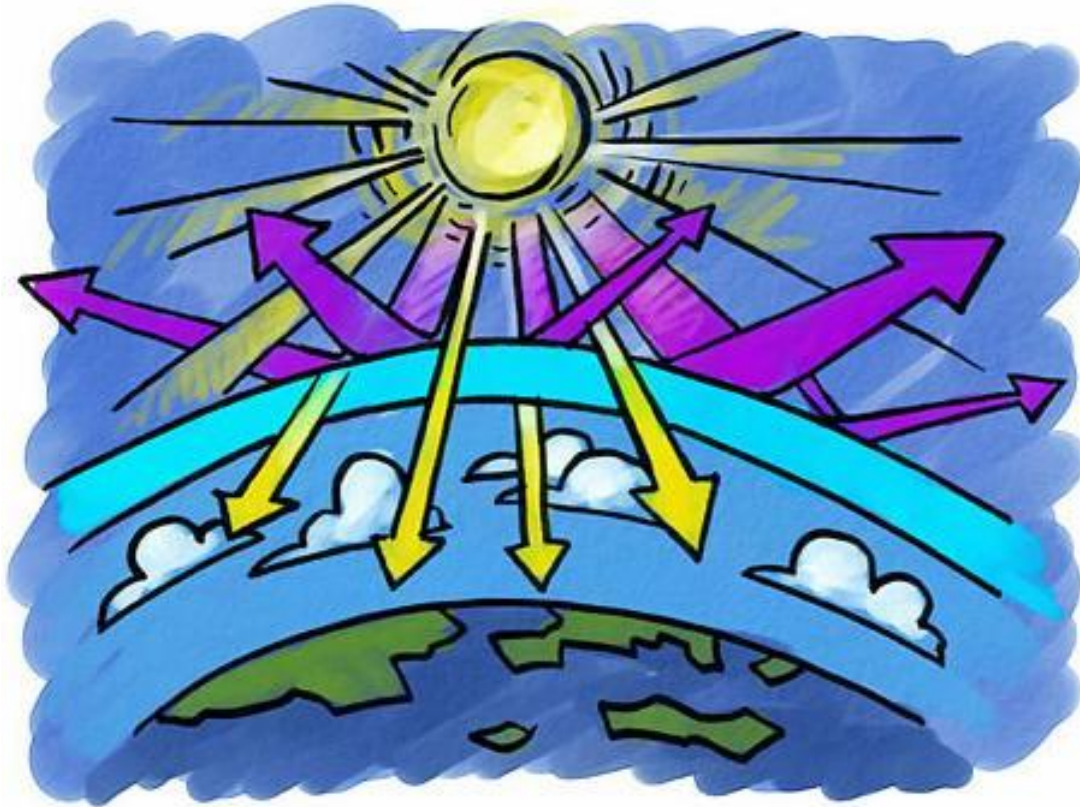


Ozone: toxic but good!... Why so?



Stratospheric Ozone

ESS 2017



Learning Objectives

I will be able to...

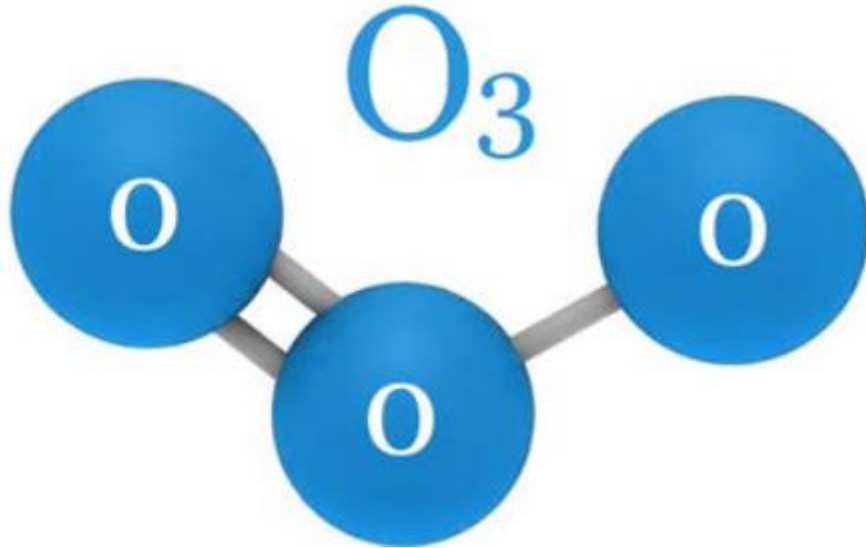
Explain the dynamic equilibrium of ozone

Describe the importance of ozone

Outline the ways in which ozone is depleted

Evaluate the role of national and international organizations in reducing the emissions of ozone-depleting substances.

What is Ozone?

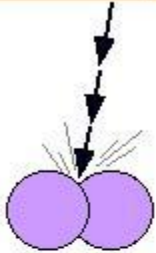


Ozone: Dynamic Equilibrium

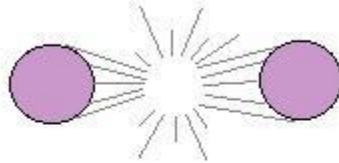
Explain what dynamic equilibrium means as simply as possible.

Dynamic Equilibrium: Ozone formation

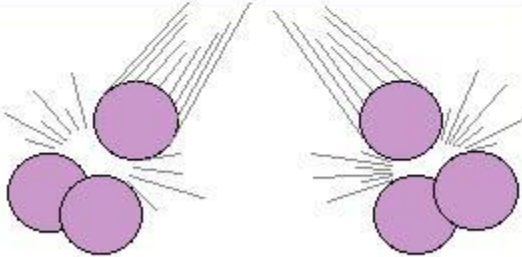
OZONE PRODUCTION IN THE STRATOSPHERE



High energy ultraviolet radiation strikes an oxygen molecule. . .



. . . and causes it to split into two free oxygen atoms.



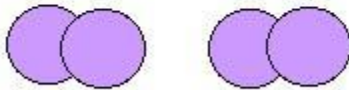
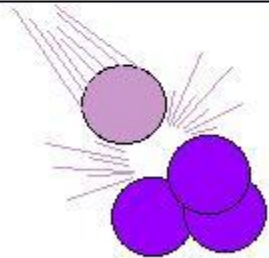
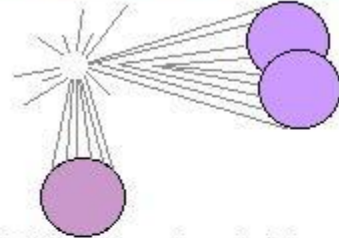
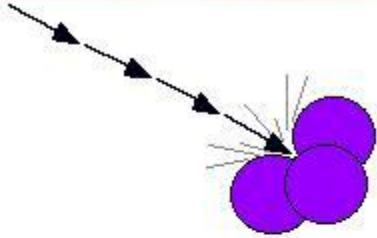
The free oxygen atoms collide with molecules of oxygen. . .



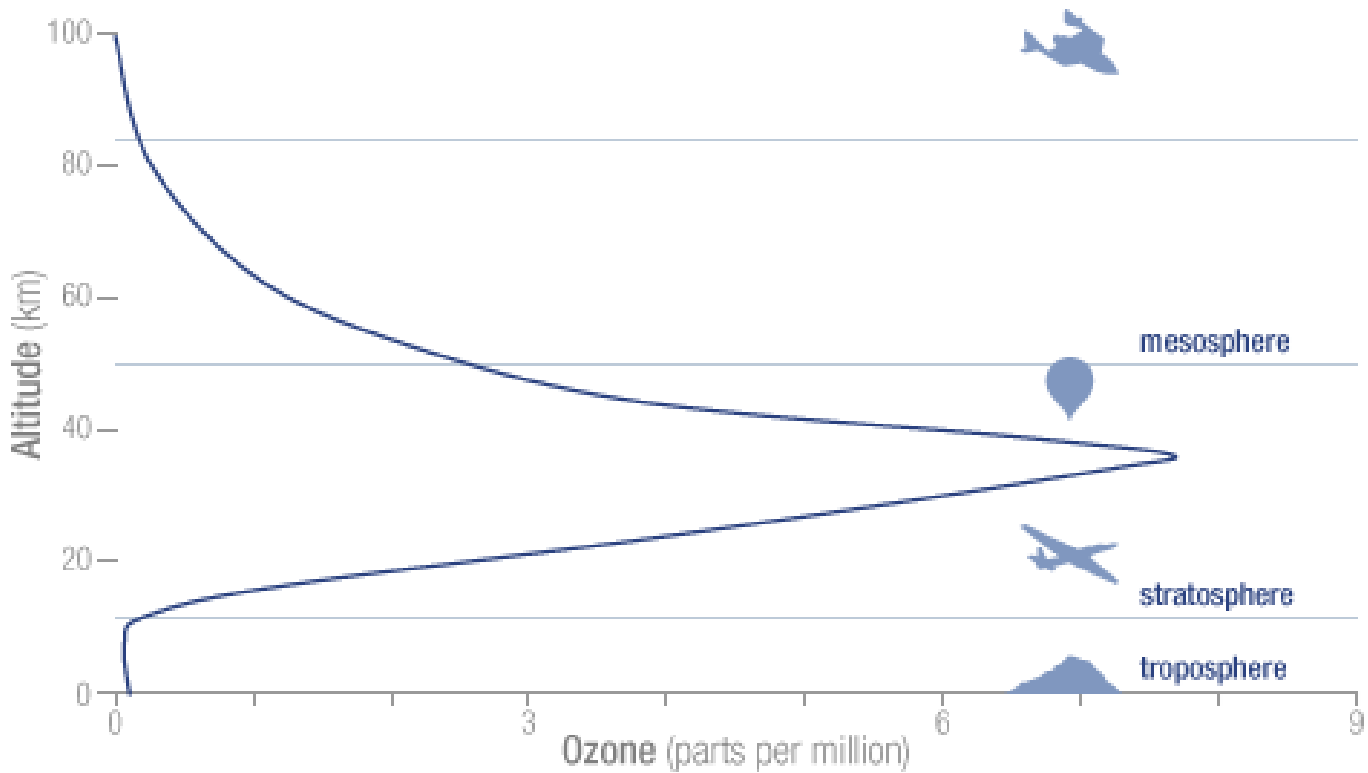
. . . to form ozone molecules.

Dynamic Equilibrium: Ozone destruction

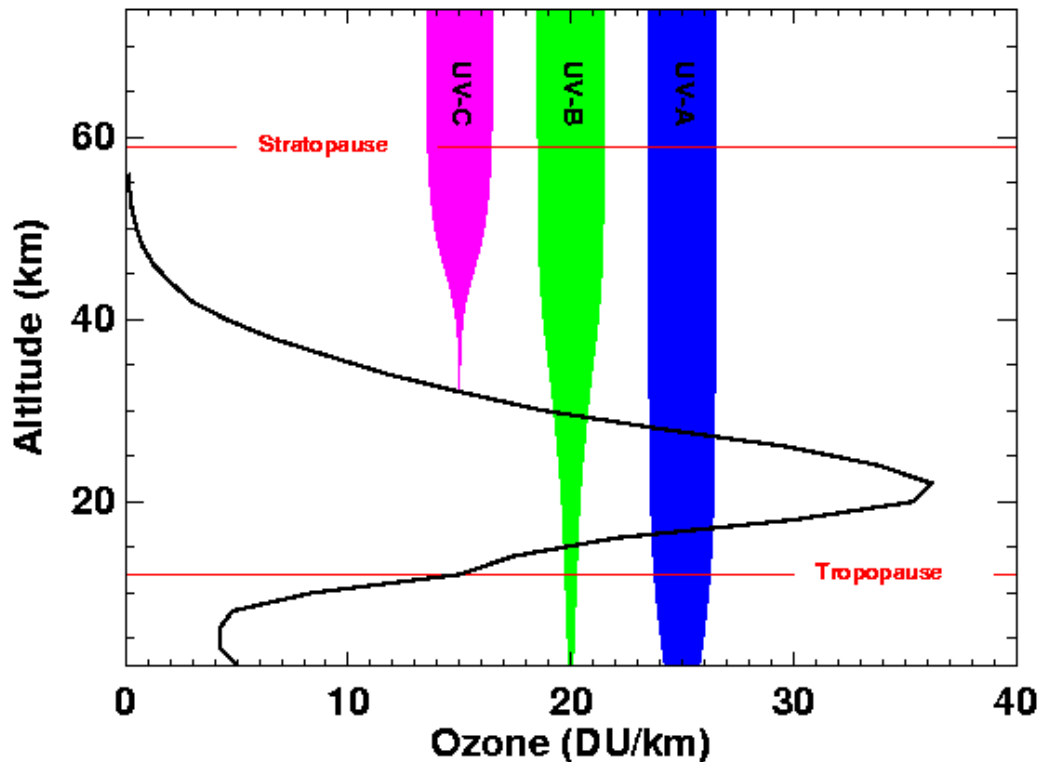
THE CHAPMAN PROCESS OF OZONE DESTRUCTION



Ozone Concentration



Ozone Importance



Protects life from damaging effects of Ultraviolet (UV)

radiation:

UV-A = longest UV wavelength, less energy, relatively harmless

UV-B = medium UV wavelength, dangerous (50% absorbed)

UV-C = shortest UV wavelength, high energy, dangerous (99% absorbed)

Ozone Importance

UV-B and UV-C are dangerous:

- Genetic mutations → ill-health e.g. cancer
- Abnormal cell division → cancer
- Damage photosynthetic organisms e.g. phytoplankton, and primary consumers e.g. zooplankton → food webs collapse
- Cataracts in lenses of eyes

Ozone Importance

UV-B and UV-C can be useful:

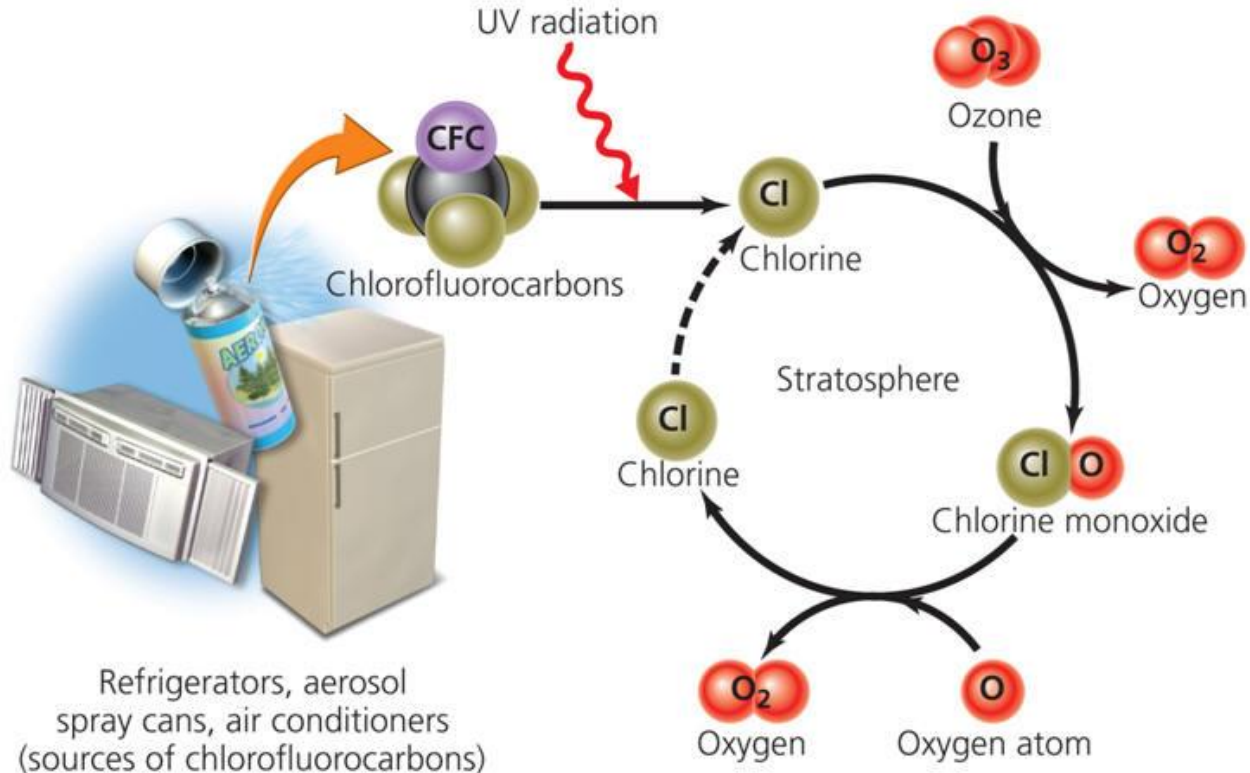
- Stimulates Vit-D production in bodies → no rickets, soft bones
- Treat skin diseases e.g. psoriasis
- Sterilizer/germicide
- Forensic analysis
- Lasers...

Destruction and depletion of Ozone

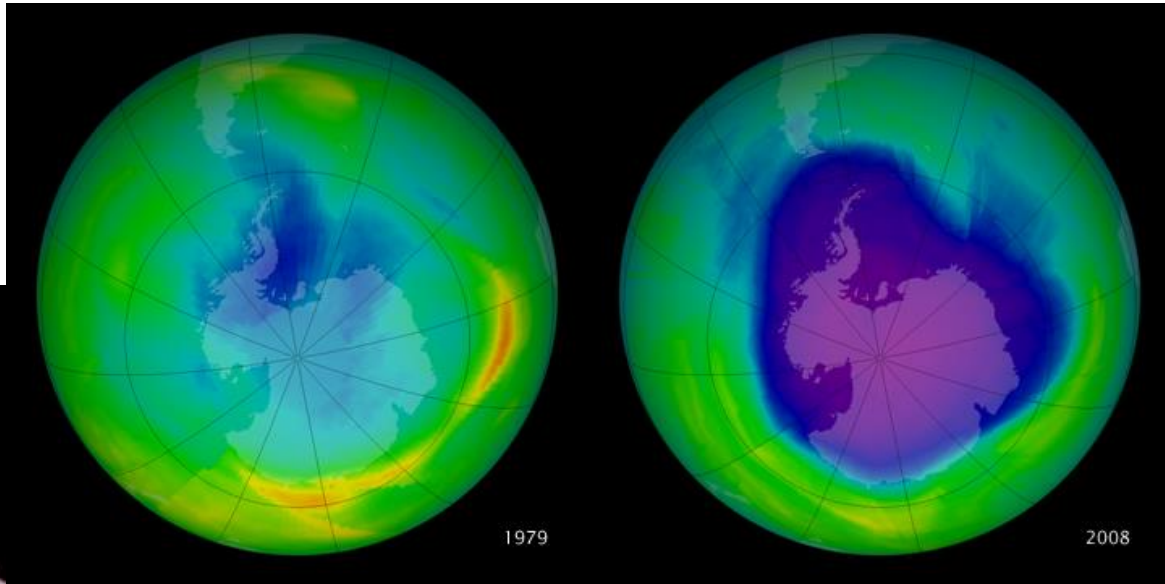
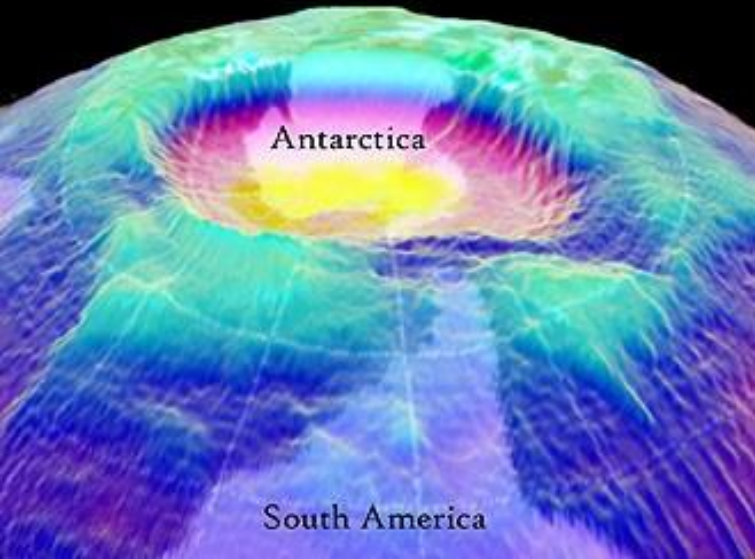
<https://www.youtube.com/watch?v=IniJx-vRHG0>

ODS = ozone depleting substances

E.g. (pg 281) CFCs, HCFCs, halons, methyl bromide, nitrogen oxides





Ozone "hole"



Sacle - pg 280

Reducing ODSs

Process of pollution	Level of pollution management
<p>HUMAN ACTIVITY PRODUCING POLLUTANT</p> 	<p>Altering human activity</p> <p>The most fundamental level of pollution management is to change the human activity that leads to the production of the pollutant in the first place, by promoting alternative technologies, lifestyles and values through:</p> <ul style="list-style-type: none">• campaigns• education• community groups• governmental legislation• economic incentives/disincentives.
<p>RELEASE OF POLLUTANT INTO ENVIRONMENT</p> 	<p>Controlling release of pollutant</p> <p>Where the activity/production is not completely stopped, strategies can be applied at the level of regulating or preventing the release of pollutants by:</p> <ul style="list-style-type: none">• legislating and regulating standards of emission• developing/applying technologies for extracting pollutant from emissions.
<p>IMPACT OF POLLUTANT ON ECOSYSTEMS</p>	<p>Clean-up and restoration of damaged systems</p> <p>Where both the above levels of management have failed, strategies may be introduced to recover damaged ecosystems by:</p> <ul style="list-style-type: none">• extracting and removing pollutant from ecosystem• replanting/restocking lost or depleted populations and communities.

As the leader of the Environment Ministry in a government...

Pg 283

Which solutions would you choose to implement?

Provide valid reasons for your choices.

Montreal Protocol and a “World Avoided”

<https://phys.org/news/2009-03-simulation-consequences-world-earth-natural.html>

- Ozone has been studied since 1830
- CFCs synthesized in 1924 → each molecule may exist for 100++ years
- Expansion of CFC market 1950 → refrigerants, industrial foam
- CFCs link to (cause of) ozone depletion 1974
- Montreal Protocol on Substances That Deplete the Ozone Layer 1987
(amendments London 1990, Copenhagen 1992)
- Maximum CFC concentrations reached 2000
- Production of CFCs (in some countries) stops 2010
- Production of CFC replacements (HCFCs) stopped 2030...?

Montreal Protocol and a “World Avoided”

Montreal Protocol...

- Best example of international cooperation
- Precautionary principle... If we don't now then...
- Many experts from different fields collaborating
- Blueprint for phased approach to reduction/elimination of substances based on development level
- Carefully monitored regulations
 - Command-and-control style
 - Setting specific legally-enforceable production/consumption targets
 - Cost effective

What is this?

Dobson Ozone Spectrophotometer

Developed in 1920s

The instrument that detected
the hole in the ozone layer...

Satellites could not detect this...

Measures total amount of ozone
in a column from the surface to
the edge of the atmosphere



Dobson D065 equipped with encoder, and laptop computer.

Why is the Montreal Protocol still relevant?

Success → 98 % of ODSs (about 2.5 million metric tonnes) have been phased out

- India and China have now agreed to phase out ODSs

Problem of “ODS legacy”

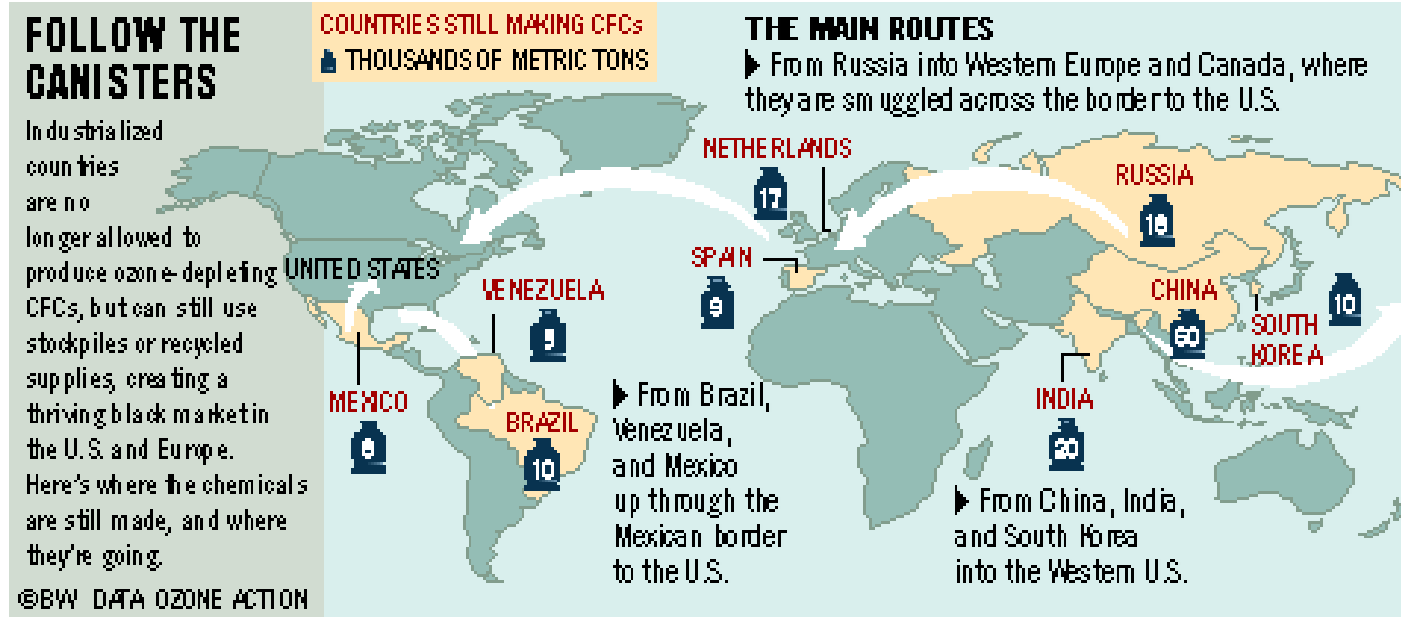
- Long life of ODS molecules/compounds... 100++ years
- Chlorine reached peak concentration in 2005 and...
- Return to pre-ODS levels (i.e. before 1924) only by 2050
- HCFCs - shorter lifetime but stronger GHG - allowed until 2030
 - phase-down would avoid up to 0.4°C of warming by 2100
 - climate change mitigation as per Paris Agreement g.m.t increase < 2°C.

Roles and Successes of Organisations

United Nations Environment Programme (UNEP) played a key role

- Forging international agreements
- Providing information
- Evaluating agreements
 - ❑ *ITHC (International Trade in Harmful Chemicals)*
 - ❑ *air pollution*
 - ❑ *contamination of international waterways*
 - ❑ *provide information to countries and public on disadvantages of pollution*

ODS Blackmarket



Montreal protocol cannot ban import/export → up to each country to implement controls

Roles and Successes of Organisations

- ❖ Pg 285 - complete “To do” (graph) activity
- ❖ (a)
 - MEDCs consumed more e.g. Europe, USSR, Oceania,...
 - Related to industrialisation and economic growth
 - MEDCs should take (took) more responsibility for reduction
- ❖ (b)
 - Information sharing, forging agreements, evaluating,...
 - Stronger enforcement on China and India...
- ❖ (c)
 - Europe reduced to less than 1%
 - Asia possibly increased e.g. 50%, due to increase in air-cons

Roles and Successes of Organisations

- ❑ From the website: <https://www.epa.gov/ozone-layer-protection/international-treaties-and-cooperation>
 - ❖ What actions have been and will be taken to protect the ozone layer?
 - ❖ Bullet points
 - ❖ State the relevant parties, action and date