

Q 7: Coherent Scattering

Coherent scattering is an interaction between electromagnetic radiation and matter in which the incident radiation is scattered by atoms without any change in its wavelength, frequency, or energy. It occurs when low-energy photons interact with tightly bound electrons of an atom. The electric field associated with the incident electromagnetic wave forces the bound electrons to oscillate about their equilibrium positions. These oscillating electrons then act as secondary sources and re-radiate electromagnetic waves of the same frequency and wavelength as the incident radiation. Since there is no transfer of energy between the photon and the atom, the scattering process is elastic in nature. The scattered waves maintain a constant phase relationship with the incident wave, and hence the process is called coherent scattering. Only the direction of propagation of the radiation changes, while its energy remains conserved. Coherent scattering is more probable for long-wavelength or low-energy radiation and occurs predominantly at small scattering angles. In the case of X-rays, coherent scattering is also known as Rayleigh scattering, where the entire electron cloud of the atom participates in the interaction.

Applications of Coherent Scattering

1. X-ray Crystallography
 - Used to study crystal structure
 - Basis for Bragg's diffraction
 - Determines lattice spacing
2. Medical Imaging
 - Contributes to image formation in: X-ray radiography
 - Affects image contrast
3. Material Science
 - Analysis of atomic arrangement
 - Used in solid-state physics research
3. Optical Phenomena Explains:
 - Blue colour of sky
 - Rayleigh scattering of light
- Advantages
 - Provides information about atomic structure
 - Useful in structural analysis
- Limitations
 - Non-destructive technique
 - Low intensity at high angles
 - Significant only for low-energy radiation

Q 8: Infrared Radiation and its Biological Applications

Infrared Radiation

Infrared radiation (IR) is an electromagnetic radiation lying between visible light and microwaves in the electromagnetic spectrum. It was discovered by William Herschel in 1800.

Characteristics of Infrared Radiation

1. Wavelength range: 700 nm to 1 mm
2. Frequency range:
 3×10^{11} Hz to 4×10^{14} Hz
3. Invisible to the human eye
4. Emitted by hot bodies
5. Produces strong heating effect
6. Travels with the velocity of light
7. Obeys laws of reflection and refraction
8. Non-ionizing radiation

Sources of Infrared Radiation

- i. **Natural Sources:** Sun, Fire
- ii. Living organisms
- iii. Hot objects
- iv. Artificial Sources
- v. Tungsten filament lamps
- vi. Infrared lamps
- vii. Electric heaters
- viii. Infrared LEDs and lasers

Interaction of Infrared Radiation with Biological Tissue i. ii. iii. iv.

- i. Infrared radiation is mainly absorbed by skin and tissues
- ii. Causes increase in temperature
- iii. Results in vasodilation and improved blood flow
- iv. Excess exposure may lead to burns and tissue damage

Biological Applications of Infrared Radiation

1. Infrared Therapy (Physiotherapy)
 - Used for relief from: Muscle pain, Joint stiffness, Arthritis
 - Improves blood circulation Promotes healing of tissues
2. Medical Diagnosis Infrared thermography is used to:
 - Detect tumors

- Identify inflammation
 - Study abnormal blood circulation
3. Neonatal Care Infrared warmers are used to:
 - Maintain body temperature of newborn babies
 - Prevent hypothermia in premature infants
 4. Treatment of Skin Diseases Used in treatment of:
 - Rheumatism
 - Muscular injuries
 - Chronic pain conditions
 - Reduces inflammation and pain
 5. Surgical Applications
 - Used in infrared and laser surgery
 - Controls bleeding by coagulation
 - Minimizes damage to surrounding tissues
 6. Sterilization
 - Used to sterilize:
 - Medical instruments
 - Laboratory equipment
 - Microorganisms are destroyed by heating effect
 7. Biological Research Used to study:
 - Metabolic activity
 - Blood flow patterns
 - Heat distribution in living organisms
- Advantages of Infrared Radiation in Biology**
- Non-invasive method
 - Painless and safe under controlled exposure
 - Quick treatment
 - Wide medical applicability

Q 9: Damaging Effects of Ultraviolet (UV) Light

1. Sunburn (Erythema) Excess exposure to UVB radiation causes redness, pain, and inflammation of the skin due to damage of skin cells.
2. Premature Ageing of Skin UVA radiation penetrates deep into the skin causing wrinkles, dryness, loss of elasticity, and early ageing.

3. **Skin Cancer** Prolonged UV exposure damages DNA in skin cells leading to cancers such as melanoma, basal cell carcinoma, and squamous cell carcinoma.
4. **DNA Damage and Genetic Mutations** UV radiation breaks DNA strands and causes mutations, leading to abnormal cell division.
5. **Eye Damage (Photokeratitis)** Short-term exposure causes inflammation of the cornea resulting in pain, redness, and temporary vision loss.
6. **Cataract Formation** Long-term exposure to UV light leads to clouding of the eye lens, causing cataracts and impaired vision.
7. **Conjunctivitis** UV radiation causes inflammation of the conjunctiva, resulting in irritation and watering of eyes.
8. **Suppression of Immune System** UV light weakens the immune response, reducing the body's ability to fight infections.
9. **Skin Pigmentation Disorders** Causes tanning, dark spots, uneven pigmentation, and discoloration of skin.
10. **Damage to Proteins and Enzymes** UV radiation alters protein structure, affecting normal cellular functions.
11. **Cell Death (Apoptosis)** High-energy UV radiation can destroy skin cells, leading to peeling and tissue damage.
12. **Damage to Cornea and Retina** Intense UV exposure can injure eye tissues and may cause long-term vision problems.
13. **Damage to Plant Life** UV radiation affects photosynthesis and reduces plant growth and crop yield.
14. **Destruction of Beneficial Microorganisms** Excess UV exposure kills useful bacteria and microorganisms, disturbing ecological balance.
15. **Dehydration of Skin Tissues** Causes loss of moisture from skin leading to dryness and cracking.
16. **Increased Risk of Occupational Hazards** Continuous exposure in welding, laboratory, and industrial environments increases health risks.