AIR POLLUTION

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Atmosphere

Major regions of atmosphere

1. Troposphere (8 km to 18 Km)

90% gases- major components N_2 , O_2, trace amounts of He, Ne and CH_4 etc.

2. Stratosphere (up to 50 Km.)

Temperature - 55 C to -5 C;N_2, O_2,O_3, water vapour .

Here is ozone layer

3. Mesosphere (50-80 Km)

- Temperature - 100 C; N_2,O_2 and O_3

Regions of air continues……

- 4. Ionophere 80-500 Km.
- contains ionized gas molecules. O
- O+,O2+, NO+, atoms
- protects Earth from cosmic rays
- reflex back radio waves enabling transmission of radio messages.
- 5.exosphere.

- Extends upto 1600 kilometre
- atomic particles of hydrogen and helium
- high temperature due to solar energy

Air pollutants

1.GASEOUS AIR POLLUTANTS

Oxides of carbon, nitrogen and sulphur, hydrogen sulphide, hydrocarbons etc.

2.PARTICULATE AIR POLLUTANTS

Non metallic, metallic and organic particulates, dust, mist, fumes ,smoke, smog etc.

Sources of air Pollution

1.NATURAL SOURCES

Volcanic action, forest fire etc.

2. Anthropogenic sources(more than 55%)

1.Automobile exhaust

CO,SO2,SO3,NO,NO2, unburnt hydrocarbons, particulate matter- soot,TEL(tetra ethyl lead)

All these lead to smog and acid rain

2.Industrial effluents(10-20%)

CO,H2S,SO2,NO,NO2, flyash,asbestos, smoke, acid vapours

All leads to smog and acid rain

Sources of air pollution ……..

3.Electric power plants

Burning of bituminous coal and sulphur content fuel oils in thermal plants prudes enormous amount of SO2 and fly ash.

4.Other sources

Incineration of domestic wastes

Freons as refrigerants

Aerosol sprays

Tobacco smoking

Demolition of buildings

Over use of fertilisers pesticides.

Explosives

Nuclear explosion

Wars and terroristic activities.

AIR POLLUTION BY OXIDES OF CARBON

CO (most abundant air pollutant)

Sources

Incomplete combustion of carbon containing compounds

Automobile exhaust, burning of domestic fuel, domestic wastes and industrial fuel.

Formed by high temperature reduction and decomposition of CO_2

Reduction $CO_2 + C \rightarrow 2CO$

Decomposition $CO_2 \rightarrow CO + O$

Poisonous effect of CO

Axphyxiation

Hb + CO → COHb (210 times readly than O2 and 300 times stable than oxy -haemoglobin)

$HbO_2 + CO \rightarrow COHb + O_2$

Inhale more than 100 ppm

Mentall abberations, throbbing headache, dizziness, nausea, vomitting, visual difficulty, breathing difficulty and unconsiousness.

Inhale more than 750 ppm

DEATH

CO…….

Smoker inhales CO leading to heart diseases, pregnant ladies when smoke leads to abortion, premature delivery or deformity to babies.

Plants- leaf drops, leaf curling, reduction leaf sizes, decrease in chlorophyll content premature ageing

CO_2

Combustion of fossil fuels in factories, vehicles, thermal power plants etc.

Decomposition of limestone during manufacture of cement

Deforestation imbalances the amount of CO_2 in air.

May lead to enhanced green house effect and Global warming

Oxides of Nitrogen

NO (main)

NO_2(Highly Toxic), N_2O,N_2O_3 and N_2O_5.

Sources

Electric power, fertiliser, automobile exhaust, explosive, gold jwellery works.cigarette.

$N_2 + O_2 \rightarrow 2NO$

$2NO + O_2 \rightarrow 2NO_2$.

NO2

Irritates mucous membrane

Higher doses- bronchitis, respiratory problems, fibrotic changes in lungs, gum inflamation, internal bleeding, lung cancer.

Leads to photochemical smog.(Los angeles type smog- 1944)

Acid rain

Attacks metals and textile fibres.

NO inhibits metabolic activities in plants, decrease photosynthesis.

OXIDES OF SULPHUR

SO_2 and SO_3

Sources

Burning of high sulphur content fuels

$S + O_2 \rightarrow SO_2$, $2SO_2 + O_2 \rightarrow SO_3$.

Irritates eyes, damage respiratory tract, cough, chocking,bronchitis, chronic asthma, lung cancer.

very high concentration leads to death.

Sulphurous smog (London smog 1952)

Acid rain

Inactivate cells of plants, tissue collapse, bleaching of leaves, dwarfing, stiffness of flower buds.

Hydrocarbons

SOURCES

From automobile,

incomplete combustion of coal ,wood,

Refining of petroleum

Leakage of industrial solvents,

Incomplete incineration of wastes

Adverse effects

Increases mucous secretion

Respiratory tract blockage, breathing difficulty, cough, leads to cancer(benzopyrene)

Hydrocarbons undergo photochemical reactions in presence of NO, NO2 causing photochemical smog.

Plants- damage leaf tissues, death of flowering parts, shedding of leaves, flowers and twigs, inhibit their growth and ageing.

PARTICULATES

Sources

Viable particulates

Microorganisms- Bacteria,fungi,moulds,algae

Non viable particulates

Smoke,

dust (<1micrometer),

mist(spray of liquids and condensed vapours- pesticides, sulphuric acid),

fumes (particles of organic solvents ,hydrocarbons, metals, metallic oxides etc.),

from automobiles- oxidised hydrocarbons,aldehydes,heterocyclic compounds, soot etc.

ADVERSE EFFECTS OF PARTICULATES

Irritation on eyes, nose, throat and lungs

- Tetraethyl lead - brain damage and cancer in children
- Asbestos dust -breathing trouble lung cancer
- Fly ash - emphysema
- polycyclic aromatic hydrocarbon(PAH) carcinogenic -example benzopyrene, Chrysene

Smog

- Mixture of smoke and fog
- Dark grey or brown haze

Types of smog

1. Classical smog or sulphurous smog or London smog
2. Photochemical smog or Los Angeles Smog

Classical smog or sulphurous smog or London smog

- Dark grey haze
- Occur in winter.
- Contains very high concentration of Sulphur dioxide
- Condense sulphur try oxide sulfuric acid and ammonium bisulphate
- reducing smog

Formation of Sulphurous smog

$S + O_2 \rightarrow SO_2$

$SO_2 + 1/2\ O_2 \rightarrow SO_3$

$SO_2 + ½\ O_2 + H_2O \rightarrow H_2SO_4$

$SO_2 + ½\ O_2 + H_2O + NH_3 \rightarrow NH_4HSO_4.$

London smog (SULPHUROUS SMOG)

Reason

- Combustion of industrial and household sulphur containing fuels
- Enhanced by presence of carbonaceous suit and fly ash and anything which helps the formation of fog
- It is also called London smog in memory of smog experienced in London on December 1952 (1952 London smog prevailed for 5 days,4000 to 5000 inhabitants died,Thousands became ill.)

Detrimental effects

- Irritates eyes nose throat and lungs
- Lead to pneumonia ,bronchitis and allied respiratory diseases
- Cause lung cancer
- Causes several motor accidents due to poor visibility condition when fog lingers over the cities

Control of sulphurous smog

- Smokestacks at factories and power plants- will carry the pollutants to higher altitudes so that winds take air pollutants and prevent from concentrating into smog.
- The implementation of strict environmental regulations on the burning of coal and other sulphur containing fuels

Photochemical smog or loss Angeles type smog

- Occur in warm, dry and Sunny climate
- A brown haze
- Components- nitrogen oxide, ozone, formaldehyde, acrolein, peroxyacetyl nitrate(PAN) and other volatile organic compounds like aldehyde and ketones
- Oxidizing smog.(NO_2 and O_3)
- This also called los Angeles type smog in memory of smog experienced in los Angeles in 1944

Reason

- Secondary compounds produced by the action of sunlight on volatile hydrocarbons and nitrogen oxides (produced from automobiles power plants and factories, burning of fossil fuels, evaporation of solvents, burning of plants.)

Formation of photochemical smog

$$2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$$

$_2$, in turn, photochemically decomposes into nitric oxide and free oxyg

$$NO_2(g) \xrightarrow{h\nu} NO(g) + O(g)$$

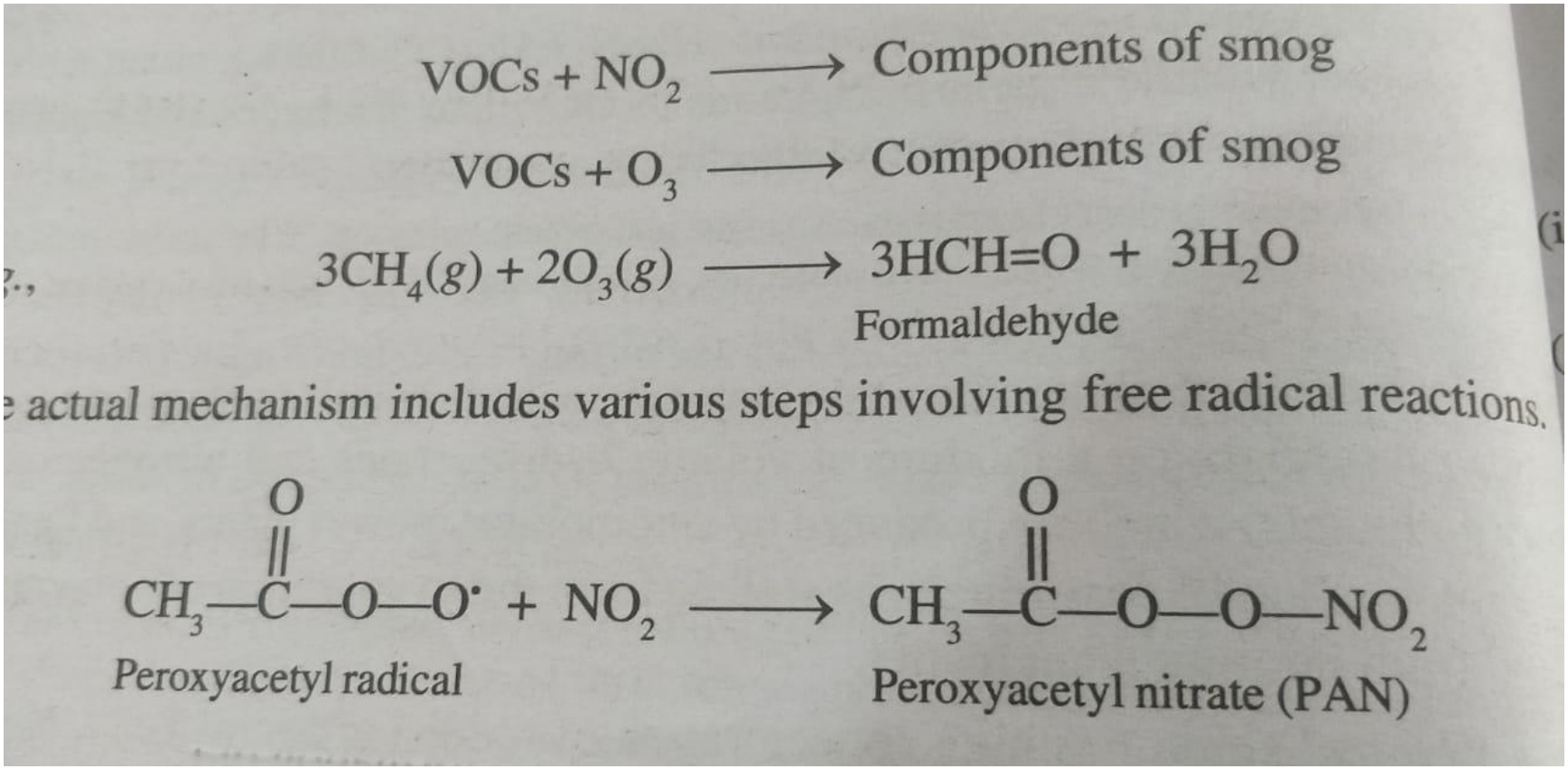
reactive oxygen atoms thus produced combine with O_2 to form *ozon*

$$O_2(g) + O(g) \rightleftharpoons O_3(g)$$

ozone oxidizes the NO formed in the previous reaction to regene
which is a major contributor to the brown haze of the smog.

$$NO(g) + O_3(g) \longrightarrow NO_2(g) + O_2(g)$$

FORMATION OF PHOTOCHEMICAL SMOG



Detrimental effects of photochemical smog

- peroxyacetyl nitrate(PAN, ozone, and aldehyde - Irritation and respiratory tract problems
- Volatile organic compounds- carcinogens
- Nitrogen oxide -- irritates nose, headache, chest pain, cough ,bronchitis, asthma, lung cancer ,heart problems.

-- Cracking of rubber, discoloration of painted surfaces corrosion of metals, degeneration of stones and building material

-- damage the leaves of plants, retard the rate of photosynthesis.

Control of photochemical smog

- Reduce the amount of oxides of nitrogen, hydrocarbons ,ozone and peroxy acetyl nitrate by using catalytic converters in automobiles.
- Use liquefied petroleum Gas (LPG) and compressed natural gas (CNG) rather than petrol and diesel.
- Decrease the number of motor vehicles on the road by walking , by the use of bicycle, by using public transport systems or by carpooling
- Another method is by spraying chemicals which produce free radicals to the atmosphere which readily combine with free radicals responsible for smog.
- Planting of certain plants (pinus, Juniparus, quircus, pyrus, and vitis)

Some other effects of air pollution

Acid rain

- Caused by nitrogen oxides and sulphur oxides

Either by wet depoition or dry deposition.

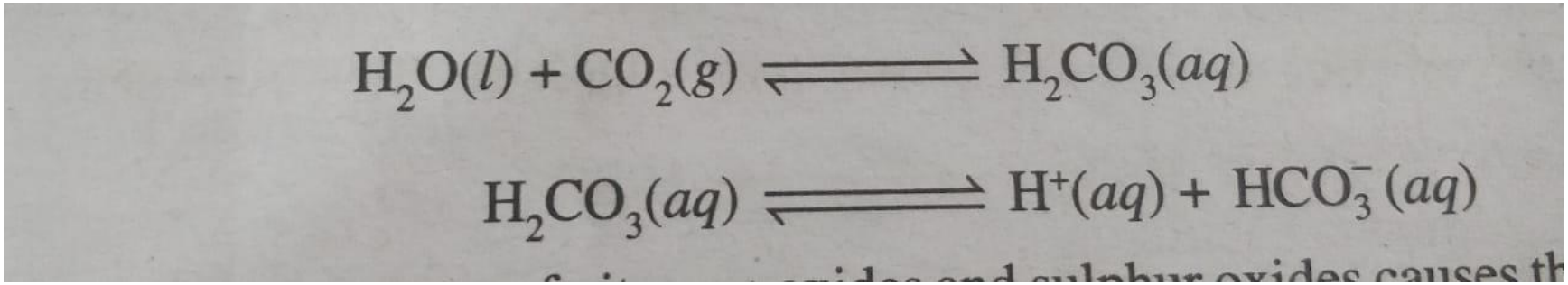
Wet deposition-along with rain, snow and fog.

Dry deposition- by incorporated into dust, smoke, etc.

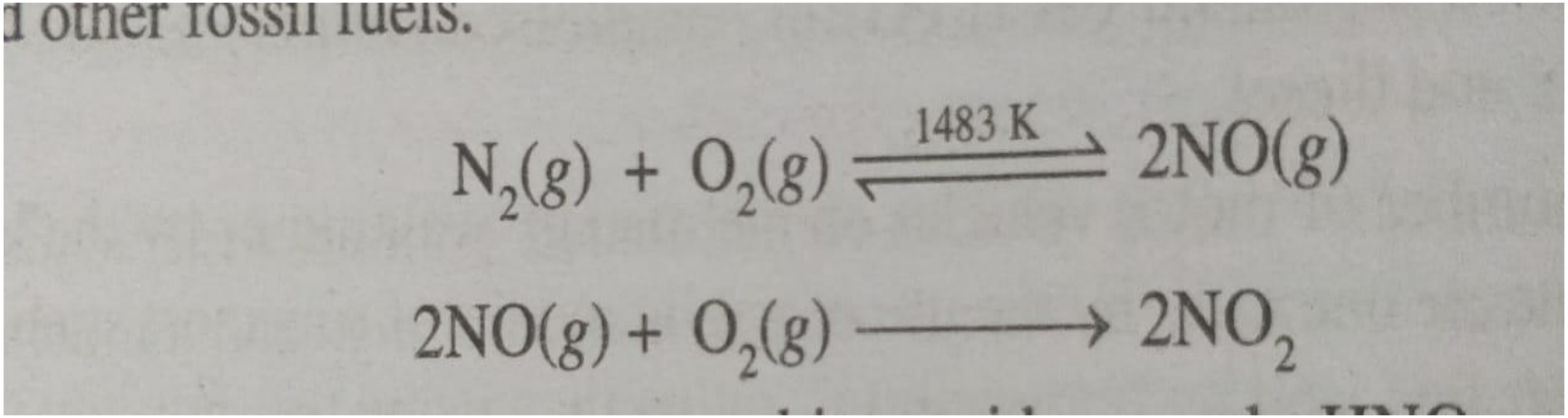
Acid rain.....

Normal pH of rain water 5.6

Acid rain – below 5.6

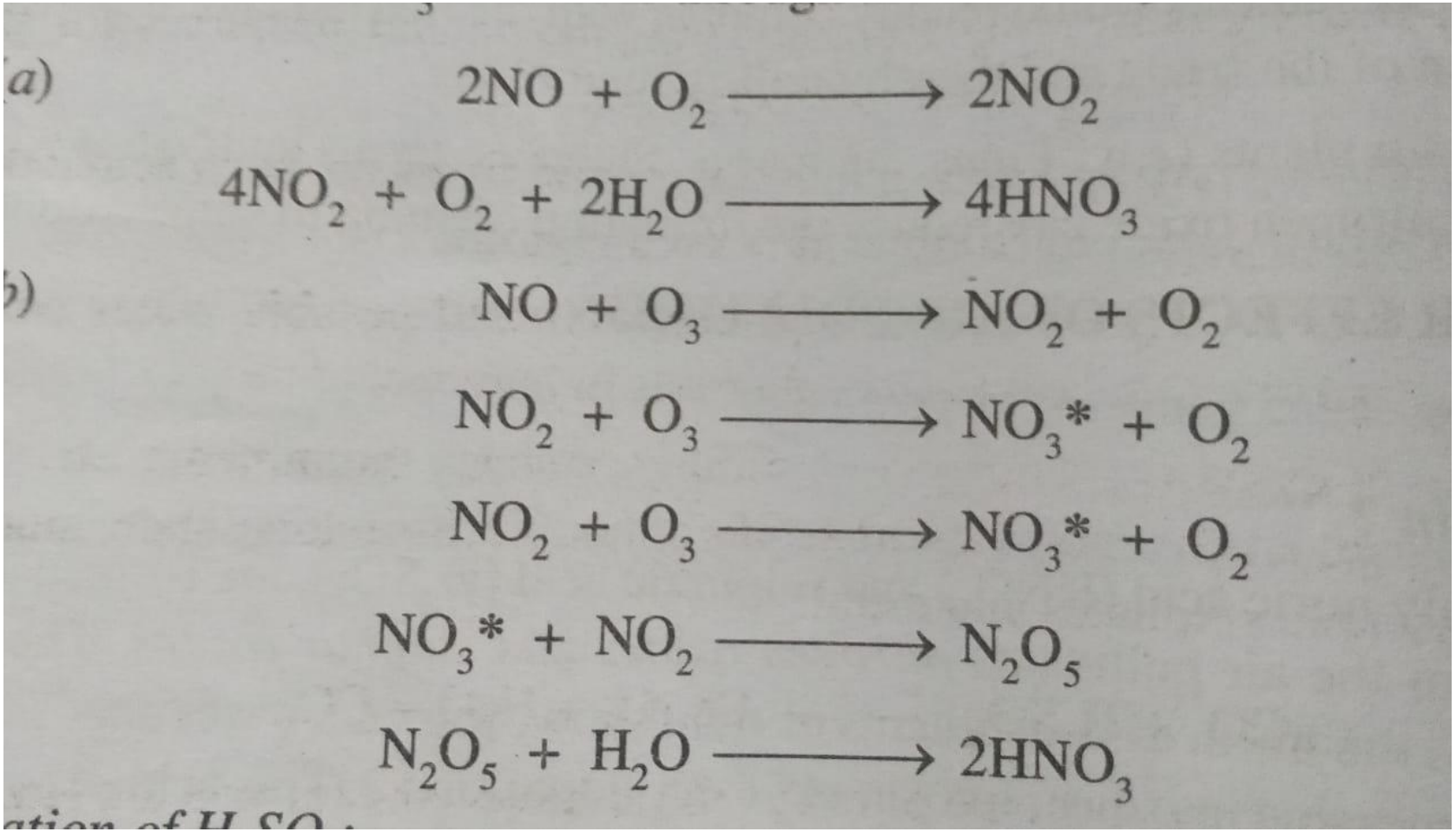


FORMATION OF ACID RAIN



Acid rain

formation of HNo3 and H2SO4 in presence of light, water, oxygen, heavy metals organic oxidants etc.. in air.



ACID RAIN .....

$SO_2 + \frac{1}{2} O_2 + H_2O \rightarrow H_2SO_4$

ADVERSE EFFECTS

- 1. Cause respiratory, neurological and digestive ailments in human being and animals.
- 2. Causes corrosion of water pipes leading to leaching of heavy metals such as iron and copper into drinking water which leads to water pollution.

Acid rain adverse effects….

- 3. Washes away the nutrients needed for the growth of trees and plants.
- 4. acidity of soil increases causing serious damage to agriculture crops. Cadmium adsorption by plants increases posing health hazard to living things.
- 5.Makes water in tanks, ponds, lakes and rivers acidic that fish and other aquatic life eliminated in such regions.
- 6. damages leaves of trees, reduces photosynthetic capability and retard growth destroying the production of pulp, paper etc.

Acid rain adverse effects….

- 7. The acid contaminated portable water causes neurological, digestive and respiratory diseases in humans
- 8. Causes extensive damage to buildings, statues and monuments. Acids in the rain attacks the sculpyural materials of marble, limestone to form sulfates and nitrates and the monument may become pitted.
- 9. Acid rain destroys materials like fabric, paper etc.

CONTROL of ACID RAIN

Short term control

by using lime in acid polluted soils and freshwater bodies.

Long term remedy

Reduce air borne nitrogen oxides and sulphur oxides.

The implementation of strict environmental regulations on the burning of coal and other sulphur containing fuels.

Solar energy should be made use in place of fossil fuels.

All measures used to control sulphurous smog and photochrmical smog can be followed to control acid rain too.

Enhanced greenhouse effect and global warming

Global warming

The significant increase in the Earths climatic temperature over a relativity short period of time as a result of anthropogenic activity.

Reason

Excess CO2, CH4, NO, CFC

GREEN HOUSE EFFECTS

PROGRESSIVE WARMING UP OF EARTHS SURFACE AND ATMOSPHERE DUE TO BANKETING EFFECT OF green house gases that absorb and emit infrared radiation.

Green House Gases like CO_2, water vapour, CH_4 and ozone

Enhanced greenhouse effect and global warming

- Enhanced greenhouse effect causes global warming
- Quantity of carbon dioxide in the atmosphere is increasing because of anthropogenic activities
- Burning of fossil used in thermal plants, factories, vehicles etc.
- Global deforestation
- Carbon dioxide is confined exclusively to troposphere

Consequences of global warming

1. Climatic changes

some areas of the world would experience high evaporation of water and unusual changes in ocean currents and winds

Abnormal changes in weather patterns and seasons

Increased desertification

Some regions of the world lose up to 30% annual rainfall while some other regions experience with high rainfall.

Consequences of global warming

2. Drop in agricultural production

Since some regions would become increasingly dry and some others increasingly wet the whole agricultural pattern would be upset consequent drop in agricultural produces.

3.Sea level rise

Increasing global warming may cause the melting of polar ice caps leading to rise in sea level which may lead to erosion and submergence of low-lying coastal area and Islands.

Consequences of global warming

4. Spread of diseases

Global warming may leads to incidence of infectious diseases like dengue, malaria, yellow fever etc.

5. Destruction of aquatic organisms

Fish and other aquatic organisms will perish because they are not able to withstand high temperature of waters.

6. Refugee problems

Climatic changes result in flood, drought ,agriculture loss homelessness and starvation results in increase of refugees which causes very serious social and economic problems.

Control of greenhouse effect

1. The burning of fossil fuels must be done judiciously
2. Use of bicycles, public transport, carpooling etc. reduces the use of fossil fuel
3. Solar energy may be used
4. Cutting down of forests must be minimised, more trees must be planted
5. Avoid unnecessary burning of dry leaves and wood.
6. Smoke in public places must be effectively prevented
7. Awareness should be given to public about enhanced greenhouse effect and global warming
8. Global policy regarding industrialization, deforestation etc. should be adopted nationwide

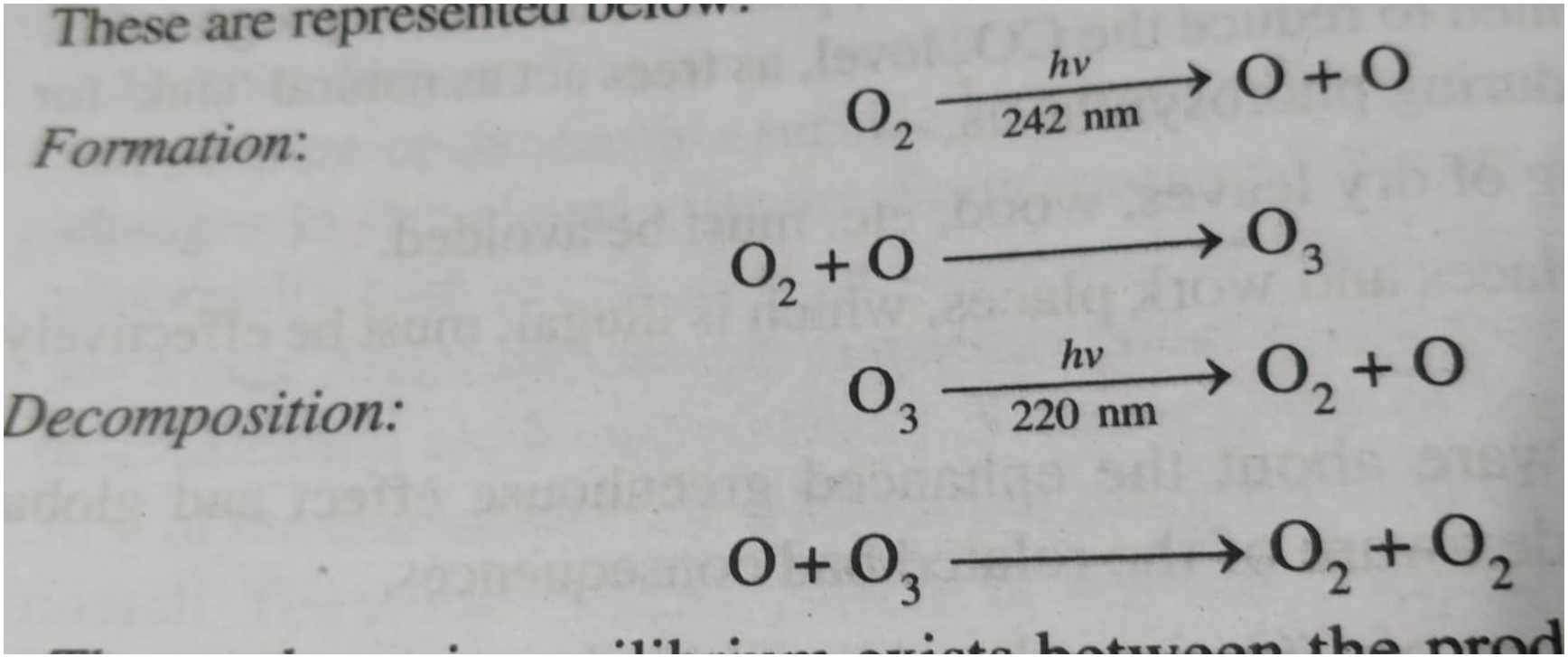
DEPLETION OF OZONE

Stratospheric ozone layer, ozone umbrella, ozone shield

Ozone is present in stratosphere.

It absorbs ultraviolet rays of a length 220- 330 nm.

Formation of stratospheric ozone layer



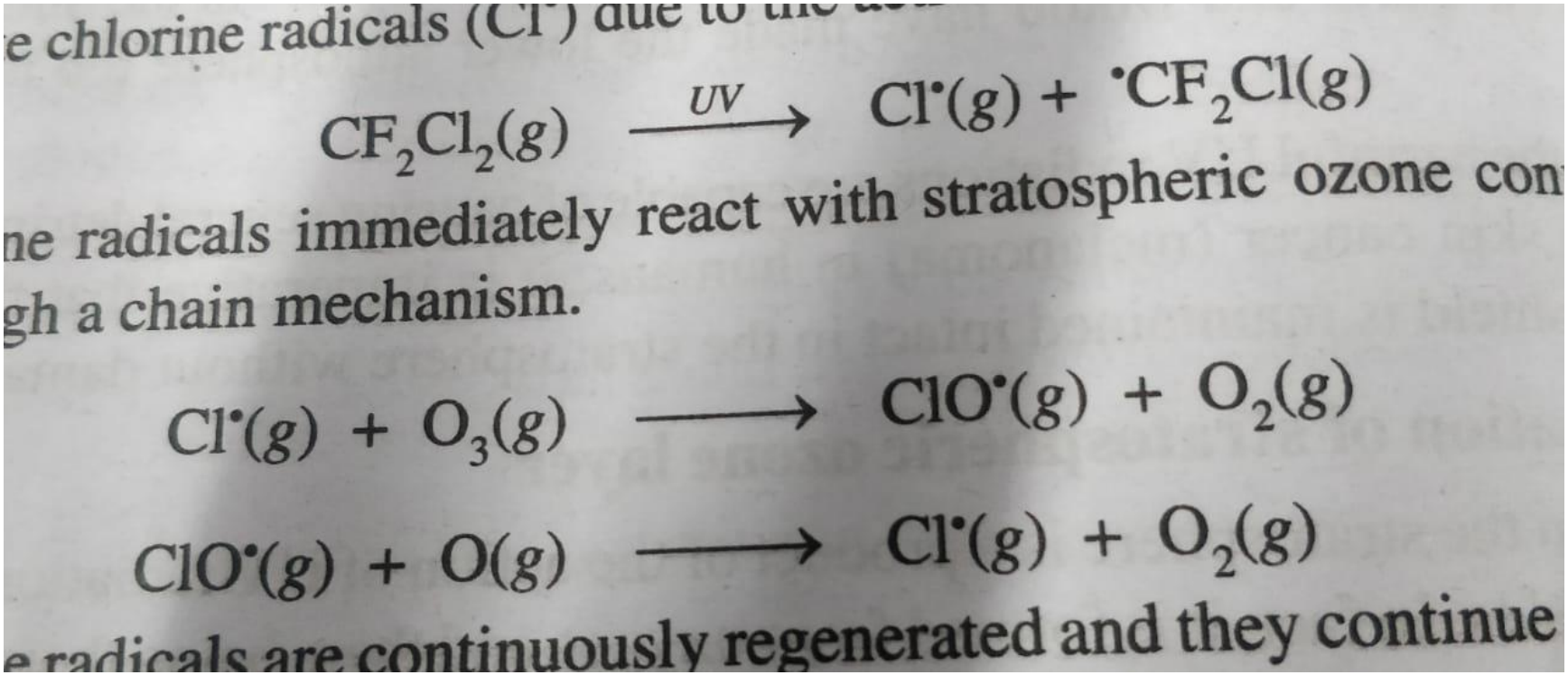
Depletion of ozone in the ozone layer

- An equilibrium concentration of ozone (10 PPM) is maintained in the stratosphere
- Chlorofluorocarbons and nitrogen oxide depletes ozone.
- 30% ozone depletion (ozone hole)-1980 over Antartica during spring season.
- 15-20% depletion over Arctic in 1990.
- Later over thickly populated European countries and USA.

Depletion of ozone in the ozone layer

- Major culprit -chlorofluorocarbons,(freons)
- Non inflammable non toxic
- Stable and innactive in troposphere
- Diffuses into stratosphere and release Cl free radical.
- One chlorine radical can destruct 1lakh ozone molecules.

Depletion of ozone by CFC….



e chlorine radicals (Cl•) due to the

$$CF_2Cl_2(g) \xrightarrow{UV} Cl^{\bullet}(g) + {}^{\bullet}CF_2Cl(g)$$

ne radicals immediately react with stratospheric ozone con
gh a chain mechanism.

$$Cl^{\bullet}(g) + O_3(g) \longrightarrow ClO^{\bullet}(g) + O_2(g)$$

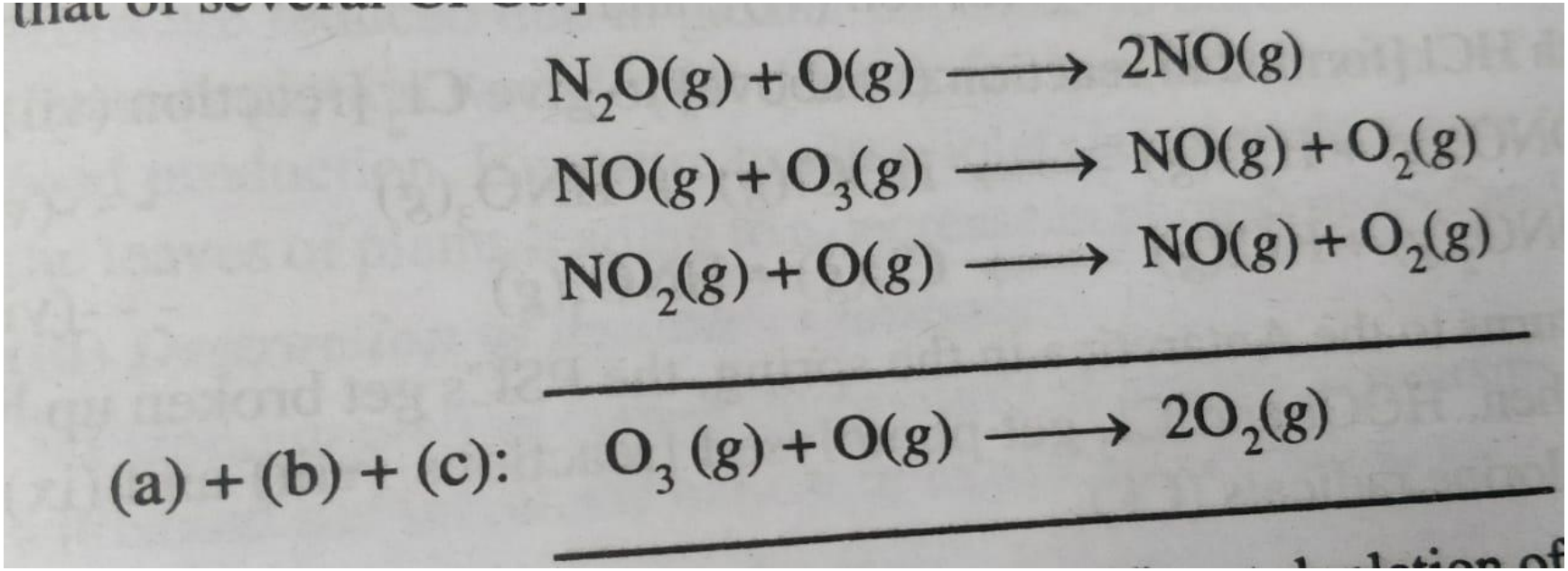
$$ClO^{\bullet}(g) + O(g) \longrightarrow Cl^{\bullet}(g) + O_2(g)$$

e radicals are continuously regenerated and they continue

DEPLETION OF OZONE BY OXIDES of N

- Oxides of nitrogen also cause ozone depletion.
- Sources of oxides of nitrogen in stratosphere
- Supersonic aircraft directly to stratosphere
- Nuclear explosions

DEPLETION OF OZONE BY OXIDES of N



Ozone hole over Antarctica

- In 1980 during spring over Antartica 30% of ozone depletion seen

Reason

Atmospheric and chemical conditions

Summer

- NO2 and ch4 excess freons by combining with ClO free radical and chlorine free radical

Winter

- clouds called polar stratospheric clouds (PSC s)---5to 6 months(Arctic region 1 to 2 months)

-78C

v)] to undergo the following reactions:

(a) hydrolysis to hypochlorous acid [reaction (vi)], and

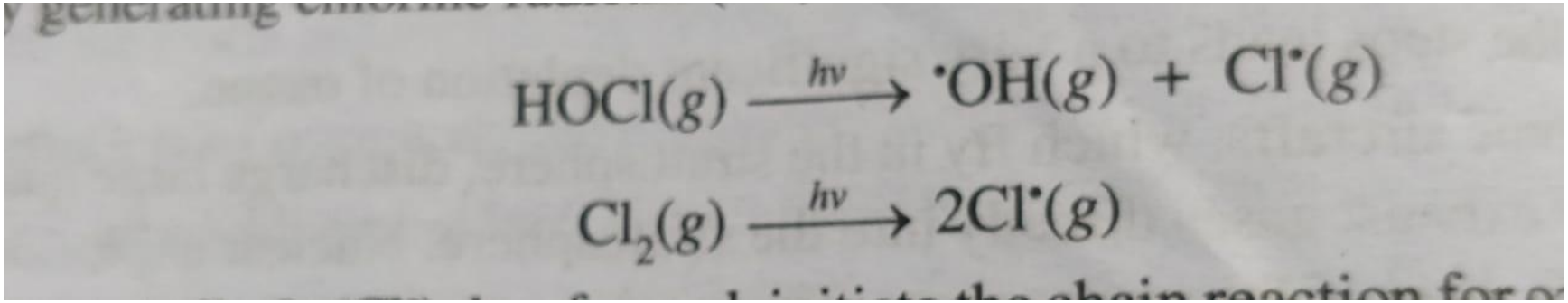
(b) reaction with HCl [formed in reaction (v) above] to give Cl_2 [rea

$$ClONO_2(g) + H_2O(g) \longrightarrow HOCl(g) + HNO_3(g)$$

$$ClONO_2(g) + HCl(g) \longrightarrow Cl_2(g) + HNO_3(g)$$

When sunlight returns to the Antarctica in the spring, the PSCs get

Spring sunlight causes photolysis of HOCl and chlorine to chlorine free radical



Impact off ozone depletion

1. Ultraviolet rays causes skin cancer

   1% reduction in ozone layer causes 6% increase in skin cancer

   Also causes leukemia and breast cancer may lead to photokeratitis and cataract

2. Drop in agricultural production

   Decreases chlorophyll content of leaves of plants leading to decrease in photosynthesis and damage to leaves

3. Destruction of aquatic organisms

   Aquatic organisms destructed as they are not able to with stand exposure to ultraviolet radiation

4. Anomalous climatic changes

   Thermal balance of Earth is destroyed causing serious climatic changes.

Prevention of ozone depletion

Stopping the production and use of CFCs

Alternative refrigerants

1. CFC alternatives

Use of hydro fluoro carbons (HFC) with zero ozone depletion potential (ODP)

Ex.1. Mixture of CH_2F_2 and CHF_2- CF_3 (R-410A).

ODP-0, global warming potential (GWP)- 1720

- 2.$C_2H_2F_4$. (HFC-134A)
- ODP -0,GWP 1410.

Alternative refrigerants …….

2. Alternative refrigerants with very low ODP and GWP.

1.Ammonia

Refrigerant code- R-744

ODP -0,GWP-0

Disadvantage- high toxicity but can be identified by smell.

Alternative refrigerants …….

2. Carbon dioxide

   Non toxic , non inflammable

   GWP - 1, ODP -0.

Draw back- Works at much higher pressure.

3.Hydrocarbons (HC)

   Earlier- ethane, propane, butane, isobutene etc.

   GWP- 8, ODP- 0

   Now – propane, isobutaneand refrigerant R-441A (blend of ethane, propane, butane, and isobutene)

Drawback –1. issues in lower troposphere, 2.highly inflammable.

The BHOPAL TRAGEDY

Midnight of 2ndDEcember 1984 in Bhopal, Madhya Pradesh.

Reason – Methyl isocyanate(CH3N=C=O)(MIC)

Traces of phosgene(COCl2), HCN from Union carbide India Limited.

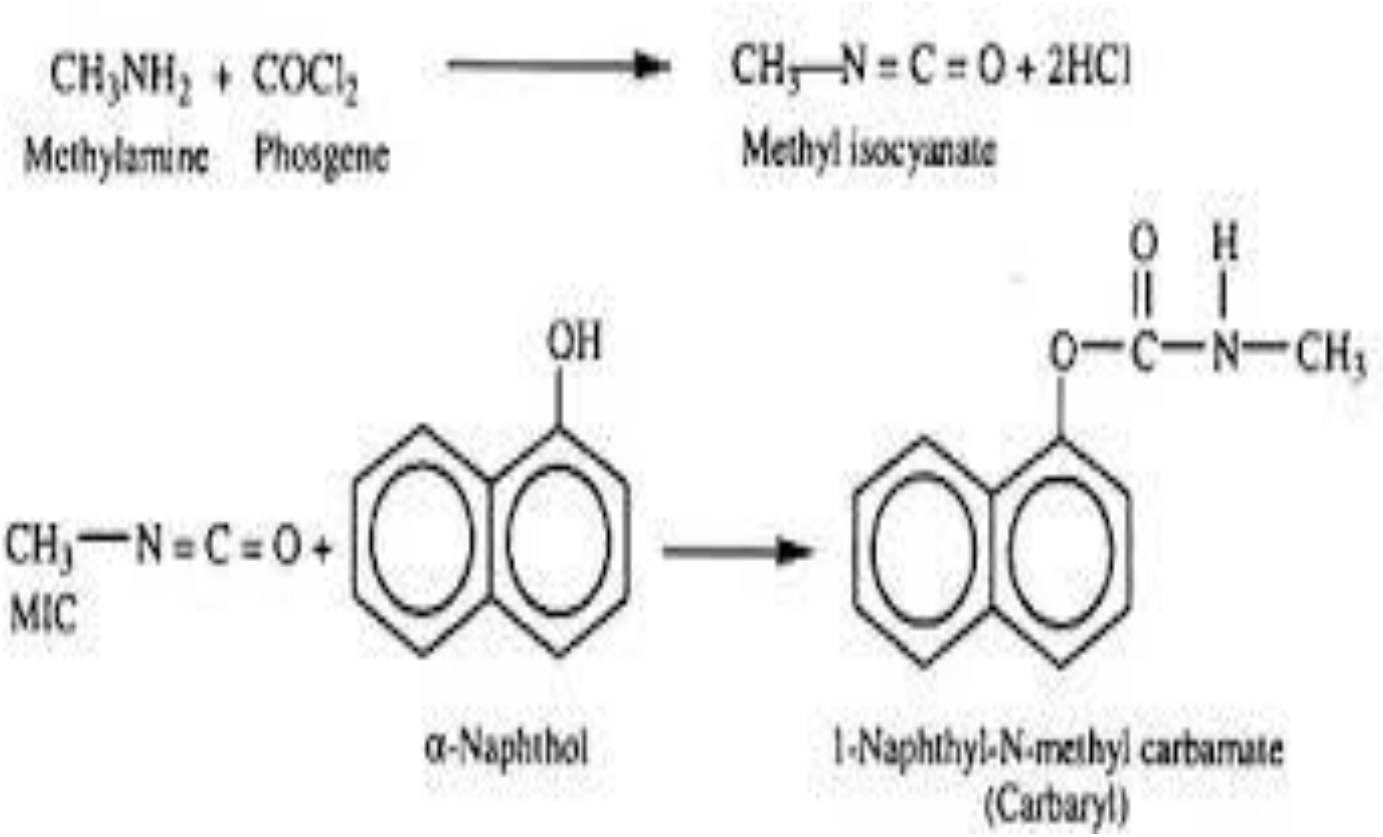
Production of insecticide carbaryl.

More than 10000 people died

More than 1000 people became blind.

1 lakh people suffered from associated illness.

The Bhopal tragedy continues….



Bhopal tragedy……

The reasons for the explosion….

Chemistry

$$2CH_3\text{-}N{=}C{=}O + H_2O \rightarrow CH_3\text{-}NH\text{-}CO\text{-}NH\text{-}CH_3 + CO_2$$

Other reasons

1.MIC tank was filled to 87% while permissible level was 50%.

2.Shold be stored at 0C, but temperature was 20C,cooling systems were defective for about 5 months.

3.The scrubber didn't contained caustic soda.If present could have neutralised the gas.

4. Flare tower to burn off the gases was damaged.

5.The safety valves, vital gauges and indicators were defective.

Control of air pollution

1. Designing of better automobile engine which will not carbon monoxide and hydrocarbons.
2. Use of gaseous fuels in engine may reduce the pollutants likeCO and hydrocarbons.
3. Use of filters, electrostatic precipitator, dust trap, adsorbent columns in factories to prevent the entry of harmful gases to air.
4. The heights of chimneys of factories should be raised to allow atmospheric dilution of effluent gases.

Control of air pollution……

5. Use of low sulphur content in thermal power plants and industries so that production of SO2 in air will be reduced.
6. Use of scrubber to dissolve away SO2
7. Prevent the excessive use of pesticides and CFCs.
8. Banning the use of asbestose
9. Banning of cigarette smoking in public places.
10. Planting trees on large scale in industrial centres.