Important topic for EVS

1) Renewable resources, Non-renewable → defination and difference b/w them.

2) Ecosystem-structure and function of different ecosystem.

3) Food chains

4) Food web.

5) Estuary ; soil erosion.

6) Biodiversity

7) Climate change

8) Global warming ; Green house gas effect

9) Acid rain

10) Threats to biodiversity ; Conservation of it

11) Solid wast Management

12) Sustainable Development

13) Environmental and Human health

14) Role of information technology in Environment and human health

15) Solid waste management

16) Vermicompost

17) Ozone depletion

18) Biogeochemical cycle - defination along with cycles

19) Ecosystem pyramid.

20) Causes, effect and control measures of pollution in detail -
a) Water b) air . c) marine d) land. e) noise

21) Water conservation.

22) Biotic + abiotic factors that might effect.

23) Population.

24) BOD and COD

25) Photochemical smog.

Harmful Effects

(a) Acid rain causes extensive damage to building and sculptural materials of marble, limestone, slate, mortar, etc. These materials become pitted and weakened mechanically as the soluble sulphates are leached out by rain water.

$$\underset{\text{Lime stone}}{CaCO_3} + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O$$

In Greece and Italy, invaluable statues have been partially dissolved by acid rain. Tajmahal at Agra, faces the same problem.

(b) The acid in the rain damage leaves of trees, plants and retards the growth of forests which are important natural resources for production of wood, pulp, paper and board.

(c) Besides damaging the flora and fauna, acid rain also affects fish mortality. These pollutants (H_2SO_4, Cd, Fe, Pb, etc.) enters rivers and lakes ; killing the fish eggs. In Sweden 85,000 lakes were slowly becoming dead by the deluge and 4000 lakes are completely dead. In Canada trees and lakes are also being killed by the acid rain, 60% of which originates from USA.

(d) Lowering of *p*H of rainwater, due to acid rain, changes the rate of metabolism of organisms.

(e) Acid rain causes irritation to eyes and mucous membrane.

(f) Acid rain accelerates the rate of corrosion.

6.6.4 Smog Formation

Smog means an odd combination of smoke and fog in air which partially reduces the atmospheric visibility. Two types of smogs are recognised :

1. **Classical or London Smog.** This type of smog occurred in London in 1952. It prevailed for five days and caused death to 4000-5000 people and made thousands ill. This smog is associated with the use of traditional fuel, coal. It is characterised by high concentration of unburnt carbon soot and high levels of SO_2 in the atmosphere. The most important source of this type of smog is the combustion of coal. It has reducing as well as acidic properties due to the presence of SO_2, a mild reducing agent and an precursor of a weak acid thus, it is also known as reducing smog. The various reactions involved are :

$$S + O_2 \longrightarrow SO_2$$

$$SO_2 + \frac{1}{2} O_2 \longrightarrow SO_3$$

This reaction takes place in presence of sunlight and particulate matter. SO_2 combines with moisture from fog to form sulphurous acid.

$$SO_2 + H_2O \longrightarrow H_2SO_3$$

$$H_2SO_3 + \frac{1}{2} O_2 \xrightarrow{\text{Metal salts}} H_2SO_4$$

$$H_2SO_4 + 2NH_3 \longrightarrow (NH_4)_2 SO_4$$

or $$SO_2 + 2NH_3 + H_2O + \frac{1}{2} O_2 \longrightarrow (NH_4)_2 SO_4$$

concentrations of these hydrocarbons varied with traffic density [illegible] (see under Photochemical Smog in this section).

Hydrocarbons are removed from the atmosphere by several chemical and photochemical reactions. They are thermodynamically unstable towards oxidation and tend to be oxidised through a series of steps. The end products are CO_2 and solid organic particulate matter that settle from the atmosphere or water-soluble products, e.g., acids and aldehydes, which are washed by rain.

Photochemical Smog

Majority of the harmful effects of hydrocarbon pollution are not due to the hydrocarbons themselves but the products of photochemical reactions in which they are involved. Hydrocarbons do not react readily with sunlight, but they are reactive towards other substances produced photochemically. An important characteristic of atmosphere which is loaded with large quantities of automobile exhausts, trapped by an inversion layer (stagnant air masses) and at the same time exposed to intense sunlight, is the formation of photochemical oxidants in the atmosphere. This gives rise to the phenomenon of *photochemical smog* which is observed in localities like Los Angeles and Denver, USA. It may be mentioned that 'smog' originally means an odd combination of smoke and fog prevalent in London. This is, however, chemically reducing with high levels of SO_2 (see Sec. on SO_2) and is called *reducing smog*, whereas *photochemical smog* is an *oxidising* smog having a high concentration of oxidants. Photochemical smog is characterised by brown, hazy fumes which irritates the eyes and lungs, and also leads to the cracking of rubber and extensive damage of plant life.

The probable mechanism of smog-forming reactions is illustrated in the flow charts (Fig. 10.6 A, B):

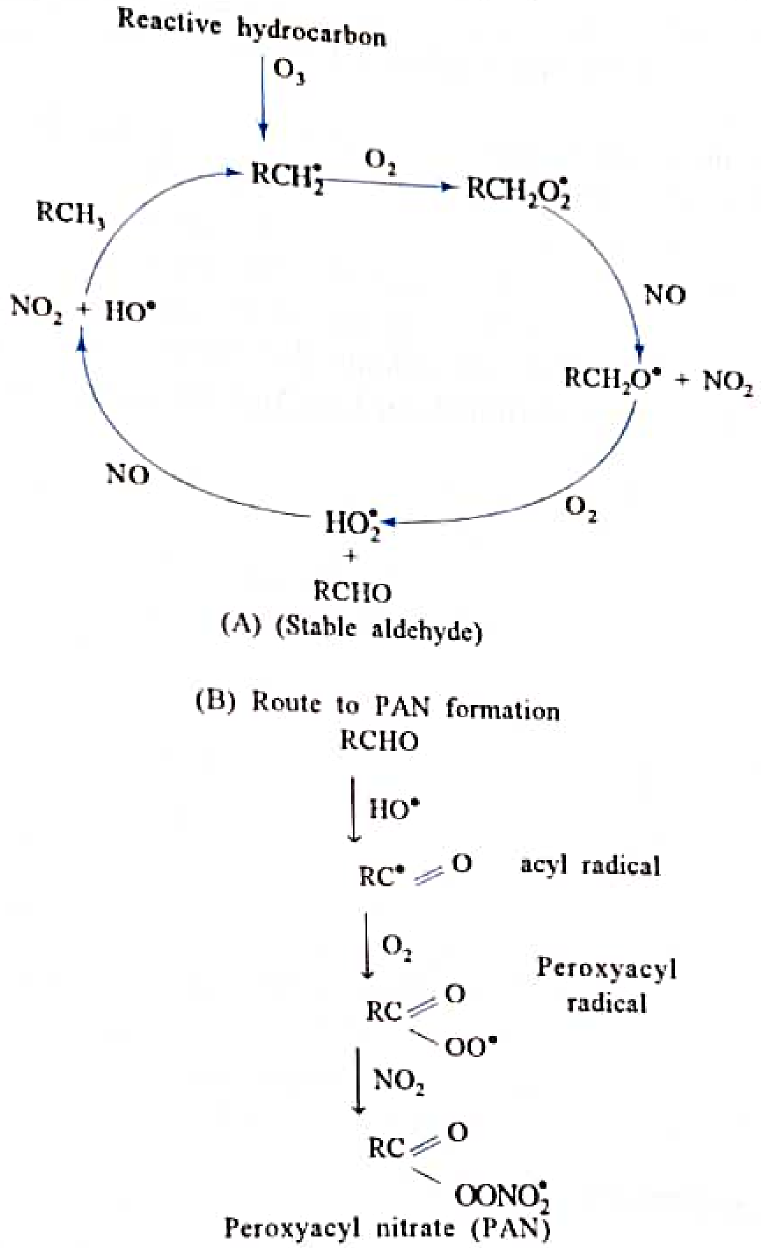


Fig. 10.6(A) Smog-formation reactions (B) PAN formation reactions

(*i*) Reactive hydrocarbons (those with C = C groups) from auto-exhaust interact with O_3 to form a hydrocarbon-free radical $RCH_2^{\bullet}$.

(*ii*) $RCH_2^{\bullet}$ rapidly reacts with O_2 to form another free radical $RCH_2O_2^{\bullet}$.

(*iii*) $RCH_2O_2^{\bullet}$ reacts with NO to produce NO_2 and the free radical $RCH_2O^{\bullet}$.

(*iv*) This new free radical next interacts with O_2 to yield a stable aldehyde, RCHO, and hydroperoxyl radical $HO_2^{\bullet}$.

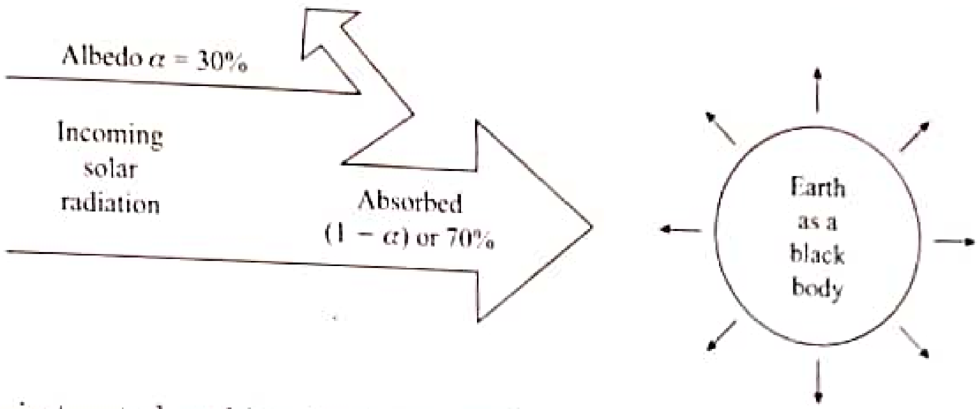
(*v*) $HO_2^{\bullet}$ then reacts with another molecule of NO to give NO_2 and $HO^{\bullet}$.

(*vi*) $HO^{\bullet}$ is extremely reactive and rapidly reacts with a stable hydrocarbon RCH_3 to yield H_2O and regenerate the hydrocarbon-free radical $RCH_2^{\bullet}$, thereby completing cycle. This goes on and on as a chain reaction. One complete cycle yields two molecules of NO_2, one molecule of aldehyde RCHO, and regenerates the free radical $RCH_2^{\bullet}$ to start all over again. Very soon there is a rapid build-up of smog products.

Ans. (a) Earth's Albedo: In a simple Radiation Balance Model (that includes the Earth's atmosphere. The fraction of incoming solar radiation that is reflected back to space, is known as the **Albedo**, and for the earth (known as **Earth's albedo**), the global annual mean value is usually estimated to be about 30%.

Symbolically, $\alpha = 30\%$.

So the energy absorbed by the earth and atmosphere $= S\pi R^2(1-\alpha)$. Energy emitted by the earth $= \sigma \cdot 4\pi R^2 \cdot T_e^4$ where, $T_e =$ effective temperature or the equivalent temperature of the earth.



As earth is treated as black body by applying same principle *i.e.* absorbed energy = radiated energy.

$$S\pi R^2(1-\alpha) = \sigma \cdot 4\pi R^2 \cdot T_e^4$$

or, $$T_e = \left[\frac{S(1-\alpha)}{4\sigma}\right]^{1/4}$$

Substituting appropriate values into the above equation yields

$$T_e = \left[\frac{1.370\ \mathrm{W/m^2}(1-0.31)}{4 \times 5.67 \times 10^{-8}\ \mathrm{W/m^2}/K^4}\right]^{1/4} = 254\mathrm{K}$$

i.e., $-18°$C so the earth should be cold. But actually the value of the earth's average temperature is about 288K (15°C), *i.e.*, 33°C hotter than the predicted value.

The factor that makes our model differ so much from reality is that it does not account the interaction between the atmosphere and the radiation that is emitted from the earth's surface, *i.e.*, it does not include the green house effect.

(b) Aquifer: An aquifer is a saturated geologic layer that is permeable enough to allow water to flow fairly easily through it. An *unconfined aquifer* (also known as *water table aquifer*) is one in which a free surface, *i.e.* a water table exists. Recharge of this aquifer takes place through infiltration of precipitation (*i.e.* rainfall, etc.) from the ground surface.

A *confined aquifer*, also known as *artesian aquifer*, is an aquifer which is confined between two impervious beds such as aquicludes or aquifuges. Recharge of this aquifer takes place only in the area where it is exposed at the ground surface. If within the zone of saturation, an impervious deposit below a pervious deposit is found to support a body of saturated material, then this body of saturated material which is a kind of aquifer is known as *perched aquifer*. Draw Fig. 4.21 and 4.22 from Chapter 4.

(c) The **catalytic converters** are usually made of noble metals, like *platinum*, *palladium*, etc., and help in oxidising CO and HC into their final end product of CO_2, and also to

Let 'N' be the population at the maximum sustainable yield point gives $1 - \frac{2N}{K} = 0$

So that, $N = \frac{K}{2}$ [for maximum sustainable yield]

4. What do you mean by Biochemical Oxygen Demand (BOD)? Prove that $BOD_t = L_0(1 - e^{-kt})$ where L_0 is the initial concentration of dissolved oxygen, K is the rate of degradation of organic waste. **2 + 3**

Ans. ***Bio-chemical Oxygen Demand (B.O.D.)*** is a measure of the oxygen utilised by the bacteria and other micro-organisms while stabilising (oxidising) biologically active or 'decomposable organic matter' in a wastewater sample under aerobic condition (in presence of free dissolved oxygen) at standardised time and temperature. The term 'decomposable organic matter' implies that the organic matters serve as food to the micro-organisms. i.e. micro-organisms will derive their energy from these matters. It is generally expressed in mg/L or in ppm.

For deduction, see Ans. to Q. 7(c) of May 2012.

5. Explain with diagram any two of the following:

(a) Sub Adiabatic Lapse rate (b) Super Adiabatic Lapse rate **$2\frac{1}{2} \times 2 = 5$**

(c) Neutrally stable lapse rate.

Rate of energy gain = Rate of energy loss?

Earth's surface: 168 + 324 + 30 = 78 + 24 + 30 + 390 (checks)

Atmosphere: 67 + 78 + 24 + 350 = 165 + 30 + 324 (checks)

Space: 107 + 165 + 30 + 40 = 342 (checks)

So, the model shows the necessary balances.

3.5 Meteorological Factors: Lapse Rates etc.

3.5.1 Lapse Rates: Ambient Lapse Rate, Adiabatic Lapse Rate

In the troposphere, the temperature of the ambient air usually decreases with an increase in altitude. This rate of temperature change is called the *lapse rate*. This rate can be determined for a particular place at a particular time by sending up a balloon equipped with a thermometer. The balloon moves *through* the air, not with it, and the temperature gradient of ambient air, which the rising balloon measures, is called the *ambient lapse rate*, the *environmental lapse rate* (ELR), or the *prevailing lapse rate*.

For calculation purposes, the cooling process within a rising parcel of air is assumed to be *adiabatic* (*i.e.*, occurring without the addition or loss of heat). Utilizing the two basic concepts of physics, the ideal-gas law and the law of conservation of energy, it is possible to establish a mathematical ratio expressing temperature change against altitude gain under adiabatic conditions. This rate of decrease is termed the *adiabatic lapse rate*.

As an air parcel, pictured as a little sphere of air, rises in the atmosphere, the height or weight of air above it becomes lesser and so does the pressure. Any gas free to expand will tend to move from the region of high pressure to the region of low pressure. As it does so, it expands to accommodate the decreasing pressure and does work on the surroundings. Since the process is usually rapid, there is no heat transfer between the air parcel and the surrounding air. Hence, for the case of an adiabatic process the first law of thermodynamics yields,

$$dQ - dW = dU \quad \text{or} \quad -dW = dU \quad [\text{since} = 0] \tag{3.18}$$

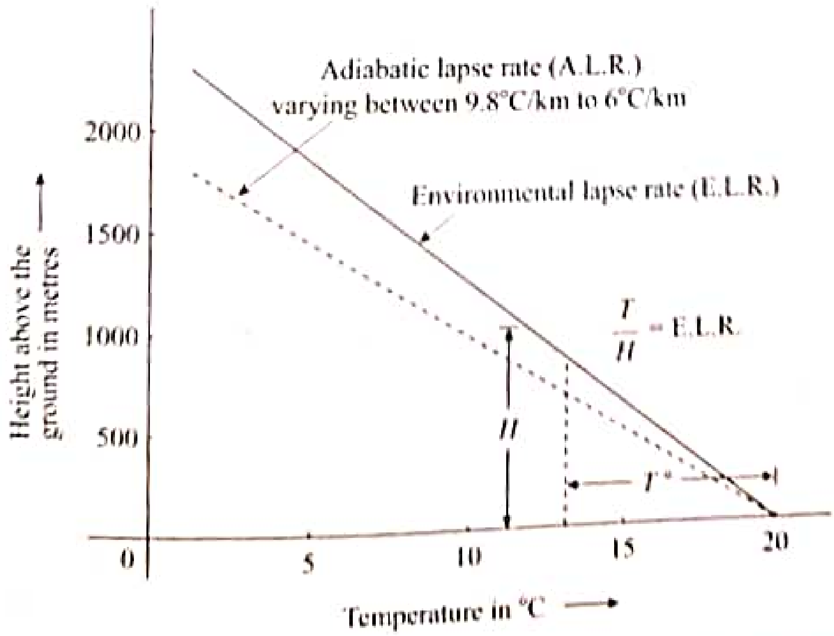


Fig. 3.18 The change of temperature with height in the environment, called E.L.R

Simple Global Temperature Models

Modeling global climate and estimating the effect of increasing concentrations of influential gases such as carbon dioxide is an extremely important, but difficult task. Such models range from very simple back-of-the-envelope calculations, to complex, three dimensional atmospheric general circulation models (GCMS) that attempt to predict climate on a regional & seasonal basis.

The starting point in predicting changes in climate begins with models that focus on factors influencing global temperature. Besides temperature, aspects of climate that are crucial include variables such as winds, ocean currents, precipitation, soil moisture, runoff, snow cover, polar sea ice and glaciers.

The earth as a black body

Using this model we calculate earth surface temperature. In this model we assume earth behaves like a black body. Radiation from the sun arrives just outside the earth's atmosphere with an average annual intensity, called the solar constant (S) equal to 1372 W/m². A simple way to calculate the total rate at which energy is absorbed by the earth is to note that all of the flux passing through a disk having radius equal to that of the earth, & placed normal to the incoming radiation, strikes the earth's surface. Energy absorbed by the earth

$$E_a = S \pi R^2 \text{ ------(1)}$$

Where E_a = Rate of energy absorption (Watts)

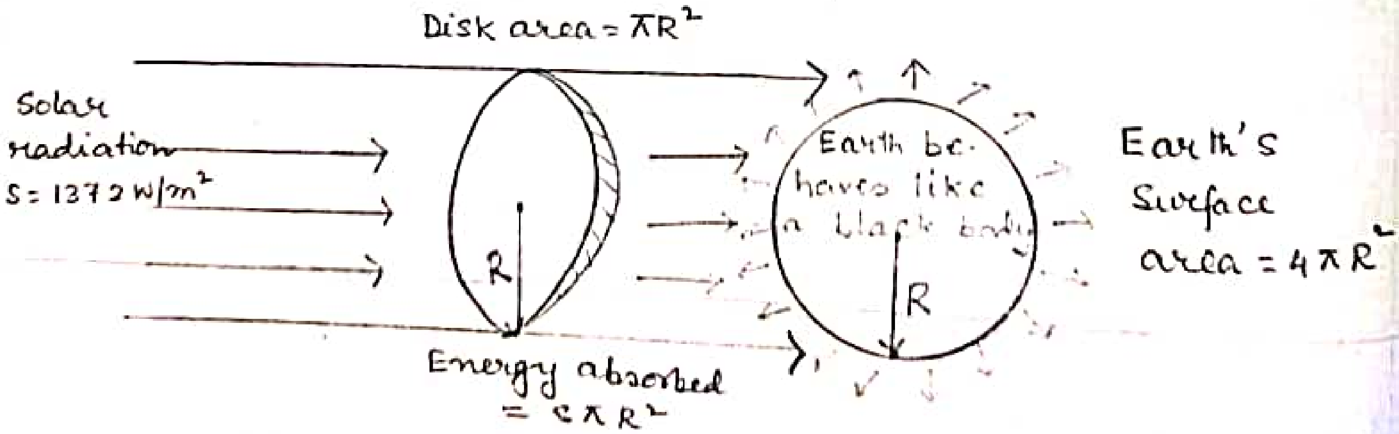
R = Radius of the earth (m).

The energy radiated by the earth surface

$$E_r = 4 \pi R^2 \sigma T_s^4$$

σ = Stefan-Boltzmann const $= 5.67 \times 10^{-8}$ W/m² K⁴

T_s = Surface temperature of the earth.



In the above figure earth is treated as a black body, absorbing all radiation impinging upon it & radiating an equal amount.

If we go on to assume steady-state conditions that the earth's temperature is not changing with time, we can equate the rate at which energy from the sun is absorbed with the rate at which energy is radiated back to space. Since space is essentially a vacuum, there is no heat transfer to it by conduction or convection. And since the earth's temperature is assumed constant, we assume that there is change in internal energy.

Absorbed energy = Radiated energy

$$S \pi R^2 = \sigma 4 \pi R^2 T_s^4$$

$$T_s = \left(\frac{S}{4\sigma}\right)^{1/4}$$

$$= \left(\frac{1372}{4 \times 5.6 \times 10^{-8}}\right)^{1/4}$$

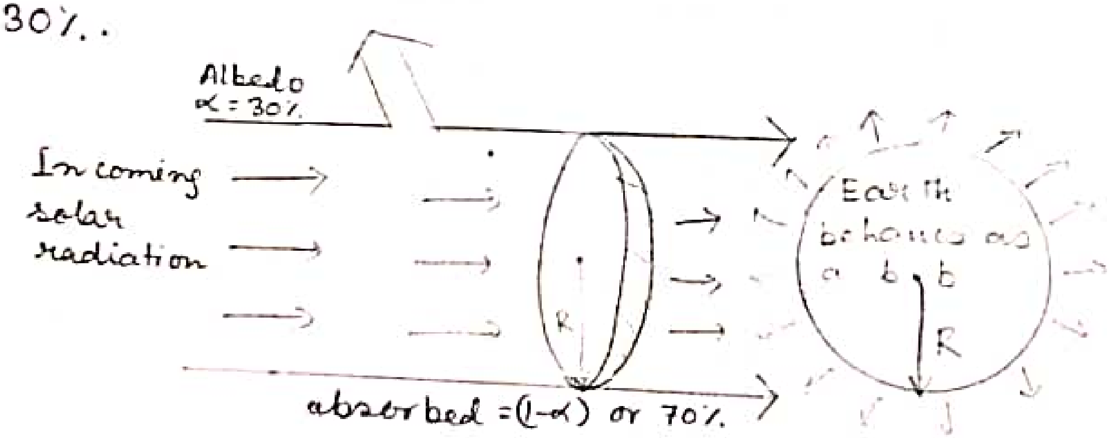
$$= 279 \text{ K}$$

This answer is remarkably close to the actual global average surface air temperature of about 288 K (15°C). Unfortunately, the apparent accuracy is to a large extent coincidental, rather than the result of this being a particularly good model.

A simple radiation balance model that includes the Earth's Albedo :-

This model is modified of the previous ~~one~~ model. In this model we assume 30% of the incoming solar radiation is not absorbed by earth or its atmosphere.

<u>Albedo</u> :- The fraction of incoming solar radiation that is reflected is known as the albedo & for the earth, the global annual mean value is usually estimated to be about 30%.



The above figure is a more realistic model that includes the earth's albedo.

In the above figure it is assumed that the earth is a black body absorbing all of the non reflected incoming solar radiation.

In this case albedo $(\alpha) = 30\%$. So the energy absorbed by the earth & atmosphere $= S(1-\alpha)\pi R^2$

Energy emitted by the earth $= \sigma 4\pi R^2 T_e^4$

T_e = Effective temperature or the equivalent (black body) temperature of the earth

** Refer to P- 10

Actual objects do not emit as much radiation as this hypothetical black body. The ratio of the amount of radiation an actual object would emit to the amount that a black body would emit at the same temperature is known as the emittance ε. The emittance of most natural materials is quite high and is not particularly related to color. The emittance of desert sand, dry ground & most wouldlands is estimated to be approximately 0.90 while water, wet sand and ice all have estimated emittances of 0.95.

While Stefan-Boltzmann's law gives the total rate at which energy is radiated from a black body, it does not tell us anything about the wavelengths emitted. A black body emits radiation with a range of wavelengths with a spectral distribution that can be described with such as the one shown in figure below. The wavelengths at which the spectrum reaches rule indicates that objects with higher temperatures reach their maximum emissive intensity at shorter wavelengths, so their spectral curves are also shifted toward the left, as is shown in figure (b).

Q. Consider the earth to be a black body with average temperature 15°c and surface are equal to $5.1 \times 10^{14}\ m^2$. Find the rate at which energy is radiated by the earth and the wavelength at which max. power is radiated.

$$E = \sigma A T^4$$
$$= 5.67 \times 10^{-8}\ W/m^2\text{-}k^4 \times 5.1 \times 10^{14}\ m^2 \times (15 + 273.15\ k)^4$$
$$= 2.0 \times 10^{17}\ W$$

The wavelength at which the max. point is reached in the earth's spectrum is, by

$$\lambda_{max}(\mu m) = \frac{2898}{T(K)} = \frac{2898}{288.15} = 10.1\,\mu m.$$

Q. Measurement made outside the earth's atmosphere indicate that the solar spectrum peaks at $0.48\,\mu m$. If the sun is considered to be a black body, what would its temperature be?

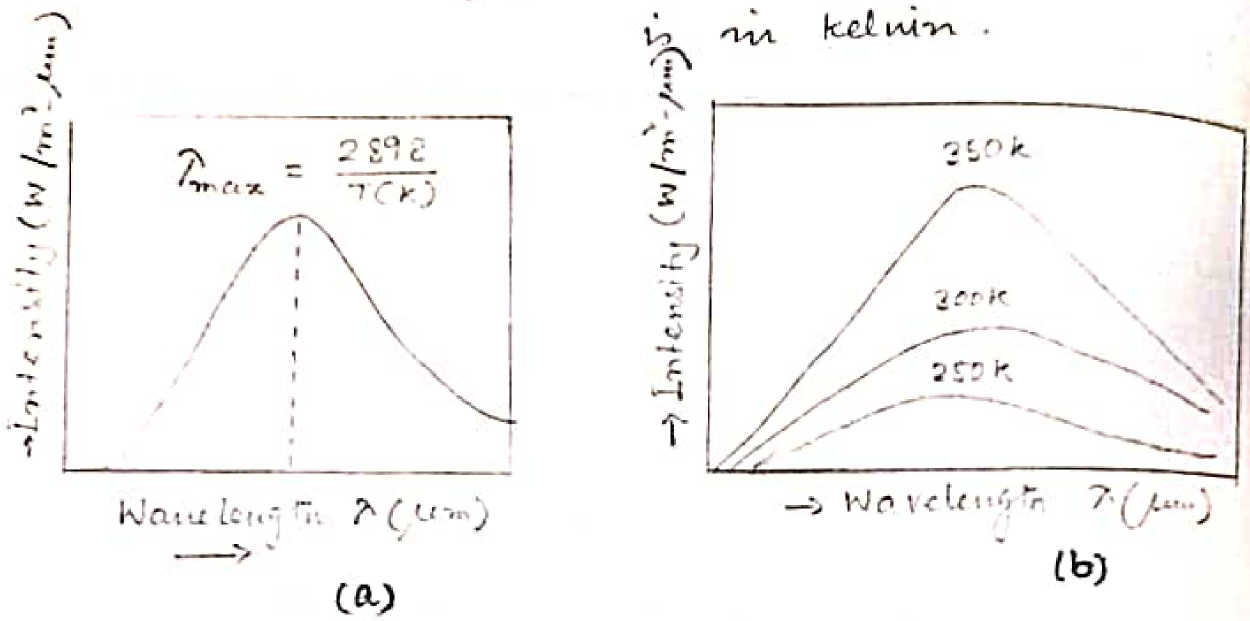
From Wien's displacement rule

$$T(K) = \frac{2898}{\lambda_{max}(\mu m)} = \frac{2898}{0.48} = 6040\ K$$

its maximum is given by the following, known as Wien's displacement rule.

$$\lambda_{max} = \frac{2898}{T(K)}$$

Where wavelength is specified in micrometers & temp is in kelvin.



spectral emissive power of a black body (a) showing Wien's rule for the wavelength at which power is a maximum & (b) showing the effect of temperature.

The way to interpret a spectral diagram is to realize that the area under the curve between any two wavelengths is equal to the power radiated by the object within that band of wavelengths. Hence, the total area under the curve is equal to the total power radiated, given by the Stefan-Boltzmann law. Objects at higher temperature have higher curves (greater area) and, in addition, Wien's

This means that the internal energy decreases thereby decreasing the temperature and the gas becomes colder. This is called *adiabatic cooling*. The decrease in temperature of a rising, expanding air parcel plays an important role in the vertical movement of air pollutants.

Dry air, expanding adiabatically, cools @9.8°C per kilometer, the *dry adiabatic lapse rate*. In wet, as in dry adiabatic process, a saturated parcel of air rises and cools adiabatically, but a second factor affects its temperature. Latent heat is released as water vapour condenses within the saturated parcel of rising air. Temperature changes of the parcel are then due to the liberation of latent heat as well as to expansion of the air. *Wet adiabatic lapse rate* (6°C/km) is thus less than dry adiabatic lapse rate. Since a rising parcel of effluent gases would seldom be completely saturated or completely dry, the actual *adiabatic lapse rate* (ALR) generally falls somewhere between these two extremes.

In many situations, because of external heating or cooling effects, the ELR may be greater or less than the ALR. The two most important conditions from the point of air pollution are the super adiabatic lapse rate (rate more than adiabatic) and negative lapse rate (inversion). On a clear summer day, rapid heating of the earth by the sun warms the air near the surface, to the point where the ELR is super adiabatic. Under this condition, the atmosphere is said to be in unstable equilibrium, and marked vertical mixing of air results. This is the condition in which pollutants are rapidly dispersed.

The opposite condition is the negative lapse rate or temperature inversion. In this case the temperature increases as we go higher. This condition is most undesirable for the dispersion of pollutants. Negative lapse rate in comparison to the normal lapse rate line is shown in Fig. 3.19.

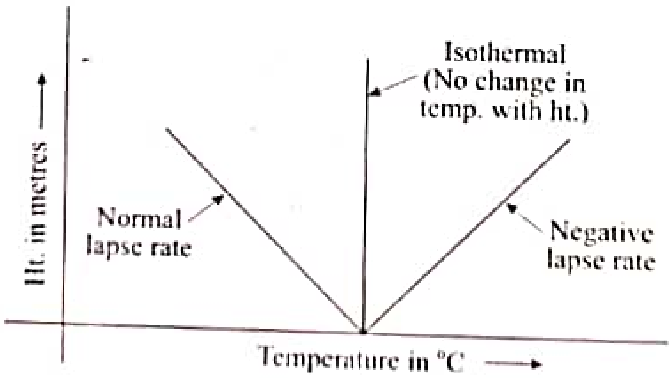


Fig. 3.19

3.5.2 Atmospheric Stability and Instability

Most weather phenomena depend on whether the air masses are stable or unstable: when the air is stable, vertical motion is suppressed; whereas, when it is unstable vertical currents develop; the air masses at high levels are then 'too heavy' to be supported by the partially warmer air masses at low levels. This results in vertical air currents; the process of overturning of unstable air masses is called *convection*.

If a unit of air, after being displaced a small distance up or down, has a tendency to return to its original level, the equilibrium is said to be *stable*. But if it shows a tendency to move further away from its original level, the equilibrium is said to be *unstable*. When the displaced unit neither returns to nor moves further away from its original level, the equilibrium is said to be neutral or indifferent.

Ans. Most weather phenomena depend on whether the air masses are stable or unstable; when the air is stable, vertical motion is suppressed; whereas, when it is unstable vertical currents develop; the air masses at high levels are then 'too heavy' to be supported by the partially warmer air masses at low levels. This results in vertical air currents; the process of overturning of unstable air masses is called *convection*.

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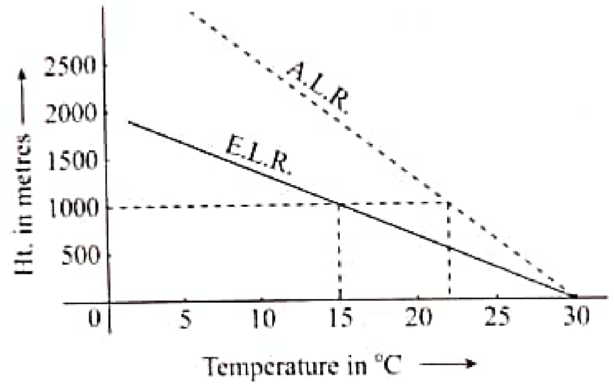

Fig. (i) Unstable Atmospheric Condition

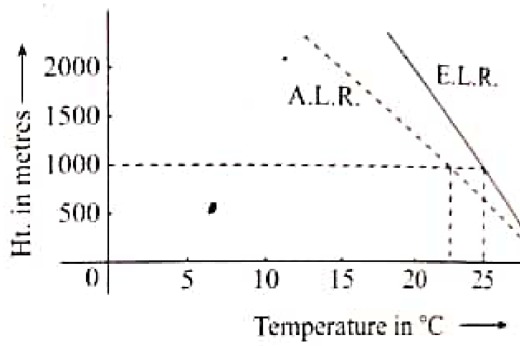

Fig. (ii) Stable Atmospheric Condition

Draw Fig. 3.22 from Chapter 3.

Criteria for stability and instability (for dry air): In the Figure [of Chapter 3, mentioned above] are shown two full lines (1 and 2) representing two hypothetical temperature curves (temperature profiles). The dotted line indicates the dry-adiabatic.

Let the curve (1) be considered first. For this curve ELR, Γ, is less than that for dry adiabatic (γ_d). That is $\Gamma < \gamma_d$.

Now let a unit of air at P be displaced upward, the unit will then follow the dry adiabatic through P. It is readily seen that the displaced unit would be colder and therefore denser than the environment. It would therefore sink down toward the level whence it came. The stratification is a *stable* one.

Next, curve (2) is considered which is characterised by $\Gamma > \gamma_d$. If the unit of air at P is displaced upward, it would cool as before, but the temperature of this unit of air moving adiabatically would now be warmer than the environment ; hence the unit would continue to rise further on account of its lesser density than the surrounding air. In this case the air is *unstable*.

As a limiting case, when the temperature curve coincides with the dry-adiabatic line [both being along (3)], the unit at P, after being displaced upward, would have exactly the same temperature as the environment. In this case the air is in a *neutral* or indifferent state of equilibrium.

The results so far obtained by displacing a unit air upwards shall also be obtained if the unit of air is displaced downward.

6. Write short notes on any two of the following: $2\frac{1}{2} \times 2 = 5$

(a) Earth's albedo (b) Aquifer (c) Catalytic converter (d) ESP.

reduce NO into nitrogen. These noble metal catalysts are highly active, and resist sulphur poisoning.

They may be made in pellets, or may be in the form of a monolithic one piece metal.

A catalytic converter is generally placed inside the tail exhaust pipe of the automobile, so as to pass through it the *partially oxidised emissions*, before they are let out into the atmosphere.

In earlier years, two different catalytic metal beds were being used for oxidising CO and HC, and for reducing NO ; but in modern days, catalysts have been designed, which catalyse both sets of reactions. These catalysts, popularly called three way catalysts, [platinum (Pt), palladium (Pd), and rhodium (Rh)], have simplified the dual bed to a single bed catalytic convertor. Hence, it is called the ***three-way catalytic converter*** (operating at around 800°C). The unit oxidises hydrocarbons and CO simultaneously to carbon dioxide and water while reducing NO_x to N_2 at the same time. The equation that follows represents the unbalanced reaction:

$$HC + CO + NO_x \xrightarrow{\text{catalyst}} H_2O + CO_2 + N_2$$

(d) Electrostatic precipitators: Write Article 3.12.5 and also merits and demerits from Table 3.21 from Chapter 3.

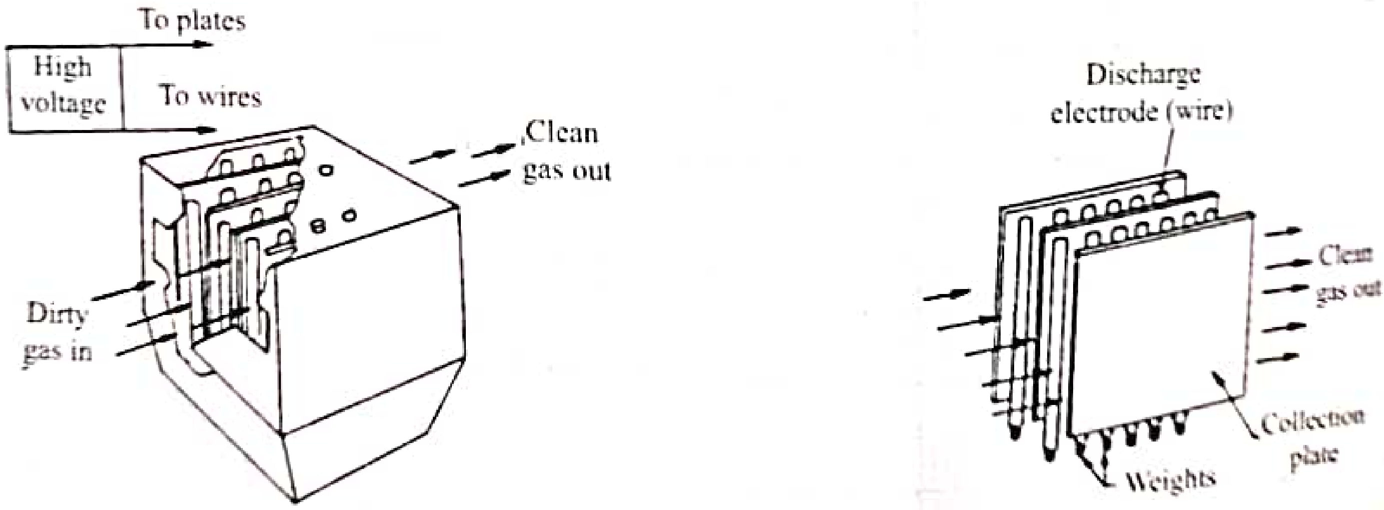

Fig. High Voltage Electrostatic Precipitator (plate type)

GROUP-C
(Long Answer Type Questions)

$3 \times 15 = 45$

Answer any *three* of the following.

7. (a) What is food chain?

(b) State the principal types of food chain with example.

(c) Write down the characteristics of food chain.

(d) What do you understand by ecological balance?

(e) What is biodiversity? Classify different types of biodiversity.

$2 + 3 + 3 + 3 + 4$

Ans. (a) and (b) Write Ans. to Q. 7(c) of May 2012.

(c) The major characteristic features of food chain are

(i) All pl... ...chain.