

UNIVERSITY GRANTS COMMISSION

GEOGRAPHY**CODE: 80****UNIT – 2 : CLIMATOLOGY****SYLLABUS****Sub Unit – 1: Composition and structure of atmosphere**

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Section – 1: Unit at a Glance

Sub Unit – 1: Composition and structure of atmosphere

The atmosphere of Earth is the layer of gases, commonly known as air that surrounds the planet Earth and is retained by Earth's gravity.

Components: The atmosphere is made up of nitrogen (78%) and oxygen (21%). The rest of the gases combined only account for about 1% of the atmosphere. Along with all of these different gases, the atmosphere also holds many tiny, floating particles and droplets of liquid that scientists collectively call aerosols.

Structure of Atmosphere:

It surrounds the earth from all sides. Generally, it **extends up to about 1600 kilometres** from the earth's surface. 97 % of the total amount of weight of the atmosphere is limited up to the height of about 30 kilometres.

Troposphere: It extends from Earth's surface to an average height of about 12 km.

Stratosphere: The stratosphere extends from the top of the troposphere to about 50 km

Mesosphere: It extends from the stratopause at an altitude of about 50 km

Thermosphere: It extends from the mesopause (which separates it from the mesosphere) at an altitude of about 80 km (50 mi; 260,000 ft) up to the thermopause at an altitude range of 500–1000 km (310–620 mi; 1,600,000–3,300,000 ft).

Ionosphere: It is also a part of thermosphere. The layer reflects radio waves that are retransmitted from the earth and again back to the earth.

Sub Unit – 2: Temperature of atmosphere

Heat Budget of Earth: Earth's heat-budget or Earth's radiation balance refers to the net flow of energy into Earth in the form of shortwave radiation and the outgoing infrared long-wave radiation into space. This balance between incoming and outgoing heat is known as Earth's heat budget. 100 units of incoming solar radiation, 34 % are scattered or reflected back to space by the atmosphere and Earth's surface.

Vertical distribution of temperature: Temperature decreases with increasing height in the troposphere but the rate of decrease varies according to seasons, duration of sunshine and location. On an average, the rate of decrease of temperature with increasing altitudes in a stationary column of air with absence of any vertical motion is 6.5°C per 1000 meters.

Regional distribution of temperature: According to ancient Greek thinkers the globe is divided into three temperature zones on the basis of latitudes-**1.Tropical zone, 2.Temperate zone, 3.Frigid zone**

Sub Unit – 3: Atmospheric pressure and circulation

Air pressure and atmospheric circulation: **Low and high pressure zones:** In the Northern Hemisphere, if a person stands with his back to the wind, the atmospheric pressure is low to the left, high to the right. This is because wind travels counterclockwise around low pressure zones in the Northern Hemisphere. **Pressure Gradient Force:** Pressure Gradient Force is created due to the difference in the atmospheric pressure, and it is directed from the high pressure to the low pressure. **The Coriolis effect :** All winds move towards their right in the northern hemisphere and towards their left in the southern hemisphere with respect to the rotating earth. Thus, in the northern hemisphere winds blow counter-clockwise along the centers of low pressure while clockwise in the southern hemisphere. **Ferrel's Law:** Because of the rotation of earth all winds are deflected to their right in the northern hemisphere and to their left in the southern.

Air pressure measuring instruments: Barometer is an instrument used for measuring the atmospheric air pressure. Air pressure at 8 kilometers above is half of the ground.

Horizontal distribution of air pressure and pressure belts: There are distinctly identifiable zones of homogeneous horizontal pressure regimes or 'pressure belts'. On the earth's surface, there are seven pressure belts. a. Equatorial low pressure belts, b. Subtropical high pressure belts (north and south), c. Sub polar low pressure belts (north and south), d. Polar high pressure belts (north and south).

General circulation of the atmosphere: The concept is proposed by G. Hadley. The pattern of planetary winds depends on: latitudinal variation of atmospheric heating and the rotation of earth.

Classification of Winds: Macro scale winds are on a global scale. **Meso scale** describes storms like thunderstorms. There are also winds and small circulations that only last for a few seconds. These smaller circulations are described with the term **micro scale**.

Trade Winds (tropical easterlies): The trade winds or easterlies are the permanent east-to-west prevailing winds that flow in the Earth's equatorial region (between 30°N and 30°S latitudes). The trade winds blow predominantly from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere.

Westerlies: The westerlies are developed between 40° and 65°S latitudes. These latitudes are often called Roaring Forties, Furious Fifties, and Shrieking Sixties – dreaded terms for sailors.

Polar easterlies: The Polar easterlies are dry, cold prevailing winds blowing from north-east to south-west direction in Northern Hemisphere and south-east to north-west in Southern Hemisphere. They blow from the polar high-pressure areas of the sub-polar lows.

Monsoons: During summer sun rays become vertical over the tropic of cancer. That's why temperature rises enormously over the land surface which responsible to make extreme low pressure on it. Whereas high pressure is being develop over the Indian ocean due comparatively low temperature on it. Thus, moisture laden wind move from Indian ocean to land surface. It brings heavy rainfall all over India, Srilanka, Bangladesh and many more countries.

Some popular theories about Monsoon-

Land Breeze and Sea Breeze: During the day the land heats up faster and becomes warmer than the sea. In the land the air rises to up and create low pressure area, whereas the sea is relatively cool and the pressure over sea is relatively high. The wind blows from the sea to the land as the sea breeze.

Valley Breeze and Mountain Breeze: In mountainous regions, during the day the slopes get heated up and air moves upslope and to fill the resulting gap the air from the valley blows up the valley. This wind is known as the valley breeze. During the night the slopes get cooled and the dense air descends into the valley as the mountain wind. The cool air, of the high plateaus and ice fields draining into the valley is called katabatic wind.

Jet stream: The jet stream is mainly found in the tropopause, at the transition between the troposphere (where temperature decreases with height) and the stratosphere (where temperature increases with height).

El Niño normally occurs around Christmas and usually lasts for a few weeks to a few months. Sometimes an extremely warm event can develop that lasts for much longer time periods. In the 1990s, strong El Niños developed in 1991 and lasted until 1995, and from fall 1997 to spring 1998.

Sub Unit – 4: Metrological Hazards

water vapor and evaporation: As a solid, we call it ice, as a liquid, we call it water, and as a gas, we call it vapor.

Condensation: Condensation is the process by which water vapor in the air is changed into liquid water.

Latent heat: The heat required to convert a solid into a liquid or vapour, or a liquid into a vapour, without change of temperature.

Humidity: Humidity is the concentration of water vapour present in air.

Humidity capacity: Humidity of the air refers to the content of water vapour present in the air at a particular time and place.

Relative humidity: The relative humidity is defined as the ratio between the amount of moisture in the air at a particular temperature to the maximum moisture air can withstand at the same temperature. The relative humidity is 100% during rainy seasons.

$RH = (\text{actual vapour density} / \text{saturation water density}) \times 100\%$

Stability: When dry adiabatic lapse rate of an ascending dry air is higher than the normal lapse rate and if it is not saturated and does not attain dew point it becomes colder than surrounding air at certain height with the result it becomes heavier and descends. This process causes

stability of atmospheric circulation due to which vertical circulation of air is resisted.

Instability: atmospheric instability is caused when the rate of cooling of rising air (dry adiabatic lapse rate) is lower than the normal lapse rate.

FOG: The fog is a cloud with its base at or very near to the ground. Because of the fog and mist, the visibility becomes poor to zero.

CLOUD: Cloud is a mass of minute water droplets or tiny crystals of ice formed by the condensation of the water vapour in free air at considerable elevations. Clouds are caused mainly by the adiabatic cooling of air below its dew point.

1. Rainfall: drop size more than 0.5 mm.
2. Drizzle: light rainfall; drop size less than 0.5 mm.
3. Mist: evaporation occurs before reaching the ground leading to foggy weather.
4. Snowfall: fine flakes of snow fall when the temperature is less than 0°C.
5. Sleet: frozen raindrops and refrozen melted snow; mixture of snow and rain or merely partially melted snow.
6. Hail: precipitation in the form of hard rounded pellets is known as hail; 5 mm and 50 mm.

Front genesis: Front genesis is a meteorological process of tightening of horizontal temperature gradients to produce fronts. In the end, two types of fronts form: cold fronts and warm fronts.

Airmass: The air with distinctive characteristics in terms of temperature and humidity is called an air mass. It is a large body of air having little horizontal variation in temperature and moisture.

Cyclone:

A cyclone is a large scale air mass that rotates around a strong center of low atmospheric pressure. In 2014 cyclone Hudhud affects majorly in Andhra Pradesh Coasts.

The following types of cyclones are –

Tornado, b) Dust devil, c) Waterspout, d) Steam devil, e) Fire whirl etc.

Tropical Cyclone:

A low pressure is a winds blowing counter-clockwise around it in the Northern Hemisphere and clockwise around it in the Southern Hemisphere. A **tropical cyclone** is a cyclone which forms in the tropics. A tropical cyclone may regenerate in higher latitudes as an extra tropical depression, but it loses its identity as a tropical storm in the process. The typical lifetime of a tropical cyclone from its birth to death is about six days.

Haricanes: A *hurricane* is a tropical cyclone that occurs in the Atlantic Ocean and northeastern Pacific Ocean. Their source of energy is water vapor which is evaporated from the ocean surface.

Beaufort number: The Beaufort scale is an empirical measure that relates wind speed to observed conditions at sea or on land.

Tornado: Due to the Coriolis effect, the rotation direction of cyclone is clockwise in the southern and anti-clockwise in the northern hemisphere.

Cloudburst: A cloudburst is an extreme amount of precipitation in a short period of time, sometimes accompanied by hail and thunder, which is capable of creating flood conditions.

La Nina: Global climate La Niña impacts tend to be opposite those of El Niño impacts

storm surge: A storm surge, storm flood, tidal surge or storm tide is a coastal flood or tsunami-like phenomenon of rising water commonly associated with low pressure weather systems (such as tropical cyclones and strong extra tropical cyclones).

Sub Unit – 5: Climatic classification

Koppen: A widely-used vegetation-based climate classification system, the *Koppen climate classification system*, was created by Wladimir Koppen, a German botanist, and climatologist. The classification system attempts to derive a formula to categorize vegetation zones or biomes across the globe, in accordance with their climatic boundaries.

Thornthwaite: Charles Warren Thornthwaite was an American geographer and climatologist. He is best known for devising a climate classification system in 1948 that is still in use worldwide, and also for his detailed water budget computations of potential evapotranspiration.

Sub Unit – 6: Climatic change

Air Pollution:

Most of this air pollution we cause results from the burning of fossil fuels, such as coal, oil, natural gas, and gasoline to produce electricity and power our vehicles. It produces carbon dioxide, carbon monoxide and other green house gases. At the same time it also increase amount of aerosols in atmosphere. Most of them are Polycyclic aromatic hydrocarbons (PAHs).

Global Warming: Global warming is the increase in the average temperature of the Earth's near-surface air and the oceans ever since the mid-twentieth century. The temperature is rising day by day. Between 1880 and 2012, the global average surface temperature increased by 0.85°C. Since 1979 the rate of warming has approximately doubled.

Acid Rain: Adding of carbon dioxide with rain water droplets creates slightly carbonic acid. It can damage soil property or calcium carbonate related heritages.

Ozone Depletion: CFCs and halons gases are released into atmosphere. It reacts with stratospheric ozone layer and makes ozone layer thinner. UV ray from sun can easily reach to the earth surface and cause skin cancer of man and disturbs plant growth.

Desertification: Cause: 'Climatic variations' and 'Human activities' can be regarded as the two main causes of desertification. Removal of the natural vegetations, agricultural activities in the vulnerable ecosystems of arid and semi-arid areas, which are thus strained beyond their capacity.

Section – 2: Key Statements

Every candidates appearing for NET/SET examination should follow these key (main) points those can help them a better understanding regarding this unit very quickly.

Basic Key Statements:

aerosols(2.1.1), nitrogen(2.1.1), atmosphere(2.1), oxygen(2.1.1), homosphere(2.1.2), Troposphere(2.1.2.1), tropopause(2.1.2.1), stratosphere(2.1.2.1), stratopause(2.1.2.1), mesosphere(2.1.2.1), mesopause(2.1.2.1), heterosphere(2.1.2.2), thermosphere(2.1.2.2), thermopause(2.1.2.2), magnetosphere(2.1.2.2), exosphere(2.1.2.2), heat budget(2.2.1), torrid(2.2.6), tropical(2.2.6), temperate(2.2.6), frigid(2.2.6), low pressure(2.3.1), high pressure(2.3.1), barometer(2.3.3), low pressure belt(2.3.4), high pressure belt(2.3.4), Hadley Cell(2.3.5), Ferrel Cell(2.3.5), Polar Cell(2.3.5), ITCZ(2.3.5), Planetary wind(2.3.6.1), trade winds(2.3.6.1), westerlies(2.3.6.1), easterlies(2.3.6.1), monsoon(2.3.6.2), land breeze(2.3.6.2), sea breeze(2.3.6.2), valley breeze(2.3.6.2), mountain breeze(2.3.6.2), evaporation(2.4.1), condensation(2.4.1), humidity(2.4.1), dew point(2.4.1), stability(2.4.2), instability(2.4.2), fog(2.4.3), cloud(2.4.4), cumulonimbus(2.4.4), cirrus(2.4.4), Orographic rainfall(2.4.5), cyclonic rainfall(2.4.5), frontal rainfall(2.4.5), lightning(2.4.5), rainfall regime(2.4.5), drizzle(2.4.5), mist(2.4.5), snowfall(2.4.5), sleet(2.4.5), hail(2.4.5), snow flacks(2.4.5), front(2.4.6), airmass(2.4.7), cyclone(2.4.8), hurricane(2.4.8), thunderstorm(2.4.9), tornado(2.4.10), hail storm(2.4.11), heat waves(2.4.12), cold waves(2.4.13), drought(2.4.14), cloud burst(2.4.15), la-nina(2.4.17), Koppen(2.5.1), Thornthwaite(2.5.2), air pollution(2.6.1), Global warming(2.6.2), rising sea levels(2.6.2), acid rain(2.6.3), ozone depletion(2.6.4), desertification(2.6.5),

Standard Key Statements:

heat retention(2.1), normal lapse rate(2.1.2.1), aurora(2.1.2.2), radio waves(2.1.2.2), insolation(2.2.1), shortwave radiation(2.2.1), longwave radiation(2.2.1), inversion of temperature(2.2.4), pressure gradient(2.3.1), Coriolis effect(2.3.1), Ferrel's law(2.3.1), katabatic wind(2.3.6.2), water vapour(2.4.1), absolute humidity(2.4.1), specific humidity(2.4.1), isoneph(2.4.4), isotach(2.4.4), isohel(2.4.4), isobar(2.4.4), isotherm(2.4.4), ice crystal(2.4.5), collision coalescence(2.4.5), convectional rainfall(2.4.5), rime(2.4.5), cold front(2.4.6), warm front(2.4.6), occluded front(2.4.6), stationary front(2.4.6), thermal efficiency index(2.5.2), Rio summit(2.6.6), Kyoto protocol(2.6.7), Paris agreement(2.6.8), heat island(2.6.2),

Advanced Key Statements:

jet stream(2.3.6), rossby waves(2.3.6), walker circulation(2.3.7), el-nino(2.3.7), latent heat(2.4.1), relative humidity(2.4.1), PAN(2.6.1), CFCs(2.6.1), smog(2.6.1), surface ozone(2.6.1), CNG(2.6.1), Dioxins(2.6.1), AQI(2.6.1), potential evaporation(2.5.2), virage(2.4.5), graupel(2.4.5)

Section – 3: Key Facts and Figures

Sub Unit – 1:

Composition and structure of atmosphere

The atmosphere of Earth is the layer of gases, commonly known as air that surrounds the planet Earth and is retained by Earth's gravity. The atmosphere of Earth protects life on Earth by creating pressure allowing for liquid water to exist on the Earth's surface, absorbing ultraviolet solar radiation, warming the surface through heat retention (greenhouse effect), and reducing temperature extremes between day and night.

2.1.1 Components:

The atmosphere is made up of nitrogen (78%) and oxygen (21%). The rest of the gases combined only account for about 1% of the atmosphere. Along with all of these different gases, the atmosphere also holds many tiny, floating particles and droplets of liquid that scientists collectively call aerosols.

2.1.1.1 Major constituents of dry air, by volume:

Gas Name	Formula	Volume in %
Nitrogen	N ₂	78.084
Oxygen	O ₂	20.946
Argon	Ar	0.9340
Carbon dioxide)	CO ₂	0.041332
Neon	Ne	0.001818
Helium	He	0.000524
Methane	CH ₄	0.000187
Krypton	Kr	0.000114

2.1.2 Structure of Atmosphere:

It surrounds the earth from all sides. Generally, it **extends up to about 1600 kilometers** from the earth's surface. 97 % of the total amount of weight of the atmosphere is limited up to the height of about 30 kilometers.

2.1.2.1 Homosphere:

a) Troposphere:

It extends from Earth's surface to an average height of about 12 km (7.5 mi; 39,000 ft), although this altitude varies from about 9 km (5.6 mi; 30,000 ft) at the geographic poles to 17 km (11 mi; 56,000 ft), at the Equator, the troposphere is bounded above by the tropopause. Here the normal lapse (temperature in Earth's atmosphere falls with altitude) rate -6.4°C/Kms .

b) Stratosphere:

The stratosphere extends from the top of the troposphere to about 50 km (31 miles i.e. Stratopause) above the ground. The infamous ozone layer is found within the stratosphere. The altitudinal range of the layer is 15 to 35 kilometers.

c) Mesosphere:

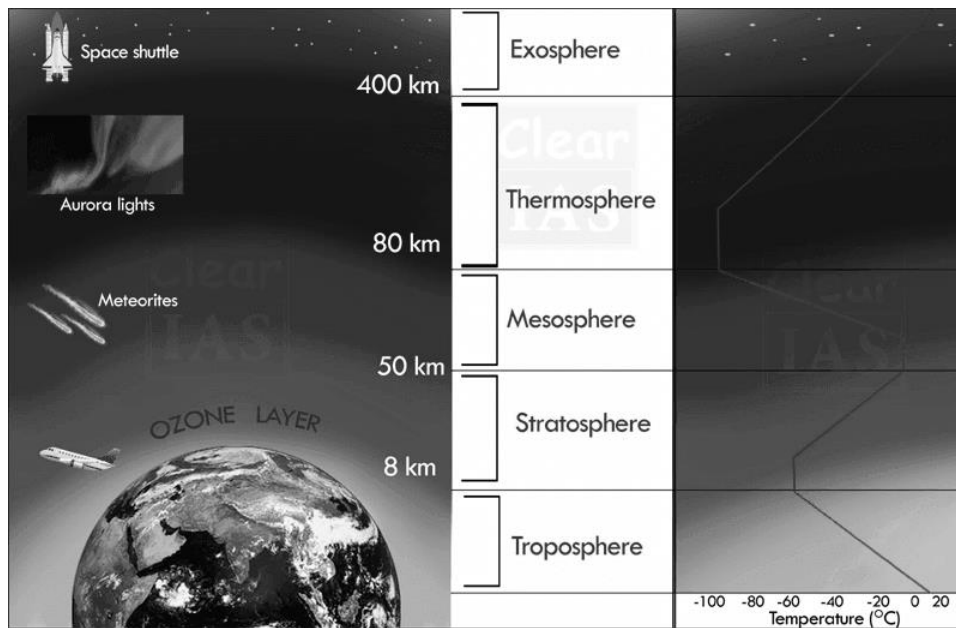
The mesosphere is the third highest layer of Earth's atmosphere, occupying the region above the stratosphere and below the thermosphere. It extends from the stratopause at an altitude of about 50 km (31 mi; 160,000 ft) to the mesopause at 80–85 km (50–53 mi; 260,000–280,000 ft) above sea level.

2.1.2.2 Heterosphere:

d) Thermosphere:

The thermosphere is the second-highest layer of Earth's atmosphere. It extends from the mesopause (which separates it from the mesosphere) at an altitude of about 80 km (50 mi; 260,000 ft) up to the thermopause at an altitude range of 500–1000 km (310–620 mi; 1,600,000–3,300,000 ft).

This layer is completely cloudless and free of water vapor. However, non-hydrometeorological phenomena such as the aurora borealis and aurora australis are occasionally seen in the thermosphere.



Ionosphere

It is also a part of thermosphere. The layer reflects radio waves that are retransmitted from the earth and again back to the earth.

Except those layers following two layers are present-

e) Magnetosphere:

It is a region of space surrounding an astronomical object in which charged particles are manipulated or affected by that object's magnetic field.

f) Exosphere:

The exosphere, the highest layer, is extremely thin and is where the atmosphere merges into outer space. It is composed of very widely dispersed particles of hydrogen and helium.

As per scientific explanation Magnetosphere and Exosphere are not the part of the atmosphere.

Previous Year Question**June - 15**

1. An aircraft is flying at an altitude of 10 km. At that altitude the temperature is -40°C . What is the ambient temperature on the ground :

- (A) 24°C
- (B) 25°C
- (C) 30°C
- (D) 20°C

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	13	A	2.1.2.1.a

December - 15

1. The fall in temperature in troposphere is known as:

- (A) Adiabatic rate
- (B) Lapse rate
- (C) Temperature rate
- (D) Thermal loss

2. Which one of the following atmospheric layers reflect radio waves that are transmitted from the earth and again back to the earth ?

- (A) Mesosphere
- (B) Ionosphere
- (C) Troposphere
- (D) Stratosphere

3. Which one of the following is devoid of atmosphere ?

- (A) Mesosphere
- (B) Stratosphere
- (C) Magnetosphere
- (D) Thermosphere

4. Match **List - I** with **List - II** and select the correct answer from the codes given below :

List - I**List - II**

(Gases in the atmosphere above (Altitudinal range) 100 km altitude)

- | | |
|--------------|-------------------------|
| (a) Nitrogen | (i) 200 - 1100 km |
| (b) Oxygen | (ii) 1100 - 3500 km |
| (c) Helium | (iii) 100 - 200 km |
| (d) Hydrogen | (iv) 3 500 km and above |

Codes :

- | | (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|-----|
| (A) | iv | ii | i | iii |
| (B) | iii | i | ii | iv |
| (C) | iii | ii | i | iv |
| (D) | ii | i | iii | iv |

5. At which of the following altitudinal ranges ozone is found in concentrated form ?

- (A) 10 - 25 km
- (B) 15 - 35 km
- (C) 35 - 50 km
- (D) 50 - 65 km

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	7	B	2.1.2.a
2.	9	B	2.1.2.2.d
3.	9	C	2.1.2.2
4.	11	B	2.1.2
5.	16	B	2.1.2.1.b

July - 16

1. The thermosphere –

- (A) has the highest air pressure of any layer of the atmosphere.
- (B) is the hottest layer of the atmosphere because it has the larger amount of carbon dioxide.
- (C) is the coldest layer in the atmosphere.
- (D) is hot because molecules in it absorb high energy short wavelengths of radiation from sun.

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	14	D	2.1.2.2

January - 17

1. Match List-I with List-II and select the correct answer from the codes given below :

List-I (Component)	List-II (Volume % in dry air)
I. Oxygen	A. 0.03
II. Argon	B. 78.08
III. Carbon-di-oxide	C. 0.93
IV. Nitrogen	D. 20.94

Codes :

	(a)	(b)	(c)	(d)
(A)	iv	ii	iii	i
(B)	iv	iii	i	ii
(C)	iii	iv	ii	i
(D)	iv	iii	ii	i

2. In which one of the following atmospheric layers the temperature decreases with height at an average rate of about 0.6 °C per 100 m ?

- (A) Troposphere
- (B) Stratosphere
- (C) Thermosphere
- (D) Ionosphere

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	10	B	2.1.1.1
2.	15	A	2.1.2.1

November - 17

1. Match List-I with the List-II and select the correct answer from the code given below :

List-I	List-II
(Gasses)	(% of Gasses in Atmosphere)
(a) N ₂	(i) 0.934%
(b) Ar	(ii) 0.039%
(c) O ₂	(iii) 78%
(d) CO ₂	(iv) 21%

Code :

(a)	(b)	(c)	(d)
(A) iii	i	ii	iv
(B) i	iii	ii	iv
(C) iii	i	iv	ii
(D) ii	iv	i	iii

2. In which one of the following atmospheric layers temperature remains constant ?

- (A) Stratosphere
- (B) Tropopause
- (C) Mesosphere
- (D) Troposphere

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	9	C	2.1.1.1
2.	11	B	2.1.2

Sub Unit – 2:**Temperature of atmosphere**
-----**2.2.1 Process of heating of atmosphere:**

Following heads are the heating and cooling processes in the atmosphere

- a. radiation
- b. absorption
- c. reflection
- d. scattering
- e. transmission
- f. conduction
- g. convection
- h. advection (Wind)

2.2.2 Heat Budget of Earth:

Earth's heat-budget or Earth's radiation balance refers to the net flow of energy into Earth in the form of shortwave radiation and the outgoing infrared long-wave radiation into space.

This balance between incoming and outgoing heat is known as Earth's heat budget. 100 units of incoming solar radiation, 34 % are scattered or reflected back to space by the atmosphere and Earth's surface.

Of these 34 units, 6 units are scattered by the air, water vapor, and aerosols in the atmosphere; 20 units are reflected by clouds; and 4 units are reflected by Earth's surface.

The 66% units of incoming solar radiation make it into Earth's atmosphere. This is equivalent to 240 watts per square meter (66% of 342 W/m²).

The atmosphere and clouds absorb 17 units of this incoming solar radiation, leaving 51 units of solar radiation that is absorbed at Earth's surface. These incoming 51 units consist of shorter wavelength solar radiation (mostly in the visible region of the electromagnetic spectrum), which is absorbed by land, water, and vegetation.

2.2.3 Factors of distribution of temperature:

The factors are following-

- a. Latitudes
- b. Altitude
- c. Distance from the coast
- d. Nature of land and water
- e. Nature of ground surface (soil)
- f. Ground slope
- g. Prevailing winds
- h. Ocean currents

The World's Coldest : Denali or Mount McKinley, USA.

The Warmest Place in the World: Al-Aziziyah, Libya.

2.2.4 Vertical distribution of temperature:

Inversion of temperature-

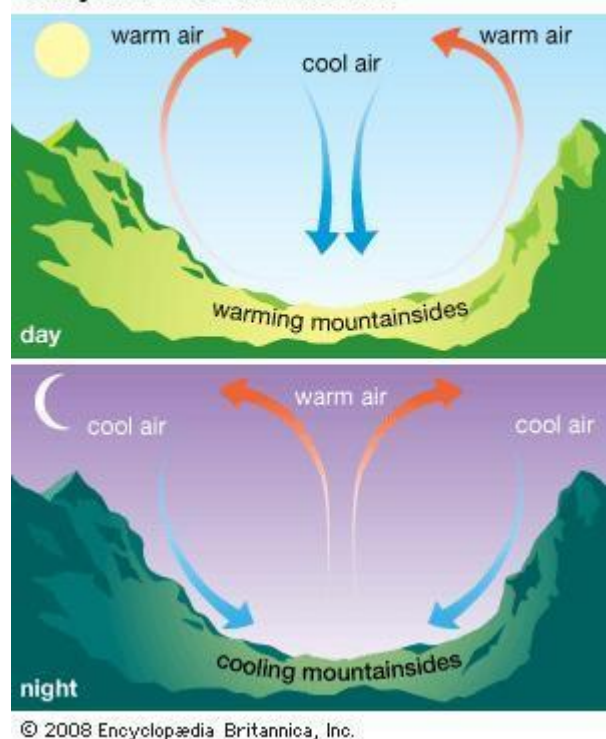
Temperature decreases with increasing height in the troposphere but the rate of decrease varies according to seasons, duration of sunshine and location. On an average, the rate of decrease of temperature with increasing altitudes in a stationary column of air with absence of any vertical motion is 6.5°C per 1000 meters.

Ideal Conditions for Temperature Inversion:

These conditions are following:

- Long winter nights.
- Cloudless clear sky
- Dry air
- Calm atmosphere
- Ice covered surface

Valley and mountain breezes



2.2.5 Horizontal distribution of temperature:

The following factors are responsible for uneven distribution of temperature-

Latitude

Presence of land and water

Relief and altitude

Ocean currents

Winds

Vegetation

Nature of the slope etc.

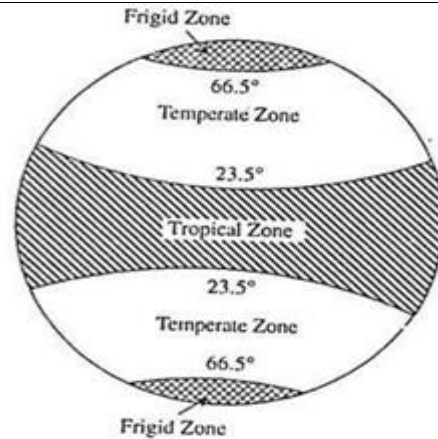
2.2.6 Regional distribution of temperature:

According to ancient Greek thinkers the globe is divided into three temperature zones on the basis of latitudes.

1.Tropical zone-Tropical zone extends between the tropics of Cancer ($23^{\circ}30''\text{N}$) and Capricorn ($23^{\circ}30''\text{S}$).

2.Temperate zone-Temperate zone extends between $23^{\circ}30''$ and $66^{\circ}30''$ latitudes in both the hemispheres.

3.Frigid zone -Frigid zone extending between $66^{\circ}30''$ latitude and the poles in both the hemispheres is characterized by more oblique sun's rays throughout the year resulting into exceptionally very low temperature.



Temperature zones according to the views of ancient Greek thinkers.

Previous Year Question**June - 14**

1. Which one of the locations listed below should have highest annual temperature range ?
- (A) Equatorial Island
 - (B) Tropical coast
 - (C) Polar ice cap
 - (D) Mid-latitude continental centre

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	9	D	2.2.6

December - 14

1. Which one of the following places on the earth is the hottest ?

- (A) Quetta
- (B) Al Aziza
- (C) Jacobabad
- (D) Jaisalmer

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	9	B	2.2.3

June - 15

1. Given below are two statements. One labelled as **Assertion (A)** and other labelled as **Reason (R)**. Select your answer from the codes given below :

Assertion (A) : Land surface is heated more quickly and to a greater extent than the water surface when subject to an equal amount of insolation

Reason (R) : The specific heat of land is more than that of water

Codes :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (B) Both (A) and (R) are true but (R) is not a correct explanation of (A)
- (C) (A) is true but (R) is false
- (D) (A) is false but (R) is true

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	15	C	2.2.2 & 2.2.4

July - 16

1. Which form of radiation do we sense as heat ?

- (A) Radio waves
- (B) Infrared
- (C) Ultraviolet
- (D) Red light

2. Which one of the followings represents a source of atmospheric energy ?

- (A) Infrared radiation emitted downward from clouds
- (B) Visible radiation scattered upward into the space
- (C) Latent heat released
- (D) Albedo of the earth and the atmosphere

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	9	C	2.2.2
2.	6	C	2.2.2

January - 17

1. Given below are two statements, one labelled as **Assertion (A)** and the other labelled as **Reason (R)**. Select your answer from the codes given below :

Assertion (A) : Tropical climates are of special geographical interest.

Reason (R) : Over 75% of the World's population inhabits between latitudes 30° N and 30° S.

Codes :

- (1) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (2) Both (A) and (R) are true, but (R) is not the correct explanation of (A).
- (3) (A) is true, but (R) is false.
- (4) (A) is false, but (R) is true.

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	11	A	2.2.6

Sub Unit – 3:

Atmospheric pressure and circulation

2.3.1 Air pressure and atmospheric circulation:

Wind direction and related laws:

a) Low and high pressure zones:

In the Northern Hemisphere, if a person stands with his back to the wind, the atmospheric pressure is low to the left, high to the right. This is because wind travels counterclockwise around low pressure zones in the Northern Hemisphere.

It is approximately true in the higher latitudes of the Northern Hemisphere, and is reversed in the Southern Hemisphere, but the angle between the pressure gradient force and wind is not a right angle in low latitudes.

b) Pressure Gradient Force:

Pressure Gradient Force is created due to the difference in the atmospheric pressure, and it is directed from the high pressure to the low pressure.

c) The Coriolis effect :

All winds move towards their right in the northern hemisphere and towards their left in the southern hemisphere with respect to the rotating earth. Thus, in the northern hemisphere winds blow counter-clockwise along the centers of low pressure while clockwise in the southern hemisphere.

d) Ferrel's Law:

Because of the rotation of earth all winds are deflected to their right in the northern hemisphere and to their left in the southern.

2.3.2 Factors of air pressure:

Factors are as follow-

- Temperature
- Height from Sea Level
- Moisture in Air (Humidity)
- Gravitation of Earth
- Rotation of Earth

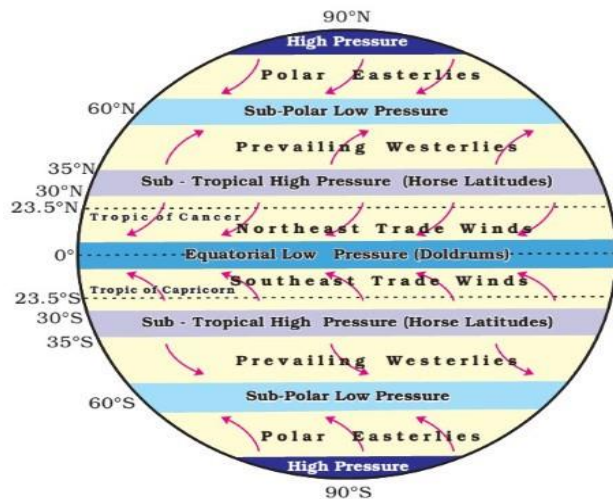
2.3.3 Air pressure measuring instruments:

Barometer is an instrument used for measuring the atmospheric air pressure. Air pressure at 8 kilometers above is half of the ground.

2.3.4 Horizontal distribution of air pressure and pressure belts

There are distinctly identifiable zones of homogeneous horizontal pressure regimes or 'pressure belts'. On the earth's surface, there are seven pressure belts.

- Equatorial low pressure belts
- Subtropical high pressure belts (north and south)
- Sub polar low pressure belts(north and south)
- Polar high pressure belts(north and south)



Major Pressure Belts and Wind System

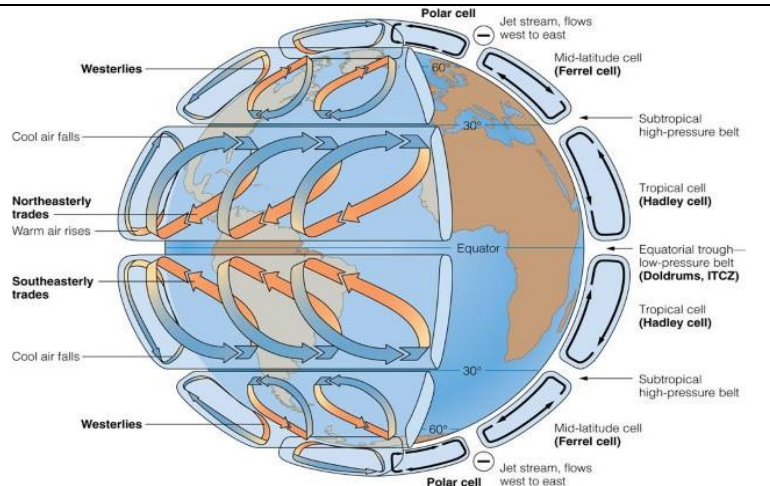
2.3.5 General circulation of the atmosphere:

The concept is proposed by G. Hadley. The pattern of planetary winds depends on:

- latitudinal variation of atmospheric heating;
- the rotation of earth.

The wind circulation cells are:
 Hadley Cells 30°-60° N/S
 Ferrel Cells 30°-60° N/S
 Polar Cells-60°- 90° N/S
 ITCZ:

The air at the Inter Tropical Convergence Zone (ITCZ) rises because of the convection currents caused by low pressure. Low pressure in turn occurs due to high insolation. The winds from the tropics converge at this low pressure zone. ITCZ gradually varies with the seasons, roughly corresponding with the location of the thermal equator. As the heat capacity



of the oceans is greater than air over land, migration is more prominent over land. Over the oceans, where the convergence zone is better defined, the seasonal cycle is more subtle, as the convection is constrained by the distribution of ocean temperatures.

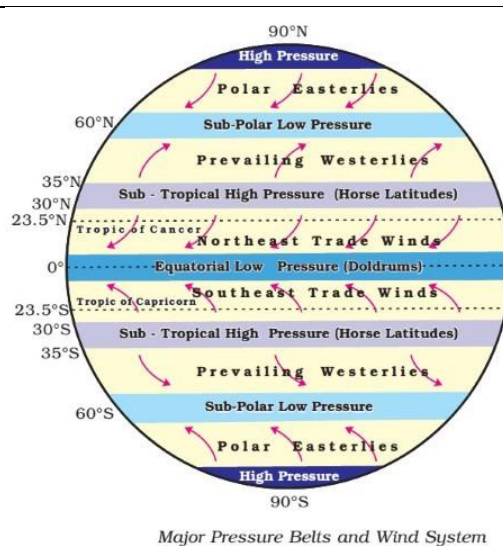
2.3.6 Classification of Winds:

Macro scale winds are on a global scale. **Meso scale** describes storms like thunderstorms. There are also winds and small circulations that only last for a few seconds. These smaller circulations are described with the term **micro scale**.

2.3.6.1 Permanent winds or Primary winds or Prevailing winds or Planetary Winds or Macro Scale winds:

a) Trade Winds (tropical easterlies):

The trade winds or easterlies are the permanent east-to-west prevailing winds that flow in the Earth's equatorial region (between 30°N and 30°S latitudes). The trade winds blow predominantly from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. Trade winds have been used by captains of sailing ships to cross the world's oceans for centuries and enabled colonial expansion into the Americas and trade routes to become established across the Atlantic and Pacific oceans.



b) Westerlies:

The westerlies are the winds blowing from the sub-tropical high pressure belts towards the sub polar low pressure belts. Shifting of trade wind belt towards poles is the essential for the

formation of equatorial westerly.

The westerlies are developed between 40° and 65°S latitudes. These latitudes are often called Roaring Forties, Furious Fifties, and Shrieking Sixties – dreaded terms for sailors.

c) Polar easterlies:

The Polar easterlies are dry, cold prevailing winds blowing from north-east to south-west direction in Northern Hemisphere and south-east to north-west in Southern Hemisphere. They blow from the polar high-pressure areas of the sub-polar lows.

The main cause of Mediterranean, or dry summer climate, is the subtropical ridge which extends northwards during the summer and migrates south during the winter due to increasing north-south temperature differences.

2.3.6.2 Secondary Winds or Periodic Winds:

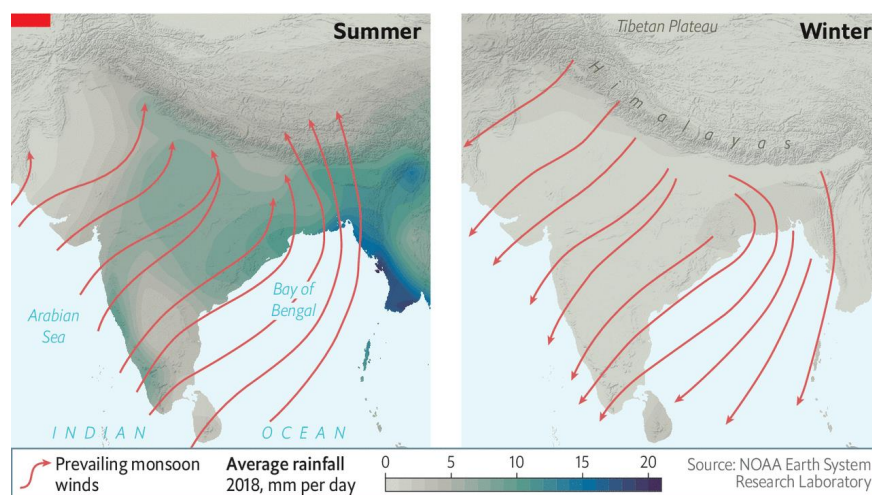
These winds change their direction with change in season.

a) Monsoons:

During summer sun rays become vertical over the tropic of cancer. That's why temperature rises enormously over the land surface which responsible to make extreme low pressure on it. Whereas high pressure is being develop over the Indian ocean due comparatively low temperature on it. Thus, moisture laden wind move from Indian ocean to land surface. It brings heavy rainfall all over India, Srilanka, Bangladesh and many more countries.

Some popular theories about Monsoon-

1	Hailey's Theory 1686	Alternative heating and cooling of land and sea
2	Flohn's theory 1951	Shifting of pressure belts
3	P koteswaram theory 1952 and	Thermal engine theory(monsoon and Tebet Plateau)
4	Monsoon Experiment (MONEX) 1972	

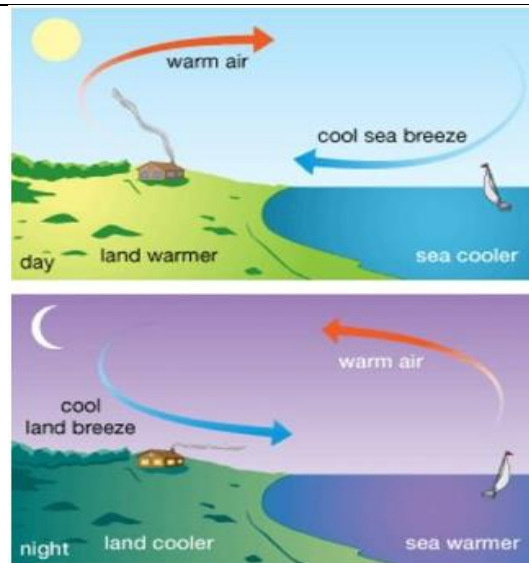


The Economist

b) Land Breeze and Sea Breeze:

During the day the land heats up faster and becomes warmer than the sea. In the land the air rises to up and create low pressure area, whereas the sea is relatively cool and the pressure over sea is relatively high. The wind blows from the sea to the land as the sea breeze.

In the night the reversal of condition takes place. The land loses heat faster and is cooler than the sea. The pressure gradient is from the land to the sea and hence land breeze results.

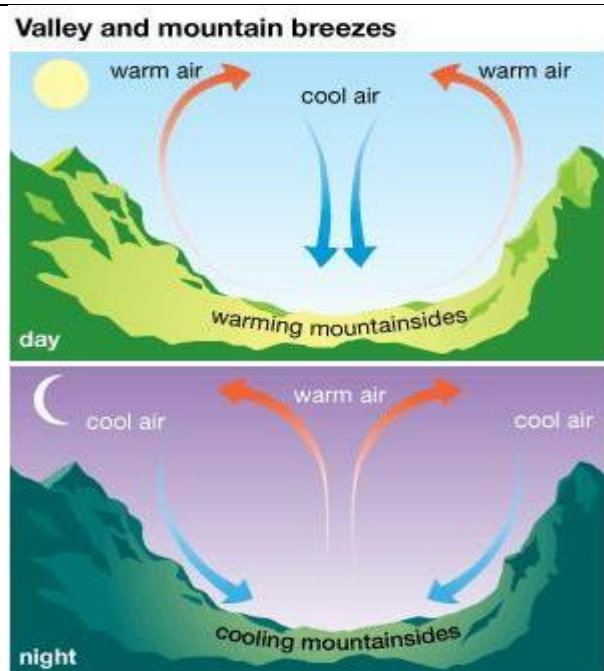


c) Valley Breeze and Mountain Breeze:

In mountainous regions, during the day the slopes get heated up and air moves upslope and to fill the resulting gap the air from the valley blows up the valley. This wind is known as the valley breeze.

During the night the slopes get cooled and the dense air descends into the valley as the mountain wind. The cool air, of the high plateaus and ice fields draining into the valley is called katabatic wind.

Another type of warm wind (katabatic wind) occurs on the leeward side of the mountain ranges. The moisture in these winds, while crossing the mountain ranges condense and precipitate. When it descends down the leeward side of the slope the dry air gets warmed up by adiabatic process. This dry air may melt the snow in a short time.



2.3.6.3 Tertiary Winds or Local Winds:

Cold winds	Warm Winds
<ol style="list-style-type: none"> 1. Pompero 2. Gregale 3. Bora 4. Tramontane 5. Mistril 	<ol style="list-style-type: none"> 1. Fohn 2. Chonook 3. Zonda 4. Loo 5. Sirocco

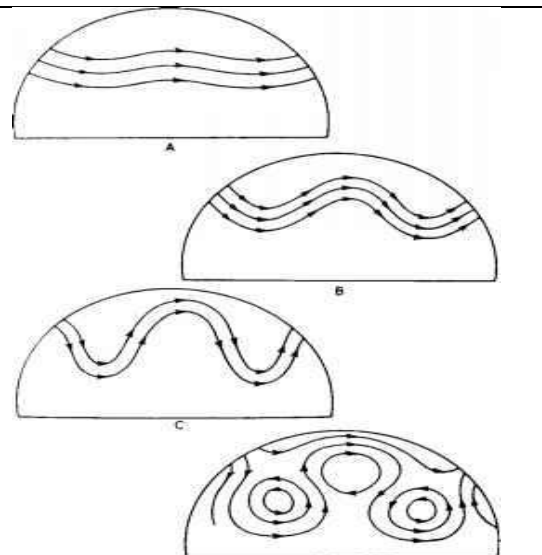
2.3.6. Jet stream

The jet stream is mainly found in the tropopause, at the transition between the troposphere (where temperature decreases with height) and the stratosphere (where temperature increases with height).

Rossby waves:

The meandering or the whirl movement of the Jet Stream is called '**Rossby Wave**'.

The geostrophic wind is the wind flow that occurs in the middle latitudes aloft in the troposphere. The winds have a more difficult time obtaining geostrophic balance in the equatorial latitudes since the Coriolis force is weak.



2.3.7 Walker circulation and El-nino-southern oscillation (ENSO):

El Niño normally occurs around Christmas and usually lasts for a few weeks to a few months. Sometimes an extremely warm event can develop that lasts for much longer time periods. In the 1990s, strong El Niños developed in 1991 and lasted until 1995, and from fall 1997 to spring 1998.

Normal Conditions

In a normal year, a surface low pressure develops in the region of northern Australia and Indonesia and a high pressure system over the coast of Peru. As a result, the trade winds over the Pacific Ocean move strongly from east to west.

Effects of El Niño:

- a) The warmer waters had a devastating effect on marine life existing off the coast of Peru and Ecuador.
- b) Fish catches off the coast of South America were lower than in the normal year (Because there is no upwelling).
- c) Severe droughts occur in Australia, Indonesia, India and southern Africa.
- d) Heavy rains in California, Ecuador, and the Gulf of Mexico etc .

Previous Year Question**June - 14**

1. Who among the following observed that summer heating of Tibetan Plateau was the most important factor in the monsoonal circulation over India ?

- (A) Fohn
- (B) Koteswaram
- (C) Frost
- (D) Halley

2. Which one of the following is not a factor that affects wind ?

- (A) Pressure gradient
- (B) Friction
- (C) Magnetism
- (D) Coriolis effect

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	6	B	2.3.6.2
2.	8	C	2.3.1 , 2.3.2

December - 14

1. What is the major wind related phenomenon responsible for summer drought in Mediterranean type of region ?

- (A) Shifting of trade winds polewards in summers.
- (B) Shifting of trade winds equatorwards in summers.
- (C) Blowing of Westerlies from the continents in summers.
- (D) Blowing South-Westerly.

2. Which one of the following is not a factor to affect the atmospheric pressure ?

- (A) Altitude
- (B) Presence of water vapour
- (C) Temperature
- (D) Rainfall

3. Find out the correct sequence of planetary winds found from the equator to pole.

- (A) Westerlies, Trade, Polar wind
- (B) Trade, Westerlies, Polar wind
- (C) Trade, Polar wind, Westerlies
- (D) Polar wind, Westerlies, Trade

4. In the **List – I** given the names of local wind and **List – II** given the names of the area.

Match correctly **List – I** and **List – II**. Select the correct answer from the codes given below :

List – I
(Local Wind)

- a. Loo
- b. Khamsin
- c. Chinook
- d. Fohn

List – II
(Area)

- i. The Rockies
- ii. The Alps
- iii. Rajasthan Desert
- iv. Egypt

Codes :

- | | (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|-----|
| (A) | i | ii | iii | iv |
| (B) | iii | iv | i | ii |
| (C) | ii | iv | iii | i |
| (D) | iv | iii | ii | i |

5. Match the following **List – I** with **List – II** and select the correct answer from the codes given :

List – I

- a. Westerlies
- b. Doldrum
- c. Horse latitudes
- d. Monsoon

List – II

- i. Between trade wind and westerlies
- ii. Seasonal wind
- iii. Roaring forties
- iv. Equatorial belt

Codes :

- | | (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|-----|
| (A) | i | ii | iii | iv |
| (B) | iii | iv | i | ii |
| (C) | ii | iii | iv | i |
| (D) | iv | ii | i | iii |

6. Find the sequence of the onset of South-West monsoon of the following areas from the earlier to later dates :

- i. Kerala
- ii. Mumbai
- iii. Andaman-Nicobar
- iv. Odisha

- (A) i, ii, iii, iv
- (B) iii, i, ii, iv
- (C) ii, iii, iv, i
- (D) iv, ii, i, iii

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	5	D	2.3.6.1
2.	6	B	2.3.2
3.	7	B	2.3.6
4.	9	B	2.3.6.3
5.	10	B	2.3.5
6.	11	B	2.3.6.2

June - 15

1. According to single-cell circulation model proposed by George Hadley the most important factor causing the global atmospheric circulation is :

- (A) The rotation of the earth
- (B) The jet stream
- (C) Subsidence at the equator
- (D) Temperature contrast between equator and pole

2. The westerlies and trade winds are example of '____ winds.'

- (A) mesoscale
- (B) toposcale
- (C) macroscale
- (D) microscale

3. The only truly continuous pressure belt on the earth is :

- (S) Southern hemisphere subtropical high
- (B) Northern hemisphere subtropical high
- (C) Equatorial low
- (D) Southern hemisphere sub polar low

4. Which two global winds originate from the subtropical highs ?

- (1) Polar easterlies and westerlies
- (2) Trade winds and polar easterlies
- (3) Trade winds and westerlies
- (4) Chinook and Foehn

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	6	D	2.3.5
2.	7	C	2.3.6.1
3.	11	D	2.3.4
4.	12	C	2.3.6.1.a & b

December - 15

1. The mean sea - level pressure of the atmosphere decreases by half at the altitude of :

- (A) 6 km
- (B) 8 km
- (C) 10 km
- (D) 12 km

2. Which one of the following is essential for the formation of equatorial westerlies ?

- (A) Large-scale earthquake over the equator.
- (B) Shifting of trade-wind belt towards poles.
- (C) Shifting of polar easterlies towards equator.
- (D) Large-scale forest-fire in the equatorial rain forest.

3. Which of the following is a local cold wind ?

- (A) Chinook
- (B) Bora
- (C) Foelin
- (D) Khainsin

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	6	B	2.3.3
2.	13	B	2.3.6.1.b
3.	15	B	2.3.6.3

July - 16

1. Which one of the following statements, regarding the length of daylight between June 21st and September 22nd, over different regions is correct ?

- (A) The length of the daylight is getting longer in the midlatitudes of Northern Hemisphere.
- (B) The Southern Hemisphere is in the middle of summer.
- (C) Day length is getting shorter in the midlatitudes of Southern Hemisphere.
- (D) Day length is getting shorter in the midlatitudes of Northern Hemisphere.

2. What would be the angle of the sun above the horizon at noon on March 20th if you were standing on the Tropic of Cancer ?

- (A) 90° directly overhead
- (B) 0° on the horizon
- (C) 66½°
- (D) 23½°

3. The cold and dense downwind flowing from mountain slopes during night is known as

- (A) Anabatic wind
- (B) Khamain
- (C) Harmattan
- (D) Katabatic

4. Which one of the following pairs is not correctly matched ?

- (A) Microscale – Turbulence
- (B) Planetary scale – Waves in the westerlies
- (C) Mesoscale – Tornadoes
- (D) Synopticscale – Valley and mountain winds

5. Which one of the following statements about polar jet stream is not true ?

- (A) It moves northwards during summer.
- (B) It supplies energy to the circulation of surface storms.
- (C) Its velocity is greater during the summer.
- (D) Its location roughly coincides with that of the polar front

6. A place located at a higher altitude generally experiences than a low elevation place in an adjoining valley.

- (A) a greater daily temperature range
- (B) a lower annual mean temperature
- (C) a lower daily temperature range
- (D) both a greater daily temperature range and lower annual mean temperature

7. What happens when Chinook wind is drawn down the leeward slopes of the mountain range ?

- (A) The saturation vapour pressure increases
- (B) The relative humidity decreases
- (C) Both (1) and (2) are correct
- (D) Both (1) and (2) are wrong

8. Given below are two statements, one labelled as Assertion (A) and other labelled as Reason (R). Select your answer from the codes given below :

Assertion (A) : Land surface is heated more quickly and to a greater extent than the water surface when subjected to equal amount of insolation.

Reason (R) : The land is opaque while water is transparent to solar radiation.

Codes :

- (A) Both (A) and (R) are true and (R) is correct explanation of (A).
- (B) Both (A) and (R) are true, but (R) is not correct explanation of (A).
- (C) (A) is true, but (R) is false.
- (D) (A) is false, but (R) is true.

9. Which one of the following statements is not true about the Coriolis Force ?

- (A) It is the effect of earth's rotation.
- (B) It is maximum over polar region.
- (C) It is directly related to frictional force.
- (D) It is proportional to wind speed.

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	6	B	2.3.6.2
2.	8	D	2.3.6.2
3.	9	D	2.3.6.2.c
4.	9	C	2.3.6
5.	10	C	2.3.6
6.	12	D	2.3.6.2.c
7.	15	D	2.3.6.3
8.	8	A	2.3.6.2.b
9.	10	D	2.3.1.c

January - 17

1. A band of wind called 'Jet Stream' is found in –
- (A) Lower Troposphere
 - (B) Middle Troposphere
 - (C) Upper Troposphere
 - (D) Whole Troposphere

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	6	C	2.3.6

November - 17

1. Given below are two statements, one labelled as **Assertion (A)** and the other labelled as **Reason (R)**. Select your answer from the code given below :

Assertion (A) : The shift of ITCZ is greater over sea than over land.

Reason (R) : The land surface gets more heated than water bodies .

Code :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (B) Both (A) and (R) are true, but (R) is not a correct explanation of (A)
- (C) (A) is true, but (R) is false
- (D) (A) is false, but (R) is true

2. Given below are two statements, one labelled as **Assertion (A)** and the other labelled as **Reason (R)**. Select your answer from the code given below :

Assertion (A) : The subpolar low of the Southern Hemisphere is nearly continuous.

Reason (R) : The land mass is less in the Southern Hemisphere than in the Northern Hemisphere.

Code :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (B) Both (A) and (R) are true, but (R) is not a correct explanation of (A)
- (C) (A) is true, but (R) is false
- (D) (A) is false, but (R) is true

3. Which one of the following is the correct sequence of surface components of pressure and wind from the equator to the poles ?

- (A) Polar easterlies, Westerlies, Subtropical highs, Trade winds
- (B) Subtropical highs, Westerlies, Trade winds, Polar easterlies
- (C) Trade winds, Polar easterlies, Westerlies, Subtropical highs
- (D) Trade winds, Subtropical highs, Westerlies, Polar easterlies

4. Given below are two statements, one labelled as **Assertion (A)** and the other labelled as **Reason (R)**. Select your answer from the code given below :

Assertion (A) : Above 1000 meter altitudes most winds follow a geostrophic or near-geostrophic course.

Reason (R) : The friction layer of the atmosphere extends to only about 1000 meters above the ground.

Code :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (B) Both (A) and (R) are true, but (R) is not a correct explanation of (A).
- (C) (A) is true, but (R) is false.
- (D) (A) is false, but (R) is true.

5. Given below are two statements, one labelled as **Assertion (A)** and the other labelled as **Reason (R)**. Select your answer from the code given below :

Assertion (A) : The trade winds are predominantly easterly.

Reason (R) : An easterly wind blows from west to east.

Code :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (B) Both (A) and (R) are true, but (R) is not a correct explanation of (A).
- (C) (A) is true, but (R) is false.
- (D) (A) is false, but (R) is true.

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	7	A	2.3.5
2.	10	A	2.3.6
3.	12	D	2.3.4
4.	13	A	2.3.6
5.	15	C	2.3.6

Sub Unit – 4:

Metrological Hazards

2.4.1 Some concepts:

a) water vapor and evaporation:

As a solid, we call it ice, as a liquid, we call it water, and as a gas, we call it vapor. Vapor is really diffused water molecules that appear as fog or mist. When water is heated, the molecules in the water vibrate and some of them escape into the air, thus becoming water vapor, or the gaseous state of water. That's why we call it **evaporation**. The liquid water becomes a gas known as vapor.

b) Condensation:

Condensation is the **process** by which water vapor in the air is changed into liquid water. In other words, the water in the air, a gas known as water vapor, from your hot shower cooled when it met the surface of the cold mirror. This caused the water vapor to **condense**, or turn into its liquid form.

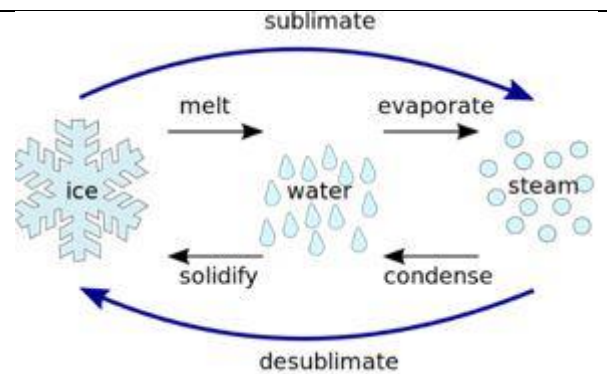
c) Latent heat:

The heat required to convert a solid into a liquid or vapour, or a liquid into a vapour, without change of temperature.

Sublimation is the transition of a substance directly from the solid to the gas phase, without passing through the intermediate liquid phase.

Super cooling is the cooling of a liquid below its freezing point without it becoming solid.

The heat energy that is associated with change in state from liquid to vapor is called latent heat of vaporization. The SI unit of latent heat is Joule per Kilogram.



d) Humidity:

Humidity is the concentration of water vapour present in air. Water vapour, the gaseous state of water, is generally invisible to the human eye. **Humidity** indicates the likelihood for precipitation, dew, or fog to be present. The amount of water vapour needed to achieve saturation increases as the temperature increases.

e) Humidity capacity

Humidity of the air refers to the content of water vapour present in the air at a particular time and place. The **moisture** retaining **capacity** or **humidity capacity** refers to the **capacity** of an air of certain volume at certain temperature to retain maximum amount of **moisture** content.

f) Absolute humidity

Absolute humidity is the measure of the actual water vapor in the air. It is expressed as grams of moisture per cubic meter of air (g/m³). The maximum absolute humidity of warm air at 30°C/86°F is approximately 30g of water vapor – 30g/m³. The maximum absolute humidity of cold air at 0°C/32°F is approximately 5g of water vapor – 5g/m³.

g) Specific humidity

Specific humidity unit is the most reliable unit of measurement of humidity. This measures the weight of water vapour per unit weight of air and it is expressed as grams of water vapour per kilogram of air g.kg⁻¹ is the specific humidity unit.

h) Relative humidity

The relative humidity is defined as the ratio between the amount of moisture in the air at a particular temperature to the maximum moisture air can withstand at the same temperature. The relative humidity is 100% during rainy seasons.

$RH = (\text{actual vapour density} / \text{saturation water density}) \times 100\%$

i) Dew Point:

The dew point is the saturation temperature for water in air. The dew point is associated with relative humidity.

2.4.2 Stability and instability of the atmosphere:

Different forms of precipitation (dew, fog, rainfall, frost, snowfall, hailstorm etc.) depend on stability and instability of the atmosphere. The air without vertical movement is called stable air while unstable air undergoes vertical movement (both upward and downward). An airmass ascends and becomes unstable when it becomes warmer than the surrounding airmass while descending airmass becomes stable.

a) Stability:

When dry adiabatic lapse rate of an ascending dry air is higher than the normal lapse rate and if it is not saturated and does not attain dew point it becomes colder than surrounding air at certain height with the result it becomes heavier and descends. This process causes stability of atmospheric circulation due to which vertical circulation of air is resisted.

b) Instability:

atmospheric instability is caused when the rate of cooling of rising air (dry adiabatic lapse rate) is lower than the normal lapse rate. Those are two types-

1. Mechanical instability
2. Conditional instability

2.4.3 FOG:

The fog is a cloud with its base at or very near to the ground. Because of the fog and mist, the visibility becomes poor to zero.

Classification of fog

1. Radiation fog
2. Advectional fog

2.4.4 CLOUD:

Cloud is a mass of minute water droplets or tiny crystals of ice formed by the condensation of the water vapour in free air at considerable elevations. Clouds are caused mainly by the adiabatic cooling of air below its dew point.

Classification:

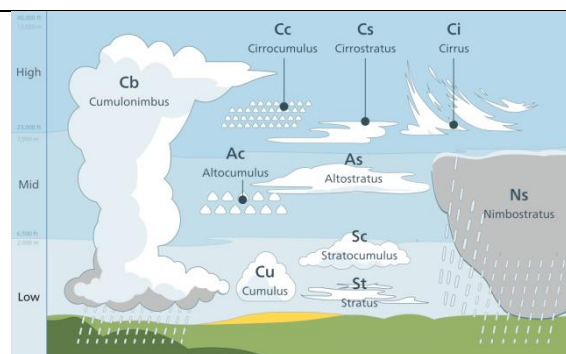
A combination of these four basic types can give rise to the following types of clouds:

High clouds – cirrus, cirrostratus, cirrocumulus;

Middle clouds – altostratus and altocumulus;

Low clouds – stratocumulus and nimbostratus (long duration rainfall cloud) and

Clouds with extensive vertical development – cumulus and cumulonimbus (thunderstorm cloud)



Some important terms:

- a) Isoneap: average percentage of cloudiness line
- b) Isohel: same duration of sunshine line
- c) Isotech: equal wind speed line
- d) Isotherm: equal temperature line
- e) Isobar: equal pressure line.
- f) Baroclinic : isobars and isotherms intersect each other.
- g) Barotropic: isotherms and isobars are parallel to each other.

2.4.5 Rainfall and Precipitation:

a. Theories about rainfall-

1. Ice Crystal Precipitation Theory by Wegener–Bergeron–Findeisen.
2. Collision Coalescence.

b. Types of rain fall

1. Conventional rainfall:
2. Orographic rainfall
3. Cyclonic rainfall or frontal rainfall

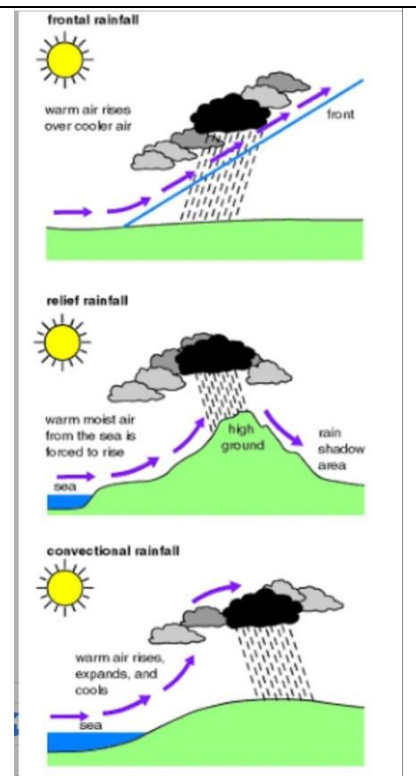
c. Lightning Formation:

The sky is filled with [electric charge](#). In a calm sky, the positive (+) and negative (-) charges are evenly spaced throughout the atmosphere. Therefore, a calm sky has a neutral charge.

d. Rainfall regime:

The character of the seasonal distribution of rainfall at any place; the chief rainfall regimes, as defined by W. G. Kendrew, are -

- a) equatorial, b) tropical, c) monsoonal, d) oceanic and e) continental westerlies, and f) Mediterranean.



e. Other forms of precipitation:

1. Rainfall: drop size more than 0.5 mm.
2. Drizzle: light rainfall; drop size less than 0.5 mm.
3. Mist: evaporation occurs before reaching the ground leading to foggy weather.
4. Snowfall: fine flakes of snow fall when the temperature is less than 0°C.
5. Sleet: frozen raindrops and refrozen melted snow; mixture of snow and rain or merely partially melted snow.
6. Hail: precipitation in the form of hard rounded pellets is known as hail; 5 mm and 50 mm.
7. Graupel: Graupel also called soft hail or snow pellets is precipitation that forms when supercooled water droplets are collected and freeze on falling snowflakes, forming 2–5 mm balls of rime. The term graupel is the German language word for sleet. Graupel is distinct from hail and ice pellets.
8. Rime: Rime ice forms when supercooled water liquid droplets freeze onto surfaces. Meteorologists distinguish between three basic types of ice forming on vertical and horizontal surfaces by deposition of supercooled water droplets. There are also intermediate formations.

These droplets, which have a diameter of about 10 μm .

the baseline ratio of rain to snow is 1 inch of rain equals 10 inches of snow. For example,

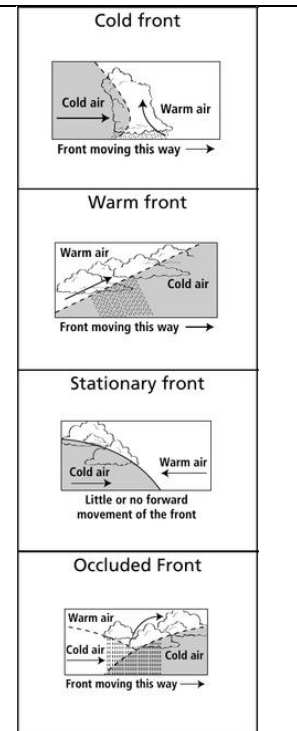
to calculate the snowfall equivalent of 3 inches of rain, multiply 3 by 10 to obtain 30 inches of snow as the baseline conversion.

9. Ice pellets are a form of precipitation consisting of small, translucent balls of ice. Ice pellets are smaller than hailstones.

2.4.6 Front genesis:

Front genesis is a meteorological process of tightening of horizontal temperature gradients to produce fronts. In the end, two types of fronts form: cold fronts and warm fronts.

1. **A cold front** is a narrow line where temperature decreases rapidly.
2. **A warm front** is a narrow line of warmer temperatures and essentially where much of the precipitation occurs. Front genesis occurs as a result of a developing baroclinic wave.
3. **Occluded front** is complex—a mixture of cold front type and warm front type weather. The formation of mid-latitude cyclones, temperate cyclones or extra-tropical cyclones are formed by occluded front.
4. **Stationary front** forms when a cold front or warm front stops moving. This happens when two masses of air are pushing against each other but neither is powerful enough to move the other. Winds blowing parallel to the front instead of perpendicular can help it stay in place.



Weather along a stationary front:

1. Cumulonimbus clouds are formed. Overrunning of warm air along such a front causes frontal precipitation.
2. Cyclones migrating along a stationary front can dump heavy amounts of precipitation, resulting in significant flooding along the front.

Vilhelm Bjerknes, formulated a model for a cyclone that forms as a disturbance along a zone of strong temperature contrast known as a front, which in turn constitutes a boundary between two contrasting air masses.

2.4.7 AIRMASS:

The air with distinctive characteristics in terms of temperature and humidity is called an air mass. It is a large body of air having little horizontal variation in temperature and moisture.

Characteristics:

1. They have uniform temperature and moisture content in horizontal direction but not uniform in vertical.
2. Those are characterized by their temperature and humidity properties.
3. The properties of air masses are determined by the underlying surface properties where

they originate.

There are 6 major source regions of air masses on the earth's surface e.g.:

- (1) Polar oceanic areas (North Atlantic Ocean between Canada and Northern Europe, and North Pacific Ocean between Siberia and Canada-during winter season),
- (2) Polar and arctic continental areas (snow-converted areas of Eurasia and North America, and Arctic region-during winter season),
- (3) Tropical oceanic areas (anticyclonic areas – throughout the year),
- (4) Tropical continental areas (North Africa-Sahara, Asia, Mississippi Valley zone of the USA – most developed in summers),
- (5) Equatorial regions (zone located between trade winds – active throughout the year), and
- (6) Monsoon lands of S.E. Asia.

The International Standard Atmosphere states the density of air is 1.225 kg/m^3 at sea level in 15°C and 1.2754 kg/m^3 at 0°C for dry air. Density is affected not only by temperature and pressure but also by the amount of water vapor in the air.

Classification

Based on thermodynamic and mechanical (dynamic) modifications and some other considerations air masses are divided into 16 types as follows:

(A) Continental Polar Air Masses:

- (1) Continental Polar Cold Stable Air mass (cPKs)
- (2) Continental Polar Cold Unstable Air Mass (cPKu)
- (3) Continental Polar Warm Stable Air Mass (cPWs)
- (4) Continental Polar Warm Unstable Air Mass (cpWu)

(B) Maritime Polar Air Masses (mp):

- (1) Maritime Polar Cold Stable Air Mass (mPKs)
- (2) Maritime Polar Cold Unstable Air Mass (mPKu)
- (3) Maritime Polar Warm Stable Air Mass (mPWs)
- (4) Maritime Polar Warm Unstable Air Mass (mPWu))

(C) Continental Tropical Air Masses (cT):

- (1) Continental Tropical Cold Stable Air Mass (cTKs)
- (2) Continental Tropical Cold Unstable Air Mass (cTKu)
- (3) Continental Tropical Warm Stable Air Mass (cTWs)
- (4) Continental Tropical Warm Unstable Air Mass (cTWu)

(D) Maritime Tropical Air Masses (mT):

- (1) Maritime Tropical Cold Stable Air Mass (mTKs)
- (2) Maritime Tropical Cold Unstable Air Mass (mTKu)
- (3) Maritime Tropical Warm Stable Air Mass (cTWs)
- (4) Maritime Tropical Warm Unstable Air Mass (cTWu)

c = continental, T = tropical, m = maritime, K = cold, W = warm, u = unstable, s = stable

2.4.8 Cyclone:

A cyclone is a large scale air mass that rotates around a strong center of low atmospheric pressure. In 2014 cyclone Hudhud affects majorly in Andhra Pradesh Coasts.

The following types of cyclones are –

Tornado, b) Dust devil, c) Waterspout, d) Steam devil, e) Fire whirl etc.

A) Tropical Cyclone:

A low pressure is a winds blowing counter-clockwise around it in the Northern Hemisphere and clockwise around it in the Southern Hemisphere. A **tropical cyclone** is a cyclone which forms in the tropics. A tropical cyclone may regenerate in higher latitudes as an extra tropical depression, but it loses its identity as a tropical storm in the process. The typical lifetime of a tropical cyclone from its birth to death is about six days.

Regional names for Tropical Cyclones:

Regions	What they are called
Indian Ocean	Cyclones
Atlantic	Hurricanes
Western Pacific and South China Sea	Typhoons
Western Australia	Willy-willies

B. Haricanes:

A *hurricane* is a tropical cyclone that occurs in the Atlantic Ocean and northeastern Pacific Ocean. Their source of energy is water vapor which is evaporated from the ocean surface. Water vapor is the "fuel" for the hurricanes because it releases the "latent heat of condensation" when it condenses to form clouds and rain, warming the surrounding air. *Hurricane Matthew* was the first Category 5 Atlantic *hurricane*. It caused catastrophic damage and a humanitarian crisis in Haiti, as well as widespread devastation in the southeastern United States.

Category	Wind speed	Efficiency
Category 1	Winds 74 to 95 mph	Minor damage
Category 2	Winds 96 to 110 mph	Extensive damage — Can uproot trees and break windows
Category 5	Winds 111 to 129 mph	Devastating — Can break windows and doors
Category 4	Winds 130 to 156 mph	Catastrophic damage — Can tear off roofs
Category 3	Winds 157 mph or higher	The absolute worst and can level houses and destroy buildings

Beaufort number:

The Beaufort scale is an empirical measure that relates wind speed to observed conditions at sea or on land.

name of wind	wind speed		description of sea surface
	knots	kph	
calm	<1	<1	sea like a mirror
light air	1–3	1–5	ripples with appearance of scales are formed, without foam crests
light breeze	4–6	6–11	small wavelets still short but more pronounced; crests have a glassy appearance but do not break
gentle breeze	7–10	12–19	large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses
moderate breeze	11–16	20–28	small waves becoming longer; fairly frequent white horses
fresh breeze	17–21	29–38	moderate waves taking a more pronounced long form; many white horses are formed; chance of some spray
strong breeze	22–27	39–49	large waves begin to form; the white foam crests are more extensive everywhere; probably some spray
moderate gale (or near gale)	28–33	50–61	sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind; spindrift begins to be seen
fresh gale (or gale)	34–40	62–74	moderately high waves of greater length; edges of crests break into spindrift; foam is blown in well-marked streaks along the direction of the wind
strong gale	41–47	75–88	high waves; dense streaks of foam along the direction of the wind; sea begins to roll; spray affects visibility
whole gale (or storm)	48–55	89–102	very high waves with long overhanging crests; resulting foam in great patches is blown in dense white streaks along the direction of the wind; on the whole the surface of the sea takes on a white appearance; rolling of the sea becomes heavy; visibility affected
storm (or violent storm)	56–63	103–114	exceptionally high waves; small- and medium-sized ships might be for a long time lost to view behind the waves; sea is covered with long white patches of foam; everywhere the edges of the wave crests are blown into foam; visibility affected
hurricane	64 and above	117 and above	the air is filled with foam and spray; sea is completely white with driving spray; visibility very seriously affected

2.4.9 Thunderstorms:

A storm with thunder and lightning and typically also heavy rain or hail.

2.4.10 Tornado:

Due to the Coriolis effect, the rotation direction of cyclone is clockwise in the southern and anti-clockwise in the northern hemisphere. There's an area in the middle of these twisting winds, called the eye of cyclone, the pressure there will be extremely low. The more the low-pressure in the eye, more speed the winds around have.

2.4.11 Hail Storm:

Hail forms in strong thunderstorm clouds, particularly those with intense updrafts, high liquid water content, great vertical extent, large water droplets, and where a good portion of the cloud layer is below freezing 0 °C (32 °F). These types of strong updrafts can also indicate the presence of a tornado.

2.4.12 Heat waves:

A heat wave, or heatwave, is a period of excessively hot weather, which may be accompanied by high humidity, especially in oceanic climate countries.

2.4.13 Cold waves:

A cold wave is a weather phenomenon that is distinguished by a cooling of the air. Specifically, as used by the U.S. National Weather Service, a cold wave is a rapid fall in temperature within a 24-hour period requiring substantially increased protection to agriculture, industry, commerce, and social activities.

2.4.14 Drought:

A *drought* is an event of prolonged shortages in the water supply, whether atmospheric (below-average precipitation), surface water or ground water.

2.4.15 Cloudburst:

A **cloudburst** is an extreme amount of precipitation in a short period of time, sometimes accompanied by hail and thunder, which is capable of creating flood conditions. Cloudburst can suddenly dump large amounts of water e.g. 25 mm of precipitation corresponds to 25,000 metric tons/km² (1 inch corresponds to 72,300 short tons over one square mile).

2.4.16 El Nino:

See 2.3.7

2.4.17 La Nina:

La Niña means *The Little Girl* in Spanish. La Niña is also sometimes called *El Viejo*, *anti-El Niño*, or simply "*a cold event*." La Niña episodes represent periods of below-average sea surface temperatures across the east-central Equatorial Pacific. Global climate La Niña impacts tend to be opposite those of El Niño impacts. In the tropics, ocean temperature variations in La Niña also tend to be opposite those of El Niño.

2.4.18 storm surge:

A storm surge, storm flood, tidal surge or storm tide is a coastal flood or tsunami-like phenomenon of rising water commonly associated with low pressure weather systems (such as tropical cyclones and strong extra tropical cyclones). The two main meteorological factors contributing to a storm surge are a long fetch of winds spiraling inward toward the storm, and a low-pressure-induced dome of water drawn up under and trailing the storm's center.

The coastal areas and off-shore islands of Bengal and adjoining Bangladesh are the most storm-surge prone, East coast of India between Paradip and Balasore in Orissa, Andhra coast between Bapatla and Kakinada holding estuaries of two major rivers Krishna and Godavari, Tamilnadu coast between Pamban and Nagapattinam, Gujarat along the west coast of India.

Previous Year Question**June - 14**

1. Which term is used to describe the conversion of a solid directly to a gas, without passing through the liquid State ?

- (A) Evaporation
- (B) Condensation
- (C) Sublimation
- (D) Freezing

2. What is the correct Sequence of the cloud types in a warm front away from its trailing edge ?

- (A) Altostratus – Nimbostratus – Cirrus - Cirrostratus
- (B) Cirrostratus – Nimbostratus – Altostratus – Cirrus
- (C) Cirrus – Nimbostratus – Altostratus - Cirrostratus
- (D) Nimbostratus – Alto Stratus – Cirrostratus – cirrus.

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	10	C	2.4.1.c
2.	9	D	2.4.4

December - 14

1. The rain-fed and rain-shadow areas are the characteristics of the

- (A) Cyclonic rainfall
- (B) Convectional rainfall
- (C) Orographic rainfall
- (D) Thermal rainfall

2. Find the incorrect statement from the following :

- (A) Equatorial regions receive heavy convectional rain.
- (B) High rainfall totals are linked to westerlies in both hemispheres.
- (C) There is an increase of precipitation at an altitude above 2 kms.
- (D) On the eastern side of the ocean in the sub-tropical region are dry regions.

3. Which of the two following cyclones did occur in India in 2014 ?

- i. Hudhud ii. Phailin
- iii. Nilopher iv. Lehar

- (A) i and ii
- (B) i and iii
- (C) ii and iii
- (D) iii and iv

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	8	C	2.4.5
2.	12	C	2.4.2
3.	14	B	2.4.8

June - 15

1. When water evaporates the energy that was used to evaporate the water :

- (A) heats up the surrounding air as evaporation takes place
- (B) will never be available again
- (C) is stored as latent heat in the evaporated water molecule
- (D) is destroyed

2. Meteorologists group tropical cyclones into three main categories according to :

- (A) barometric pressure in the eye of storm
- (B) precipitation
- (C) diameter of the storm
- (D) wind velocity

3. A given volume of air holds 20 gram of water vapor. At that temperature, the air would be saturated with 80 grams of water vapor. What is the relative humidity ?

- (1) 40%
- (2) 100%
- (3) 25%
- (4) 80%

4. Coastal area greatly affected by storm surge is :

- (A) Andhra coast
- (B) West Bengal coast
- (C) Chennai coast
- (D) Kerala coast

5. Match the **List - I** and **List - II** select the correct answer from the codes given below :

List - I**List - II**

- | | |
|---------------|--|
| (a) Isohel | (i) line joining places having same average percentage of cloudiness |
| (b) Isohaline | (ii) line joining the places having same duration of sunshine |
| (c) Isotach | (iii) line joining the places having equal salinity in the ocean |
| (d) Isoneph | (iv) line joining places having equal wind speed |

Codes :

- | (a) | (b) | (c) | (d) |
|--------|-----|-----|-----|
| (A) ii | iii | i | iv |
| (B) i | ii | iii | iv |
| (C) ii | iii | iv | i |
| (D) iv | iii | i | ii |

6. Which one of the following is not a necessary condition for condensation ?

- (A) Saturation
- (B) Surface
- (C) High altitude
- (D) Water vapour

7. Which of the following does not enhance the instability of air ?

- (A) radiation cooling of earth's surface after sun set
- (B) radiation cooling from cloud top
- (C) heating an air mass from below as it passes over a warm surface
- (D) intense solar heating in the lowermost atmosphere

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	8	C	2.4.1.c
2.	9	D	2.4.7.a
3.	10	C	2.4.1.h
4.	13	B	2.4.18
5.	10	C	2.4.4.a
6.	14	C	2.4.1.b
7.	16	A	2.4.2 & 2.4.2.b

December - 15

1. Hurricane carries which of the following Beaufort Number ?

- (A) 9
- (B) 10
- (C) 11
- (D) 12

2. Given below are two statements, one labelled as **Assertion (A)** and other labelled as **Reason (R)**. Select your answer from the codes given below :

Assertion (A) : Tropical cyclones have a life span of about one week time.

Reason (R) : They can produce low amount of rainfall due to low atmospheric pressure.

Codes :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (B) Both (A) and (R) are true, but (R) is not the correct explanation of (A)
- (C) (A) is true, but (R) is false
- (D) (A) is false, but (R) is true

3. Identify the correct normally occurring life cycle of frontal depressions from the following :

- (A) 1 - 2 days
- (B) 2 - 3 days
- (C) 3 - 4 days
- (D) 4 - 5 days

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	8	D	2.4.8
2.	12	C	2.4.8
3.	17	D	2.4.8

July - 16

1. V. Bjerkne's model is related to

- (A) Origin of Tropical Cyclones
- (B) Origin of Monsoons
- (C) Origin of Anticyclones
- (D) Origin of mid-latitudinal Cyclones

2. Given below are two statements, one is labelled as **Assertion (A)** and other labelled as **Reason (R)**. Select your answer from the codes given below :

Assertion (A) : Stable air resists vertical movement and unstable air ascends freely because of its own buoyancy.

Reason (R) : When stable air is forced aloft, the clouds that form are wide spread and have little vertical thickness.

Codes :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).
- (C) (A) is true, but (R) is false.
- (D) is false, but (R) is true.

3. The zeropoint of the _____ temperature scales represents the temperature at which the molecular motion is presumed to cease.

- (A) Celsius
- (B) Kelvin
- (C) Fahrenheit
- (D) Both Kelvin and Celsius

4. An air temperature of 50 °F with actual vapour pressure of 4.6 hPa and saturation vapour pressure of 12.3 hPa would have a relative humidity of

- (A) 7.9%
- (B) 3.7%
- (C) 37%
- (D) 30%

5. What is the correct sequence of the cloud types in warm front away from its trailing edge ?

- (A) Nimbostratus, Altostratus, Cirrostratus, Cirrus
- (B) Altostratus, Nimbostratus, Cirrus, Cirrostratus
- (C) Cirrostratus, Nimbostratus, Altostratus, Cirrus
- (D) Cirrus, Nimbostratus, Altostratus, Cirrostratus

6. Given below are two statements, one is labelled as **Assertion (A)** and other labelled as **Reason (R)**. Select your answer from the codes given below.

Assertion (A) : When the air is very dry heat loss by evaporation is increased.

Reason (R) : A hot and dry air feels warmer and more uncomfortable than a hot and humid air.

Codes :

- (A) Both (A) and (R) are true, (R) is the correct explanation of (A).
- (B) Both (A) and (R) are true, (R) is not the correct explanation of (A).
- (C) (A) is true, but (R) is false.
- (D) (A) is false, but (R) is true.

7. Which one of the following statements concerning horizontal variation in air pressure is incorrect ?

- (A) A cold air mass will produce highest surface pressure than a warm humid air mass.
- (B) A warm dry air mass will exhibit higher pressure than a warm humid air mass.
- (C) A cold humid air mass will have higher air pressure than an equally cold dry air mass.
- (D) A warm humid air mass will have a lower air pressure than an equally warm dry air mass.

8. Match **List-I** with **List-II** and select the correct answer from the given below.

List – I

I. Graupel

II. Ice pallets

III. Rime

IV. Snow flacks

List – II

A. transparent grains of ice formed when condensation takes place below freezing point.

B. precipitation in solid form is comprised of ice grains of white color and is opaque for light.

C. form when air temperature is greater than -5°C but less than 0°C .

D. is an opaque coating at tiny white granular ice particles caused by rapid freezing of supercooled water droplets on impact with an object.

Codes :

- | | (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|-----|
| (A) | i | ii | iv | iii |
| (B) | ii | I | iv | iii |
| (C) | iv | iii | ii | i |
| (D) | iii | ii | i | iv |

9. Supercooled water is water which is

- (A) Produced from dry ice
- (B) A special form of ice
- (C) Still liquid at temperature below zero degree
- (D) Partly liquid and partly solid

10. Given below are two statements, one labelled as **Assertion (A)** and other labelled as **Reason (R)**. Select your answer from the codes given below :

Assertion (A) : Hurricane cannot develop along the equatorial region

Reason (R): Coriolis force is at its maximum over the equator

Codes :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
- (B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).
- (C) (A) is true, but (R) is false.
- (D) (A) is false, but (R) is true.

11. The actual amount of water vapour in a given quantity of air is greatest for which of the following temperature-relative humidity combinations ?

- (A) 40 °C – 100%
- (B) 25 °C – 100%
- (C) 0 °C – 100%
- (D) 30 °C – 50%

12. Match the **List – I** with **List – II** and select the correct answer from the codes given below

List – I	List – II
I. Absolute humidity	A. The ratio of weight of water vapour to the weight of per unit volume of dry air
II. Relative humidity	B. Mass of water vapour in grams contained in one kilogram of air including water vapour
III. Specific humidity	C. The ratio of the amount of water vapour actually present in the air having definite volume and temperature to its maximum amount air can hold at that temperature
IV. Mixing ratio	D. The total weight of moisture content per unit volume of air

Codes :

- | | (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|-----|
| (A) | i | ii | iii | iv |
| (B) | iv | iii | ii | i |
| (C) | ii | iv | iii | i |
| (D) | iv | ii | i | iii |

13. Which one of the following processes is important for the formation of lightning in a developing cloud ?

- (A) Absorption of solar cosmic rays
- (B) Small lapse rate
- (C) Strong vertical air currents
- (D) Heavy rainfall

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	7	D	2.4.6
2.	10	C	2.4.2
3.	10	B	2.4.1
4.	11	C	2.4.1.h
5.	12	A	2.4.4
6.	13	C	2.4.1
7.	15	C	2.4.6
8.	16	B	2.4.5.e
9.	11	C	2.4.1.c
10.	13	C	2.4.7
11.	14	A	2.4.1.d,e,f
12.	16	A	2.4.1.f,g,h
13.	7	C	2.4.5

January - 17

1. In which of the following areas, the main centre of 'Hurricane Mathew' that occurred in Caribbean Sea in the 1st week of October, 2016 was located ?
 - (A) Florida
 - (B) Georgia
 - (C) South Carolina
 - (D) South-West Haiti

2. How much of the liquid precipitation is equivalent to ten inches of snowfall at deep/near freezing temperature ?
 - (A) About 3 inches
 - (B) About 2 inches
 - (C) About 1 inch
 - (D) At times about one inch and at times about two inches

3. Which one of the following descriptions is appropriate for the term 'barotropic' ?
 - (A) Isobars and isotherms are parallel.
 - (B) Isobars and isotherms are not parallel.
 - (C) Isobars and isohalines are parallel.
 - (D) Isobars and isohalines are not parallel.

4. Which one of the following is the main energy source for the formation of hurricanes ?
 - (A) Geothermal energy of the Earth
 - (B) Latent heat derived from condensed water vapour
 - (C) Large scale fossil fuel burning
 - (D) Formation of Ozone (O₃) hole

5. Which one of the followings is the correct average air mass density at the surface of the Earth ?
 - (A) 0.9 kg m⁻³
 - (B) 1.2 kg m⁻³
 - (C) 1.5 kg m⁻³
 - (D) 0.7 kg m⁻³

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	8	B	2.4.8
2.	21	C	2.4.5.e
3.	8	A	2.4.4
4.	13	B	2.4.8
5.	14	B	2.4.6

November - 17

1. Which one of the following is the correct average slope of a typical 'front' in weather phenomena ?

- (A) 1 : 150
- (B) 1 : 100
- (C) 1 : 50
- (D) 1 : 5

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	9	B	2.4.6

Sub Unit – 5:

Climatic classification

2. 5. 1 Koppen:

A widely-used vegetation-based climate classification system, the *Köppen climate classification system*, was created by Wladimir Köppen, a German botanist, and climatologist. The classification system attempts to derive a formula to categorize vegetation zones or biomes across the globe, in accordance with their climatic boundaries.

The Köppen climate classification divides climates into five main climate groups, with each group being divided based on seasonal precipitation and temperature patterns. The five main groups are *A* (tropical), *B* (dry), *C* (temperate), *D* (continental), and *E* (polar). Each group and subgroup is represented by a letter. All climates are assigned a main group (the first letter)

In 1900, the climatic classification was a novel concept. In 1918, Köppen revised his classification system and republished, and continued revising the system until his death in 1936.

Climate Types According to Köppen

Group	Type	Letter Code	Characteristics
A-Tropical Humid Climate	Tropical wet Tropical monsoon Tropical wet and dry	Af Am Aw	No dry season Monsoonal, short dry season Winter dry season
B-Dry Climate	Subtropical steppe Subtropical desert Mid-latitude steppe Mid-latitude desert	BSh BWh BSk BWk	Low-latitude semi arid or dry Low-latitude arid or dry Mid-latitude semi arid or dry Mid-latitude arid or dry
C-Warm temperate (Mid-latitude) Climate	Humid subtropical Mediterranean Marine west coast	Cfa Cs Cfb	No dry season , warm summer Dry hot summer No dry season , warm and cool summer
D-Cold Snow-forest Climates	Humid continental Subarctic	Df Dw	No dry season , severe winter Winter dry and very severe
E-Cold climate	Tundra Polar ice cap	ET EF	No true summer Perennial ice
H-highland	Highland	H	Highland with snow cover

2. 5. 2. Thornthwaite:

Charles Warren Thornthwaite was an American geographer and climatologist. He is best known for devising a climate classification system in 1948 that is still in use worldwide, and also for his detailed water budget computations of potential evapotranspiration.

Thornthwaite introduced the following indices in his climatic classification:

- i. Precipitation effectiveness index.
- ii. Thermal efficiency index.
- iii. Concept of potential evapotranspiration and water balance.
- iv. Moisture adequacy index.

Precipitation Effectiveness Index:

He conceived that tropical rainforest grows most rapidly and has the densest vegetation because of constantly high temperature and abundant rainfall. As such, their efficiency must be maximum in rainforests.

Humidity	P/E index	Vegetation
A (wet)	> 127	Rainforest
B (humid)	64 – 127	Forest
C (subhumid)	32 – 63	Grassland
D (semiarid)	16 – 31	Steppe
E (arid)	<16	Desert

ii. Thermal Efficiency Index:

Calculation of thermal efficiency index (TIE ratio) is similar to that of P/E ratio as indicated above, except that T (monthly temperature) replaces P (monthly precipitation).

Temperature efficiency	T/E index
A – Tropical rainforest	> 127
B – Temperate rainforest	64 - 127
C – Microthermal rainforest	32 – 63
D – Taiga	16 – 31
E – Tundra	1 – 16
F - Forest	0

iii. Concept of Potential Evapotranspiration and Water Balance:

In 1948, Thornthwaite introduced the concept of potential evapotranspiration (PET) and water balance (WB) to revise his classification of 1931. He developed the concept of thermal efficiency. According to him, thermal efficiency is PET (cm).

Thermal provinces	T/E index
A – Mega – thermal	> 44.88
B ₁ to B ₄ – Meso- thermal	22.4 to 44.8
C ₁ to C ₂ – Micro – thermal	11.2 to 22.4
D – Tundra	5.6 to 11.2
E – Frost	< 5.6

iv. Moisture Adequacy Index:

Thornthwaite revised his classification further in 1955, by introducing four more climatic criteria: moisture adequacy index (I_m), thermal efficiency, humidity index (I_h) and aridity index (I_a) based on PET and precipitation.

The moisture regimes according to this revised classification are

Climatic type	I _m
A – Perhumid	100 and above
B ₄ – Humid	80 to 100
B ₃ – Humid	60 to 80
B ₂ – Humid	40 to 60
B ₁ – Humid	20 to 40
C ₂ – Moist subhumid	- 33.3 to 0
C ₁ – Dry subhumid	- 33.3 to 0
D – Semiarid	- 66.7 to - 33.3
E – Arid	- 100 to - 66.7

Previous Year Question**June - 14**

1. According to Koppen's Scheme of climatic classification 'E' (Polar or Mountain) type climatic is found in
- (A) Nagaland
 - (B) Arunachal Pradesh
 - (C) Sikkim
 - (D) Jammu & Kashmir

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	7	D	2.5.1

December - 15

1. The 'Bhvk' climate of Koppen is found in which of the following ?

- (A) Mongolia
- (B) Thar Desert
- (C) Patagonia
- (D) Sri Lanka

2. A type of climate after Koppen which is characterised by an almost uniform distribution of precipitation throughout the year with the precipitation for the driest month more than 6 cms. and a very low daily range of temperature is denoted by :

- (1) Aw
- (2) Af
- (3) Am
- (4) As

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	5	B	2.5.1
2.	14	B	2.5.1

July - 16

1. Which one of the 'C' types of climate receives the bulk of its precipitation during the cold season ?
- (A) Cfa
 - (B) Cs
 - (C) Cwa
 - (D) Cfc

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	9	B	2.5.1

January - 17

1. Match **List-I** with **List-II** and select the correct answer from the codes given below :

List-I	List-II
(Surface condition)	(Precipitation Efficiency (P-E) index)
I. Forest	A. > 127
II. Desert	B. < 16
III. Rain forest	C. 32 – 63
IV. Grasslands	D. 64 – 127

Codes :

	(a)	(b)	(c)	(d)
(A)	iii	i	ii	iv
(B)	iii	i	iv	ii
(C)	iv	ii	iii	i
(D)	iv	ii	i	iii

2. In Koppen's classification of climate the symbol Aw refers to

- (A) Monsoon climate
- (B) Tropical rainforest climate
- (C) Steppe climate
- (D) Tropical savanna climate

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	9	D	2.5.2
2.	12	D	2.5.1

November - 17

1. Which one of the following isotherms for the average temperature of the Warmest month is generally accepted as equator ward edge of the Tundra climate ?

- (A) 2°C
- (B) 10°C
- (C) 5°C
- (D) 15°C

2. Which one of the following types of climate is appropriate for BWh in Koppen's World Climate classification ?

- (A) Subtropical Desert Climate
- (B) Subtropical Steppe Climate
- (C) Midlatitude Desert Climate
- (D) Midlatitude Steppe Climate

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	14	B	2.5.2
2.	16	A	2.5.1

Sub Unit – 6:

Climatic change

2.6.1 Air Pollution:

Cause: Most of this air pollution we cause results from the burning of fossil fuels, such as coal, oil, natural gas, and gasoline to produce electricity and power our vehicles. It produces carbon dioxide, carbon monoxide and other green house gases. At the same time it also increase amount of aerosols in atmosphere. Most of them are Polycyclic aromatic hydrocarbons (PAHs).

Effects:

- a) Global temperature is rising
- b) Respiratory disease of human
- c) Heart disease etc.

PAN: Peroxyacetyl nitrate is a toxic chemical that is an important component of smog. **It** effects in the human body such as reduced respiratory function and eye irritation.

Shoot: Maximum soot is released from Thermal Power Plants. It helps to increase global temperature.

CFCs: chlorofluorocarbon basically generates from air-conditioning, refrigeration, blowing agents in foams, insulations and packing materials, propellants in aerosol cans etc.

UVI: The ultraviolet index or UV Index is an international standard measurement of the strength of sunburn-producing ultraviolet (UV) radiation at a particular place and time. The scale was developed by Canadian scientists in 1992, and then adopted and standardized by the UN's World Health Organization and World Meteorological Organization in 1994. It is primarily used in daily forecasts aimed at the general public, and is increasingly available as an hourly forecast as well.

Smog: Smog is a type of severe air pollution. Smog is primarily associated with the photochemical formation of ozone and sulfur dioxide. An erupting volcano can emit high levels of sulfur dioxide. Beijing is most worst affected by the smog calamities.

Surface ozone: Ozone is produced in the troposphere by photochemical oxidation of CO, CH₄ and non-methane volatile organic carbons (NMVOCs) in the presence of oxides of nitrogen.

CNG: to reduce carbon emission Compressed Natural Gas (Methane, Ethane etc.) is introduced in New Delhi. As a result 20% of pollution is controlled by introducing CNGs. Actually the originated hydrogen cell gives energy to move the vehicle.

Dioxins: The toxicity of other dioxins and chemicals like PCBs that act like dioxin are measured in relation to TCDD. Dioxin is formed as an unintentional by-product of many industrial processes involving chlorine such as waste incineration, chemical and pesticide manufacturing and pulp and paper bleaching.

Air Quality Index By India: The National Air Quality Index (AQI) was launched in New Delhi on September 17, 2014 under the Swachh Bharat Abhiyan. AQI will consider eight pollutants PM₁₀ ie particulate matter upto 10 micrometers, PM_{2.5} i.e. particulate matter 2.5 micrometers, NO₂, SO₂, CO, O₃, NH₃, and Pb

2.6.2 Global Warming:

Global warming is the increase in the average temperature of the Earth's near-surface air and the oceans ever since the mid-twentieth century. The temperature is rising day by day. Between 1880 and 2012, the global average surface temperature increased by 0.85°C. Since 1979 the rate of warming has approximately doubled.

Cause : Human activity since the Industrial Revolution has increased the amount of greenhouse gases in the atmosphere, leading to increased radioactive forcing from CO₂, methane, tropospheric ozone, CFCs, and nitrous oxide. It causes green house effect.

Effects: Ongoing effects include **rising sea levels** due to thermal expansion and melting of glaciers and ice sheets, and warming of the ocean surface, leading to increased temperature stratification. Other possible effects include large-scale changes in ocean circulation. Global climate change is also an effect.

Heat island (UHI) is an urban area or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities, concrete construction bitumen road etc.. It creates local low pressure zone. Wind flow in urban region is heavier rather than rural areas.

2.6.3 Acid Rain:

Adding of carbon dioxide with rain water droplets creates slightly carbonic acid. It can damage soil property or calcium carbonate related heritages.

2.6.4 Ozone Depletion:

CFCs and halons gases are released into atmosphere. It reacts with stratospheric ozone layer and makes ozone layer thinner. UV ray from sun can easily reach to the earth surface and cause skin cancer of man and disturbs plant growth.

2.6.5 Desertification:

Cause: 'Climatic variations' and 'Human activities' can be regarded as the two main causes of desertification. Removal of the natural vegetations, agricultural activities in the vulnerable ecosystems of arid and semi-arid areas, which are thus strained beyond their capacity.

319 million hectares of **Africa** are vulnerable to **desertification** due to sand movement. The assessment is done by FAO and UNEP. They suggest that the desert is moving at an annual rate of 5 km in the semi-arid areas of West **Africa**.

2.6.6 Rio summit or Earth Summit or Agenda 21

Signed	3 to 14 June 1992.
Location	Rio de Janeiro, Brazil.
Core agenda	Sustainable Development

The issues addressed included:

systematic scrutiny of patterns of production — particularly the production of toxic components, such as lead in gasoline, or poisonous waste including radioactive chemicals

alternative sources of energy to replace the use of fossil fuels which delegates linked to global climate change

new reliance on public transportation systems in order to reduce vehicle emissions, congestion in cities and the health problems caused by polluted air and smoke

the growing usage and limited supply of water.

List of Earth Summits:

1. 1972 - The United Nations Conference on the Human Environment (UNCHS) in Stockholm
2. 1982 - The 1982 Earth Summit in Nairobi (Kenya). An Earth Summit was held in Nairobi, Kenya, from 10 to 18 May 1982. The events of the time (Cold War) and the disinterest of US President Ronald Reagan (who appointed his delegated daughter Of the United States) made this summit a failure. It is not even mentioned as an official Earth Summit.
3. 1992 - The United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro (Brazil)
4. 2002 - The World Summit on Sustainable Development (WSSD) in Johannesburg (South Africa)
5. 2012 - The United Nations Conference on Sustainable Development (UNCSD) or Rio+20, also took place in Rio de Janeiro (Brazil)

2.6.7 Kyoto Protocol:

Signed	11 December 1997
Location	Kyoto, Japan
Effective	16 February 2005
Condition	Ratification by at least 55 states to the Convention
Expiration	In force (first commitment period expired 31 December 2012)
Signatories	84
Parties	192(European Union, Cook Islands, Niue, and all UN member states except Andorra, Canada, South Sudan, and the United States)
Depository	Secretary-General of the United Nations
Core Agenda	Convention on Climate Change(increasing of greenhouse gases causes Global Warming.)

2.6.8 Paris Agreement:

Drafted	30 November – 12 December 2015 in Le Bourget, France
Signed	22 April 2016
Location	New York City, United States
Sealed	12 December 2015
Effective	4 November 2016
Condition	Ratification and accession by 55 UNFCCC parties, accounting for 55% of global greenhouse gas emissions
Signatories	195
Parties	185
Depository	Secretary-General of the United Nations

Previous Year Question

December - 15

1. Given below are two statements, one labelled as **Assertion (A)** and other labelled as **Reason (R)**. Select your answer from the codes given below :

Assertion (A) : Presence of CO₂ in the earth's atmosphere is essential.

Reason (R) : CO₂ can absorb heat.

Codes :

- (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
- (B) Both (A) and (R) are true, but (R) is not the correct explanation of (A)
- (C) (A) is true, but (R) is false
- (D) (A) is false, but (R) is true

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	10	A	2.6.2

November - 17

1. Which one of the following ranges of percentage of increase of CO₂ in the atmosphere since 1750 is correct ?

- (A) 5 - 10%
- (B) 10 - 15%
- (C) 15 - 30%
- (D) More than 30%

2. The UVI (Ultra Violet Index) was developed in :

- (A) 1950s
- (B) 1990s
- (C) 2000s
- (D) 2010s

3. Match **List - I** with the **List - II** and select the correct answer from the code given below :

List - I**(Conferences/Reports)**

- (a) Global climate change impacts in the United States
- (b) Stockholm Conference
- (c) Fourth Assessment Report of the IPCC
- (d) Rio Conference

List - II**(Held in/Published in)**

- (i) 2007
- (ii) 1992
- (iii) 1972
- (iv) 2009

Code :

- | | (a) | (b) | (c) | (d) |
|-----|-----|-----|-----|-----|
| (A) | i | ii | iii | iv |
| (B) | ii | i | iii | iv |
| (C) | iv | iii | ii | i |
| (D) | iv | iii | i | ii |

Answer with Reference Table

SL. NO.	QUESTION NO.	ANSWER	REFERENCE NO.
1.	6	D	2.6.2
2.	8	B	2.6.1
3.	10	D	2.6.6