CHEMISTRY

Acidic Environment Assignment

1. Table of non-metal oxides + classification of acidic /neutral :

Non-metal Oxides	Chemical Formula	Acidic / Neutral
Carbon Dioxide	CO2	Acidic
Nitrogen Dioxide	NO2	Acidic
Phosphorous Trioxide/ Diphosphorous Trioxide	P2O3	Acidic
Phosphorous Pentoxide/ Diphosphorous Pentoxide	P2O5	Acidic
Sulfur Trioxide	SO3	Acidic
Chlorine Dioxide	Cl2O	Acidic
Sulfur Dioxide	SO2	Acidic
Nitric Pentoxide / Dinitrogen Pentoxide	N_2O_5	Acidic
Nitric Trioxide Dinitrogen Trioxide	N_2O_3	Acidic
Arsenic Pentoxide	As_2O_5	Acidic
Selenium Dioxide	SeO_2	Acidic
Carbon Monoxide	CO	Neutral
Nitric Oxide	NO	Neutral
Nitrous Oxide	N2O	Neutral

2. **Basic oxides + equations:**

A basic oxide (metallic oxide) is one that

Reacts with acids to form salts (basic anhydrides)

$CuO_{(s)} + H_2SO_{4(aq)} \longrightarrow CuSO_{4(aq)} + H_2O_{(l)}$

(Formation of salt Copper Sulfate and water, by reaction of Copper Oxide and Sulfuric Acid)

$MgO_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2\,(aq)} + H_2O_{(l)}$

(Formation of the salt Magnesium Chloride and water by reaction of Magnesium oxide and Hydrochloric acid)

$Na_2O_{(s)} + H_2SO_{4\,(aq)} \longrightarrow Na_2SO_{4\,(aq)} + H_2O_{(l)}$

(Formation of salt Sodium sulphate and water by reaction of Sodium Oxide and Sulfuric Acid)

$Fe_2O_{3(s)} + 6HNO_{3\,(aq)} \longrightarrow 2Fe\,(NO_3)_{3(aq)} + 3H_2O_{(l)}$

(Formation of the salt Iron (III) nitrate and water by reaction of Iron (III) oxide and Nitric acid)

React with WATER to form bases *(Basic oxides are oxides of metals and if they are soluble in water, they react with water to produce hydroxides)*: **examples**

$Na_2O_{(s)} + H_2O_{(l)} \longrightarrow 2NaOH_{(aq)}$

(Formation of Sodium Hydroxide from Sodium oxide reacting with water)

$MgO_{(s)} + H_2O_{(l)} \longrightarrow Mg\,(OH)_{2\,(aq)}$

(Formation of Magnesium Hydroxide from Magnesium oxide reacting with water)

$CaO_{(s)} + H_2O_{(l)} \longrightarrow Ca(OH)_{2\,(aq)}$

(Formation of Calcium Hydroxide from Calcium oxide reacting with water)

$K_2O_{(s)} + H_2O_{(l)} \longrightarrow 2KOH_{(aq)}$

(Formation of Potassium Hydroxide from Potassium oxide reacting with water)

Does not react with alkali solutions (NaOH / KOH)

3. Conditions under which oxides of non-metals act as acids + chemical equations:

Oxides of non-metals which act as acids are known as **acidic oxides.** Conditions that allow these oxides of non-metals to act as acids are when they combine with water to produce acids; being soluble in water. Some non-metal oxides that act as acids are: **CO_2** (carbon dioxide), **SO_2** (sulfur dioxide), **NO_2** (nitrogen dioxide) and **P_2O_5** (phosphorus pentoxide), when these combine with water, they produce acids, **e.g.**

1. $SO_{2\,(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3\,(aq)}$ ***(sulfurous acid)***

   (Sulfur dioxide reacts with water to form *sulfurous acid)*

2. $2NO_{2\,(g)} + H_2O_{(l)} \longrightarrow HNO_{3\,(aq)} + HNO_{2\,(aq)}$ **(** ***Nitrous/ Nitric Acid)***

   (Nitrogen dioxide reacts with water to form a mixture of Nitrous and Nitric Acid)

3. $P_2O_{5\,(g)} + 3H_2O_{(l)} \longrightarrow 2H_3PO_{4\,(aq)}$ ***(phosphoric acid)***

   (Diphosphorous pentoxide reacts with water to form phosphoric acid)

4. $CO_{2\,(g)} + H_2O_{(l)} \longrightarrow H_2CO_{3\,(aq)}$ ***(carbonic acid)***

   (Carbon dioxide reacts with water to form carbonic acid)

(The exceptions are the neutral oxides include ***N_2O*** *(Dinitrogen oxide),* ***CO*** *(carbon monoxide) and* ***NO*** *(nitric oxide), they do not form acids.)*

4. (a) When and what is the Industrial revolution

The Industrial Revolution was a time of change in British History from 18th to 19th century. There were major changes in agriculture, mining, manufacturing, and transport. This largely affected the socio-economic and cultural circumstances of the United Kingdom. Like a domino effect, is spread through Europe, North America and eventually became a global phenomenon Advances in agricultural practices resulted with increased food supplies, domestic and foreign trade. It started in the late 18th century, where parts of Great Britain's earlier manual labour and draft-animal based industry/economy made a transition into machine-based manufacturing. There was a gradual expansion of iron-making techniques which required large amounts of refined coal, this also introduced steam power fuelled by coal and utilisation of powered machinery. Improvements in coal mining came in the form of improved tunnel ventilation, underground and surface transportation, and the use of gunpowder to blast away at the coal seams, and improved tunnel illumination through the use of safety lamps. This period of change experienced exponential increases of output in the manufacturing industry of the pre-electricity age and along with it, exponential increases in the emissions of nitrogen oxides, sulfur dioxide and carbon dioxide.

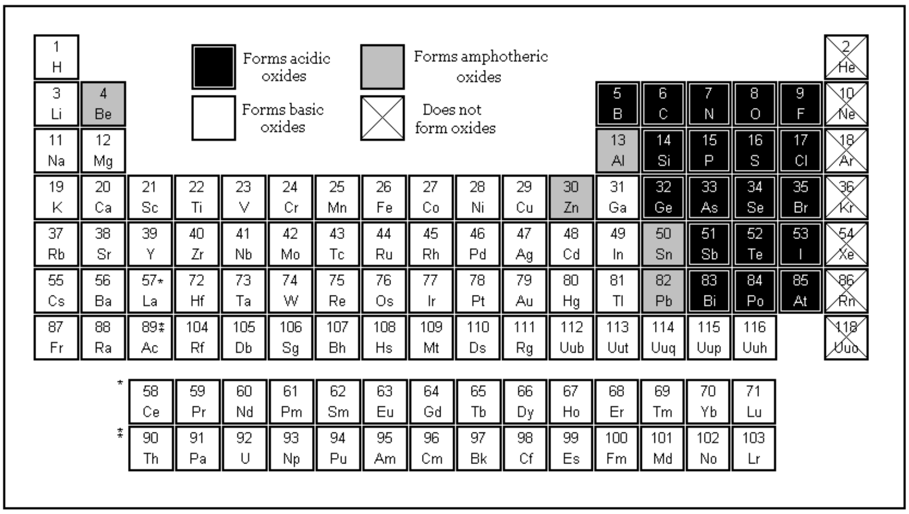
(b) Why there as an increase in acidic oxides in the air during Industrial revolution:

In the early 1800's after the Industrial revolution, there was a great increase in emissions of sulfur dioxide to the air in growing industrial cities; evidence for this is that the air quality of major industrial cities, such as London, deteriorated greatly which resulted from excessive coal burning and the extraction of metals to power transportation etc. Specifically, coal and crude oil were fossil fuels that contained sulfur in metallic sulphide ores and organic sulphides. Processes including the combustion of coal and refined petroleum products lead to the release of sulfur dioxide. Exhausts from new power stations also contained oxides of nitrogen that formed due to reaction between nitrogen and oxygen in the air that produce nitrogen monoxide/dioxide. When fossil fuels are burnt Oxides of nitrogen and Sulfur dioxide are released into the atmosphere which react with water vapour and oxidants in the atmosphere and is thus chemically transformed into sulfuric and nitric acids with sunlight (which increases the rate of most of the reactions) and oxygen. These gasses decreased the water pH to levels below 7 making it more acidic (acid rain).

(c) Oxides of noble gases

It is understood that noble gases were believed to be incapable of forming compounds due to their full valence shell of electrons that cause them to be chemically stable and un-reactive. However, this fact was over turned when in 1933, Linus Pauling predicted that heavier noble gases such as Xenon and Krypton were able to form compounds with fluorine and oxygen. In recent years, several compounds of noble gases, particularly xenon, have been prepared. Among these are the xenon fluorides (XeF_2, XeF_4, XeF_6), oxyfluorides ($XeOF_2$, $XeOF_4$, XeO_2F_2, XeO_3F_2, XeO_2F_4) and **oxides (XeO_3 and XeO_4).**

(d) Analysis of position of non-metals in Periodic table and generalisation about relationship between position of elements in the Periodic table and acidity/ basicity of oxides + amphoteric oxides.



In general, the trend in **oxide acidity** moves across the periodic table from **basic → amphorteric→ acidic.** It is evident from the table that the metallic oxides are basic whilst non-metallic oxides are acidic. From left to right across the period, oxide acidity goes from decreasingly basic to amphorteric to increasingly acidic. Group VIII usually forms no oxides due to their 0 valency. The acidity of the oxide of an element increases from left to right on the periodic table. Basic oxides become more basic moving down a group, acidic oxides become more acidic up a group. These trends could be explained in relation to the electronegativities (ability of an atom to attract electrons) of the elements in which oxygen is bonded. For example, in the third period the electronegativity of the elements increases gradually across the period from Sodium to Chloride. Therefore, as ionic bonding occurs between Sodium and Oxygen (sodium with low electronegativity/ Oxygen with high electronegativity), the electrons from the sodium atom are completely transferred to the oxygen atom to form Na^+ and O^{2-} ions. When the O^{2-} dissolve in water, it reacts to form a hydroxide ion (basic). Non-metallic oxides on the left could be explained with bonding of oxygen and sulfur. There is covalent bonding in SO_3 which is slightly polar, thus, when SO_3 is dissolved in water, the sulfur atom accepts a hydroxide ion as it is partially charged. This produces H^+ ions and HSO_4^- ions (found in sulfuric acid solution) --: acidic oxides. Amphorteric oxides are able to react with **both** H^+ and OH^- and found as oxides of elements located near the middle of the Periodic Table (transition metals).

They exhibit some properties of both metals/non-metals. Thus they have sufficient ionic character for their oxides to react with H^+ but also the ability to form covalent bonds to the O atoms of OH^- ions.

1. **$Na_2O + H_2O$ ---> $2NaOH$ (this is a metal oxide (base) reacting with water to form an alkali)**

2. **$SO_3 + H_2O$---- H_2SO_4 (non metal oxide (acidic) reacting with water to from acid)**

8. Natural and industrial sources of sulfur dioxide and oxides of nitrogen in table

Substance	Natural	Industrial	References
Sulfur Dioxide	Sulfur rich - Geothermal hot springs Volcanoes	Processing and burning fossil fuels Extracting metals from sulphide ores	Conquering Chemistry (HSC COURSE) –*Fourth Edition.* Author: Roland Smith Pages: 121- 123 Reprinted: 2005 Date Used: 17/11/09
Nitric Oxide	Similar to Nitrous Oxide, the source of nitric oxide is also lightning. At high temperatures produced by lightning, nitrogen gases and atmospheric oxygen combine to form nitric oxide.	At high temperatures within combustion chambers, nitrogen and oxygen in the air combine to form nitric oxide. (This slowly converts into Nitrous Oxide). Exhausts from power stations and vehicles also produce Nitric oxide.	Conquering Chemistry (HSC COURSE) –*Fourth Edition.* Author: Roland Smith Pages: 121- 123 Reprinted: 2005 Date Used: 17/11/09
Nitrogen Dioxide	First step is caused by a lightning stoke which is at a very high temperature. The lightning bolt causes oxygen and nitrogen in the air to react to form **nitric oxide.** The nitric oxide very quickly reacts with more oxygen to form **nitrogen dioxide.**	Released during the combustion of gasoline in transportation (cars / buses). Power stations also release large volumes of NO_2 into the atmosphere.	Conquering Chemistry (HSC COURSE) –*Fourth Edition.* Author: Roland Smith Pages: 121- 123 Reprinted: 2005 Date Used: 17/11/09
Nitrous Oxide	Formed by action of certain bacteria on nitrogenous material in the soil (on root nodules of legume plants)	Increase use of nitrogenous fertiliser that provides raw material for bacteria in Agriculture	Conquering Chemistry (HSC COURSE) –*Fourth Edition.* Author: Roland Smith Pages: 121- 123 Reprinted: 2005 Date Used: 17/11/09

9. **Examples of chemical reactions which release sulfur dioxide and chemical reaction which release oxides of nitrogen + equations**

Sulfur Dioxide:

1. Bacteria may decompose organic matter under certain conditions that produces hydrogen sulphide (H_2S). When Hydrogen sulphide is oxidised, sulfur dioxide is formed + water.

   $2H_2S_{(g)} + 3O_{2\,(g)} \longrightarrow 2SO_{2\,(g)} + 2H_2O_{(l)}$

2. Sulfur oxides released into the atmosphere result from the burning of fossil fuels in power stations and the smelting of sulphide ores.

   $S\ (\text{in fuel})_{(s)} + O_{2\,(g)} \longrightarrow SO_{2\,(g)}$

3. The extraction of metals from metal sulfides also releases sulfur dioxide. E.g. smelting of galena for lead + lead (II) oxide:

   $2PbS_{(s)} + 3O_{2\,(g)} \longrightarrow 2PbO_{(s)} + 2SO_2$

4. Roasting of zinc sulfide during the extraction of zinc produces sulfur dioxide + Zinc Oxide

   $2ZnS_{(s)} + 3O_{2\,(g)} \longrightarrow ZnO_{(s)} + 2SO_{2(g)}$

5. During the burning of fossil fuels such as coal, impurities of sulfur compounds remain. Thus, when the fuels are burnt, the sulfur (usually in the form of iron sulfide : FeS_2 in coal) is oxidised to produce SO_2

   $4FeS_{2(s)} + 11O_{2\,(g)} \longrightarrow 2Fe_2O_{3(s)} + 8SO_{2(g)}$

Oxides of Nitrogen:

1. Nitric oxide is produced when high temperature combustion environments (in the vicinity of lightning strike) Nitrogen, oxygen and high heat temperatures produces NO:

   $N_{2\,(g)} + O_{2\,(g)} \longrightarrow 2NO_{(g)}$

   The same reaction occurs in the high temperatures of engines or power plants, and vehicle engines. (Atmospheric Hydrogen and Oxygen)

2. Nitrogen dioxide is formed when nitric oxide reacts with oxygen in the air:

   $2NO_{(g)} + O_{2\,(g)} \longrightarrow 2NO_{2\,(g)}$

3. Nitrogen dioxide reacts with water, forming nitric acid

   $4NO_{(g)} + 3O_2 + 2H_2O_{(g)} \longrightarrow 4HNO_{3\,(g)}$