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Acidic Environment Notes

INDICATORS

2.1.2. identify data and choose resources to gather information about the colour changes of a range of indicators

Indicator Name	pH Range	Lower-range colour	Upper-range colour
Alizarine Yellow	10.2-12.0	Yellow	Red
Bromocresol Green	3.8-5.4	Yellow	Cyan
Methyl Red	4.4-6.2	Red	Yellow
Phenol Red	6.8-8.4	Yellow	Red
Thymol Blue	1.2-2.8	Red	Yellow

2.1.3 identify that indicators such as litmus, phenolphthalein, methyl orange and bromothymol blue can be used to determine the acidic or basic nature of a material over a range, and that the range is identified by change in indicator colour

Indicator Name	Range	Lower-range colour	Upper-range colour
Litmus	5.0- 8.0	Red	Blue
Phenolphthalein	8.3- 10.0	Colourless	Red
Methyl Orange	3.1- 4.4	Red	Yellow
Bromothymol Blue	6.0- 7.6	Yellow	Blue

An indicator is a substance which, in solution, changes colour depending on the pH of a substance.

However, indicators do not quantitatively measure a substance's pH by itself, as a change in colour only gives a loose guide as to the nature of the substance. Generally, an indicator will only show you if a substance is an acid or a base, but will not tell you how strongly acidic and basic the substance is.

An exception to this is universal indicator, which can be used to give a relatively accurate indication of a substance's nature.

An effective indicator is one that allows you to easily distinguish between an acid and a base. One that gradually changes (Large range) is not as useful as one with a noticeable point at which it changes (Small range).

<u>How indicators work</u>:

- An indicator is a solution containing a **weak acid** in equilibrium with its **conjugate base**:
$$HIn + H_2O \rightleftharpoons In^- + H_3O^+$$
- It has one colour (1) in acidic form (HIn) and colour 2 (In^-) in its conjugate base form.
- The colour will change depending on the concentration of H^+.

2.1.4 classify common substances as acidic, basic or neutral

Acids are substances which generally taste sour, and will corrode metal. Stronger concentrations of acid will also give a burning feeling upon contact. Acids can conduct electricity.

Examples of common substances which are acidic in nature include: Lemon juice, vinegar, formic acid from ant and bee stings, as well as common acids within the classroom such as carbonic, hydrochloric, and sulfuric acid.

Bases are often bitter tasting, and slippery to the touch. Like acid, stronger concentrations will often give a burning sensation if it comes into contact with skin. Bases also conduct electricity.

Examples of common substances which are basic in nature include: Ammonia, baking soda, soap, toothpaste, antacids, and various household detergents and cleaning solutions, as well as common bases within the classroom such as sodium hydroxide, potassium hydroxide, and calcium carbonate.

Examples of neutral substances include common table salt (NaCl) and pure water.

2.1.5 solve problems by applying information about the colour changes of indicators to classify some household substances as acidic, neutral or basic

An **acid** is a substance which, in solution, produces hydrogen ions, H^+ (or H_3O^+, hydronium ions).
A **base** is a substance which either contains the oxide O^{2-} or hydroxide ion OH^- or which in solution produces the hydroxide ion. Bases are usually metal hydroxides or metal oxides.

– A soluble base is an **alkali** (a subgroup of bases).

	Acidic	Basic	Neutral
Properties	• Sour taste; corrosive • In solution, acids conduct electricity. • Acids turn **blue** litmus **red**. • $pH < 7$	• Bitter taste; soapy feel • In solution, alkalis are good conductors of electricity. • Mainly insoluble in water (aqueous bases are alkalis). • Bases turn **red** litmus **blue**. • $pH > 7$	• $pH = 7$ • Neutral substances do not react with most metals and do not react with fats.
Examples	• vinegar (acetic acid) • vitamin C (ascorbic acid) • lemon juice (citric acid) • aspirin (salicylic acid) • 'fizzy' drinks (carbonic acid) • milk	• oven/drain cleaners (sodium hydroxide) • household cleaners (ammonia) • antacid tablets (calcium carbonate) • baking powder (sodium bicarbonate) • washing powder (sodium carbonate Na_2CO_3) • blood • sea water	• pure water • salt water • sugar

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2.1.6 identify and describe some everyday uses of indicators including the testing of soil acidity/basicity

Indicators find a wide variety of uses every day. Below is a list of some uses:

Soil- Different plants, flowers, fruits and vegetables require different levels of pH in order to thrive. In addition, environmentalists often monitor and record soil pH in different areas for various purposes. For example, hydrangeas grow purple flowers in acidic conditions and pink flowers in basic conditions. Monitoring pH is thus important if a specific colour is desired.

Soil pH is measured using electronic instruments or universal indicator.

If using indicator, the soil can hide any colour change, so neutral, white barium Sulfate is added to damp soil then indicator is added so that any colour change is visible.

Fish tanks- Different fish require different levels of pH (Although this range is quite narrow) in order to thrive. For freshwater fish the pH must be around NEUTRAL. Salt water fish survive under a pH of 8.5

Swimming pools- Swimming pools must be maintained at a pH a little higher than 7 for safety reasons. (Neutral, close to 7.4) to prevent skin irritation

- Sodium hypochlorite ($NaOCl$) is added to swimming pools to kill microbes. Hypochlorous acid ($HOCl$) is the active form, which kills microbes but is relatively unstable.

$$OCl^- + H_2O_{(l)} \rightarrow HOCl + OH^-$$

  - The presence of OH^- ions makes the water basic, so HCl is added to return to neutrality. This must be done to protect the eyes and throats of swimmers from becoming irritated.
- A pool test kit is used to test samples of the pool water, or pH paper soaked in indicator can be used.

Monitoring pH of chemical wastes

<u>Monitoring pH of chemical wastes</u>:

- The pH of the acidic wastes produced from laboratories must be neutralised before disposal.
- Indicators are used to measure pH, and substances added to neutralise it.

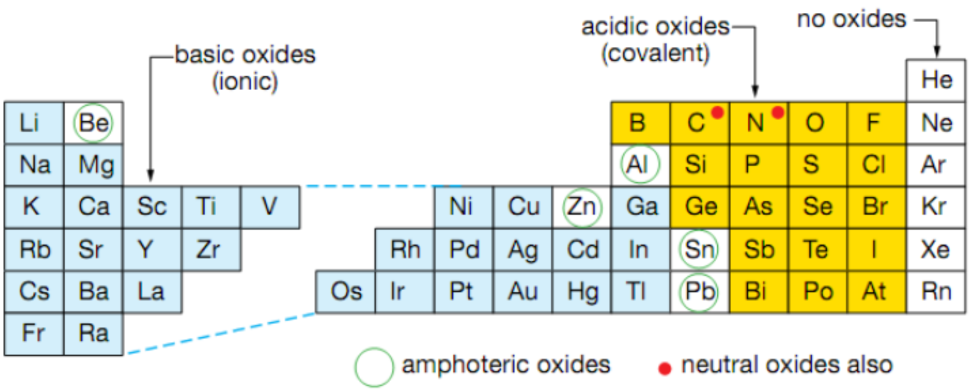
ACIDIC OXIDES AND THE ATMOSPHERE

2.2.1 Identify oxides of non-metals which act as acids and describe the conditions under which they act as acids

Most oxides of non-metals are acidic when in solution, except the neutral oxides of carbon monoxide, nitrogen monoxide and nitrous oxide (CO, NO and N2O respectively). Examples of acidic oxides include CO2 and NO2.

*Non-metal oxides are acidic in solution

2.2.2 Analyse the position of these non-metals in the Periodic Table and outline the relationship between position of elements in the Periodic Table and acidity/basicity of oxides



<u>Acidic oxides</u> (CO_2, SO_2, NO_2, P_2O_5)

- React with water to form acids:

$$CO_{2\,(g)} + H_2O_{(l)} \rightarrow H_2CO_{3\,(aq)}$$
$$P_2O_{5\,(s)} + 3H_2O_{(l)} \rightarrow 2H_3PO_{4\,(aq)}$$

- React with bases to form salts:

$$CO_{2\,(g)} + 2NaOH_{(aq)} \rightarrow H_2O_{(l)} + Na_2CO_{3\,(aq)}$$
$$P_2O_{5\,(s)} + 6NaOH_{(aq)} \rightarrow 3H_2O_{(l)} + 2Na_3PO_{4\,(aq)}$$

- **Acidic oxides** are generally oxides of **non-metals**. Noble gases have no oxides. They are all **covalent compounds** and occur towards the **right and top** of the Periodic table.

<u>Basic oxides</u> (CuO, Fe_2O_3)

- React with acids to form salts:

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

- Do NOT react with alkali solutions.
- **Basic oxides** are generally oxides of **metals**. They are *generally* **ionic compounds** and occur towards the **left** of the Periodic table.

Amphoteric oxides (ZnO, PbO, Al_2O_3, $Al(OH)_3$)

– **Amphoteric oxides** react with *both* strong **acids** and strong **bases** (i.e. display both acidic and basic properties). They are located on the **borderline** between metals and non-metals.
  - Aluminium hydroxide as a *basic* oxide:
$$Al(OH)_{3\,(s)} + 3H^+{}_{(aq)} \rightarrow Al^{3+}{}_{(aq)} + 3H_2O_{(l)}$$
  - Aluminium hydroxide as an *acidic* oxide:
$$Al(OH)_{3\,(s)} + OH^-{}_{(aq)} \rightarrow Al(OH)_4{}^-{}_{(aq)}$$
  - Aluminium(III) oxide as a *basic* oxide:
$$Al_2O_{3\,(s)} + 6H^+ \rightarrow 2Al^{3+} + 3H_2O_{(l)}$$
  - Aluminium(III) oxide as an *acidic* oxide:
$$Al_2O_{3\,(s)} + 2OH^- \rightarrow 2AlO_2{}^-{}_{(s)} + H_2O$$

Neutral oxides (CO, NO, N_2O)

– Do not react with either acids or bases.

2.2.3 Define Le Chatelier's principle

When a system at chemical equilibrium is disturbed, the system will shift in the direction to minimise the disturbance.

Characteristics of a system at equilibrium:

- It is a closed system (no matter or energy can enter or leave the system)
- Macroscopic properties will stay constant
- Concentrations of reactants and products stay constant but not necessarily equal
- Continual microscopic change occurs between reactants and products
- Rate of forward reaction is equal to the rate of reverse reaction (equilibrium is dynamic)
- A catalyst will increase the rate of a reversible reaction in both directions. It will make a system reach equilibrium faster, but will not change the concentration of substances at equilibrium or the equilibrium position

2.2.4 Identify factors which can affect the equilibrium in a reversible reaction

- Concentration
  - If a reactant or product is added to a solution or gas phase reaction mixture at equilibrium, then the equilibrium moves in the direction which consumes some of the added substances
- Pressure (only affects gases)
  - If the pressure on a reaction system is increased, the equilibrium moves in the direction which tends to reduce pressure. This is the direction which corresponds to a decrease in the no. of moles of gas (since a decrease in no. of moles of gas in a container of fixed volume leads to a decrease in pressure)
  - Note: If the no. of moles of gases of reactants is equal to the no. of moles of gases of products, then a change in pressure will not affect the position of equilibrium
- Temperature
  - If the temp. of a reaction mixture at equilibrium is increased, the equilibrium moves in the direction which absorbs heat (and thus minimises the applied temperature rise)

- Volume (think in terms of pressure; increase in volume = decrease in pressure)
- Addition of water
    - If water is added to change the total volume of a reaction mixture not involving gases, the equilibrium will shift to oppose the change
- Addition of reagent
    - If the addition of reagent reacts with a reactant or product, the equilibrium will shift to oppose the change

2.2.5 Describe the solubility of carbon dioxide in water under various conditions as an equilibrium process and explain in terms of Le Chatelier's principle

The carbon dioxide, water and carbonic acid system is made up of three equilibria:

1. The solution of carbon dioxide gas in water:
$$CO_{2\,(g)} \rightleftharpoons CO_{2\,(aq)}$$
2. The reaction of dissolved carbon dioxide with water:
$$H_2O_{(l)} + CO_{2\,(aq)} \rightleftharpoons H_2CO_{3\,(aq)} + heat$$
3. Carbonic acid behaves as an acid by releasing a hydrogen ion:
$$H_2CO_{3\,(aq)} \rightleftharpoons H^+{}_{(aq)} + HCO_3{}^-{}_{(aq)}$$

– Net Equation:
$$CO_{2\,(g)} + H_2O_{(l)} \rightleftharpoons H^+{}_{(aq)} + HCO_3{}^-{}_{(aq)}$$
$$CO_{2\,(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3\,(aq)} \;\; [\Delta H < 0]$$
  - An equilibrium shift to the left releases carbon dioxide gas.
  - An equilibrium shift to the right dissolves carbon dioxide gas.

When you have soft drink in a glass or open bottle, bubbles are rising in it. This is because the carbon dioxide gas is constantly escaping, thereby constantly favouring the backwards reaction in an attempt to minimise the disturbance to the system. In comparison, a closed bottle of soft drink has no bubbles unless shaken, because it is in equilibrium.

$$CO_{2\,(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3\,(aq)} + \text{Heat}$$

Using the above equilibrium as a practical example of Le Chatelier's principle:

- An increase in the concentration of $CO_{2\,(g)}$ will shift the equilibrium to the right, converting carbon dioxide and water into carbonic acid in order to reduce the concentration of carbon dioxide.
- An increase in pressure will shift the equilibrium to the right, converting carbon dioxide and water into carbonic acid in order to reduce the pressure.
- An increase in the volume of $CO_{2\,(g)}$ will shift the equilibrium to the right, converting carbon dioxide and water into carbonic acid in order to reduce the volume of carbon dioxide. Thus the system will attempt to counteract this change by favouring the backwards reaction.
- An increase in temperature will shift the equilibrium to the left, converting carbonic acid into carbon dioxide and water in order to reduce the temperature.

Note: Le Chatelier's Principle will ensure that the equilibrium is reached once gain. However, this new point of equilibrium will not be same as the original point of equilibrium, as the impact was only minimised, not completely reversed. Therefore, opened soft drinks will go "flat" irreversibly.

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2.2.6 Identify natural and industrial sources of Sulfur dioxide and oxides of nitrogen

Sulfur dioxide, or SO_2, is a colourless gas with a strong, suffocating odour. It dissolves easily in water.

Natural sources:

- Two-thirds of Sulfur dioxide (SO_2) are produced naturally by geothermal hot springs and volcanoes
- Natural decay of vegetation on land, in wetlands and in oceans

Industrial sources:

- Burning of fuels containing Sulfur, such as coal and oil
    - $S(s) + O_2(g) \rightarrow SO_2(g)$
- Extraction of metals from ores, e.g. extracting metals from sulphide ores (smelting)
    - $2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$
    - Note: Sulfur is combusted to completion (forward arrow)

At least ten different oxides of nitrogen (e.g. NO, N_2O, NO_2). The commonly used shorthand form NO_x symbolises a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2)

Natural sources:

- Nitrogen monoxide (NO) is produced by lightning, as the high localised temperatures created by lightning (over 1000 degrees) are sufficient to convert oxygen and nitrogen in the atmosphere to form nitrogen monoxide. Nitrogen monoxide then reacts slowly with oxygen to form nitrogen dioxide (NO_2)
    - $O_2(g) + N_2(g) \rightarrow 2NO(g)$

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

- Nitrous oxide (N_2O) is created naturally by the action of microorganisms on nitrogenous material in soils.

Industrial sources:

- Internal combustion engines reach the temperatures required to produce NO_x. The main source of NO_x is combustion of fossil fuels in motor vehicles
- Combustion of oil and coal at electrical power plants

NOTE: NO_2 is acidic, NO and N_2O are neutral