Beckfoot

Subject: Chemistry	Topic: Period 3 Oxides 3.2.4	Year Group: 13

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Reactions of Na & Mg with water

1	**Na reacting with water** is significantly **more vigorous** than Mg reaction with water—sodium produces a **faster rate of effervescence** but Mg produces very few bubbles, Na **melts into a ball** (releases much more heat) whereas Mg remains the same. The pH of the NaOH solution formed is 12-14 whereas for Mg produces a mildly alkaline solution of pH 9-10.
2	**Explanations for the difference in reactions**: *one electron needs to be lost from sodium whereas 2 electrons need to be lost from Mg to ionise*. The **second ionisation energy is greater than the first ionisation energy** (more energy needed to lose the second electron). Mg forms a lower pH solution in water as magnesium hydroxide is less soluble in water so only a few hydroxide ions are produced.
3	**Equations:** $2\ Na + 2\ H_2O$ ————> $2\ NaOH + H_2$ $Mg + 2\ H_2O\ (l)$ ——-> $Mg(OH)_2 + H_2$
4	Magnesium reacts more vigorously with steam in the absence of air. The Mg burns with a bright white flame and a **white solid** is formed (magnesium oxide) $Mg + H_2O\ (g)$ ————-> $MgO + H_2$

Melting point (mpt) trends of oxides

1	**Na_2O, MgO, Al_2O_3** = metal oxide that have **IONIC** bonding and therefore **GIANT IONIC LATTICES**. Aluminium oxide has ionic bonding with some covalent character. The *many strong bonds between oppositely charged ions* means the mpt's are high for these oxides.
2	**Why has MgO got a higher mpt than Na_2O?** Mg forms a 2+ ion whereas Na forms a 1+ ion so the 2+ ion attracts the *oxide ion* more than the 1+ ion meaning that the ionic bonding is stronger
3	**Why has Al_2O_3 got a lower mpt than MgO?** The high charge density of the Al^{3+} ion distorts oxygen's electron cloud making the *bonds partially covalent*
4	**SiO_2** = non-metal oxide that has **COVALENT** bonding & a **GIANT COVALENT LATTICE** structure. As there are *many strong covalent bonds*, a lot of energy is needed to break them.
5	**P_4O_{10}, SO_2, SO_3** = Non-metal oxides that have **COVALENT** bonding and a **SIMPLE MOLECULAR** structure. They have *weak intermolecular forces between molecules* which require relatively less energy to break
6	**Why does P_4O_{10} have a higher mpt than SO_2 or SO_3?** P_4O_{10} is a *bigger molecule* so there are *stronger van der Waal's forces between molecules* which require more energy to break.

Key Vocabulary

1	Amphoteric	Having both acidic and basic properties. For example, aluminium oxide is an amphoteric oxide. It forms salts both with acids and with alkalis
2	Acid	A substance that donates protons in a reaction
3	Base	A substance that accepts protons in a reaction
4	Strong acid	An acid that dissociates fully in aqueous solution
5	Weak acid	An acid that does not dissociate fully in water
6	Trend	A repeating pattern in properties across a period

EXAM BULLET POINTS: Describe a test you could carry out in a test tube to distinguish between sodium oxide & the product of the reaction between phosphorus & an excess of oxygen [3]

1	Add water to each solid (to get a solution) [1]
2	Check the pH using a pH meter or Universal Indicator [1]
3	Na_2O gives a pH of 12-14 whereas P_4O_{10} will give a pH of 1-2 with a pH probe [1]
4	With Universal Indicator solution, Na_2O will give a blue colour and P_4O_{10} will give a red colour [1]

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The reaction of oxides with water

1	**Na_2O, MgO** = **ionic oxides** contain the **oxide ion,** O^{2-} so when they dissolve in water, the *oxide ion accepts protons* from the water molecules to **form hydroxide ions**. They form **ALKALINE SOLUTIONS**. **$O^{2-} + H_2O$ ——-> $2OH^-$**
2	Sodium oxide forms sodium hydroxide in water which is much more alkaline (pH 12-14) than the magnesium hydroxide (pH 9-10) that MgO forms. NaOH is *more soluble than MgO so produces **more hydroxide ions*** in solution and therefore a higher pH (**more alkaline**)
3	**P_4O_{10}, SO_2, SO_3** = **covalent oxides** form **ACIDIC SOLUTIONS**. They all form hydrogen ions in solution. P_4O_{10} forms phosphoric acid with a pH of 0-1; SO_2 forms sulphurous acid / sulfuric (IV) acid with a pH of 2-3 and SO_3 forms sulfuric (VI) acid with a pH of 0-1.
4	**SiO_2** = **Giant covalent structure** that is **INSOLUBLE** in water. We know it is an **ACIDIC OXIDE** because it reacts with **BASES** to form salts.
5	**Al_2O_3** = **Ionic with covalent bonding** and is **INSOLUBLE** in water. It is an **AMPHOTERIC OXIDE** because it can act as both an acid and a base. Hence, it can react with either an acid or base to make a salt.
6	**Equations:** $Na_2O + H_2O$ ———> $2\ NaOH$ $MgO + H_2O$ ———-> $Mg(OH)_2$ $P4O_{10} + 6\ H_2O$ —-> $4\ H_3PO_4$ $SO_2 + H_2O$ ——> H_2SO_3 $SO_3 + H_2O$ ———> H_2SO_4

Reactions of oxides with acids / bases

1	**General equation**	Acid + base ——-> Salt + Water
2	**Basic oxides such as Na_2O and MgO neutralise acids…**	$Na_2O + 2\ HCl$ ——-> 2 **NaCl** + H_2O $MgO + H_2SO_4$ ——-> **$MgSO_4$** + H_2O
3	**Acidic oxides such as SiO_2 and P_4O_{10} neutralise bases**	$SiO_2 + 2\ NaOH$ ——-> **Na_2SiO_3** + H_2O (sodium silicate = salt) $P_4O_{10} + 12\ NaOH$ ——-> **$4\ Na_3PO_4$** + $6\ H_2O$ (sodium phosphate salt) $SO_2 + 2\ NaOH$ ——-> **Na_2SO_3** + H_2O (sodium sulfite salt) $SO_3 + 2\ NaOH$ ——-> **Na_2SO_4** + H_2O (sodium sulfate salt)
4	**Amphoteric oxides (Al_2O_3) neutralises both acids and bases**	$Al_2O_3 + 3\ H_2SO_4$ ——> **$Al_2(SO_4)_3$** + $3\ H_2O$ (aluminium sulfate salt) $Al_2O_3 + 2\ NaOH + 3\ H_2O$ —> **$2\ NaAl(OH)_4$** (sodium aluminate)

EXAM BULLET POINTS: Explain why Na_2O & MgO form alkaline solutions in water but SO_2 & P_4O_{10} form acidic solutions? [2]

Sodium oxide & magnesium oxide are oxides of metals [1] whereas sulfur (IV) oxide and phosphorus (V) oxide are oxides of non-metals [1]

EXAM BULLET POINTS: Compare the reaction of sodium with water & magnesium with water in terms of observations. Give an explanation for the differences [4]

Na forms many more bubbles & much more quickly in water than Mg with water (more vigorous) [1]. Sodium forms a yellow flame but Mg does not [1]. Sodium releases so much heat that it melts into a ball but magnesium does not [1]. Sodium forms a solution of pH12-14 but magnesium forms a solution of pH 9-10 [1].The reaction with magnesium is less vigorous since Mg needs to lose 2 electrons per atom whereas Na only loses one [1]. Secondly, as Mg needs to lose a second electron, the second ionization energy is greater than the first [1]

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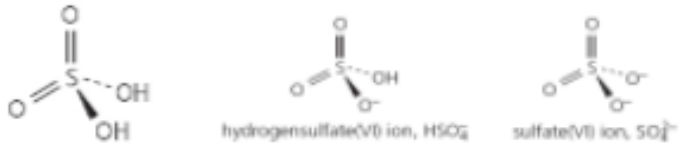
Reaction of elements with oxygen (usually to highest oxidation state except for sulfur)

Oxide Formula	Oxidation state	Extent of reaction	Flame colour	Equation
Na_2O	+1	Vigorous	Yellow	$4\,Na + O_2 \rightarrow 2\,Na_2O$
MgO	+2	Vigorous	White	$2\,Mg + O_2 \rightarrow 2\,MgO$
Al_2O_3	+3	Slow (faster if powdered)	White	$4\,Al + 3\,O_2 \rightarrow 2Al_2O_3$
SiO_2	+4	Slow	Bright yellow (purple hint)	$Si + O_2 \rightarrow SiO_2$
P_4O_{10}	+5	Spontaneously combusts	White	$P_4 + 5\,O_2 \rightarrow P_4O_{10}$
SO_2	+4	Burns steadily	Blue	$S + O_2 \rightarrow SO_2$

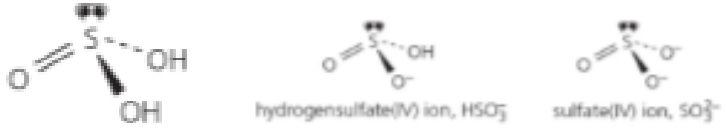
The structure of acids & anions: Sulfuric (IV) acid

Sulfuric (VI) acid (tetrahedral, bond angle 109.5°)



The structure of acids & anions: Sulfuric (IV) acid

Sulfuric (IV) acid / Sulfurous acid (pyramidal, 107.5°)



The structure of acids & anions: Phosphoric acid

Phosphoric acid is **tetrahedral with a bond angle of 109.5°**. The three hydrogen atoms are acidic as they are bonded to a highly electronegative oxygen atom & so can be donated as H^+ ions. The structure of the three anions are shown below—they are all tetrahedral with a bond angle of 109.5°.