GLOBAL WARMING

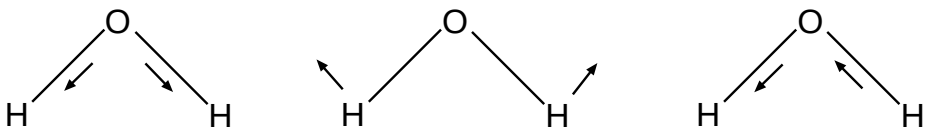
Greenhouse gases	CARBON DIOXIDE	CO_2	contains	C=O bonds
	WATER VAPOUR	H_2O	contains	O-H bonds
	METHANE	CH_4	contains	C-H bonds

The 'Greenhouse Effect' of a given gas is dependent on its...

- **atmospheric concentration**
- **ability to absorb infrared radiation**

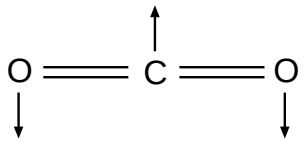
Introduction Different covalent bonds have different strengths due to the masses of different atoms at either end of the bond. As a result, they vibrate at different frequencies (imagine two balls on either end of a spring) . The frequency of vibration can be found by detecting when the molecules absorb electro-magnetic radiation.

Various types of vibration are possible. **Bending** and **stretching** are two examples and are found in water molecules. Each occurs at a different frequency.



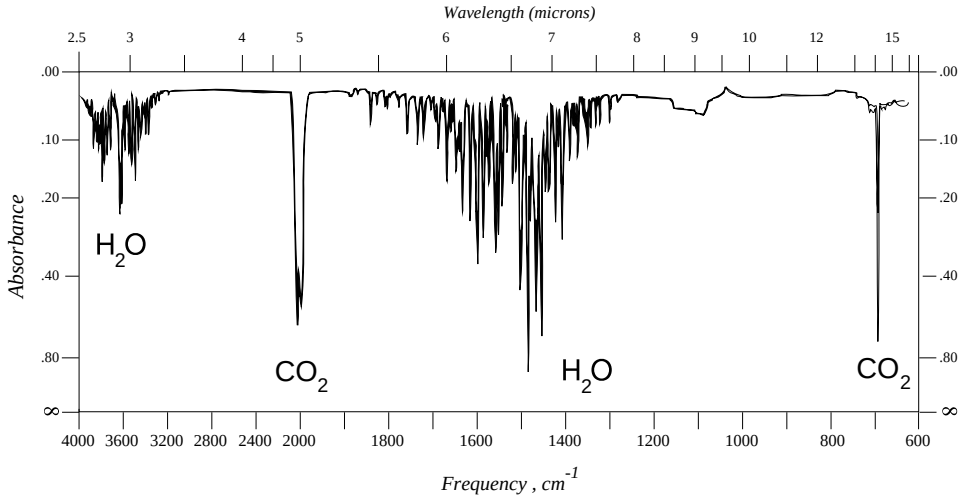
Symmetric stretching | Bending | Asymmetric stretching

Bending in a carbon dioxide molecule



The frequencies lie in the INFRA RED part of the electromagnetic spectrum and can be detected using **infra red spectroscopy**.

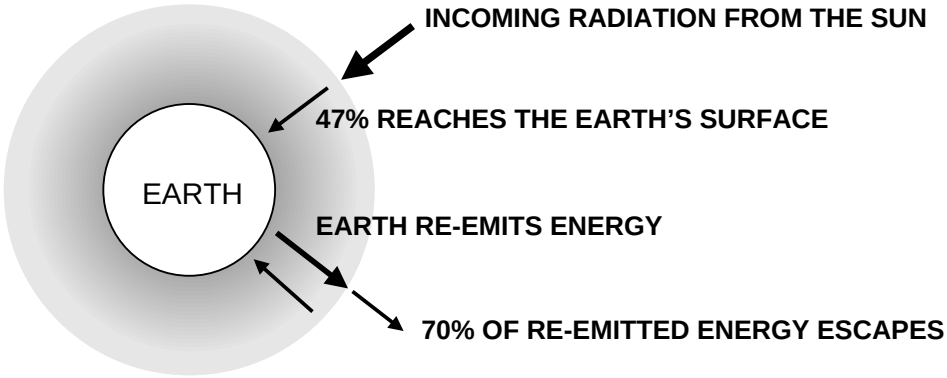
An infra red spectrum of atmospheric air



It is the absorption of infra red radiation by atmospheric gases such as methane, carbon dioxide and water vapour that contributes to global warming.

THE GREENHOUSE EFFECT

Process



- incoming energy from the sun is in the ultra violet, visible and infra red regions
- the earth is warmed up by the energy
- radiation re-emitted from the earth is in the infra red region
- 70% of the radiation (between 7000nm and 12500nm) returns to space
- greenhouse gases absorb the remainder

Gas	*wavelength of radiation adsorbed / nm*
CO_2	**12500 - 17000**
H_2O	**4500 - 7000** and **above 17000**

- they can return this energy to earth to keep it warm

Problems An increase in the concentration of greenhouse gases leads to **global warming**

Possible Effects

-
-
-
-
-
-
-
-

Answers What can chemists do to minimise climate change from global warming?

- provide scientific evidence to governments to confirm warming is taking place
- monitor progress against initiatives such as the Kyoto protocol
- investigate solutions to environmental problems

CCS **Carbon Capture and Storage**

Waste CO_2 is...
- injected as a liquid deep into the oceans
- stored in deep geological formations
- reacted with metal oxides to form carbonate minerals

$MgO + CO_2 \longrightarrow MgCO_3$ (or CaO)

DEPLETION OF THE OZONE LAYER

OZONE Although ozone is a reactive and poisonous gas, it protects us from harmful UV radiation which would affect life on earth. UV radiation can cause skin cancer.

Ozone in the stratosphere breaks down naturally $2O_3 \longrightarrow 3O_2$

Ozone (trioxygen) can break up to give ordinary oxygen and an oxygen radical $O_3 \longrightarrow O\bullet + O_2$

Ultra violet light can supply the energy for the process.
That is why the ozone layer is important as it protects us from the harmful rays.

BUT The breakdown is easier in the presence of chlorofluorcarbons (CFC's)

CFC's There is a series of complex reactions but the basic process is :-

- *CFC's break down in the presence of UV light to form chlorine radicals* $CCl_2F_2 \longrightarrow Cl\bullet + \bullet CClF_2$
- *chlorine radicals react with ozone* $O_3 + Cl\bullet \longrightarrow ClO\bullet + O_2$
- *chlorine radicals are regenerated* $ClO\bullet + O \longrightarrow O_2 + Cl\bullet$

Overall, chlorine radicals are not used up so a small amount of CFC's can destroy thousands of ozone molecules before the termination stage.

NOx Oxides of nitrogen, NOx, formed during **thunderstorms** or by **aircraft** break down to give NO (nitrogen monoxide) which also catalyses the breakdown of ozone.

- *nitrogen monoxide reacts with ozone* $O_3 + NO \longrightarrow NO_2 + O_2$
- *nitrogen monoxide is regenerated* $NO_2 + O \longrightarrow O_2 + NO$

Q.1 *CFC's were developed by chemists for specific purposes. What uses were they put to?*

-
-
-
-

POLLUTANT GASES FROM INTERNAL COMBUSTION ENGINES

Carbon monoxide CO

Origin
- incomplete combustion of hydrocarbons in petrol because of insufficient oxygen

Effect
- poisonous
- combines with haemoglobin in blood
- prevents oxygen being carried

Oxides of nitrogen NO_x (NO, N_2O and NO_2)

Origin
- combination of atmospheric nitrogen and oxygen under high temperature

eg $\mathbf{N_2}(g) + \mathbf{O_2}(g) \longrightarrow \mathbf{2NO}(g)$

Effect
- aids formation of **photochemical smog** which is irritating to eyes, nose, throat
- aids formation of **low level ozone** which affects plant growth and is irritating to eyes, nose and throat

i) sunlight breaks down NO_2 $\quad \mathbf{NO_2 \longrightarrow NO + O}$

ii) ozone is produced $\quad \mathbf{O + O_2 \longrightarrow O_3}$

Hydrocarbons C_xH_y

Origin
- hydrocarbons that have not undergone combustion

Effect
- toxic and carcinogenic (cause cancer)

EQUATIONS FOR POLLUTION FORMATION

Nitrogen combines with oxygen	$N_2(g) + O_2(g) \longrightarrow 2NO(g)$
Nitrogen monoxide is oxidised	$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$
Incomplete hydrocarbon combustion	$C_8H_{18}(g) + 8½O_2(g) \longrightarrow 8CO(g) + 9H_2O(l)$

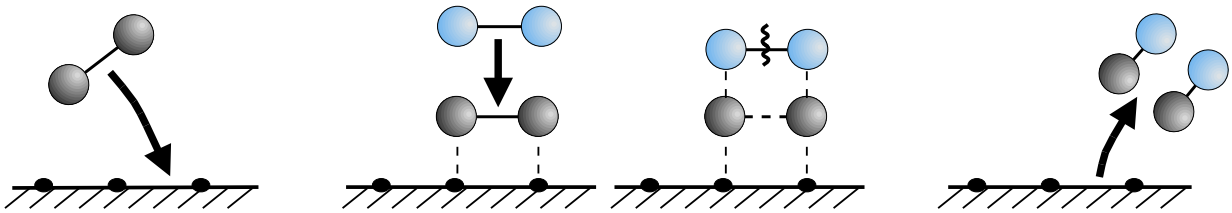
EQUATIONS FOR POLLUTION REMOVAL

Oxidation of carbon monoxide	$2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$
Removal of NO and CO	$\mathbf{2CO(g) + 2NO(g) \longrightarrow N_2(g) + 2CO_2(g)}$
Aiding complete H/C combustion	$C_8H_{18}(g) + 12½O_2(g) \longrightarrow 8CO_2(g) + 9H_2O(l)$

CATALYTIC CONVERTERS

Operation

- CO is converted to CO_2
- NO_x are converted to N_2 **$2NO(g) + 2CO(g) \longrightarrow N_2(g) + 2CO_2(g)$**
- Unburnt hydrocarbons converted to CO_2 and H_2O **$C_8H_{18}(g) + 12½O_2(g) \longrightarrow 8CO_2(g) + 9H_2O(l)$**
- catalysts are rare metals - **RHODIUM**, **PALLADIUM**
- metals are **finely divided** for a **greater surface area** - **more active sites**



Stages

Adsorption
- NO and CO seek out active sites on the catalyst surface
- they bonds with surface weakens the bonds in the gas molecules
- this makes a subsequent reaction easier

Reaction
- being held on the surface increases chance of favourable collisions
- bonds break and re-arrange

Desorption
- the products N_2 and CO_2 are then released from the active sites

Q.2 *Using leaded petrol was not a good idea if a catalytic converter was fitted. Why?*

What was done to stop motorists putting leaded petrol in cars with catalytic converters?