Atmosphere

It is the vast expanse of air surrounding the Earth, within which all weather phenomenon occurs.

Composition of the atmosphere

- The atmosphere is comprised of several gases, dust particles, and water vapour.
- The presence of oxygen becomes insignificant at the height of 120 km from the surface of the earth with respect to the composition of the atmosphere.
- Water vapors and Carbon dioxide occur only up to 90 km.

Ozone Gas

- Present around 10-50 km above earth surface and acts as a filter, absorbing UV (ultraviolet rays) from the sun.
- Ozone averts the harmful rays from reaching the surface of the earth.

Water Vapour

- Water vapour is a variable gas, declines with altitude.
- It also drops towards the poles from the equator.
- It acts like a blanket letting the earth to neither to become too hot nor too cold.
- It also contributes to the stability and instability in the air.

Dust Particles

- Dust particles are in higher concentration in temperate and subtropical regions due to dry winds in contrast to the Polar Regions and equatorial regions.
- They act as hygroscopic nuclei over which water vapour of atmosphere condenses to create clouds.

Nitrogen

- 78.03% of the total volume of the atmosphere
- Gaseous Nitrogen was discovered by Rutherford. It was initially called Rutherford.
- Since Nitrogen constitutes the largest proportion of the atmosphere, the phenomenon such as pressure, force of winds and reflection of light is largely due to Nitrogen.
- Properties : No colour, No odour, No taste, Prevents quick burning
- Importance : generates protein which is essential for the natural growth of plants and animals and also human beings
- Commercial usage : nitrogenous fertilizers
- The atmosphere is composed of 78% nitrogen.
- Nitrogen cannot be used directly from the air.
- Biotic things need nitrogen to make proteins.
- The Nitrogen Cycle is the way of supplying the required nitrogen for living things.

Oxygen

- 20.99% of the atmosphere volume.
- Importance : Life giver as it is essential for respiration, fuel combustion, provides base to industries
- The atmosphere is composed of 21% oxygen.
- It is used by all living things and is essential for respiration.
- It is obligatory for burning.

Argon

- 0.94%
- It enters the atmosphere due to radioactive breakdown of potassium within surface rocks
- The rate of formation is very slow
- It is an inert gas
- They are mainly used in light bulbs.

Carbon Dioxide

- It was the first gas to be studied
- 0.03% in the atmosphere
- It is the heaviest gas
- It is confined to lower layers
- Importance : growth of vegetation, green house effect, asphyxiant gas
- Properties : colourless, odourless, naturally occuring in atmosphere, groundwater,etc, water soluble
- It is used in fire extinguishers, for oil recovery, as a refrigerant and also for coal bed methane recovery
- Plants use it to make oxygen.
- It is significant as it is opaque to outgoing terrestrial radiation and transparent to incoming solar radiation.
- It is also responsible for the greenhouse effect.

Other major components of the air: Neon Helium Methane Krypton Hydrogen Water vapor (variable percentage)

Layers of Atmosphere Based on Composition of Constituents

It is the thin layer, in which most of the atmospheric processes take place. According to the concentration of the gases, atmosphere is divided into:

1. **Homosphere**: the lower part of atmosphere, upto the height of 90-100 kms. The proportion of gases is homogenous throughout the zone, hence the name ‘homosphere’. Main constituents are nitrogen and oxygen. However, the natural homogeneity is nowadays being disturbed by the economic activities of mankind.
2. **Heterosphere**: It extends from 100 kms. to the outer limits of atmosphere. Here the layers vary largely in their physical and chemical properties.

Importance of Atmosphere

- Base of life
- All the phenomenon concerning weather and climate
- Heat balance
- Protection against sun’s harmful Ultra violet rays through the Ozone layer

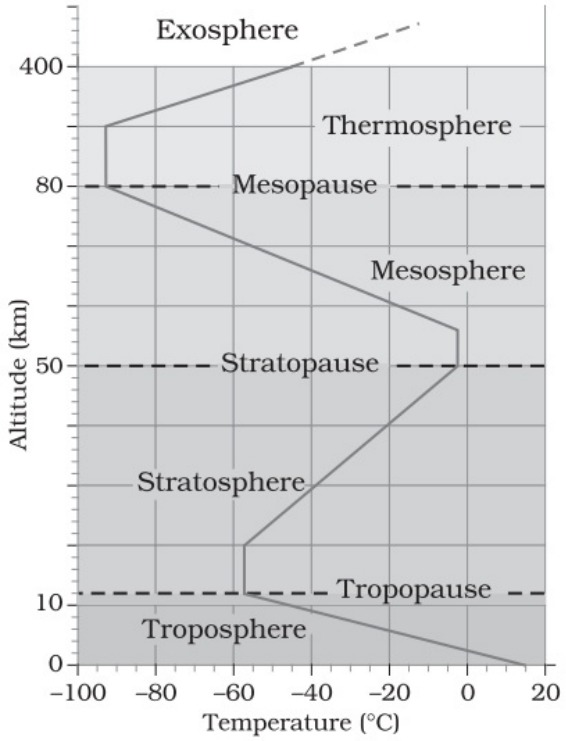
Ionosphere layer helps in radio broadcasting.

Our atmosphere is composed of many components. But the structure of the atmosphere is a combination of various layers.

Structure of Atmosphere

There are five layers in the structure of the atmosphere depending upon temperature. These layers are:

- Troposphere
- Stratosphere
- Mesosphere
- Thermosphere
- Exosphere



Troposphere

- It is considered as the lowest layer of Earth's atmosphere.
- The troposphere starts at surface of the earth and goes up to a height of 7 to 20 km.
- All weather occurs within this layer.
- This layer has water vapour and mature particles.
- Temperature decreases at the rate of 1 degree Celsius for every 165 m of height.
- Tropopause separates Troposphere and Stratosphere.

Stratosphere

- It is the second layer of the atmosphere found above the troposphere.
- It extends up to 50 km of height.
- This layer is very dry as it contains little water vapour.

- This layer provides some advantages for flight because it is above stormy weather and has steady, strong, horizontal winds.
- The ozone layer is found in this layer.
- The ozone layer absorbs UV rays and safeguards earth from harmful radiation.
- Stratopause separates Stratosphere and Mesosphere.

Mesosphere

- The Mesosphere is found above the stratosphere.
- It is the coldest of the atmospheric layers.
- The mesosphere starts at 50 km above the surface of Earth and goes up to 85 km.
- The temperature drops with altitude in this layer.
- By 80 km it reaches -100 degrees Celsius.
- Meteors burn up in this layer.
- The upper limit is called Mesopause which separates Mesosphere and Thermosphere.

Thermosphere

- This layer is found above Mesopause from 80 to 400 km.
- Radio waves which are transmitted from the earth are reflected back by this layer.
- The temperature increases with height.
- Aurora and satellites occur in this layer.

Ionosphere

- The lower Thermosphere is called the Ionosphere.
- Ionosphere consists of electrically charged particles known as ions.
- This layer is defined as the layer of the atmosphere of Earth that is ionized by cosmic and solar radiation.
- It is positioned between 80 and 400 km above the Mesopause.

Exosphere

- It is the outermost layer of the atmosphere.
- The zone where molecules and atoms escape into space is mentioned as the exosphere.
- It extends from the top of the thermosphere up to 10,000 km.

General Circulation of the Atmosphere

- The pattern of the movement of the planetary winds is called the general circulation of the atmosphere.

Factors for General Circulation of the Atmosphere

- The pattern of planetary winds largely depends on:
- Latitudinal variation of atmospheric heating
- The emergence of pressure belts
- The migration of belts following the apparent path of the sun
- The distribution of continents and oceans
- The rotation of the earth
- The general circulation of the atmosphere also sets in motion the marine water circulation which affects the climate of the Earth.
- The air at the ITCZ (Inter Tropical Convergence Zone) upsurges because of convection caused by high insolation and low pressure is generated.
- The winds from the tropics join at this low-pressure zone.
- The joined air upsurges along with the convective cell.
- It reaches the top of the troposphere up to an altitude of 14 km.
- It further moves toward the poles. This causes accumulation of air at about 30^{o} North and South.
- Another reason for sinking is the cooling of air when it reaches 30 degrees North and South latitudes.
- Downward near the land surface, the air flows towards the equator as the easterlies.
- The easterlies from either side of the equator converge in the Inter-Tropical Convergence Zone (ITCZ).
- Such circulations from the surface up and vice-versa are called cells.
- This type of cell in the tropics is called the Hadley Cell.
- In the mid-latitudes, the circulation is that of dipping cold air that comes from the poles and the mounting warm air that blows from the subtropical high.
- At the surface, these winds are called westerlies and the cell is known as the **Ferrel cell.**
- At polar latitudes, the cold dense air subsides near the poles and blows towards middle latitudes as the polar easterlies. This cell is called the **polar cell**.
- These Ferrel cells, Hadley Cell, and polar cell set the configuration for the general circulation of the atmosphere.

General Atmospheric Circulation and its Effects on Oceans

- The general circulation of the atmosphere also influences the oceans.
- Warming and cooling of the Pacific Ocean is most significant in terms of general atmospheric circulation.
- The warm water of the central Pacific Ocean gradually drifts towards the South American coast and substitutes the cool Peruvian current.

- Such presence of warm water off the coast of Peru is known as the El Nino.
- The El Nino is associated with the pressure variations in Australia and Central Pacific.
- This variation in pressure condition over the Pacific is known as the southern oscillation.
- The combined phenomenon of El Nino and southern oscillation is known as ENSO.

Heating and Cooling of Atmosphere

- There are various ways of heating and cooling of the atmosphere.
- The earth after being warmed by insolation transfers the heat to the atmospheric layers in long waveform.

Conduction

- The air in interaction with the land gets heated gradually and the upper layers in touch with the lower layers also get heated. This process is called conduction.
- This process takes place when two bodies of uneven temperature are in contact with one another, there is a flow of energy from the warmer to the cooler body.
- The heat transfer continues until both the bodies reach the same temperature or the contact is interrupted.
- This process is significant in heating the lower layers of the atmosphere.

Convection

- The air in contact with the earth upsurges vertically on heating in the form of currents and transfers the heat of the atmosphere.
- This vertical heating of the atmosphere is known as convection.
- The convective transfer of energy is limited only to the troposphere.

Advection

- The transfer of heat through horizontal movement of air is called advection.
- Horizontal movement of the air is comparatively more significant than the vertical movement.
- Most of the diurnal variation in weather is caused by advection only in the middle latitudes.
- During summer in tropical regions predominantly in Northern India, local winds called ‘loo’ is the result of advection process.

Atmospheric Pressure:

- The weight of a column of air contained in a unit area from the mean sea level to the top of the atmosphere is called the atmospheric pressure.

- It is measured in force per unit area.
- It is expressed in ‘milibar’ or mb unit.
- In application level, the atmospheric pressure is stated in kilo-pascals.

  It is measured by the aneroid barometer or mercury barometer.
- In lower atmosphere, pressure declines rapidly with height.
- The vertical pressure gradient force is much larger than that of the horizontal pressure gradient and is commonly balanced by an almost equal but opposite gravitational force.
- Low-pressure system is encircled by one or more isobars with the lowest pressure at centre.
- High pressure system is also encircled by one or more isobars with highest pressure in centre.
- Isobars are lines connecting places having equal pressure.

Pressure gradient

- The rate of change of pressure in regard to distance is the pressure gradient.

Pressure belts

- There is a pattern of alternate high and low-pressure belts over the earth.
- There are seven pressure belts.
- Except the Equatorial low, there are two Sub-Tropical highs (in North and South), the two Sub-polar lows (in North and South), and the two Polar highs (in North and South).
- The above-given pressure belts oscillate with the movement of the sun.
- In the northern hemisphere, they move southwards in winter, and in summers they move northwards.
- The Equatorial region gets abundant heat and warm air being light, the air at the Equator rises, generating a low pressure.

Equatorial low

- It is found near the equator.
- The sea level pressure is low

Subtropical high

- The region in 30 degrees North and 30 degrees South, which are high-pressure areas.

Sub-polar Lows

- The region in 60 degrees North and 60 degrees South, which are low-pressure belts.

Polar Highs

- These occur near poles which have high pressure.

Pressure belts of the earth

- On the earth's surface, there are seven pressure belts. They are the Equatorial Low, the two Subtropical highs, the two Subpolar lows, and the two Polar highs. Except the Equatorial low. the others form matching pairs in the Northern and Southern Hemispheres.
- There is a pattern of alternate high and low pressure belts over the earth. This is due to the spherical shape of the earth—different parts of the earth are heated unequally.
- The Equatorial region receives great amount of heat throughout the year. Warm air being light, the air at the Equator rises, creating a low pressure. At the poles the cold heavy air causes high pressure to be created/ formed. It is also due to the rotation of the earth. In the Subpolar region around latitudes 60° to 65° North and South of the Equator, the rotation of the earth pushes up the bulk of the air towards the Equator, creating a low pressure belt in this region.

(i) Equatorial Low Pressure Belts

This low pressure belt extends from 0 to 5° North and South of Equator. Due to the vertical rays of the sun here, there is intense heating. The air therefore, expands and rises as convection current causing a low pressure to develop here. This low pressure belt is also called as doldrums, because it is a zone of total calm without any breeze.

(ii) Subtropical High Pressure Belts

At about 30°North and South of Equator lies the area where the ascending equatorial air currents descend. This area is thus an area of high pressure. It is also called as the Horse latitude. Winds always blow from high pressure to low pressure. So the winds from subtropical region blow towards Equator as Trade Winds and another wind blows towards Sub-Polar Low-Pressure as Westerlies.

(iii) Circum-Polar Low Pressure Belts

These belts located between 60° and 70° in each hemisphere are known as Circum-Polar Low Pressure Belts. In the Subtropical region the descending air gets divided into two parts. One part blows towards the Equatorial Low Pressure Belt. The other part blows towards the Circum- Polar Low Pressure Belt. This zone is marked by ascent of warm Subtropical air over cold polar air blowing from poles. Due to earth's rotation, the winds surrounding the Polar region blow towards the Equator. Centrifugal forces operating in this region create the low pressure belt appropriately called Circumpolar Low Pressure Belt. This region is marked by violent storms in winter.

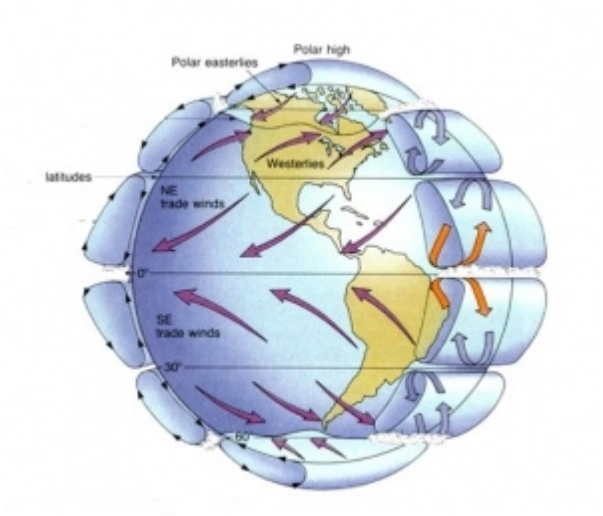
(iv) Polar High Pressure Areas

At the North and South Poles, between 70° to 90° North and South, the temperatures are always extremely low. The cold descending air gives rise to high pressures over the Poles.

These areas of Polar high pressure are known as the Polar Highs. These regions are characterised by permanent Ice Caps.

Shifting of pressure belts

If the earth had not been inclined towards the sun, the pressure belts, as described above, would have been as they are. But it is not so, because the earth is inclined 23 1/2° towards the sun. On account of this inclination, differences in heating of the continents, oceans and pressure conditions in January and July vary greatly. January represents winter season and July, summer season in the Northern Hemisphere. Opposite conditions prevail in the Southern Hemisphere. When the sun is overhead on the Tropic of Cancer (21 June) the pressure belts shift 5° northward and when it shines vertically overhead on Tropic of Capricorn (22 December), they shift 5° southward from their original position. The shifting of the pressure belts cause seasonal changes in the climate, especially between latitudes 30° and 40° in both hemispheres. In this region the Mediterranean type of climate is experienced because of shifting of permanent belts southwards and northwards with the overhead position of the sun. During winters Westerlies prevail and cause rain. During summers dry Trade Winds blow offshore and are unable to give rainfall in these regions. When the sun shines vertically over the Equator on 21st March and 23rd September (the Equinoxes), the pressure belts remain balanced in both the hemispheres.



Insolation Solar Radiation

Incoming solar radiation is known as Isolation and it is received in the form of short waves. The earth's surface receives the radiant energy at the rate of 2 calories per sq. cm. per minute.

Factors effecting the distribution of Insolation:

1. Distance between Earth & Sun: The average distance between these two bodies is about 149 million km. On January 3 the earth comes closer to the sun, called "perihelion". On July 4, the earth is little farther from the sun and this position is called 'aphelion'. Hence the amount of incoming solar radiation is about 7 per cent more in January.

2. Angle of Incidence: The oblique rays have to travel longer distance through the atmosphere before they strike the surface of the earth and large amount of energy is lost by various

processes of reflection, absorption, scattering, etc. At mid-day the intensity of insolation is maximum. In winter and high latitudes , the insolation received is small.

3. Duration of Sunshine: The most important causes for the variation in the amount of solar energy reaching the earth are the seasonal changes in the angle at which the sun's rays strike the surface and the length of the day.

Summer Solstice: 21st June

Winter Solstice: 22nd December

Autumnal Equinox: 23rd September

Spring Equinox: 21st March

4. Solar Constant: When the sun spots appear in larger number, the intensity of the solar radiation received is increased. The number of sunspot changes on a regular basis in a cycle of 11 years.

5. Transparency of Atmosphere:

Reflection from dust, salt, smoke particles, etc returns short wave radiation to space. Similarly clouds tops deplete the amount of insolation. Transparency of the atmosphere is closely related to the latitudes. In the higher latitudes the sun's ray are more oblique. In winter when the altitude of the sun is relatively lower, there is greater loss of incoming solar radiation than in Summer.

Heat budget

The average temperature of the earth remains rather constant. It has been possible because of the balance between the amount of incoming solar radiation and the amount of terrestrial radiation returned to space. This balance of incoming and outgoing radiation has been termed as the earth's heat budget.

Let us assume that the total heat received at the top of the atmosphere is 100 units. About 35 units are reflected back to space even before reaching the earth's surface. Of these, 27 units are reflected back from the top of the clouds and 2 units from the snow and ice-covered areas of the earth. The reflected amount of radiation is called the Albedo of Earth.

The remaining 65 units are aborbed, 14 units within the atmosphere and 51 units by the earth's surface. The earth radiates back 51 units in the form of terrestrial radiation. Of these, 17 units are radiated to space directly and the remaining 34 units are absorbed by the atmosphere 6 units absorbed directly the atmosphere, 9 units through convection and turbulence and 19 units through latent heat of condensation. About 48 units absorbed by the atmosphere (14 units from insolation and 34 units from terrestrial radiation) and also radiated back into the space. Thus the total radiation returning from the earth and the atmosphere respectively is 17 + 48 = 65 units which balance the total of 5 units received from the sun. Hence the heat balance of the earth is always maintained.

Factors Influencing Temperature

1. Latitude: In general the temperature decreases from the equator to the poles as per the altitude of the mid-day sun.

2. Altitude: Temperature falls by 6.5° C for every 1 km ascent.

3. Ocean Currents: Warm ocean currents, moving pole wards, carry tropical warmth into the high latitude. This warming influence is very marked in latitudes 40° to 65° on the west side of the continents, especially along the sea-board of Western Europe. Cold currents have fewer effects upon temperature because they usually lie under offshore winds. However, there are some exceptions e.g. the coast of Labrador, where the summer temperatures are lowered by on shore winds which blow over the cold Labrador current.

4. Distance from Sea: The sun's heat is absorbed and released more slowly by water than by the land. So the sea-adjoining areas experience warming and cooling effects. The climatic regions whose temperatures are influenced greatly by the sea are called "maritime or oceanic or insular climate". Climate whose temperature is greatly influenced by the remoteness from the sea are called "continental climate"

5. Winds: In temperate latitudes, prevailing winds from the land lower the winter temperature but raise the summer temperature and the prevailing winds from the sea raise the winter temperature but lower the summer temperature. In tropical latitudes, on-shore winds modify the temperature of the coastal regions. Local winds sometimes produce rapid upward or downward changes in the temperature.

6. Cloud Cover and Humidity: Clouds reduce the amount of solar radiation reaching the earth's surface and the amount of earth radiation leaving the earth's surface. The heavy cloud cover of equatorial regions does not allow a day temperature over 30°C. In hot desert the absence of clouds results in very high day temperature of over 38°C and clear sky allows the earth heat to escape freely resulting in fall of temperature up 20°C at night.

7. Aspects: South facing slopes are warmer than north-facing slopes in the Northern Hemisphere while, in the Southern Hemisphere the reverse is true. In the high latitude the mid-day sun is at a low angle in winter and hence blocks of flats are usually built far apart to enable all the flats to receive some sunshine.

8. Length of Day: The length of day also influences the temperature.

9. Amount of Dust and Other Impurities in the Air: In the industrial areas and large urban centres, the polluted particles are abundant in the air .These particles not only absorb larger amount of insolation but also greatly absorb the terrestrial radiation. Hence these areas show larger temperature than the surrounding areas and are converted into **"Heat Islands".**

Between January and July all the isotherms in the northern hemisphere move northward. This movement of isotherm is greater over the land than over the oceans. The highest temperatures for both January and July are over the continents. The isotherms bend pole ward over the ocean but equator ward over the continent in January. The isotherms bend equator ward over the ocean but pole ward over the continents in July. The seasonal changes are less marked over the southern continents than over the northern ones. The range of temperature increases from the equator to the poles. The coastal regions have a smaller range of temperature than the continental interiors.

The range of temperature on the eastern sides of Asia and North America is greater than on the Western side in the same latitude.

Temperature Anomaly: Temperature varies even along the same parallel of latitude because of the factors like altitude, land and water contrasts, prevailing winds and ocean currents. The difference between the mean temperature of any place and the mean temperature of its parallel

is called the Temperature Anomaly or Thermal Anomaly. It therefore, expresses deviation from the normal.

Inversion of Temperature: Air temperature also varies according to the altitude, at higher altitudes air becomes less dense; it is unable to absorb heat, resulting in colder air temperature. The normal drop of temperature with height is known as normal lapse rate which is 6.4°C per km on an average. Temperature inversion is the situation where there is increase in temperature, with height before beginning to drop into the normal lapse rate. In cases where the temperature remains the same with increase of altitude, the layer of atmosphere is called Isothermal.

Pressure & Wind: Wind can be defined as air in motion. The principal cause of winds is the difference in pressure. Air always moves from areas of high pressure to those with low pressure. The slope of the pressure from high to low is known as the pressure gradient and the direction of this gradient decides the direction of the winds.

Owing to the earth's rotation, all the winds are deflected to the right in the northern hemisphere and to the left in the southern hemisphere. This is referred to as the Ferrel's Law and the force occuring due to the rotation of the earth is called the Coriolis force.

Buys Ballot's Law: In northern hemisphere, if a person stands with his back to the wind, low pressure lies to his left and high pressure lies to his right. In S-Hemisphere it is reversed since the Coriolis deflection is to his left.

Types of winds:

(i) Planetary winds or Prevailing winds: Trade winds, Westerlies and Easterlies.

(ii) Periodic winds: Land breeze, Sea breeze & Monsoon winds.

(iii) Local winds: Loo, Fohn, Chinook, Mistral and Jet Streams.

(iv) Atmospheric Disturbances: Tropical Cyclones and Temperate Cyclones.

I. Planetary Winds: The wind systems that are bound to occur at the global level on any planet having an atmosphere and rotating about its axis. The specific characteristics of trade winds, Westerlies and Easterlies may be determined by several conditions but the broad features are constant over the globe.

Trade Winds: These winds blow from the subtropical high pressure towards the equatorial region of low pressure regularly throughout the year. It brings little rain except on the line of convergence of the two trade wind systems-

Westerlies: The Westerly winds are those which blow with great frequency from the Horse latitudes towards the Polar region throughout the year with varing intensity and cause rain near the Polar Regions. Westerlies. are stronger in the Southern Hemisphere because of the vast expanse of ocean waters. Owing to their ferocious nature, they are also described as "Roaring Forties", "Furious Fifties" and "Shrieking Sixties" in southern hemisphere.

Doldrums: Also known as Intertropical convergence, it is the equatorial belt of low atmospheric pressure where the north-east and south east Trade winds converge. It is a region of calmness, the calm periodically broken by storms, accompanied by heavy rains.

Horse Latitude: They are the sub-tropical belts of high atmospheric pressure over the oceans (near 30° latitude} between the regions of trade winds and Westerlies. They are regions of calm, light variable winds and dry air .

II. Periodic Winds:

Monsoon: The word monsoon has been derived from the Arabic word "Mausim" which means season. The monsoon winds thus refer to the wind systems that have a pronounced seasonal reversal of direction. The monsoon winds blow over India, Pakistan, Bangladesh, Burma, Sri Lanka, Arabian Sea, Bay of Bengal, S.E. Asia, N. Australia, China and Japan.

Summer Monsoon: During summer, a thermal low Is developed over southern Asia in the lower levels of the atmosphere. From the Indian Ocean and the south western Pacific, warm humid air moves northward and north westward into Asia passing over India and China. This summer monsoon is accompanied by heavy rainfall in south-east Asia.

Winter Monsoon: The Winter monsoon is a gentle drift of air in which the winds generally blow from the north east. Retreating monsoon causes sporadic rainfall especially in the north-eastern parts and Tamil Nadu coastal areas of India. Outside India, in the East Asian countries e.g. China and Japan, the winter monsoon is stronger than the summer monsoon.

III. Local Winds: There are winds that develop as a result of local conditions in temperature and pressure of air .They affect small areas in the lowest levels of Troposphere.

Loo: A very hot and dry wind (hot wave) in the North Western India and Pakistan which blows from the west in the afternoon of May and June and may cause sunstroke.

Chinook and Fohn: Warm and dry local winds, also called 'snow-eater' blow on the leeward sides of the mountains. These are called Chinook in the USA and Fohn in Switzerland.

Harmattan: The warm and dry winds blowing from north-east and east to west in the eastern parts of Sahara desert are called Harmattan. Similar winds are called 'brick fielder' in Australia, 'blackroller' in USA, 'shamal' in Mesopotamia and Persian Gulf and 'Norwesters' in New Zealand.

Sirrocco: It is a warm, dry and dusty wind which blows in northward direction from Sahara desert and after crossing Mediterranean Sea reaches Italy, Spain etc. Similar winds are known as Khamsin' in Egypt, 'Gibli' in Libya, 'Chilli' in Tunisia, and 'Simoom' in Arabia.

Diurnal Variation in Atmospheric Circulation

Diurnal wind systems occur frequently in many tropical areas. They also occur in other areas but rather irregularly and less frequently. There are two major types of diurnal wind systems:

1. Land and Sea Breezes: These occur along the coast or near large water bodies. They are caused by the thermal differences between the land and water surface.

Sea Breeze: Takes place during the day when a local thermal low develops over the land with the winds blowing from the sea towards the land.

Land Breeze: Take place during the night when the land cools off rapidly while the sea is still warm. Then the winds blow from the land towards the sea.

2. Mountain (Katabatic) and Valley (Anabatic) Winds: During the day when insolation is intense the more exposed hill slopes are heated more than the valley bottoms. Thus winds blow upward from the valley. These are valley or anabatic (up slope) winds. The high lands cool off rather rapidly because of terrestrial radiation losses. Cold and dense air then drains downslope into valleys. Such cold winds are known as mountain or Katabatic winds.

Cyclones: This is a depression in a mass of air whose isobars form an oval or circular shape with low pressure at the centre. The air converges at the centre and then rises. The winds rotate anti clock wise in the northern hemisphere while in the southern hemisphere the circular movement of winds is in a clockwise direction: Moving cyclones are of three types:

A. Extratropical Cyclones:

1. Typical of middle and high latitudes; usually called a depression.

2. This cyclone varies in diameter from 200 km to 300 km.

3. Appearance may be circular or elongated or may be broad shallow, weak depressions.

4. Usually travel in groups or "Families" from the West to East.

5. Average speed is about 30-50 km per hour.

B. Tropical Cyclones:

1. Tropical Cyclones are found in low latitudes over oceans.

2. It is almost circular centre of extremely low pressure into which winds spiral.

3. The diameter of the storm ranges from 160 to 650 km and the velocity of the wind varies from a minimum of about 120 to 200 km per hour.

4. The life span of a tropical cyclone is about a week and the storm travels at the rate of 15-30 km per hour.

5. Tropical cyclones are characterized by violent winds and heavy rains.

6. The source of energy for the maintenance of tropical cyclones is the latent heat of condensation.

C. Tornadoes:

1. The most violent storms of lower troposphere.

2. The funnel shape cloud extends downwards from the base of cumulonimbus cloud layer.

3. Tornadoes which occur in conjunction with scattered thunderstorms are usually short-lived and have irregular paths.

4. The circulation of wind is usually in a counter clockwise direction; wind velocities are very high almost about 100 m/sec.

5. Occur frequently east of the Rockies Mountains in the Mississippi Basin in USA, in eastern India and east of the Andes Mountain.

6. At sea, tornadoes become water spouts having same characteristic except that they are small in diameter.

Anti-cyclones: It is opposite to the cyclones where two types of anticyclones are observed:

1. Relatively Stationary, also called, as warm anticyclones.

2. Travelling anticyclones, which are also called as cold anticyclones, are mainly found in the high latitude within continental polar air.

3. Barometric pressure is highest at its centre and decreases outward. Anticyclonic wind system blows out from the centre and because of the Coriolis Effect it has a clockwise circulation in the Northern hemisphere and counter clockwise in Southern hemisphere.

Beaufort scale: In 1806 “Admiral Beaufort” proposed a scale for estimating the wind velocity and developed the Beaufort scale.

Precipitation: It Is the process by which condensed water vapour falls to the earth's surface as rainfall, snowfall and other forms.

Dew point: it is the temperature at which a parcel of air would have to be cooled in order to reach saturation. The favourable conditions are moist air, light winds and clear night skies to ensure maximum cooling by radiation.

Condensation: In this process the water vapour is changed into liquid state. If air is cooled below its dew point, some of air's water vapour becomes liquid. Thus any further cooling of saturated air starts the process of condensation. Condensation depends upon two factors - relative humidity of air and degree of cooling.

Necessary Conditions for Condensation are:

1. The air must be saturated. Saturation occurs either when the air is cooled below the dew point or when vapour is added to the air.

2: There must be a surface on which the water vapour may condense For dew or frost, solid objects at the ground do this work. But when the condensation occurs in the air, the surface is provided by the dust particles or aerosols and these particles are known as "hygroscopicnuclei".

On the basis of its origin, precipitation may be classified into three main types:

1. Convectional Precipitation: It is caused when moist winds are drawn into the convection currents of a hot region. It generally occurs in equatorial region. The thundery rain of a summer afternoon is a typical example.

2. Orographic Precipitation: It is caused by the surface relief of the land, mainly, by the presence of mountain range. There is heavy rain on the windward side.

3. Cyclonic Precipitation: It is associated with the passage of a cyclone or depression.

Rainfall: When precipitation is in the form of water drops, we call it rainfall. Only when temperature of water vapour is above 0°C, rainfall will occur. At sub-zero level temperatures, snowfall will occur. Main determinants of rainfall are- latitude distance from the sea, direction of winds, proximity of mountains and seasons. The regions of heavy rainfall in the world are -

Equatorial regions, Tropical Monsoon regions and mid-latitude West Margin regions. Regions of low rainfall (below 25 cm annual) are- tropical desert, mid-latitude deserts and Polar Regions.

Humidity: It refers to the content of water vapour present in air in gaseous form at a particular time and place. It is measured through an instrument called 'hygrometer.'

Absolute Humidity: The total weight of moisture content or water vapour per volume of air at definite temperature is called absolute humidity.

Specific Humidity: It is defined as the mass of water vapour in grams contained in a kilogram of air and it represents the actual quantity of moisture present in a definite air .

Relative Humidity: It is defined as a ratio of the amount of water vapour actually present in the air having definite volume and temperature (i.e.. absolute humidity) to the maximum amount the air can hold at that temperature (i.e. humidity capacity).

Forms of Precipitation

Rain: Of liquid water particles in the form of drops of more than 0.5 mm dia.

Drizzle: Fine drops of water (diameter less than 0.5 mm), very closer to one another.

Snow: White and opaque grains of ice.

Sleet: Mixture of rain and snow.

Hail: Small pieces of ice with diameter ranging from 5 to 50 mm.

Zero Visibility: When the object cannot be seen easily beyond 25 m.

'9' Visibility: When the object can be seen easily upto 50 km.

World Distribution of rainfall:

After examining the latitudinal pattern of distribution of rainfall it will be seen that the maximum is received in the equatorial zone and the minimum is in the Polar Regions. A secondary maximum lies in the belt of 40°-60° N and 40°-60° S and a secondary minimum occurs around 30° N and 30° S latitudes. This pattern of rainfall distribution is closely related to the distribution of major pressure belts of the world. The two zones of maximum precipitation are related to the equatorial low pressure and sub-polar low pressure. These low pressure belts are regions of ascending air and therefore precipitation is greater than elsewhere. The belts of minimum precipitation are zones of polar high pressure and subtropical high pressure. As the capacity to hold water vapour decreases sharply with temperature, precipitation is generally higher in the low latitudes than in the high latitudes,

This broad latitudinal pattern is modified by the distribution of continents and oceans, and the direction of prevailing winds. Winds blowing from the oceans towards the landmasses are called on shore winds. Such winds are moisture laden and give rainfall along the coast. When winds blow from the land masses towards the oceans, they are called off-shore winds. These are not rain bearing winds.

In the belt of trade winds, there is maximum precipitation in the eastern margins of continents as the easterly winds blow from the oceans. In this belt rainfall decreases towards

the west. The western margins of continents are deserts. These are the tropical deserts of the world.

In the mid-latitudes, the westerly winds give maximum rainfall to the western margins of continents. Rainfall decreases gradually towards the east and the interiors of large continents are dry, These are mid-latitude deserts,

The location of mountain ranges with reference to prevailing winds also influences the distribution of precipitation, Maximum precipitation is received where the mountain ranges lie right across the path of prevailing winds e.g. the Western Ghats in India.

(a) The regions of heavy precipitation (more than 150 cm):

1. Equatorial regions: The Amazon and the Congo basins, Malaysia, Indonesia and New Guinea.

2. Tropical Monsoon regions: Parts of India, South-east Asia and South China,

3. Mid- latitude West Margin regions: Coastal regions of British Columbia, North-west Europe, South Chile and South Island of New Zealand.

(b) Moderate rainfall of 100 to 150 cm per year is received in the eastern margins of continents in the trade-wind belt. These are the sub- tropical eastern margins of China, the U.S.A., Brazil, South Africa and Australia,

(c) Regions of extremely low rainfall (less than 25 cm)

1. Tropical deserts Western margins of continents in the trade wind belt- Californian desert in the United States, Atacama, Kalahari, southern Africa, Sahara, Arabia and then in Afro Asia, and West Australia.

2. Mid-latitude desert in the interiors of large continents such as Asia and North America.

3. Polar Regions.

1. **Fog**: It is microscopically small drops of condensed water suspended in the air near the earth surface in sufficient number. It reduces the horizontal visibility to less than 1 km. For aviation purpose the reporting of fog is done only when the visibility is less than 9 km. On the basis of appearance the fogs may be classified as-

2. Smog: It is formed in the polluted air of large industrial centres having large number of soot and dust particles, generally dirty and mixed with smoke.

3. Haze: It limits the visibility between 2 km and 5 km.

4. Mist: It is intermediate between fog and haze (visibility between 1 and 2 km).

5. Smaze: It is an a mixture of smoke and haze.

6. Frost-Smoke: It is formed in the Arctic region when the air temperature falls much below the freezing point. It is a kind of fog having innumerable ice particles and super-cooled water droplets, formed by the process of condensation. It generally takes place on the surface of water bodies and later carried over to the land by winds.

Condensation in Atmosphere: The cooling needed to produce condensation can occur in a number of ways:

1. Relatively warm moist air moving over a colder surface.

2. The mixing of warm, moist unsaturated air with colder unsaturated air.

3. Radiative cooling from the land surface.

4. Upward motion of air.

Condensation Nuclei: The particles which serve as condensation nuclei are hygroscopic, that is, they have affinity for water.

Adiabatic Lapse Rate: The rate at which temperature decreases in rising and expanding as parcel is known as the adiabatic lapse rate. Until condensation occurs, temperature fall at the rate of about 9.8°C per/km. This is known as dry adiabatic lapse.

Multiple choice questions:

1. What is the meaning of the Albedo of earth?
a) The reflected amount of radiation
b) The absorbed amount of radiation
c) Terrestrial radiation
d) The heat budget
2. Which one of the following is mainly responsible for slow heat transfer from the equatorial to the Polar Regions?
a) Absorption
b) Conduction
c) Advection
d) Expansion
3. Which areas on earth are converted into “heat islands”?
a) Islands located near equator
b) Industrial and urban centers
c) Desert areas
d) Forested areas
4. The rainfall related to mountains is called:
a) Orographic rainfall
b) Cyclonic rainfall
c) Convectional rainfall
d) Frontal rainfall
5. Which one of the following pressure belts is called ‘Doldrums’?
a) Equatorial low pressure belt
b) Polar high pressure belt
c) Subtropical high pressure belt
d) Sub polar low pressure belt

6. Mistral is a:
a) Hot Dry Local Wind
b) Warm Dry Local Wind
c) Warm Moist Local Wind
d) Cold Dry Local Wind
7. Most of the weather phenomena take place in the:
a) Stratosphere
b) Troposphere
c) Ionosphere
d) Thermosphere
8. 'Horse Latitude' is the term applied to the:
a) 0°- 5° N and S Latitude
b) 60°- 65° N and S Latitudes
c) 30°- 35° N and S Latitudes
d) 40°- 60° N and S Latitudes
9. The average atmospheric pressure at sea level is:
a) 890 millibars
b) 1013.25 millibars
c) 1033.50 millibars
d) 1060 millibars
10. The ozone layer, above the stratosphere, protect the earth from:
a) X-Rays
b) Alpha Rays
c) Ultra Violet Rays
d) Infra Red Rays
11. On the earth's surface, there are in all_____ pressure belts.
a) 3
b) 5
c) 7
d) 9
12. Match List I with List II and select the correct answer from the codes given below the lists:

List I	List II
A. Tornado	1. Area of low rainfall
B. Cyclone	2. Heavy rainfall
C. Doldrums	3. Funnel shaped whirlwind
D. Volcano	4. Molten magma

Codes:

	A	B	C	D
a)	2	3	1	4
b)	3	1	2	4
c)	4	3	1	2
d)	1	3	2	4

13. Which of the following four instruments is a simple hygrometer?
a) Rain Gauge
b) Six's max and min thermometer
c) Wall thermometer
d) Wet and dry bulb thermometer
14. What we call to the imaginary lines drawn on maps joining all places receiving the same amount of rainfall.
a) Isohyets
b) Isotherms
c) Isobars
d) Isoseismic
15. Which of the following is not a type of precipitation?
a) Snow fall
b) Fog
c) Hail stone
d) Sleet
16. Which process transfer heat directly by molecular activity?
a) Radiation
b) Advection
c) Convection
d) Conduction
17. Which of the following is associated with clear skies, mild winds and dry conditions?
a) Anti- Cyclone
b) Norwesters
c) Loo
d) Cyclones
18. In which region do the four O' clock showers occur almost every day?
a) Temperate
b) Equatorial
c) Mediterranean
d) Monsoon
19. The name of the hot, dry and dusty winds which blow across Egypt is:
a) Loo
b) Harmattan
c) Khamsin
d) Chinook
20. 'Horse Latitude' is the term applied to the:
a) 0°- 5° N and S Latitude
b) 60°- 65° N and S Latitudes
c) 30°- 35° N and S Latitudes
d) 40°- 60° N and S Latitudes
21. Vertical movement of air is known as:
a) Wind
b) Air current
c) Moving air

d) None of them
22. These places experience moderate climate:
a) Mumbai and Kolkata
b) Patna and Lucknow
c) Bikaner and Jaisalmer
d) Ranchi and Asansol
23. Chinook is a:
a) Cold wind in Europe
b) Tropical desert storm in West Asia
c) Warm wind in North America
d) Depression in South Africa
24. The humidity of air measured in percentage is called:
a) Absolute humidity
b) Specific humidity
c) Relative humidity
d) All of the above
25. Albedo effect would be relatively higher in:
a) Early morning and late evening
b) Early morning only
c) Noon
d) Late evening only
26. The Westerlies have their origin in the:
a) Polar highs
b) Subtropical highs
c) Equatorial lows
d) Sub polar lows
27. Mid- Latitude cyclones:
a) Usually move across North- America from east to west
b) Are generally found only over the Ocean
c) Generally bring clear skies and little precipitation
d) Are formed in regions of strong temperature contrasts
28. What is the most important element of weather and climate?
a) Rainfall
b) Pressure
c) Temperature
d) Humidity
29. What is true about Troposphere?
a) Contains all the atmospheric water vapours
b) Contains more than half the atmospheric ozone
c) Maintains a constant temperature at a given height
d) With decreasing temperature pressure reduces.
30. The normal lapse rate of temperature continues up to:
a) Mesopause

b) Tropopause
c) Stratosphere
d) Stratopause
31. The mistral is experienced in:
a) Southern France
b) Iraq and Iran
c) California
d) North Adriatic Coast
32. A local wind blowing in the North Adriatic coast region is the:
a) Chinook
b) Burg
c) Bora
d) Brick fielders
33. In a Cyclone in the Northern Hemisphere winds blow
a) Anticlockwise
b) Clockwise
c) Radially outward
d) Straight centreward
34. Which one of the following weather conditions indicates a sudden fall in barometer reading?
a) Stormy weather
b) Calm weather
c) Cold and dry weather
d) Hot and sunny weather
35. Rain shadow effect is associated with
a) Cyclonic rainfall
b) Orographic rainfall
c) Convectional rainfall
d) Frontal rainfall
36. Match List 1 and List 2 and select the correct answer using the code given below the list:

List 1 (Winds)	List 2 (Areas)
A. Zonda	1. Australia
B. Khamsin	2. New Zealand
C. Nor-wester	3. Argentina
D. Brick filders	4. Egypt

Code:	A	B	C	D
a)	3	4	2	1
b)	3	2	4	1
c)	1	4	3	2
d)	2	3	4	1

37. Which one of the following gases is found in highest quantity in exosphere?
a) Hydrogen
b) Helium
c) Nitrogen
d) Oxygen

38. The Coriolis effect is the result of
a) Pressure gradient
b) Earth’s axis of inclination
c) Earth’s rotation
d) Earth’s revolution
39. Consider the following characteristics of a tropical cyclone:
1. A warm sea temperature of > 26 Degree Celcius
2. High relative humidity of atmosphere at a height of > 700 m
3. Atmospheric instability
The above mentioned characteristics are associated with which one of the following cycles of its development?
a) Formulation and initial stage
b) Modification stage
c) Full maturity
d) Decay
40. Logically, what does a continually rising air pressure indicate?
a) Advent of unsettled and cloudy weather
b) Advent of cyclone
c) Fine and settled weather
d) Fine and unsettled weather
41. The thickness of the troposphere increases in
a) Summer
b) Winter
c) Spring
d) Never Changes
42. The fall in the temperature with increasing elevation is called
a) Thermal anomaly
b) Thermal reduction
c) Thermal fall
d) Lapse rate
43. Where is doldrums belt located?
a) Near the Equator
b) Near the Polar Regions
c) On the tropic of cancer
d) On the tropic of Capricorn
44. What is the name given to the wind blowing from sub tropical high pressure region to the equator?
a) Westerlies
b) Trades
c) Northerlies
d) Doldrums
45. The reason for the fact that stratosphere is ideal for flying jet air craft is-
a) That this layer is rich in ozone which reduces fuel consumption
b) That the temperature is constant and ideal for aircraft engine efficiency
c) That this layer is out of the firing range of anti aircraft guns

d) That the absence of clouds and other weather phenomena
46. Incoming solar radiation is known as:
a) Radiation
b) Refraction
c) Insolation
d) Reflection
47. The velocity of wind is governed by-
a) Farrel's law
b) Pressure gradient
c) Rotation of the earth
d) Temperature
48. Why does the sky look blue
a) Because the blue light is scattered by dust particle
b) Because blue is the natural colour of the sky
c) Because of the presence of water vapour in the sky
d) Because blue colour has longest wave length
49. Water content in the atmosphere
a) Is not dependent on temperature
b) Increases as temperature increases
c) Remain unchanged as temperature changes
d) Can not be measured
50. The instrument used for measuring humidity
a) Barometer
b) Thermometer
c) Hygrometer
d) Hydrometer
51. Farrel's law describes
a) Velocity of wind
b) Direction of wind
c) Temperature of wind
d) None of these
52. Blizzards are found in
a) Equatorial region
b) Tropical region
c) Antarctic region
d) Temperate region
53. The importance of ozone in the atmosphere is
a) That it provides condensation nuclei
b) That it provides protection against ultraviolet radiation
c) That it helps in scattering blue light
d) That it creates greenhouse effect on earth
54. What is cyclone?
a) High pressure system with clock wise wind in the northern hemisphere

b) A low pressure system with clock wise wind in the northern hemisphere
c) A high pressure system with anti-clock wise wind in the northern hemisphere
d) A low pressure system with anti-clock wise wind in the northern hemisphere
54. What is anti-cyclone?
a) A high pressure system with clock wise wind in the northern hemisphere
b) A low pressure system with clock wise wind in the northern hemisphere
c) A low pressure system with clock wise wind in the northern hemisphere
d) A low pressure system with clock wise wind in the southern hemisphere
55. In the some part of the atmosphere very high velocity wind system is found which is called
a) Monsoon
b) Jet stream
c) A cyclone
d) An anti-cyclone
56. What is tornado?
a) A very high pressure centre
b) A very low pressure centre
c) A very high ocean wave
d) None of these
57. The process of changing water vapour into ice directly is called
a) Condensation
b) Sublimation
c) Snow
d) Precipitation
58. When humidity is expressed as percentage, it is called
a) Absolute humidity
b) Relative humidity
c) Specific humidity
d) Percentage humidity
59. What is vapour pressure?
a) The pressure due to vapour in the air only
b) Barometric pressure
c) Presence of vapour in the air
d) None of these
60. Sling Psychorometer is used for
a) Measuring temperature
b) Measuring humidity
c) Measuring pressure
d) Measuring wind velocity
61. The temperature at which the air is fully saturated is called
a) Saturation point
b) Dew point
c) Critical temperature
d) Condensation point

62. What is fog?
a) A low status cloud
b) A cirro status cloud
c) An altocumulus cloud
d) None of these
63. Hail consists of
a) Water droplets
b) Crystals of ice
c) Granular ice
d) Masses of ice in layers one above another
64. When mountain comes in the way of wind, it causes rain fall, it is called
a) Cyclonic rain
b) Orographic rain
c) Convectional rain
d) Adiabatic rain
65. The leeward side of a mountain does not receive rain fall is known as
a) Desert area
b) Dry zone
c) Rain shadow area
d) Convectional dry area
66. Which one of the following is used for measuring wind velocity?
a) Anemometer
b) Barometer
c) Hygrometer
d) Ammeter
67. Which one of the following is the pattern of circulation around a low- pressure area in the northern hemisphere?
a) Counter- clockwise and away from the centre
b) Clockwise and away from the centre
c) Counter- clockwise and towards the centre
d) Clockwise and towards the centre
68. What would be the influence on the weather conditions when in mid- winter a feeble high pressure develops over the north- western part of India?
1. High and dry winds would blow outward from this high pressure area.
2. The northern plain would become cold.
3. Scorching winds (locally called loo) would blow during the day time.
4. There would be torrential rains brought by thunderstorms.
Select the correct answer using the code given below.
a) 1 and 2 only
b) 2 and 3 only
c) 3 and 4 only
d) 1, 2, 3 and 4