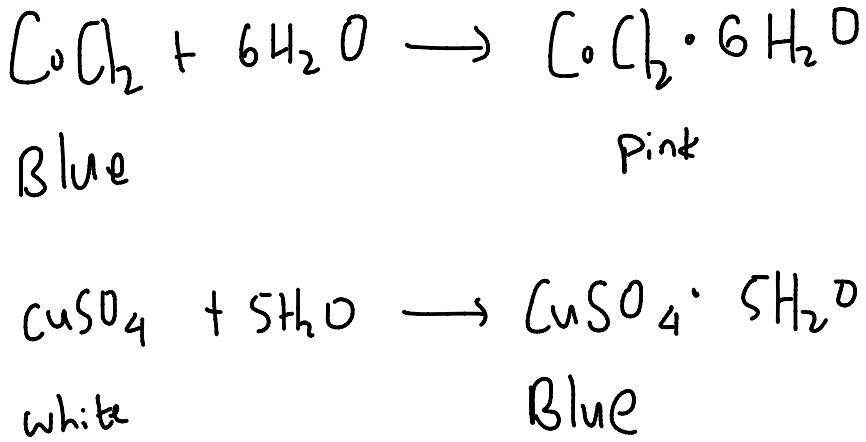
Air and Water

Wednesday, December 2, 2020 8:49 PM

11.1:
Water

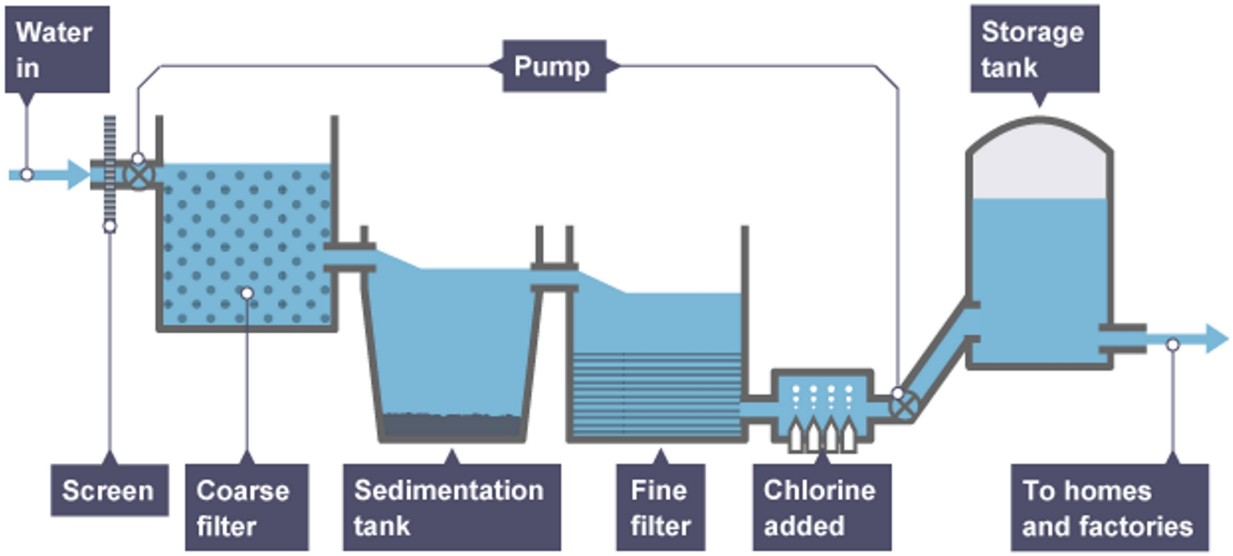
The presence of water can be either tested by $CuSO_4$ or $CoCl_2$.

When water is present,



Water is first treated before distributed.

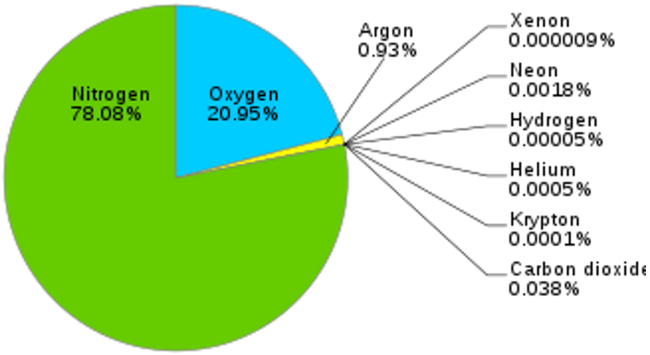
1) Screening --> Darkish color --> screening is done to remove large particles such as pebbles
2) Coagulation --> To add $Fe_2(SO_4)_3$ in order to coagulate smaller particles and settle down at the bottom
3) Aeration --> Air is blown upwards to bring the coagulated particles to the top which is then skimmed of
4) Filtration(1) --> Sand is used to remove small particles with size relative to sand itself
5) Filtration(2) --> Charcoal is used to remove even smaller particles as well to remove the odor of the water
6) Chlorination --> Chlorine is added to kill bacteria
7) Fluorination --> Fluorine is added to prevent tooth decay
8) Storage



(simplified version) https://www.bbc.co.uk/bitesize/guides/zvxvgdm/revision/3

Use of water in our daily lives is pretty obvious. In the industry, it is used a solvent (water is the universal solvent), as a coolant as well as well as washing.

11.2:
Air



https://en.wikipedia.org/wiki/Air_separation

Air can be separated into its individual components through fractional distillation.

1) Air is first cooled to -200 degrees Celsius. At 0 degrees, water freezes. At -78.5, CO_2 freezes. Hence, fractional distillation is not a suitable method to obtain CO_2
2) Do know that when water is cooled to this temperature, only N_2, O_2 and Ar are in liquid state. The rest are still gaseous. These 3 are the only gases extracted from the fractional distillation of liquified air
3) The gas is then heated slowly where nitrogen boils first than oxygen

Common pollutants:

1) CO
2) SO_2

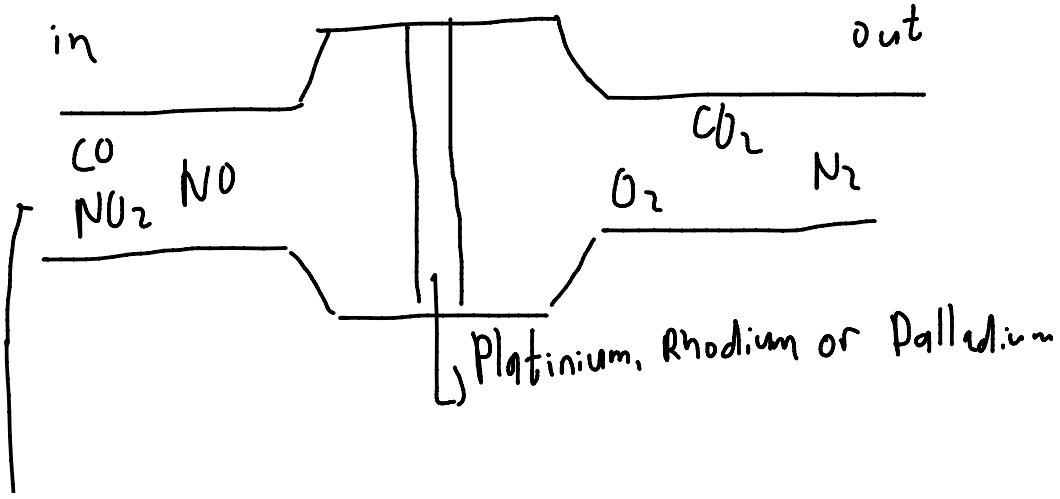
3) NO_2
4) NO
5) Lead compounds

Be able to differentiate pollutants from greenhouse gasses. CO_2 and CH_4 are greenhouse gasses and NOT pollutants.

Pollutants	Source(s)	Impact / significance
CO	Incomplete combustion of hydrocarbons	When breathed in, it will react with hemoglobin and cause suffocation and subsequently, death. (CO is also odorless which makes it that much more deadly)
SO_2	Burning fuel containing sulfur $S + O_2 \rightarrow SO_2$ $2SO_2 + O_2 \rightarrow 2SO_3$ $SO_3 + H_2O \rightarrow H_2SO_4$	Acid rain ; Corroding building made up of $CaCO_3$
NO_2 and NO	When nitrogen and oxygen react in combustion chamber under **high pressure and temperature** (Nitrogen is very unreactive. In RTP, it would not react with oxygen)	Acid rain, breathing problems, lung cancer
Lead compound	Burning of fuel containing lead	Retardation Harms the nervous system and causes brain damage

As we can see, most of these pollutants comes from cars. This is why cars are equipped with a **catalytic convertor** whos job is to covert these pollutants to less harmful products.

Catalytic convertor:



Global Warming	NO_x , CO_2 and CH_4
Acid rain	NO_x and SO_2
Photochemical smog	NO_x , CO and unburnt Hydrocarbons

$2NO_2 \longrightarrow N_2 + 2O_2$

$2NO \rightarrow N_2 + O_2$

Oxygen from the reduction of NOx i

$CO + \frac{1}{2}O_2 \longrightarrow CO_2$

Simplified overall reaction (IGSE does not prefer this compared to the step by step explanation above)

$2NO_2 + 4CO \rightarrow N_2 + 4CO_2$

Rust is mainly made up of Fe_2O_3. Rust is formed under the presence of oxygen and moisture(water). There are 3 methods of preventing rusting:

1) Painting --> Painting the layer of iron prevents oxygen for coming in contact with the iron itself
2) Sacrificial coating --> This is often used in ships and oil rigs where a **metal more reactive than iron is attached to it**. Let us say magnesium

$Mg \longrightarrow Mg^{2+} + 2e$

Since iron needs to oxidize to rust, if magnesium is there, magnesium oxidizes instead of iron as it is more reactive. This electrons is then transferred to iron and therefore, iron cannot lose electrons (hence cannot oxidize)

3) Galvanizing --> A more reactive metal is coated. Common example is zinc. Galvanizing is a combination of method 1 and 2. it acts as a barrier to prevent oxygen from coming in contact. However, even if oxygen comes in contact due to damaged coating, iron will not rust as per method 2

11.3:
Nitrogen and Fertilizers

Fertilizers are often made up of NPK --> Nitrogen, Phosphorus and Potassium

Along the same lines, ammonia, which is a weak base, can be displaced by a strong base.

$$NaOH + NH_4Cl \rightarrow NaCl + H_2O + NH_3$$

Haber process: An industrial process to obtain ammonia.

$$N_{2(g)} + 3H_{2(g)} \longrightarrow 2NH_{3(g)} \quad \Delta H(-)$$

300°C → 450°C
200 atm
Finely divided iron

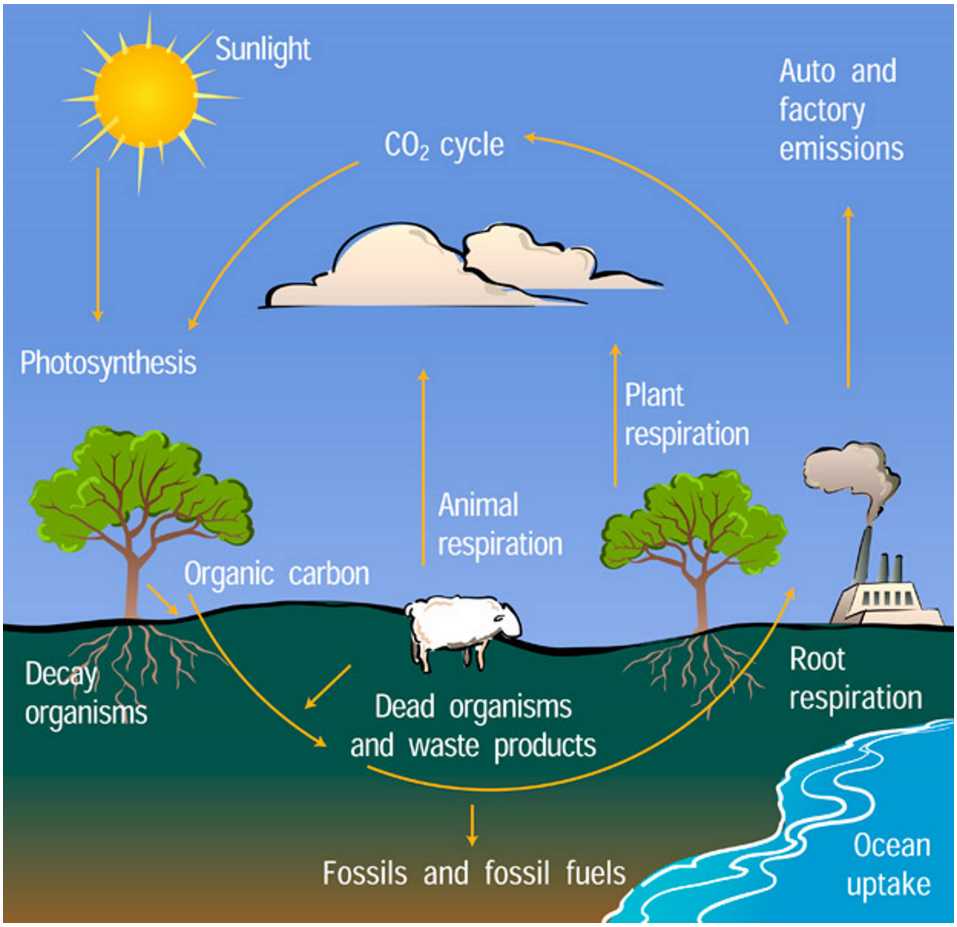
Nitrogen is obtained from the fractional distillation of liquified air. Hydrogen can be obtained from cracking of long-chained hydrocarbons.

11.4:
Carbon dioxide and Methane

Carbon dioxide and methane are examples of greenhouse gasses. An excess amount of these gasses contribute to global warming.

Carbon dioxide is a side product of:

1) Respiration
2) Complete combustion
3) Reaction between acid and metal carbonates
4) Thermal decomposition of metal carbonates



https://scied.ucar.edu/carbon-cycle

On the other hand, methane is formed due to decomposition of vegetation as well as waste gases from digestion in animals.

Exam tips:

1) Memorize the Haber process and understand why those conditions are used(tradeoff between yield and rate of reaction)
2) Understand the difference between pollutants and greenhouse gasses
3) Know the reactions behind the catalytic convertor
4) Understand the methods of preventing rust
5) Understand the industrial methods of obtaining raw materials such as that of hydrogen, nitrogen and oxygen

Sulfates and Carbonates

Saturday, December 5, 2020 10:15 AM

12 & 13:
Sulfur and Carbonates

Sulfur:
Sulfur is widely used in the manufacturing industry. It is most commonly used to produce sulfuric acid.

Sulfur can be found near native volcanoes as well as crude oil, natural gas and metal sulfides.

In the previous chapter, we understood that ammonia was produced from the Haber process. Here, in one of the steps to produce sulfuric acid, Contact process undergoes.

Production of sulfuric acid:

1) $S + O_2 \rightarrow SO_2$ (sulfur is burnt in the presence of excess oxygen)
2) $2SO_2 + O_2 \rightleftharpoons 2SO_3$ (Contact process)
   Temperature = 450 degrees Celsius
   Pressure = 1 - 2 atm
   Catalyst = V_2O_5
3) $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$
   Although sulfur trioxide can be directly mixed with water to form sulfuric acid, this will produce an uncontrollable fog of sulfuric acid. Here, sulfur trioxide is first added to sulfuric acid to form oleum.
4) $H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$

Sulfuric acid is used in the production of shampoos as well as paint pigments. Sulfur dioxide is used as a food preservative and is used to bleach wood pulp for making paper.

Carbonates:

Calcium carbonate is very abundant in planet Earth. It is otherwise known as limestone. From limestone itself, we can produce other industrial chemicals mainly lime(CaO) and slaked lime($Ca(OH)_2$).

$CaCO_3 \rightarrow CaO + CO_2$ (Thermal decomposition)

$CaO + H_2O \rightarrow Ca(OH)_2$

Use	Compound	How is it used?
Treating acidic soils	CaO or $Ca(OH)_2$ Weaknesses of both have been discussed in Acid and Base chapter	Powder is sprinkled on top of soil
Flue gas desulfurization	CaO or $Ca(OH)_2$	React with sulfur compounds such as SO_2 in flue gases to form $CaSO_3$
Manufacture of iron	$CaCO_3$	$CaCO_3$ is broken down to CaO due to high temperatures. CaO reacts with SiO_2 to form slag
Manufacture of cement	$CaCO_3$	Limestone is heated with clay and then, $CaSO_4$ is added