JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT
TEST -2, EXAMINATION- 2026
M.Tech-I/M.Sc.Semester 2th/4TH (BT)

(56)

COURSE CODE (CREDITS): 20M1WBT231/~~21MS2MB414~~ (3) MAX. MARKS: 25
COURSE NAME: QUALITY CONTROL ANALYSIS AND MANAGEMENT
COURSE INSTRUCTOR: Dr. Gopal S Bisht MAX. TIME: 1 Hour 30 Min

Note: (a) All questions are compulsory.
(b) The candidate is allowed to make Suitable numeric assumptions wherever required for solving problems
(c) Use of calculator is not allowed

Q.No	Question	Marks
Q1	A pharmaceutical company, XXX Laboratories, manufactures a generic antihypertensive drug containing Amlodipine as the active pharmaceutical ingredient (API). As part of routine batch release testing, the Quality Control (QC) laboratory performs High-Performance Liquid Chromatography (HPLC) analysis to determine the assay and impurity profile of the finished tablet formulation. The QC laboratory operates under strict regulatory frameworks established by International Council for Harmonization of Technical Requirements for Pharmaceuticals for Human Use, United States Pharmacopeia, and World Health Organization Good Manufacturing Practices. The validated reverse-phase HPLC method uses a C18 column (250 × 4.6 mm, 5 µm) with a mobile phase consisting of acetonitrile and phosphate buffer (pH 3.0) in a 60:40 ratio. Detection is carried out at 237 nm using a UV detector with a flow rate of 1.0 mL/min. During routine analysis of Batch AML-12345 the analyst observes irregular chromatographic behavior. The standard solution produces a sharp peak with expected retention time (≈ 5.8 min). However, when the sample solution is injected, the chromatogram shows significant peak tailing (tailing factor ≈ 2.6) and variation in retention time (5.5–6.4 min) across replicate injections. The calculated assay values vary widely between 93% and 107%, whereas the pharmacopeial specification requires 95–105% of label claim. A system suitability test (SST) performed before analysis reveals the following observations: a) Theoretical plates: 1800 (specification ≥ 2000) b) Tailing factor: 2.6 (limit ≤ 2.0) c) %RSD of peak area for standard injections: 3.2% (limit ≤ 2.0%) These results indicate that the HPLC system does not meet the required performance criteria. Upon reviewing laboratory records, the analyst discovers that the HPLC column has been used for more than 1000 injections without regeneration, the mobile phase was prepared two days earlier, and the pump flow rate calibration has not been performed in the past month, despite SOP requirements for weekly verification. Additionally, during sample preparation, the analyst notices slight turbidity in the sample solution before filtration, suggesting incomplete dissolution of the tablet powder. The QC manager must now determine the root cause of the analytical inconsistencies. Possible factors include column degradation, mobile phase instability, instrumental calibration errors, or improper sample preparation. Accurate troubleshooting and documentation are essential because batch release decisions depend on reliable analytical data, and failure to comply with regulatory standards could lead to batch rejection or regulatory observations.	[10]

	a) Which system suitability parameters indicate that the HPLC system is not performing correctly in this case study? Explain their significance in chromatographic analysis. b) Identify and explain the possible causes of peak tailing and retention time variation observed in the chromatograms. c) How can improper sample preparation affect HPLC assay results in pharmaceutical quality control? d) Propose a systematic troubleshooting strategy to identify the root cause of the analytical problem. e) Explain the importance of regulatory guidelines and analytical method validation in maintaining reliability of HPLC-based quality control testing.	
Q2	Develop a comprehensive audit checklist based on GLP guidelines to evaluate the performance of a QC laboratory involved in microbial or biopharmaceutical testing.	[5]
Q3	A biotechnology company specializing in plant-based bioactive products lavender essential oil using a hybrid process involving microbial fermentation to enhance precursor compounds, followed by steam distillation. Recently, the quality control (QC) team observed batch-to-batch variability in linalool concentration (target ≥ 35%), along with occasional contamination indicated by abnormal GC-MS peaks. A HAZOP (Hazard and Operability) study was initiated to evaluate deviations across the production and QC workflow. The background analysis revealed that fermentation conditions (pH, temperature, and aeration) were not consistently maintained, potentially affecting precursor biosynthesis. Additionally, deviations were identified in sample preparation protocols some analysts used different dilution solvents, leading to inconsistent chromatographic profiles. Instrument validation was also questioned when the GC-MS system showed drifting retention times, suggesting possible calibration issues. Further, improper cleaning of the distillation apparatus raised concerns about cross-contamination between batches. The objective of the HAZOP study was to systematically identify deviations in process parameters and QC steps, assess risks to product quality, and recommend corrective actions. Key challenges included distinguishing between process-related variability and analytical errors, ensuring compliance with standards such as ISO 9235 (natural aromatic raw materials) and ISO/IEC 17025 (laboratory competence), and implementing robust standard operating procedures (SOPs). **Questions** 1. Identify the critical deviations detected during the HAZOP study and explain their potential impact on essential oil quality. [3] 2. How can improper sample preparation affect GC-MS analysis in essential oil quality control? [2] 3. Discuss briefly, the importance of instrument calibration and validation in ensuring reliable QC results. [2] 4. Suggest corrective and preventive actions (CAPA) to address contamination and variability issues. How do international standards guide quality assurance in essential oil production and testing? [3]	