Question Bank with Previous Year Question

Dept. of Botany
Dinakrushna College, Jaleswar, Balasore

Semester 1, Core – 1, Paper: Major-II

Based on NEP 2020 Syllabus

Paper II: Analytical Techniques in Plant Sciences

Questions are grouped unit-wise (Unit I–IV). Within each unit you will find, in order:

Section A – Fill in the Blanks (1 mark each), with answers provided.

Section B – Short Answer / Short Notes (2 marks each); a few numerical problems are included.

Section C – Notes (5 marks each) – "Write notes on the following."

Section D – Long Answer / Essay Type (8 marks each).

Unit I: Microscopy & Imaging Techniques

Section A — Fill in the Blanks (1 Mark each)

1. The lens of a compound microscope that gathers and focuses light rays onto the specimen is the _____ lens. **[2024]**

Answer: Condenser lens

2. _____ is a molecule that absorbs light and then re-emits it as a different colour. **[2025]**

Answer: Fluorophore (fluorochrome)

3. The first electron microscope was invented by _____. **[2025]**

Answer: Ernst Ruska

4. The resolving power of the human eye is approximately _____. **[2024]**

Answer: 0.1 mm (about 100 µm)

5. _____ is the branch of science dealing with the study of minute objects with the help of a microscope.

Answer: Microscopy

6. In fluorescence microscopy, the _____ filter allows only the emitted light to pass to the observer while blocking the excitation light.

Answer: Emission (barrier) filter

7. FACS is the full form of _____.

Answer: Fluorescence-Activated Cell Sorting

8. In a Transmission Electron Microscope, the image is formed by electrons that _____ through an ultra-thin specimen.

Answer: Transmit (pass through)

9. _____ is the technique of evaporating a heavy metal at an angle onto a specimen surface to reveal its 3-D surface detail under the electron microscope.

Answer: Shadow casting

10. _____ is the rapid freezing of a specimen to preserve its structure without ice-crystal formation, prior to electron microscopy.

Answer: Cryofixation

11. SEM images are formed mainly by detecting _____ electrons released from the surface of the specimen.

Answer: Secondary electrons

Section B — Short Answer / Short Notes (2 Marks each)

1. What is cryofixation? **[2025]**

2. What is negative staining? **[2025]**

3. What is microscopy? State any two functions of a microscope. **[2025]**

4. Write the principle of TEM. **[2025]**

5. What is the magnifying power of a microscope? **[2024]**

6. Write the components of SEM. **[2024]**

7. What is freeze fracture?

8. What is freeze etching?

9. What is shadow casting used for?

10. Define the resolving power of a microscope.

11. What is FACS? Mention one application.

Section C — Write Notes on the Following (5 Marks each)

1. Shadow casting **[2025]**

2. Flow cytometry **[2025]**

3. Resolution power of microscope **[2024]**

4. Principle of light microscopy

5. Principle and working of fluorescence microscopy

6. Negative staining technique

7. Cryofixation

8. Freeze fracture and freeze etching techniques

9. Sample preparation for electron microscopy

10. Working principle of TEM

Section D — Long Answer / Essay Type (8 Marks each)

1. Give an account of the Scanning Electron Microscope (SEM) and its application. **[2024, 2025]**

2. Explain the working principle of a fluorescence microscope. **[2025]**

3. What is flow cytometry? Give an account of it with an example. **[2024]**

4. Describe the principle, construction and working of a Transmission Electron Microscope (TEM).

5. Describe the principle, construction and working of a compound (light) microscope.

6. Give a detailed account of sample-preparation techniques for electron microscopy (cryofixation, negative staining, shadow casting, freeze fracture, freeze etching).

7. Explain the difference between light microscopy and electron microscopy with respect to resolution, magnification and image formation.

8. Describe the freeze fracture and freeze etching techniques used in electron microscopy.

9. Discuss the principle, instrumentation and applications of fluorescence microscopy in plant sciences.

10. Explain the concept of resolving power and numerical aperture in microscopy.

11. Give an account of Flow Cytometry (FACS): principle, instrumentation and applications.

Unit II: Centrifugation & Radioisotopes

Section A — Fill in the Blanks (1 Mark each)

1._____ centrifugation is the process used to fractionate sub-cellular organelles. **[2025]**

Answer: Differential centrifugation

2. Sedimentation coefficient is expressed in _____ units. **[2025]**

Answer: Svedberg (S)

3. The maximum speed of a standard ultracentrifuge is about _____ rpm. **[2025]**

Answer: 60,000–100,000 rpm

4. One Svedberg unit (S) is equal to _____ seconds. **[2024]**

Answer: 10^{-13} seconds

5. Catalase is the marker enzyme of the _____. **[2024]**

Answer: Peroxisome

6. The positively charged beta particles are known as _____. **[2024]**

Answer: Positrons

7. _____ gradient centrifugation uses caesium chloride solution to separate nucleic acids according to their buoyant density.

Answer: $CsCl_2$ (isopycnic) gradient

8. _____ centrifugation uses an optical detection system to observe sedimentation in real time, allowing determination of purity and molecular weight.

Answer: Analytical centrifugation

9. _____ is a technique in which a photographic emulsion is exposed to a radioactively labelled specimen to localise the isotope.

Answer: Autoradiography

10. In a _____ experiment, cells are briefly exposed to a radiolabelled precursor and then chased with a non-radioactive excess of the same compound to trace its metabolic fate.

Answer: Pulse-chase

11. The time required for half the atoms of a radioactive isotope to decay is called its _____.

Answer: Half-life

Section B — Short Answer / Short Notes (2 Marks each)

1. What is a rotor in centrifugation? How does it work? **[2025]**

2. What is cell fractionation? **[2025]**

3. Write the factors affecting sedimentation. **[2024]**

4. What is the half-life of a radioactive isotope? **[2024]**

5. What is differential centrifugation?

6. What is density gradient centrifugation?

7. Differentiate between differential and density gradient centrifugation (any two points).

8. What is ultracentrifugation?

9. What is the principle of the pulse-chase experiment?

10. Numerical: A radioisotope has a half-life of 8 days. Calculate the fraction of the original activity remaining after 24 days.

11. Numerical: A sample has an initial activity of 800 dpm and a half-life of 6 hours. Calculate its activity after 18 hours.

Section C — Write Notes on the Following (5 Marks each)

1. Pulse-chase experiment **[2024, 2025]**

2. Auto-radiography **[2024, 2025]**

3. Ultracentrifugation **[2024]**

4. $CsCl_2$ gradient **[2024]**

5. Differential centrifugation

6. Sucrose density gradient centrifugation

7. Analytical centrifugation

8. Use of radioisotopes in biological research

9. Half-life of a radioactive isotope

10. Factors affecting sedimentation rate

Section D — Long Answer / Essay Type (8 Marks each)

1. Write an essay on density gradient centrifugation. **[2025]**

2. Describe the principle and types of centrifugation with their applications in biomolecule separation.

3. Explain differential centrifugation and its role in cell fractionation, with a labelled diagram.

4. Explain $CsCl_2$ (isopycnic) density gradient centrifugation and its use in separating nucleic acids.

5. Discuss the principle, construction and working of an ultracentrifuge.

6. Describe the applications of radioisotopes in biological research.

7. Explain the technique and applications of autoradiography.

8. Describe the pulse-chase experiment and its significance in tracing metabolic pathways.

9. Discuss the factors affecting the sedimentation of particles during centrifugation.

Unit III: Spectroscopy

Section A — Fill in the Blanks (1 Mark each)

1. IR spectrophotometers use light in the wavelength range of _____. **[2025]**
   Answer: 2.5–25 µm (4000–400 cm^{-1})

2. In a bomb calorimeter, the sample is burnt in the presence of _____ gas. **[2025]**
   Answer: Oxygen

3. In a spectrophotometer, the desired wavelength of light is selected by a component called the _____. **[2024]**
   Answer: Monochromator

4. According to the _____ law, the absorbance of a solution is directly proportional to its concentration and the path length of light.
   Answer: Beer-Lambert law

5. UV-Visible spectroscopy is based on the absorption of light in the _____ nm range.
   Answer: 200–800 nm

6. In fluorescence spectroscopy, the emitted light always has a _____ wavelength than the absorbed (excitation) light.
   Answer: Longer

7. Chlorophyll a shows a characteristic red fluorescence emission peak at about _____ nm.
   Answer: 685 nm

8. A _____ photometer measures the intensity of light emitted by metal ions when introduced into a flame.
   Answer: Flame photometer

9. Atomic Absorption Spectrophotometry uses a _____ lamp as its light source.
   Answer: Hollow cathode lamp

10. Optical density is another term for _____.
    Answer: Absorbance

11. A bomb calorimeter measures the _____ value of a biological/food sample.
    Answer: Calorific (heat) value

Section B — Short Answer / Short Notes (2 Marks each)

1. Write two advantages of fluorescence spectroscopy. **[2024]**

2. What is optical density? **[2024]**

3. State the Beer-Lambert law.

4. What is the working principle of a flame photometer?

5. What is chlorophyll a fluorescence used to study?

6. Differentiate between UV and IR spectroscopy (any two points).

7. What is the principle of Atomic Absorption Spectroscopy?

8. Numerical: A solution has a molar absorptivity (ε) of 5000 $M^{-1}cm^{-1}$, path length 1 cm, and absorbance 0.5. Calculate the concentration of the solution.

9. Numerical: A solution transmits 40% of the incident light. Calculate its absorbance.

10. What is the difference between absorbance and transmittance?

11. What is meant by a chromophore and an auxochrome?

Section C — Write Notes on the Following (5 Marks each)

1. Fluorescence spectroscopy **[2025]**

2. Flame photometer **[2025]**

3. Beer-Lambert's law **[2024]**

4. Principle of IR spectroscopy **[2024]**

5. Principle of UV-Visible spectroscopy

6. Components of a spectrophotometer

7. Bomb calorimeter

8. Atomic Absorption Spectrophotometer

9. Chlorophyll a fluorescence

10. Optical density and its measurement

Section D — Long Answer / Essay Type (8 Marks each)

1. Give the functions of UV-Visible spectroscopy. **[2025]**

2. Explain the principle and working mechanism of UV-Visible spectroscopy. **[2025]**

3. Describe the principles and applications of spectrophotometry. **[2024]**

4. Explain the principle, instrumentation and applications of IR spectroscopy.

5. Describe the principle, instrumentation and applications of fluorescence spectroscopy.

6. Discuss chlorophyll a fluorescence and its significance in photosynthesis research.

7. Explain the principle and working of a flame photometer with its applications.

8. Describe the principle and working of a bomb calorimeter.

9. Explain the principle, instrumentation and applications of Atomic Absorption Spectrophotometry (AAS).

10. Discuss the Beer-Lambert law and its significance in spectrophotometric analysis.

11. Describe the components and working mechanism of a UV-Visible spectrophotometer.

Unit IV: Chromatography, Electrophoresis & Allied Techniques

Section A — Fill in the Blanks (1 Mark each)

1. The substance that remains fixed in place during chromatography is called the _____ phase. **[2025]**
   Answer: Stationary phase

2. _____ is an anionic detergent used in electrophoresis. **[2025]**
   Answer: SDS (Sodium dodecyl sulphate)

3. The full form of AGE is _____. **[2025]**
   Answer: Agarose Gel Electrophoresis

4. _____ reagent is used to detect amino acids in paper chromatography. **[2024]**
   Answer: Ninhydrin

5. SDS-PAGE stands for _____. **[2024]**
   Answer: Sodium Dodecyl Sulphate–Polyacrylamide Gel Electrophoresis

6. Agarose is a polymer of the monosaccharide _____. **[2024]**
   Answer: Galactose

7. Electrophoresis, as a technique, was pioneered by _____. **[2024]**
   Answer: Arne Tiselius

8. _____ chromatography (also called gel filtration) separates molecules on the basis of size.
   Answer: Molecular sieve chromatography

9. _____ chromatography separates biomolecules on the basis of a specific, reversible binding interaction.
   Answer: Affinity chromatography

10. In mass spectrometry, molecules are first converted into _____ before being separated according to their mass-to-charge ratio.
    Answer: Ions

11. _____ uses the diffraction pattern of X-rays passed through a crystal to determine the 3-D structure of a macromolecule.
    Answer: X-ray crystallography

Section B — Short Answer / Short Notes (2 Marks each)

1. Write the application of PAGE. **[2025]**

2. State the role of SDS in SDS-PAGE. **[2025]**

3. What is the principle of column chromatography?

4. What is Thin Layer Chromatography (TLC)?

5. What is HPLC? State one advantage over conventional column chromatography.

6. What is ion-exchange chromatography?

7. What is the Rf value in chromatography? How is it calculated?

8. What is the principle of mass spectrometry?

9. Numerical: In gel filtration, a column has void volume (Vo) = 30 mL and total bed volume (Vt) = 120 mL. A 66 kDa protein elutes at 45 mL and a 12 kDa protein elutes at 85 mL. Calculate the Kav for each protein.

10. What is the difference between AGE and PAGE (any two points)?

Section C — Write Notes on the Following (5 Marks each)

1. HPLC **[2025]**

2. Paper chromatography **[2025]**

3. X-ray diffraction **[2025]**

4. Affinity chromatography **[2025]**

5. Ion exchange chromatography **[2024]**

6. X-ray crystallography **[2024]**

7. PAGE **[2024]**

8. Principle of chromatography

9. Column chromatography

10. Thin Layer Chromatography (TLC)

11. Molecular sieve (gel filtration) chromatography

12. SDS-PAGE

13. Mass spectrometry

Section D — Long Answer / Essay Type (8 Marks each)

1. Describe ion-exchange chromatography. **[2025]**

2. Give an account of paper chromatography with its applications. **[2024]**

3. Describe Agarose Gel Electrophoresis (AGE) with its advantages. **[2024]**

4. Describe the principle and applications of column chromatography.

5. Explain the principle, procedure and applications of Thin Layer Chromatography (TLC).

6. Discuss the principle, instrumentation and applications of HPLC.

7. Explain molecular sieve (gel filtration) chromatography and its applications in protein purification.

8. Describe affinity chromatography with its principle and an example.

9. Explain the principle and procedure of SDS-PAGE for protein separation, and the role of SDS in it.

10. Discuss the principle and applications of Mass Spectrometry in biomolecule characterisation.

11. Describe the principle and applications of X-ray diffraction and X-ray crystallography in determining biomolecular structure.