water	<ul style="list-style-type: none"> No reaction as completely insoluble
How does it react with acids	<ul style="list-style-type: none"> No reaction in common with other covalent oxides
How does it react with alkalis	<ul style="list-style-type: none"> Other covalent oxides do react with alkali. Difficult for SiO₂ to react due to the giant covalent structure. Does react with hot, concentrated alkali to form H₂O plus SiO₃²⁻ <ul style="list-style-type: none"> $SiO_2 + 2OH^- \rightarrow SiO_3^{2-} + H_2O$

Oxide	Structure	Reaction with water	Reaction with acid	Reaction with base	Nature of oxide
Na ₂ O	ionic	soluble pH 14 O ²⁻ reacts to form OH ⁻ (O ²⁻ + H ₂ O → 2OH ⁻) Na ₂ O + H ₂ O → 2NaOH	O ²⁻ reacts to form H ₂ O (O ²⁻ + 2H ⁺ → H ₂ O) Na ₂ O + 2H ⁺ → 2Na ⁺ + H ₂ O	no reaction	basic
MgO	ionic	slightly soluble pH 10 O ²⁻ reacts to form OH ⁻ (O ²⁻ + H ₂ O → 2OH ⁻) MgO + H ₂ O → Mg(OH) ₂	O ²⁻ reacts to form H ₂ O (O ²⁻ + 2H ⁺ → H ₂ O) MgO + 2H ⁺ → Mg ²⁺ + H ₂ O	no reaction	basic
Al ₂ O ₃	ionic with covalent character	insoluble	O ²⁻ reacts to form H ₂ O (O ²⁻ + 2H ⁺ → H ₂ O) Al ₂ O ₃ + 6H ⁺ → 2Al ³⁺ + 3H ₂ O	Al ₂ O ₃ reacts to form Al(H ₂ O) ₄ (OH) ₂ ⁻ Al ₂ O ₃ + 2 OH ⁻ + 7 H ₂ O → 2 [Al(H ₂ O) ₂ (OH) ₄] ⁻	amphoteric
SiO ₂	covalent (giant)	insoluble	no reaction	SiO ₂ reacts to form SiO ₃ ²⁻ SiO ₂ + 2OH ⁻ → SiO ₃ ²⁻ + H ₂ O	acidic
P ₄ O ₁₀	covalent (molecular)	soluble pH 0 H ₂ O attacks δ+ P to form H ⁺ and PO ₄ ³⁻ (H ₃ PO ₄ strong acid) P ₄ O ₁₀ + 6H ₂ O → 4H ₃ PO ₄	no reaction	P ₄ O ₁₀ reacts to form PO ₄ ³⁻ P ₄ O ₁₀ + 12OH ⁻ → 4PO ₄ ³⁻ + 6 H ₂ O	acidic
SO ₂	covalent (molecular)	soluble pH 3 H ₂ O attacks δ+ S to form H ⁺ and SO ₃ ²⁻ (H ₂ SO ₃ weak acid) SO ₂ + H ₂ O → H ₂ SO ₃	no reaction	SO ₂ reacts to form SO ₃ ²⁻ SO ₂ + 2OH ⁻ → SO ₃ ²⁻ + H ₂ O	acidic
		soluble pH 0			