Question 2

(a) Define ceramic and nano ceramic materials. Why the nano-ceramics show better properties than their ceramic counterparts? Write their applications of ceramic materials.

(A) Definition of Ceramic Materials:-

Ceramic materials are those inorganic non-metallic solids which are made up of clay that have been shaped and then hardened by heating to high temperatures.

(B) Definition of Nano-ceramic Materials:-

Nano-ceramic materials are those ceramic materials which are fabricated from ultrafine particles. These are less than 100nm in diameter.

and classified as inorganic, heat resistant, non-metallic solids.

(c) Reasons that nano-ceramics show better properties than Ceramic Materials:-

(i) Enhanced mechanical properties :-

Nano-ceramics typically have higher hardness, strength, and toughness as compared to ceramics.

(ii) Improved fracture resistance:-

Nano-ceramics have the fine grained structure which reduces crack propagation and makes them more resistant to fracture. However, This type of structure is lacked in ceramics.

(iii) Increased electrical and thermal conductivity :-

Nano-ceramics have higher electrical and thermal conductivity compared to their bulk counterparts.

(iv) Greater Surface Area :-

Nano-ceramics have a higher surface area due to their smaller particle size. This increased surface area is advantageous for different catalytic applications.

(v) Improved optical properties :-

Nano-ceramics exhibit enhanced optical properties including improved transparency and light dispersion. This property makes them suitable for optical components as compared to ceramics where optical properties are not improved.

(D) Applications of Ceramic Materials :-

Ceramics have applications in the following areas.

(i) Aerospace :-

Ceramics are used in the formation of parts of space shuttle, rockets and space stations.

(ii) Consumer Usage :-

Ceramics have great usage in homes like glassware, pottery, dinnerware, and home electronics.

(iii) Automative Industry :-

Ceramics are widely used in automative industry. For example, catalytic converters, filters, rotors, valves, spark plugs, etc, are ceramics.

(iv) Medical (Bio-ceramics) :-

Ceramics are used in medical field especially in dental and bone fillings and in bone implants.

(v) Military equipment :-

Structural components for grand, air and naval vehicles of military are made from ceramics.

(vi) Building and construction :-

Manufacturers use ceramics to make bricks, tiles, piping and other construction materials.

(vii) Computers and Electronics :-

Computer parts like insulators, resistors, superconductors, etc. are made up of ceramics.

(b) What is 'Black Hole'? How black holes are formed and discovered?

(A) Black Hole:-

(i) Definition of Black Hole:-

A black hole is a region of spacetime where gravity is so strong that nothing, including light and other electromagnetic waves, has enough energy to escape it.

(ii) Size of Black Hole:-

Black hole comes in various sizes, with stellar-mass black holes being several times more massive than Sun and supermassive black holes found at the centre of galaxies, can be millions or billions of times more massive than Sun. There are also intermediate-mass black holes with masses between these extremes.

(iii) Properties of Black Hole:-

Black hole is often

characterized by three main properties.

1) **Mass:** This refers to the total amount of matter contained within the black hole.

2) **Spin (angular momentum):** Black hole can rotate, and its angular momentum exhibits interesting phenomena.

3) **Charge:** Black hole carries electrical charge which influences its behavior.

(iv) Examples of Black Hole:-

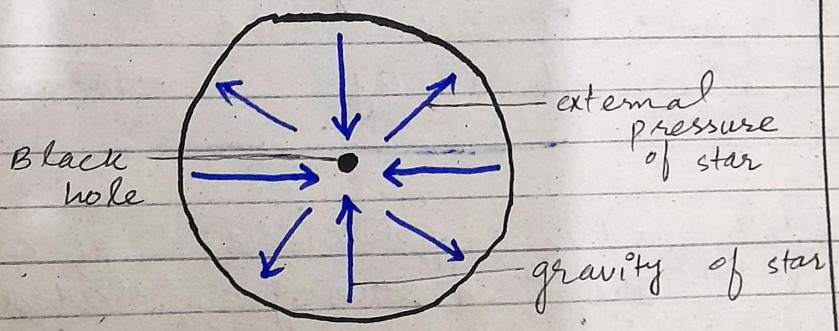
Some examples of Black Hole are:

1) Cygnus X-1
2) Sagittarius A

(B) Formation of Black Hole:-

A black hole forms through the gravitational collapse of a massive star at the end of its life cycle. As the star evolves, it undergoes nuclear fusion, generating energy that counteracts the inward pull of gravity.

However, when star's core accumulates iron, it can no longer support itself against the relentless force of gravity. This leads to a rapid and catastrophic core collapse, triggering a supernova explosion that expels the outer layers of the star. The remaining core contracts further, creating a gravitational field so intense that it forms a singularity at its centre- a point with infinite density. This singularity is hidden behind an event horizon, a boundary beyond which nothing, not even light can escape, making the birth of a black hole.



(C) Discovery of Black Hole:-

Black holes can be discovered through a combination

of methods as they cannot be directly observed due to their light-absorbing nature. Astronomers use instruments like X-ray and gamma-ray telescopes to detect high energy transmissions from black holes. By using these telescopes, they also study gravitational lensing effects, and analyze radio emissions near black holes. Moreover, the recent development of gravitational wave detectors such as the Laser Interferometer Gravitational-Wave Observatory (LIGO) has allowed direct detection of black hole mergers through the observation of gravitational waves. By using these methods, black hole is discovered by astronomers.

(c) Write two applications of each of the following electromagnetic radiations:

(i) Ultraviolet (ii) Infrared
(iii) Microwaves (iv) Radiowaves
(v) X-rays

(A) Applications of Ultraviolet Radiations :-

Ultraviolet radiations have the following applications.

i) Ultraviolet light is used by powerful telescopes like the Hubble Telescope to see far away stars.

ii) Ultraviolet light synthesizes Vitamin D in skin, and controls the endocrine system.

(B) Applications of Infrared Radiations :-

Infrared radiations have following applications.

i) Infrared radiation is used in thermography which is the imaging of temperature variations in objects or scenes.

ii) Infrared Spectroscopy is a valuable analytical technique used for identifying molecules determining their chemical composition. It is widely used in research.

quality control, and forensic science.

(C) Applications of Microwaves:-

The microwaves have following applications.

i) Microwave ovens use microwave radiations to heat and cook food quickly and efficiently. The microwaves excite water molecules in the food, and thus cook or reheat the food in a matter of minutes.

ii) Microwaves are extensively used in long-distance communication system particularly in microwave transmission towers and satellite communication.

(D) Applications of Radiowaves:-

The radiowaves have following applications.

i) Radiowaves are used for broadcasting information including radio and television broadcasts. Radio stations transmit audio signals while

send both audio and video signals using radio waves.

ii) Radio waves form the basis for wireless communication systems including AM and FM radio, cellular networks, Wi-Fi, and Bluetooth. These waves also play a vital role in two-way radio systems and public safety communication networks.

(E) Applications of X-rays :-

X-rays have following applications.

i) X-rays are used in medicine for diagnostic imaging by helping physicians diagnose and monitor a wide range of medical conditions. Common medical applications include X-ray Radiography, Computed Tomography (CT) scans, and Fluroscopy.

ii) X-ray technology is employed in industrial setting for non-destructive testing and quality control. It is used to inspect the internal structures of

materials such as welds, pipelines, and manufactured components.

(d) What is Wildfire? Explain its types, causes, spread and preventions.

(A) **Definition(s) of Wildfire:-**

According to **National Geographic Society**, a wildfire is an uncontrolled fire that burns in wildland vegetation, often in rural areas.

OR

A wildfire is simply an uncontrolled fire that is wiping out large fields and areas of land. It can wipe out an entire forest and destroy almost every organic matter in it.

Wildfires can be termed as forest fires, grass fires, peat fires and bush fires depending on type of vegetation being burnt.

(B) # Types of Wildfire :-

Wildfires are classified into different types based on characteristics, causes and behavior. These types are:

(i) Surface Fires :-

These are the most common type of wildfires and typically burn in the understory of forests or grasslands. They can spread quickly but are generally less destructive than other types.

(ii) Crown Fires :-

Crown fires are extremely dangerous and destructive wildfires that burn through the upper canopy of trees in forests. These fires can spread rapidly and can be challenging to control.

(iii) Ground Fires :-

Ground fires, also known as sub-surface fires or peat fires, occur below the surface of ground, in organic-rich soils or peatlands. They can release significant amounts of smoke and greenhouse gases

(iv) Grass Fires :-

Grass fires primarily burn in grasslands and agricultural areas. They spread quickly and can be particularly dangerous during dry and windy conditions.

(c) Causes of Wildfire :-

Some of the common causes of wildfire are:

(i) Lightening :-

Lightening strikes are a natural cause of wildfires. When a lightening bolt strikes a dry area, it can ignite vegetation and start a fire.

(ii) Campfires :-

Campfires left unattended or improperly extinguished can spread and start wildfires.

(iii) Smoking :-

Discarding lit cigarettes, cigars, or other smoking materials in dry grass or forests can easily spark a fire.

(iv) Burning debris :-

Burning debris or trash in dry conditions can also lead to wildfires

D) Spreading of Wildfires :-

Wildfires spread in following ways.

(i) Ignition :-

Wildfires start when a heat source such as spark or open flame comes into contact with dry vegetation, dead plant matter, or other flammable materials.

(ii) Fuel :-

The presence of fuel sources is critical for wildfires to spread

(iii) Convection :-

Fire generates its own wind patterns, creating updrafts that pull in oxygen and promote the fire's growth.

(iv) Radiation :-

Heat from the fire can radiate and preheat nearby fuels making them more prone to ignition.

(E) Preventions for Wildfire:-

Some key wildfire prevention measures are:

(i) Follow local Regulations:-

Be aware of and comply with local and state regulations regarding campfires, outdoor burning, and fireworks.

(ii) Campfire Safety:-

When camping use established fire rings or grills and keep fires small. Always fully extinguish campfires before leaving the area.

(iii) Fireworks Safety:-

In areas prone to wildfires, avoid the use of fireworks which can easily ignite dry vegetation.

(iv) Equipment Maintenance:-

Ensure that equipment like chainsaws, vehicles, and off-road vehicles are in good working order and do not have exposed metal parts that could create sparks