I

Name _____

Roll No. _____ Year 20____20____

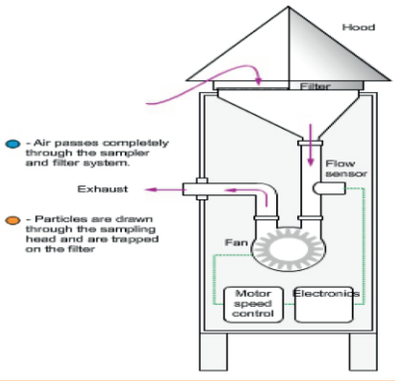
Exam Seat No. _____

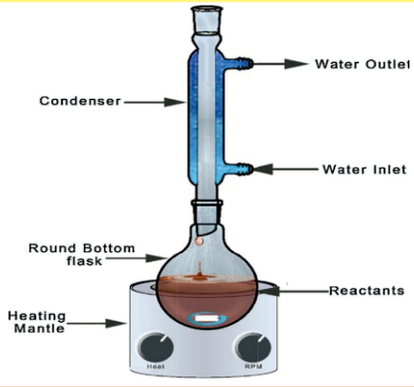
CHEMICAL GROUP | SEMESTER - V | DIPLOMA IN ENGINEERING AND TECHNOLOGY

A LABORATORY MANUAL

FOR

ENVIRONMENTAL TECHNOLOGY (22511)





MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001 : 2015) (ISO / IEC 27001 : 2013)

VISION

To ensure that the Diploma level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization.
- Well designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based program.
- Technical skills do need support of life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual

for

Environmental Technology

(22511)

Semester – V

(CH)

Maharashtra State
Board of Technical Education, Mumbai
(Autonomous) (ISO:9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO:9001: 2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on May,2019)

Maharashtra State
Board of Technical Education

Certificate

This is to certify that Mr. / Ms ……. Roll No…….. of Fifth Semester of Diploma in Chemical Engineering of Institute …… …… (Code……..) has completed the term work satisfactorily in course **Environmental Technology (22511)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ……. Enrollment No……

Date:…..... Exam Seat No. …….....

Course Teacher **Head of the Department** **Principal**

Seal of the Institute

Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programmes with outcome-base education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'I' scheme laboratory manual development team designed the practicals to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practicals to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Chemical technologists have to deal with Environmental Pollution and control in chemical process industries. Students have to apply environmental science, environmental monitoring and electronic devices used for monitoring and analysis of environmental pollution generated by various sources. Information about the environmental Pollution and control methods may used to control air and water pollution. Students have to undertake waste water treatment, solid waste management and environmental audit with ISO 14000. These practicals are designed to equip the students with necessary knowledge and skills related to the monitoring and testing of environmental pollution.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Programme Outcomes (POs) to be achieved through Practical of this Course:

Following POs and PSO are expected to be achieved through the practicals of Environmental Pollution and Control

PO1. **Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the **Chemical Engineering** problems

PO2. **Discipline knowledge:** Apply **Chemical Engineering** knowledge to solve industry based Chemical Engineering problems.

PO3. **Experiments and practice:** Plan to perform experiments and practices to use the results to solve technical problems related to **Chemical Engineering**.

PO4. **Engineering tools:** Apply relevant technologies and Chemical Engineering tools with an understanding of the limitations.

PSO2 **Material management and quality control:** manage chemicals and equipment to produce quality chemical products.

****

List of Industry Relevant Skills

The following industry relevant skills of the competency 'qulitative & analytical skills.' are expected to be developed in you by undertaking the practicals of this practical manual.

1. Follow the various safety norms and use of PPE.
2. Handle various chemicals safely
3. Prepare setups for various analyses.
4. Operate various lab equipment.

Practical - Course Outcome matrix

Course Outcomes (COs) :

a. Identify the source of global warming and ozone depletion
b. Use relevant equipment for the control of air pollution in chemical process industry.
c. Test the different properties of waste water.
d. Use land fill and incineration methods for treatment of industrial solid waste.
e. Apply ISO14000 environmental protection norms for chemical industry.

S. No.	Practical Outcome	CO a.	CO b.	CO c.	CO d.	CO e.
1.	Measure particulate pollutants using High Volume Sampler.	-	√	-	-	-
2.	Determine the composition of flue gases using Orsat apparatus	-	√	-	-	-
3.	Determine the composition of air using Kjeldahl apparatus	-	√	-	-	-
4.	Measure the concentration of pollutants from vehicle exhaust.	√	-	-	-	-
5.	Determine the chloride content in waste water.	-	-	√	-	-
6.	Determine the total solids in waste water.	-	-	√	-	-
7.	Determine the dissolved oxygen in waste water.	-	-	√	-	-
8.	Determine biological oxygen demand of waste water.	-	-	√	-	-
9.	Determine the Chemical oxygen demand of waste water.	-	-	√	-	-
10.	Determine the turbidity of waste water using turbidity meter.	-	-	√	-	-
11.	Measure the appropriate dosage of alum for raw water using jar test method.	-	-	√	-	-
12.	Determine the Sulphate content in waste water	-	-	√	-	-
13.	Determine the neutralization point for charcoal treatment of acidic waste water.	-	-	√	-	-
14.	Determine the strength of alkaline material in waste water using acid base titration.	-	-	√	-	-
15.	Determine the density of municipal solid waste.	-	-	-	√	-
16.	Determine the density of hazardous waste.	-	-	-	-	√

Guidelines to Teachers

1. ***Teacher need to ensure that a dated log book*** for the whole semester, apart from the laboratory manual is maintained by every student which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practicals.
3. For difficult practicals if required, teacher could provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teachers can maintain various practical related question bank for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines

Instructions for Students

1. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher*** in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning itself of each practical, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, IS codes, Safety norms, Electricity act/rules, technical manuals, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practicals.

Content Page

List of Practicals and Progressive Assessment Sheet

Note: To be transferred to Proforma of CIAAN-2017.

Practical No.: 1 Measure particulate pollutants using High Volume Sampler.

I. Practical Significance

Particulate matter enters respiratory track during inhalation. The effects of inhaling particulate matter have been widely studied in humans and animals include asthma, lung cancer, cardiovascular issues, respiratory diseases, birth defects, and premature death. High volume sampler is used to determine the strength of these particulate matters in surrounding air.

II. Relevant Program Outcomes (POs)

PO 1. ***Basic knowledge:*** *Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.*
PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering*.

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***'Conserve environment using various pollution control measures'.***

1. Operate high volume sampler to measure concentration of pollutants.
2. Follow SOP while operating equipment.

IV. Relevant Course Outcomes

Use relevant equipment for the control of air pollution in chemical process industry.

V. Practical Outcome

Measure particulate pollutants using High Volume Sampler.

VI. Relevant Affective domain related Outcomes

1) Follow safe practices.
2) Practice good housekeeping.
3) Work as a leader/a team member.

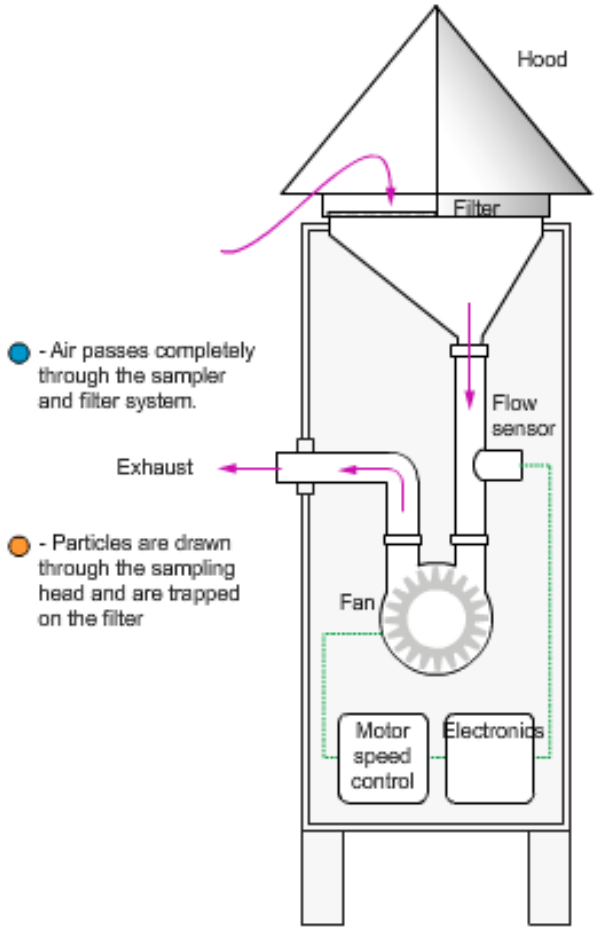
VII. Minimum Theoretical Background

Air pollution occurs when the air contains gases, dust, fumes or odor in harmful amounts. That is, amounts which could be harmful to the health or comfort of humans and animals or which could cause damage to plants and materials. Atmospheric particulate matter – also known as particulates or particulate matter (PM) – are tiny pieces of solid or liquid matter present or dispersed in air. They are suspended in the atmosphere as atmospheric aerosol, a term which refers to the particulate/air mixture, as opposed to the particulate matter alone. However, aerosols refer to the particulate component alone. Sources of particulate matter can be man-made or natural. They can adversely affect human health

and also have impacts on climate and precipitation. Subtypes of atmospheric particle matter include suspended particulate matter (SPM), respirable suspended particle matter (RSPM; particles with diameter of 10 μ or less), fine particles (diameter of 2.5 μ or less), ultrafine particles, and soot respectively.

High Volume Sampler is a device for sampling large volumes of an atmosphere by collecting the particulate matter inside the air by filtration. It consists of a high-capacity blower, a filter to collect suspended particles, and a means for measuring the flow rate. Air is drawn into the sampler and through a glass fiber or quartz filter by means of a blower, so that particulate material collects on the filter surface. Without a 10 μm size-selective inlet, particles of 100 μm size and less enter the sampling inlet and are collected on the downstream filter. The collection efficiencies for particles larger than 20 μm decreases with increasing particle size, and it varies widely with the angle of the wind with respect to the roof ridge of the sampler shelter. When glass fiber filters are used, particles of 100-0.1 μm or less in diameters are ordinarily collected. With a size-select inlet, particles of 10 μm diameter or less are collected on the quartz filter.

VIII. Practical set up:



IX. Resources required

S. No.	Instrument /Components	Specification	Quantity
1.	High Volume Sampler	High volume sampler Motor: 0.6 HP, Power: 6.25amp, 750W, Flow set point: 40SFCM, Mass flow control accuracy: +/-2.5% deviation (24 Hrs), Power source: 110 V 1 Phase, 60 HZ	01

X. Precautions to be followed

1 Check electrical connections while using apparatus.
2 Make airtight connections while placing filter paper.

XI. Procedure

1. Clean the apparatus thoroughly.
2. Weigh the clean and dry filter paper using electronic balance and note its initial weight (W_1).
3. Filter paper should not be folded.
4. Open the dome and place filer paper on gasket.
5. Tightly close dome to avoid any air leakage.
6. Place high volume sampler at suitable location in open space.
7. Start blower of high volume sampler and adjust flow rate between 1 to 1.5 m^3/min.
8. Note down the value of initial flow rate (Q_1).
9. Set the time for 24 hours.
10. After 24 hrs note down final flow rate (Q_2).
11. Stop the blower and open the dome.
12. Remove filter paper carefully and dry it.
13. Weigh the filter paper and note down final weight (W_2).

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and calculations

1. Sample location: ……
2. Initial weight of filter paper (W_1) = …….. gm
3. Final weight of filter paper (W_2) = …….. gm
4. Initial flow rate (Q_1) = …….. m^3/min
5. Final flow rate (Q_2) = …….. m^3/min

Total volume of air taken for sample

$V = [(Q_1 + Q_2)/2] \times T$

Where

V= volume of air sample (m^3)

Q_1 = Initial flow rate m^3/min

Q_2 = Final flow rate m^3/min

T = Sampling time in min

V = ……..

= ……..

Concentration of RSPM in $\mu g/m^3$

$= [(W_2 - W_1) \times 10^6] / V$

= ……..

= ……..

XVI. Results

The concentration of suspended matter in air is found to be …… $\mu g/m^3$

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Write name of manufacturing companies of high volume sampler
2. Write material of construction of filter paper.
3. Write your observation of manometer reading after 24 hrs use of sampler.
4. What is the neutralization point in this experiment?
5. Give the uses of acetic acid.

[Space for Answers]

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XX. References / Suggestions for further Reading

1. https://www.thermofisher.com/order/catalog/product/HVAIR100
2. https://tisch-env.com/high-volume-air-samplers/
3. https://www.qld.gov.au/environment/pollution/monitoring/air/air-monitoring/measuring/samplers

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of the chemicals and apparatus.	20%
2	Recording of readings	20%
3	Calculations and Result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.2: Determine the composition of flue gases using Orsat Apparatus

I. Practical Significance

Flue gas is the gas exiting to the atmosphere via a flue, which is a pipe or channel for conveying exhaust gases from a fireplace, oven, furnace, boiler or steam generator. Its composition depends on what is being burned, but it will usually consist of mostly nitrogen (typically more than two-thirds) derived from the combustion air, carbon dioxide (CO2), and water vapor as well as excess oxygen (also derived from the combustion air). It further contains a small percentage of a number of pollutants, such as particulate matter (like soot), carbon monoxide, nitrogen oxides, and sulfur oxides. Orsat apparatus is used to to determine the percentages of flue gases.

II. Relevant Program Outcomes (POs)

PO 1. ***Basic knowledge:*** *Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.*
PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***Conserve environment using various pollution control measures'.***

1. Operate Orsat apparatus to measure concentration of pollutants.
2. Follow SOP while operating equipment.

IV. Relevant Course Outcomes

Use relevant equipment for the control of air pollution in chemical process industry.

V. Practical Outcome

Determine the composition of flue gases using Orsat apparatus

VI. Relevant Affective domain related Outcomes

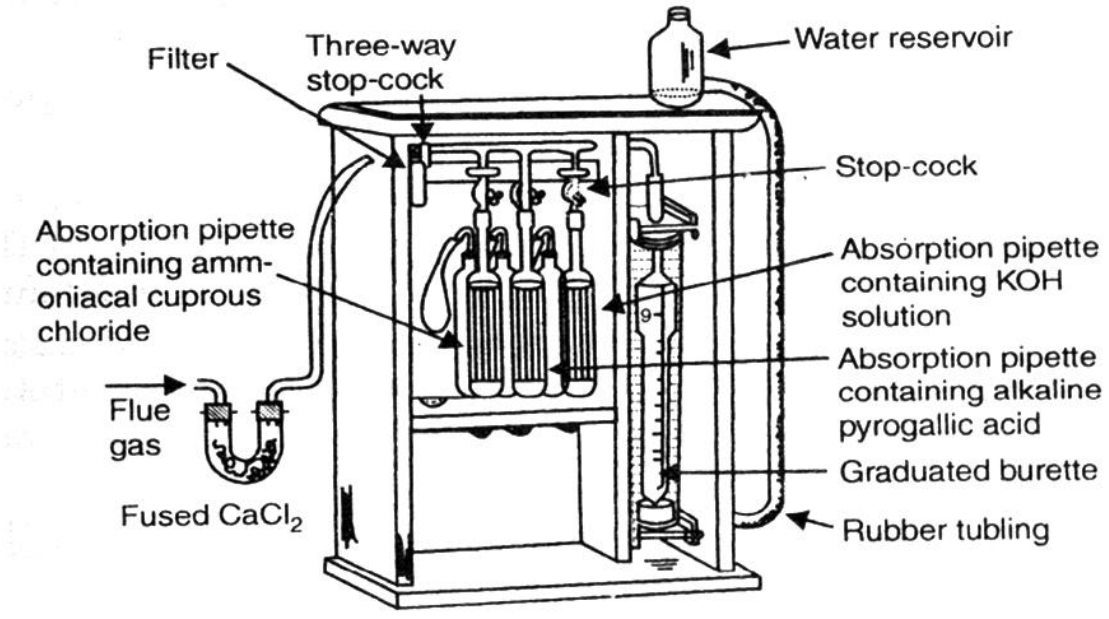
1. Follow safe practices.
2. Practice good housekeeping.

VII. Minimum Theoretical Background

Orsat apparatus consists of a water-jacketed measuring burette, connected in series to a set of three absorption bulbs. Using each stop cock control flow of flue gas inside the absorption bulb. The other end is provided with a three-way stop-cock, the free end of which is further connected to a U-tube packed with glass wool (for avoiding the incoming

of any smoke particles, etc.) The graduated burette (also known as Eudiometer tube) is surrounded by a water-jacket to keep the temperature of the gas constant during the experiment. The lower end of the burette is connected to a water reservoir (also known as aspirator bottle) by means of a long rubber tubing. The absorption bulbs are usually filled with very small diameter glass tubes; so that the surface area of contact between the gas and the solution is increased.The absorption bulbs have solutions for the absorption of CO_2, O_2 and CO respectively. First bulb has 'potassium hydroxide' solution and it absorbs only CO_2. Second bulb has a solution of 'alkaline pyrogallic acid which it can absorb CO_2 and O_2. Third bulb contains ammoniacal cuprous chloride solution which can absorb CO_2, O_2 and CO. Hence, it is necessary that the flue gas is passed first through potassium hydroxide bulb, where CO_2 is absorbed, then through alkaline pyrogallic acid bulb, when only O_2 will be absorbed (because CO_2 has already been removed) and finally through ammoniacal cuprous chloride bulb, where only CO will be absorbed.

VIII. Experimental set up



IX. Resources required

S. No.	Apparatus	Specification	Quantity
1	Orsat Appartus	Three absorption pipette, Two compartment type, 100ml gas burette with outer jacket, manifold with stopcocks and aspirator bottle for the analysis of CO, O_2, CO_2 particularly in fuel and furnace gas. Wooden cabinet with sliding doors.	1
2	Potassium hydroxide (KOH) solution	Dissolve 250 gm of KOH in 500 ml distilled water	
3	Alkaline pyrogallic acid ($C_6H_6O_3$)	Dissolve 25 gm of pyrogallic acid and 200gm KOH in 500 ml of distilled water	
4	Ammoniacal cuprous chloride	Dissolve 100 gm cuprous chloride ($CuCl_2$) and 125 ml liquor ammonia in 375 ml of water	

X Precautions to be followed

1. Use safety precaution while handling flue gas
2. Use hand gloves while handling concentrated chemicals.

XI Procedure

1. The whole apparatus is thoroughly cleaned, stoppers greased and then tested for air-tightness. The absorption bulbs are filled with their respective solutions to level just below their rubber connections. Their stop-cocks are then closed. The jacket and leveling reservoir are filled with water.
2. The three-way stop-cock is opened to the atmosphere and reservoir is raised, till the burette is completely filled with water and air is excluded from the burette. The three-way stop-cock is now connected to the flue gas supply and the reservoir is lowered to draw in the gas, to be analyzed in the burette.
3. The sample gas mixed with some air is present in the apparatus. So the three-way stop-cock is opened to the atmosphere, and the gas expelled out by raising the reservoir. This process of sucking and exhausting of gas is repeated 3-4 times, so as to expel the air from the capillary connecting tubes, etc.
4. Finally, gas is sucked in the burette and the volume of the flue gas is adjusted to 100 ml at atmospheric pressure.
5. For adjusting final volume, the three-way stop-cock is opened to atmosphere and the reservoir is carefully raised, till the level of water in it is the same as in the burette, which stands at 100 ml mark. The three-way stop-cock is then closed.
6. The stopper of the absorption bulb, containing caustic potash solution is opened and all the gas is forced into this bulb by raising the water reservoir. By lowering the

reservoir the gas is again sucked inside the burrette.The gas is again sent to the burette. This process is repeated several times to ensure complete absorption of CO2 [by KOH solution].

7. The unabsorbed gas is finally taken back to the burette, till the level of solution in the CO2 absorption bulb stands at the constant mark and then, its stop-cock is closed. The levels of water in the burette and reservoir are equalized and the volume of residual gas is noted. The decrease in volume-gives the volume of CO2 in 100 ml of the flue gas sample.
8. The volumes of O2 and CO are similarly determined by passing the remaining gas through alkaline pyrogallic acid bulb and ammoniacal cuprous chloride bulb respectively. The gas remaining in burette after absorption of CO2, O2 and CO is taken as nitrogen.

XII Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
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2			
3			
4			
5			

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations:

Initial volume of gas in graduated burette (V_1) = …….. ml

Volume after CO_2 absorption (V_2) = …….. ml

Volume after O_2 absorption (V_3) = …….. ml

Volume after CO absorption (V_4) = …….. ml

Volume of flue gas taken for analysis = V_1 = ……..ml

Volume of CO_2 absorbed = $V_1 - V_2$ = ……..……ml

Volume of O_2 absorbed = $V_2 - V_3$ =…….ml

Volume of CO absorbed = $V_3 - V_4$ =……ml

Volume of nitrogen = $V_1 - V2 - V_3 - V_4$ =……ml

% composition of flue gas =

XVI Results

Sr. No.	Component	%
1	Carbon dioxide	
2	Oxygen	
3	Carbon monoxide	
4	Nitrogen	

XVII Interpretation of results

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XVIII Conclusions

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XIX Practical related Questions

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1) Write the source used for flue gas.
2) Write the concentrations of chemicals used for practical.
3) How flue gas is dried before sending to Orsat apparatus
4) Write the name of inventor of Orsat apparatus.

[Space for Answers]

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XX References / Suggestions for further Reading

- https://www.chemistryworld.com/opinion/orsats-gas-analyser/7207.article
- https://nptel.ac.in/courses/113104058/mme_pdf/Lecture10.pdf

XXI Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of the chemicals and apparatus.	20%
2	Recording of readings	20%
3	Calculations and Result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1……

2……

3……

4……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.03: Determine the total nitrogen content in waste water using Kjeldahl apparatus.

I. Practical Significance

The element Nitrogen is a primary growth ingredient found in numerous chemical compounds such as fertilizers, foods, oils, water/wastewater, and hundreds of man-made compounds (drugs to textiles). Its importance is well documented by the nitrogen cycles of plants and animals. In large concentrations within lakes or streams, nitrogen indirectly increases oxygen demands, often depleting oxygen levels to toxic conditions, killing fish and other aquatic organisms. Nitrogen occurs in many forms including ammonia, organics, nitrate and nitrites. The two the most common tests for nitrogen are in the forms of organic and inorganic nitrogen.

II Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. Operate high vol. sampler
2. Follow SOP while operating equipment.

IV. Relevant Course Outcomes

Test the different properties of waste water

V. Practical Outcome

Determine the total nitrogen content in waste water using Kjeldahl apparatus

VI. Relevant Affective domain related Outcome

1) Follow safe practices
2) Practice energy conservation

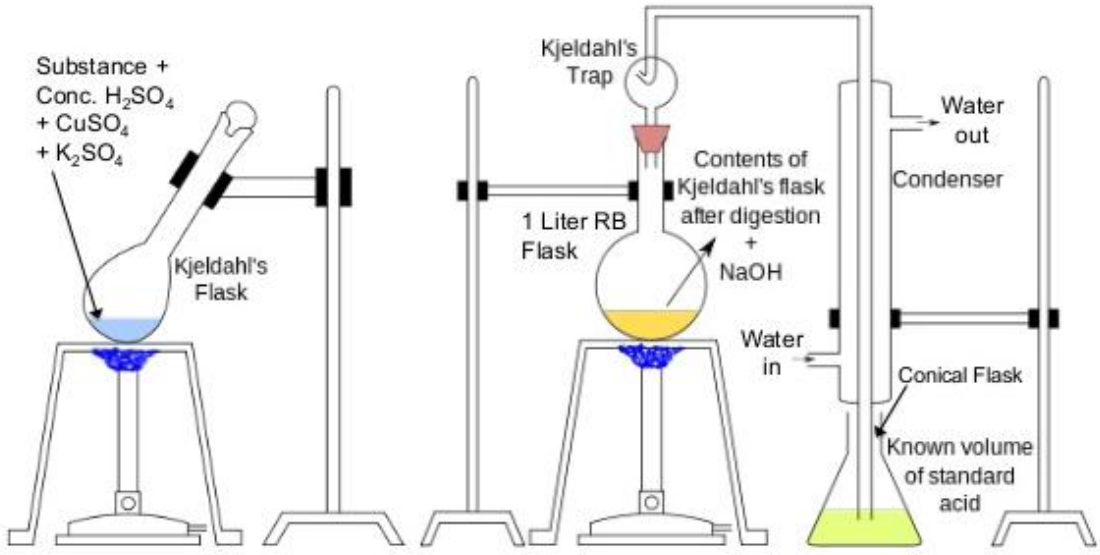
VII. Minimum Theoretical Background

There are several different methods used to test for nitrogen in ammonia. Choosing a specific method should be based upon the expected level of nitrogen concentration and what forms of chemical interferences might be present within the sample. Whichever method is selected, it is important that historical comparison data using the same analytical method be available within the specific laboratory or industrial application

market. For this reason, compendiums of analytical methods from dozens laboratory industry associations still reference chemistry testing methods well over a hundred years old.

Nitrogen is one of the five major elements found in organic materials such as protein. The Kjeldahl method of nitrogen analysis is the worldwide standard for calculating the protein content in a wide variety of materials ranging from human and animal food, fertilizer, waste water and fossil fuels. The Kjeldahl method consists of three steps: A. Digestion B. Distillation C. Titration

VIII. Experimental set up



IX. Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	kjeldal flask	500 ml	1
2	Hot plate		1
3	Burette		
4	Pipette		
5	Measuring cylinder		
6	Distillation apparatus		1
7	Digestion reagent	▪ Dissolve 134 gram K_2SO_4 and 7.3 g $CuSO_4$ in 800 ml dH_2O ▪ Add gently 134 ml conc. H_2SO_4 ▪ Dilute to 1000 ml by H_2O	

S. No.	Instrumentation/components	Specification	Quantity
8	Sodium hydroxide-sodium thiosulfate reagent	▪ Dissolve 500 g NaOH ▪ 25g $Na_2S_2O_3.5H_2O$ ▪ Dilute to 1000 ml (1L) by dH_2O ▪ Dilute the volume up to 1 litter	
9	Mixed indicator solution	Dissolve 200mg Methyl Red indicator in 100ml 95% ethyl or (isopropyl)Alcohol, dissolve 100mg methylene blue in 50ml 95% ethyl or (isopropyl) alcohol, combine solution	
10	Indicating boric acid solution	20g H_3BO_3 in Ammonia free distilled, Add 10 ml mixed indicator, dilute to 1L dH_2O	
11	Standard sulfuric acid 0.02 N		

X Precautions

1. Care should be taken when acid fumes are evaporated during boiling
2. Handle all chemicals and Acid with proper safety
3. Use hand gloves and goggle while handling sulfuric acid.

XI Procedure

1) In a kjeldal flask (500 ml), place 50 ml water sample (or 25 ml) of sewage water Sample.
2) Place glass beads in flask. (to prevent our bulbs formation).
3) Add 50 ml digestion solution.
4) Heat under hood to remove acid fumes.
5) Heat to continue the digestion until the colored or turbid samples become transparent and pale green.
6) Cool, dilute to 300 with H_2O
7) mix well.
8) Tilt the flask and carefully add :
   50 ml $NaOH/Na_2S_2O_3$ to form alkaline layer at flask bottom Connect the flask to steamed out distillation apparatus and shake flask, mix well, block precipitate, HgS will form, pH >11.
9) Collect 200 ml distillate below surface of 50 ml absorbent solution (indicating boric acid solution)
   - Color will be lavender (violet)
   - As distillation proceeds, color change to pale green.
10) Titrate with 0.02N H_2SO_4; the end point is obtained when, Color green → violet (lavender)

XII Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity

XIII Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations:

$$NH_3\text{-N (mg /L)} = \frac{(A-B)*280}{ml\ sample}$$

A = volume H_2SO_4 titrated for sample, ml.
B = volume H_2SO_4 titrated for blank, ml.

XVI Results

Total nitrogen in waste water =_____ mg/l.

XVII Interpretation of results

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XVIII Conclusion

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XIX Practical related Questions

Note-Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1. Write significance of Kjeldahl method.
2. Write three steps used in above experiment.
3. Write precaution taken while handling sulfuric acid.
4. Write the names of various parts of distillation setup.

[Space for Answers]

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XX. References / Suggestions for further Reading

- http://users.metu.edu.tr/chem223/kjeldahl.pdf
- https://www.epa.gov/sites/production/files/201510/documents/method_1687_draft_2001.pdf
- https://www.velp.com/en/service_support/kjeldahl_nitrogen
- https://www.youtube.com/watch?v=wJc9eC6ly48

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculations and Result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1 ……

2 ……

3 ……

4 ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.04: Measure the concentration of pollutants from vehicle Exhaust.

I. Practical Significance

Passenger vehicles are a major pollution contributor, producing significant amounts of nitrogen oxides, carbon monoxide, and other pollutants. Transportation contributed more than half of the carbon monoxide and nitrogen oxides, and almost a quarter of the hydrocarbons emitted into our air. Measurement of concentration of pollutants from vehicle exhaust can give idea of vehicle condition, which can be improved to make pollution under control.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***Conserve environment using various pollution control measures'.***

1. Operate automobile Emission Gas Analyzer
2. Follow SOP while operating equipment.

IV. Relevant Course Outcomes

Use relevant equipment for the control of air pollution in chemical process industry

V. Practical Outcome

Measure the concentration of pollutants from vehicle exhaust

VI. Relevant Affective domain unrelated Outcome(s)

1 Follow safe practices
2 Work as a leader/ team member

VII. Minimum Theoretical Background

Exhaust gas or flue gas is emitted as a result of the combustion of fuels such as petrol, diesel. According to the type of engine, it is discharged into the atmosphere through an exhaust pipe. The fuel used to run engine is not considered environmental friendly due to the products it is made from, the processes used to create the fuel and the emissions created from using this fuel. The largest part of most combustion gas is nitrogen (N_2),

water vapor (H_2O) (except with pure-carbon fuels), and carbon dioxide (CO_2) (except for fuels without carbon); these are not toxic or noxious (although carbon dioxide is a greenhouse gas that contributes to global warming). A relatively small part of combustion gas is undesirable, noxious, or toxic substances, such as carbon monoxide (CO) from incomplete combustion, hydrocarbons (properly indicated as C_xH_y, but typically shown simply as "HC" on emissions-test slips) from unburnt fuel, nitrogen oxides (NO_x) from excessive combustion temperatures, and particulate matter (mostly soot). Concentration of exhaust gas can be measured using various gas analyzers. Due to rapid development in instrumentation technology results are directly obtained in percentage or in ppm.

VIII. Experimental set up

IX. Resources required

S. No.	Instrumentation/components	Specification	Quantity
1.	Automobile gas analyzer	Measurement CO, CO_2, O_2, NO, HC, LCD display, + or – 4% accuracy	01

X. Precautions

1 Proper warm up time should be provided to gas analyzer
2 Do not expose to vehicular emission directly.
3 Use hand gloves while inserting analyzer probe

XI. Procedure

1. Gas sampling probe can be inserted into the exhaust pipe to a depth of at least 300 mm.
2. If this prove impossible owing to the exhaust pipe configuration, a suitable extension to the exhaust pipe(s), making sure that the connection is leak proof, shall be provided.
3. The vehicle shall have attained normal thermal conditions Means the thermal conditions attained by an engine and its drive line after a run of at least 15 min. on a variable course, under normal traffic conditions.
4. For PUC testing of diesel cars, the accelerator of the car is completely pressed to get an accurate reading on the level of emission.
5. Procedure is repeated five times, and each time the reading is noted down, then the average of these readings are taken as the final reading.
6. For PUC testing of petrol vehicles, the car is switched on and the engine is kept running without applying the accelerator.
7. This process is done only once and an accurate reading is noted as the final reading.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			
4			
5			

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations:

S. No.	Pollutant	Value	
1	CO		%
2	CO_2		%
3	O_2		%
4	HC		ppm

XVI. Results

Concentration of pollutants from vehicle exhaust are …….

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

***Note**-Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO*

1. Write name of manufacturing company of gas analyzer.
2. Write the effect of CO on human health.
3. Write the content of PUC certificate issued by Maharashtra Motor Vehicle Department
4. Write name of present BS code?

[Space for Answers]

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XX References / Suggestions for further Reading

- https://www.araiindia.com/CMVR_TAP_Documents/Part-05/Part-05_Chapter03.pdf
- https://www.nova-gas.com/analyzers/engine-exhaust.
- http://www.isca.in/IJENS/Archive/v2/i1/7.ISCA-IRJEvS-2012-099.pdf
- https://www.netel-India.com/downloads/productcatalogs/ pucinstruments/ multigasanalyzer/MGA1.pdf

XXI Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculations and Result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 05: Determine the chloride content in waste water.

I. Practical Significance

Chloride is categorized as a pollutant for many reasons. Chloride is necessary for water habitats to thrive, yet high levels of chloride can have negative effects on an ecosystem. Chloride may impact freshwater organisms and plants by altering reproduction rates, increasing species mortality, and changing the characteristics of the entire local ecosystem. Chloride determination in natural waters is useful in the selection of water supplies for human use. Chloride determination is used to select the type of desalting apparatus to be used.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***Conserve environment using various pollution control measures'.***

1. To prepare solution of required concentration.
2. To perform titration.
3. To observe the end point of titration and record correct readings.

IV. Relevant Course Outcomes -

Test the different properties of water

V. Practical Outcome

Determine the chloride content of waste water

VI. Relevant Affective domain unrelated Outcome(s)

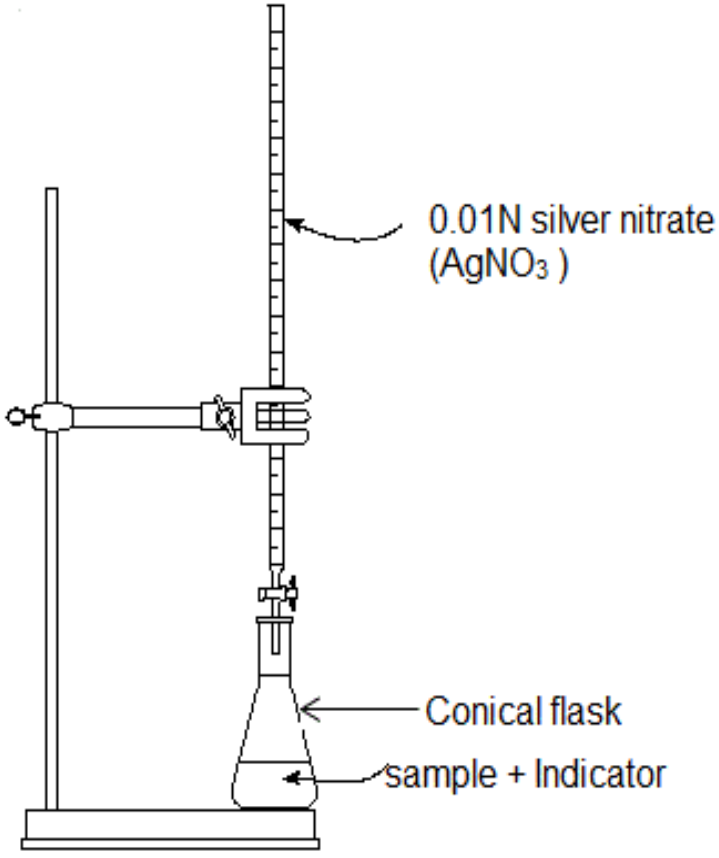
1. Follow safe practices
2. Practice good housekeeping
3. Work as a leader/a team member

VII. Minimum Theoretical Background

Chloride in the form of chloride (Cl-) ion is one of the major inorganic anions in water and wastewater. The chloride concentration is higher in wastewater than in raw water because sodium chloride is a common article of diet and passes unchanged through the digestive system (Average estimate of excretion: 6 g of chlorides/person/day; additional chloride burden due to human consumption on wastewater: 15 mg/L). Along the sea coast chloride may be present in high concentration because of leakage of salt water into the

sewage system. It also may be increased by industrial process. In potable water, the salty taste produced by chloride concentration is variable and depends on the chemical composition of water. Some waters containing 250 mg/L Cl- may have a detectable salty taste if sodium cation is present. On the other hand, the typical salty taste may be absent in waters containing as much as 1000 mg/L when the predominant cations are calcium and magnesium. In addition, a high chloride contents may harm metallic pipes and structures as well as growing plants. The measured chloride ions can be used to know salinity of different water sources. For brackish water (or sea water or industrial brine solution), it is an important parameter and indicates the extent of desalting of apparatus required. It also interferes with COD determination\ and thus it requires a correction to be made on the basis of amount present or else a complexing agent, such as HgSO4 can be added. Further, chloride ions are used as tracer ions in column studies to model fate of different contaminants in soil and liquid media

VIII. Experimental set up used in laboratory



IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	Beaker	100ml	02
2	Conical flask	100ml	02
3	Burette	50ml	01
4	Pipette	10ml	01
5	Silver nitrate ($AgNO_3$) solution	0.1 N	100ml
6	Potassium chromate solution	5%	100ml
7	Distilled water		100ml

X. Precautions

1. The pH must be in the range of 7 to 8 as silver ions are precipitated as AgOH at high pH levels and the chromate ions are converted to $Cr_2O_7^{2-}$ at low pH values.
2. A definite amount of indicator must be used to provide a certain concentration of chromate ions, otherwise silver chromate may form too soon or not soon enough.
3. Caution should be made to notice indicator color change as it can varies person-to person. The usual range is 0.2 to 0.4 mL of titrant.
4. While handling $AgNO_3$, care should be taken so that it is not spilled on your skin.

XI. Procedure

1. Take 100ml of the sample in conical flask.
2. Adjust its pH between 7.0 to 8.0 either with sulphuric acid or sodium hydroxide solution. Otherwise, $Ag(OH)_2$ is formed at high pH level or CrO_4^{-2} is converted to CrO_7^{-2}at low pH levels.
3. Wash the burette, pipette and flask with water.
4. Rinse the burette with0.01N silver nitrate ($AgNO_3$) solution and fill the burette with it.
5. Remove air bubble; if present in the pipette and adjust zero level.
6. Rinse the pipette with given water sample and then pipette out 10 ml of given water sample in titration flask.
7. Add 2 drops of potassium chromate (K_2CrO_4) indicator in titration flask. Flask solution turns to yellow.
8. Then add $AgNO_3$ from burette, slowly and drop wise, with constant shaking, till color change from yellow to brick red .
9. Note the volume of silver nitrate added as (A) ml, repeat titration to get two constant readings.
10. If more quantity of potassium chromate is added, Ag_2CrO_4 may form too soon or not soon enough.
11. For better accuracy, titrate distilled water in the same manner.
12. Note the volume of silver nitrate added for distilled water (B).

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
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2			
3			
4			
5			

XIII. Actual procedure followed

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XIV Precautions followed

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XV. Observations and Calculations

1. Solution in burette : 0.01N $AgNO_3$.
2. Solution in pipette : Water sample (10ml).
3. Indicator : K_2CrO_4.
4. End point : yellow to brick red precipitate.

For water sample titration

Burette level	Burette Reading in ml			Constant Burette reading in ml
	I	II	III	
Initial				A = ……ml
Final				
Difference				

For distilled water titration

Burette level	Burette Reading in ml			Constant Burette reading in ml
	I	II	III	
Initial				B = ……ml
Final				
Difference				

$$\text{Chloride in (mg/l)} = \frac{(A-B)\text{x Normality of AgNO3 X 35.5X 1000}}{\text{volume of the sample taken}}$$

= ……mg/l or ppm

XVI. Results

Chloride content of given water sample = _____ mg/l

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 Give reason for storing silver nitrate in brown bottle.
2 Write the colour of potassium chromate
3 Write effect of chlorine content in water on metal pipe.
4 Write the precaution taken while pipette out solution.

(Space for Answers)

XX. References / Suggestions for further Reading

1. http://web.iitd.ac.in/~arunku/files/CEL212_Y13/CEL%20212%20Lab%204b%20Chloride.pdf
2. https://environment.umn.edu/wp-content/uploads/2016/03/MS-0008-12-Final-Addendum.pdf
3. http://qu.edu.iq/el/pluginfile.php/102914/mod_resource/content/1/exp4chlor_pdf.pdf
4. https://www.youtube.com/watch?v=Set3XdRshGo

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculations and Result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.06: Determine the total solids in waste water

I. Practical Significance

Total Solids includes both total suspended solids, the portion of total solids retained by a filter and total dissolved solids, the portion that passes through a filter. Practically, they are defined as particles large enough to not pass through the filter used to separate them from the water. Smaller particles, along with ionic species, are referred to as dissolved solids. In considering waters for human consumption or other uses, it is important to know the concentrations of both suspended and dissolved solids. The most common pollutant in the world is "dirt" in the form of TSS.

II. Relevant Program Outcomes (POs)

*PO 1.**Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.*

*PO 3.**Experiments and practice:** Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*

*PO 4. **Engineering tools:** Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

II. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To collect effluent sample for test
2. To use balance correctly
3. To observe and record the readings

.

IV. Relevant Course Outcomes

Test different properties of water

V. Practical Outcome

Determine total solids in waste water

VI. Relevant Affective domain related Outcome

1. Follow safe practices
2. Practice good housekeeping
3. Demonstrate working as leader/ a team member

VII. Minimum Theoretical Background

Solids present in an effluent can be mainly classified as total solids, suspended solids and dissolved solids.

- Total Solids (TS) :

Residue left after the evaporation and subsequent drying in oven at specific temperature 103-105°C of a known volume of sample are total solids.

- Suspended Solids (SS):
  These are the solids in the effluent that retained on the filter paper after filtering the sample through a fine filter. (Whatman's filter paper no.42). Their minimum diameter is about 1µm and it contains much of the organic matter.
- Dissolved Solids (DS):
  The filtrate remaining in beaker after filtering the sample through filter contains dissolved solids. It includes mainly inorganic salts, small amount of organic salts.
  The concentration of total dissolved solids affects the water balance in the cells of aquatic organisms. An organism placed in water with a very low level of solids, such as distilled water, will swell up because water will tend to move into its cells, which have a higher concentration of solids. An organism placed in water with a high concentration of solids will shrink somewhat because the water in its cells will tend to move out. A high concentration of total solids will make drinking water unpalatable and might have an adverse effect on people who are not used to drinking such water. Levels of total solids that are too high or too low can also reduce the efficiency of wastewater treatment plants, as well as the operation of industrial processes that use raw water. Total solids also affect water clarity. Higher solids decrease the passage of light through water, thereby slowing photosynthesis by aquatic plants. Water will heat up more rapidly and hold more heat; this, in turn, might adversely affect aquatic life that has adapted to a lower temperature regime. Sources of total solids include industrial discharges, sewage, fertilizers, road runoff, and soil erosion. Total solids are measured in milligrams per liter (mg/L).

VIII. Experimental set up

IX. Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	Desiccator	250mm	01
2	Weighing balance	Max 500 gm	01
3	Porcelain dish	150ml	01
4	Oven	Max temp 200^{o}C	01
5	Measuring cylinder	100 ml	01

X. Precautions

1. Check electrical connections of oven.
2. Use hand gloves while handling hot porcelain dish.

XI. Procedure

1. Weigh the given porcelain dish (clean and dry) and record its weight as (W_1) gm.
2. Take 100 ml of well mixed effluent sample (graduated cylinder is rinsed to ensure transfer of all suspended matter) in porcelain dish.
3. Place the dish in an oven.
4. Evaporate to dryness in an oven at 103ºC to 105ºC for about 1 to 2Hrs.
5. Sample with high concentration may require additional drying at 180ºC.
6. Cool the dish in a desiccators and record weight as (W_2) gm.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			
4			
5			

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations

Sr. No.	Effluent sample details	Volume of sample(ml)	Weight of dish(gm)		Weight of Total Solids (W_2-W_1)
			Initial (W_1)	Final(W_2)	
1					
2					
3					

Concentration of Total Solids,(mg/l) $= \frac{(W2-W1)x1000x1000}{volume of sample\ in\ ml}$

=---------- mg/l

XVI. Results

Total solid content in given sample of water is _____ mg/lit

XVII. Interpretation of result

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XVIII Conclusions

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XIX. Practical related Questions

Note-Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1. Write the name of manufacturing company of oven
2. Write reason to use porcelain dish for practical
3. Write value of temperature maintained during practical.
4. Write relation between TDS, TSS and TS.

[Space for Answers]

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XX. References / Suggestions for further Reading

1. https://archive.epa.gov/water/archive/web/html/vms58.html
2. https://www.water-research.net/index.php/water-treatment/tools/total-dissolved-solids
3. http://indiawrm.org/HP-1/download/10%20How%20to%20measure%20solids.pdf

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of the chemicals and apparatus.	20%
2	Recording of readings	20%
3	Calculation and result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1……

2……

3……

4……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.07: Determine the dissolved oxygen in waste water

I. Practical Significance

Dissolved oxygen analysis measures the amount of gaseous oxygen (O_2) dissolved in an water. Oxygen gets into water by diffusion from the surrounding air, by aeration, and as a waste product of photosynthesis**.** Organic waste requires oxygen during its degradation in water. DO value is very important parameter during determination of biological oxygen demand.

II. Relevant Program Outcomes (POs)

*PO 1.**Basic knowledge:** Apply knowledge of basic mathematics, sciences and basic engineering to solve the Chemical engineering problems.*
*PO 3.**Experiments and practice:** Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
*PO4 **Engineering tools:** Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To collect effluent sample for test
2. To use balance correctly
3. To observe and record the readings

.

IV. Relevant Course Outcomes

Test different properties of water

V. Practical Outcome

Determine the dissolved oxygen in waste water

VI. Relevant Affective domain related Outcome

1. Follow safe practices
2. Practice good housekeeping
3. Demonstrate working as leader/ a team member

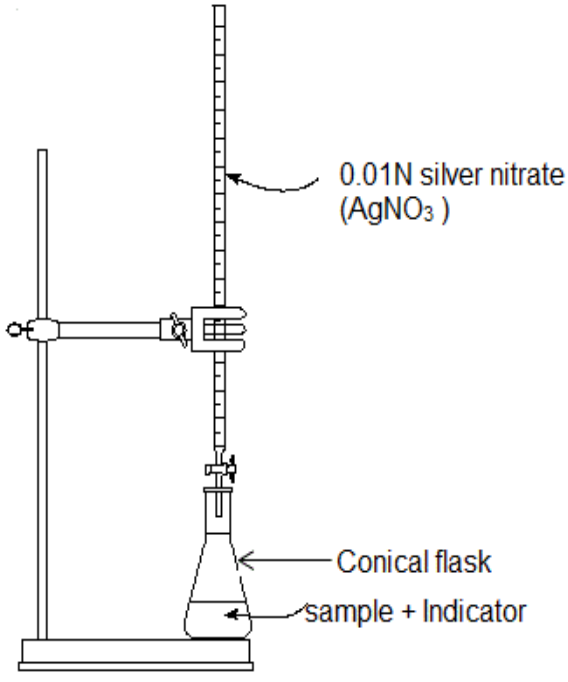
VII. Minimum Theoretical Background

Running water, because of its churning, dissolves more oxygen than still water, such as that in a reservoir behind a dam. Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen. Wastewater from sewage treatment plants often contains organic materials that are decomposed by microorganisms, which use oxygen in the process. (The amount of oxygen consumed by these organisms in breaking

down the waste is known as the biochemical oxygen demand or BOD. A discussion of BOD and how to monitor it is included at the end of this section.) Other sources of oxygen-consuming waste include storm water runoff from farmland or urban streets, feedlots, and failing septic systems. Oxygen is measured in its dissolved form as dissolved oxygen (DO). If more oxygen is consumed than is produced, dissolved oxygen levels decline and some sensitive animals may move away, weaken, or die.

For domestic water supply, D.O. value should remain in the range 6 to 8 mg/l. The minimum D.O. required for survival of fish and other forms of aquatic animals is 4 mg/l. High value of D.O. causes corrosion of water supply pipes. Addition of organic pollution leads to reduction in D.O. content because of consumption of oxygen by bacteria in decomposition and oxidation of the organic matter. In order to decompose all biological matter sufficient D.O. should be available in water then the end products are stable and do not produces foul smell.

VIII. Experimental set up



IX. Resources required

S. No.	Instrumentation/ components	Specification	Quantity
1	BOD bottle	250 ml	02
2	Measuring cylinder	50ml	01
3	Burette	25ml	01
4	Pipette	25 ml	01
5	Manganese Sulphate solution	Dissolve 480g $MnSO_4.4H_2O$, or 400g $MnSO_4.2H_2O$ or 364g $MnSO_4.H_2O$ in distilled water, filter and dilute in 1L.	1 l
6	Alkali – Azide - Iodide reagent	Dissolve 500 gm of sodium hydroxide (NaOH) and 150 gm of potassium iodide (KI) in distilled water and dilute to one liter. Dissolve 10 gm of sodium azide (NaN_3) in 40 ml of water separately and pour it into above solution.	50 ml
7	Concentrated sulfuric acid (H_2SO_4) (36 N)		10 ml
8	Standard Sodium Thiosulphate (0.025N)	Dissolve 6.025 g $Na_2S_2O_3.5H_2O$ in distilled water, boil and make the volume to 1L. Add 1.5 ml 6N NaOH.	1 l
9	Starch Indicator	Dissolve 2 gm of LR grade soluble starch in distilled water and pour this emulsion into 100 ml boiling water. Allow to boil for few minutes , add 0.2 gm of salicyclic acid or toluene as preservative.	10 ml
10	Dilution water saturated with air	Sufficient quantity of distilled water is aerated with aerator for more than 8-10 hours, and the aerated water is kept at low temperature till use. At the time of experiment this water is used for preparation of different dilution of the sample.	5 l
11	Phosphate buffer	Dissolve 8.5 g mono potassium phosphate (KH_2PO_4)' 21.75 g dipotassium phosphate (K_2HPO_4) . 33.4 g disodium hydrogen phosphate (Na_2HPO_4'$7H_2O$) and 1.7 g ammonium chloride (NH_4Cl) in 500 ml distilled water. Dilute to 1L. pH of the solution is 7.5.	50 ml
12	Calcium chloride solution (CaCl2)	Dissolve 27.5 g anhydrous $CaCl_2$ in distilled water and make the volume to 1 liter.	1 l
13	Ferric chloride solutions (FeCl3'8H2O)	Dissolve 0.25 g of $FeCl_3$'H_2O in distilled water and make the volume to 1 liter.	1 l

X. Precautions

1 Use hand gloves and goggle while handling sulfuric acid
2. Do not pipette out acid using mouth. Use rubber sucker.

XI. Procedure

1. Make dilution water by adding 2mL/L of following reagents in distilled water:
   a. Phosphate buffer solution
   b. Magnesium sulfate solution
   c. Calcium chloride solution
   d. Ferric chloride solution
   e. Sodium Sulfite solution
2. Take 300 mL sample in BOD bottle.
3. For a given sample bottle, add 1 mL of alkali azide and then 1 mL manganous sulfate solution. Shake well the bottle and keep it open for 5 minutes to settle the precipitate. Add 2 mL concentrated H2SO4 and place the cap on the bottle. Shake well the bottle till all the precipitate is dissolved.
4. Take 203 mL of sample in conical flask and titrate with standard sodium thiosulfate solution (0.025N) till the colour changes from dark yellow to light yellow. Then add few drops of starch indicator and continue to titrate till the color of the solution becomes either colorless or changes to its original sample colour. Note down volume of 0.025N sodium thiosulfate consumed

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1.			
2.			
3.			
4.			
5.			

XIII. Actual procedure followed

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XIV. Precautions followed

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XV. Observations and Calculations

Sr. No.	Source of the sample	Bottle No.	Burette reading		Sodium thiosulphate (ml)	DO (mg/l)
			Initial (1) ml	Final (2) ml	(1-2)	
01						
02						
03						

1 ml 0.025 N sodium thiosulphate is equivalent to 0.2 mg of O_2, since the volume of sample is 200 ml. Hence 1 ml of sodium thiosulphate is equal to 1 mg/l of DO.

XVII. Results

Dissolved oxygen of given sample water is _____ mg/l

XVII. Interpretation of result

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XVIII. Conclusions

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XIX. Practical related Questions

Note: *Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO*

1) Define Dissolved oxygen.
2) Write PPE used in laboratory while handling acids.
3) Write the use of DO values in waste water treatment.
4) Write reason to titrate 200 ml sample.
5) Write the BOD limits for various industrial waste water

[Space for Answers]

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XX. References / Suggestions for further Reading

1. http://web.iitd.ac.in/~arunku/files/CEL212_2012/Lab%206%20Dissolved%20Oxygen.pdf
2. https://archive.epa.gov/water/archive/web/html/vms52.html
3. https://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Preparation of experimental set up	20%
2	Safety measures	20%
3	Calculation and result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	10%
5	Answers to practical related questions	10%
Total (25 Marks)		**100 %**

Names of Student Team Members

1……

2……

3……

4……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related (10)**	**Total (25)**	

Practical No. 08: Determine biological oxygen demand of waste water

I. Practical Significance

BOD is the only test that gives a measure of amount of biologically oxidizable organic matter present in wastewater that can be used to determine the rate at which oxidation will occur or BOD will be exerted in receiving bodies of water. It is the principal test applied to domestic and industrial waste to determine strength in terms of oxygen required for stabilization. BOD is the major criterion used in stream pollution control where organic loading must be restricted to maintain the desired DO levels.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency ***Conserve environment using various pollution control measures'.***

1. To prepare solution of required concentration.
2. To perform titration.
3. To observe the end point of titration and record correct readings.

IV. Relevant Course Outcomes

Test the different properties of water

V. Practical Outcome

Determine biological oxygen demand of waste water

VI. Relevant Affective domain unrelated Outcome(s)

1. Follow safe practices
2. Practice good housekeeping
3. Work as a leader/a team member

VII. Minimum Theoretical Background

Polluted water will continue to absorb oxygen for many months to decompose the organic matter present in it. It is not practically feasible to determine the ultimate oxygen demand. Hence the BOD of water during 5 days at $20^{o}C$ is generally taken as the standard demand which is known as BOD_5 and is about 68 to 80% of the total demand. A 10 day BOD is about 90% of the total oxygen demand.

- It is used to check the quality of effluent discharge into streams and sewers.

- Information concerning BOD of waste is an important consideration in the design of treatment facilities.
- It helps in the choice of treatment method and also used to determine the size of wastewater treatment units particularly Trickling filters and Activated sludge units.
- When once the treatment plants are placed in operation, BOD test is used to evaluate the efficiency of various units.
- BOD incubators are the type of incubators which are used to maintain a temperature of 20°C essential to perform a test known as Biochemical Oxygen Demand. This test is then used in various fields like waste water treatment, medicine, research laboratories, and agriculture. These BOD incubators are used in a lot of precision studies like Plant and Insects Studies, Bacterial Culturing, Germination studies etc

VIII. Experimental set up used in laboratory

IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	BOD incubator	Chamber Volume: 285lit, Cu. Ft-10, Internal size: CMS-57X57 X 88, External size: CMS 70X85X166, Shelves-2: Range :+5^{o}C to 60^{o}C	1
2	BOD bottle	250 ml	02
3	Measuring cylinder	50ml	01
4	Burette	25ml	01
5	Pipette	25 ml	01
6	Manganese Sulphate solution	Dissolve 480g $MnSO_4.4H_2O$, or 400g $MnSO_4.2H_2O$ or 364g $MnSO_4.H_2O$ in distilled water, filter and dilute in 1L.	1 l
7	Alkali – Azide - Iodide reagent	Dissolve 500 gm of sodium hydroxide (NaOH) and 150 gm of potassium iodide (KI) in distilled water and dilute to one liter. Dissolve 10 gm of sodium azide (NaN_3) in 40 ml of water separately and pour it into above solution.	50 ml
8	Concentrated sulfuric acid (H_2SO_4) (36 N)		10 ml
9	Standard Sodium Thiosulphate (0.025N)	Dissolve 6.025 g $Na_2S_2O_3$.5HO in distilled water, boil and make the volume to 1L. Add 1.5 ml 6N NaOH.	1 l
10	Starch Indicator	Dissolve 2 gm of LR grade soluble starch in distilled water and pour this emulsion into 100 ml boiling water. Allow to boil for few minutes , add 0.2 gm of salicyclic acid or toluene as preservative.	10 ml
11	Dilution water saturated with air	Sufficient quantity of distilled water is aerated with aerator for more than 8-10 hours, and the aerated water is kept at low temperature till use. At the time of experiment this water is used for preparation of different dilution of the sample.	5 l
12	Phosphate buffer	Dissolve 8.5 g mono potassium phosphate (KH_2PO_4)' 21.75 g dipotassium phosphate	50 ml

S. No.	Instrumentation/components	Specification	Quantity
		(K_2HPO_4) 33.4 g disodium hydrogen phosphate (Na_2HPO_4'7H2O) and 1.7 g ammonium chloride (NH_4Cl) in 500 ml distilled water. Dilute to 1L. pH of the solution is 7.5.	
13	Calcium chloride solution ($CaCl_2$)	Dissolve 27.5 g anhydrous CaCl2 in distilled water and make the volume to 1 liter.	1 l
14	Ferric chloride solutions ($FeCl_3$'$8H_2O$)	Dissolve 0.25 g of $FeCl_3$'H_2O in distilled water and make the volume to 1 liter.	1 l

X. Precautions

1 Use hand gloves and goggle while handling sulfuric acid
2. Do not pipette out acid using mouth. Use rubber sucker.

XI. Procedure

A. Preparation of dilution water.
1. Prepare dilution water saturated with air as discussed earlier.
2. Add 1 ml each of phosphate buffer, magnesium sulphate and calcium chloride and ferric chloride solution for each liter of dilution water and mix it well.
3. In case of the waste which is not expected to have sufficient bacterial population add seed.

B. Dilution of sample.
1. Neutralize the sample to pH around 7.0, if it is highly alkaline or acidic. For acidifying do not use organic acid, use only mineral acid.
2. Sample having high DO content i.e. DO 9 mg/l due to either algal growth or some other reason, reduce the DO content by aerating and agitating samples.
3. Make the several dilution of sample to obtain required depletion. Following dilutions are suggested.
   - 0.1 to 1% for strong treated waste
   - 1.0 to 5.0% for raw settled waste
   - 5.0 to 25.0% for oxidized effluent and
   - 25.0 to 100% for polluted river waters
4. Prepare the desired mixture by adding sample in dilution water.
5. Fill up one 300 ml bottle with the mixture and other one with dilution water (blank) in two sets.
6. Keep one set in BOD incubator for 5 days for incubation at 20^0C.
7. Determine the DO of blank and sample immediately before incubation (i.e. first day)
8. Determine the DO of blank and sample after incubation for 5 days (i.e. fifth day)

C. Determination of DO for blank and sample on first day.
1. Take BOD bottle containing blank.

2. Add 2 ml of manganese sulphate solution by means of pipette, dipping the end of the pipette just below the surface of water in BOD bottle containing blank.
3. Add 2 ml Azide alkali potassium iodide in a similar manner.
4. Insert the stopper with care to extrude bubble and mix by repeatedly inverting and shaking the bottle vigorously.
5. Red precipitate will form if DO is present in water. Allow the precipitate to settle half way, and mix again.
6. Again allow the precipitate to settle half way
7. Add 2 ml of concentrated H_2SO_4in the same manner as done in step 2 and 3 and insert the stopper and mix up thoroughly as before.
8. Allow the solution to stand for at last 5 minutes to ensure formation of I_2, which is to be titrated against sodium thiosulphate.
9. Take 203 ml of solution in the conical flask.
10. Fill the burette with 0.025 N sodium thiosulphate solution and note the initial burette reading.
11. Titrate the sample immediately with 0.025 N sodium thiosulphate solution, until the yellow colour becomes very light.
12. Add 1 ml of starch solution. This will give blue colour. Now continue the titration by adding sodium thiosulphate drop by drop, till the blue color just disappears. Record the final burette reading (B1).
13. Take BOD bottle containing sample.
14. Repeat the procedure from step 2 to step 12 and note down the initial and final burette reading (D1).

D. Determination of DO for blank and sample on 5^{th} day after incubation.

1. Take BOD bottle containing blank.
2. Repeat the procedure from step 2 to step 12 as done earlier. Note down the initial and final burette reading (B2)
3. Take BOD bottle containing sample.
4. Repeat the procedure from step 2 to step 12 as done earlier. Note down the initial and final burette reading (D2)

Note : For 200 ml of sample the difference in initial and final burette reading in ml directly gives the amount of Oxygen (DO).

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
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XIII. Actual procedure followed

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XIV Precautions followed

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XV. Observations and Calculations

Observation table for Biochemical Oxygen Demand.

Sr. No.	Source of the sample	Bottle No.	Burette reading		Sodium thiosulphate (ml)	DO (mg/l)
			Initial (1) ml	Final (2) ml	(1-2)	
01		…..……..(blank) (First day)			(B_1)	
02		…….(sample) (First day)			(D_1)	
03		…..……..(blank) (Fifth day)			(B_2)	
04		…….(sample) (Fifth day)			(D_2)	

1 ml 0.025 N sodium thiosulphate is equivalent to 0.2 mg of O_2, since the volume of sample is 200 ml. Hence 1 ml of sodium thiosulphate is equal to 1 mg/l of DO.

BOD mg/l = $[(D_1-D_2) – (B_1-B_2)]$ x Volume of diluted sample / Volume of sample taken

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XVI. Results

BOD of given water sample = _____ mg/l.

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 Write temperature range available in BOD incubator
2 Write BOD limit of effluent for petrochemical industry as per CPCB norms.
3 Write significance of BOD test.
4 Mention the time required to attain temperature in incubator.
5 Write the dimensions of BOD incubator.

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XX. References / Suggestions for further Reading

1 https://water.usgs.gov/owq/FieldManual/Chapter7/NFMChap7_2_BOD.pdf
2 https://nptel.ac.in/courses/105105048/M9_L12.pdf
3 http://home.iitk.ac.in/~anubha/WQ.pdf
4 http://www.polyseed.com/misc/BODforwebsite.pdf

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculation and result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 09: Determine chemical oxygen demand of waste water

I. Practical Significance

The COD value indicates the amount of oxygen which is needed for the oxidation of all organic substances in water in mg/l. The COD (Chemical Oxygen Demand) is closely related to the laboratory standard method named Dichromate-Method. With this method the chemical oxygen demand is determined during chromic acid digestion of organic loads in waste water. Based on this method the COD became a commonly used sum parameter in waste water analysis. It is used for planning of waste water treatment plants, for controlling the cleaning efficiency and for the calculation of waste water taxes.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*

PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*

PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To prepare solution of required concentration.
2. To perform titration.
3. To observe the end point of titration and record correct readings.

IV. Relevant Course Outcomes

Test the different properties of water

V. Practical Outcome

Determine chemical oxygen demand of waste water.

VI. Relevant Affective domain unrelated Outcome(s)

1. Follow safe practices
2. Practice good housekeeping
3. Work as a leader/a team member

VII. Minimum Theoretical Background

Oxidation of most organic compounds is up to 95-100% of the theoretical value. The organic matter gets oxidised completely by potassium dichromate ($K_2Cr_2O_7$) with silver sulphate as catalyst in the presence of concentrated H_2SO_4 to produce CO_2 and H_2O. The excess $K_2Cr_2O_7$ remaining after the reaction is titrated with ferrous ammonium sulphate $[Fe(NH_4)_2(SO_4)_2]$. The dichromate consumed gives the oxygen (O_2) required for

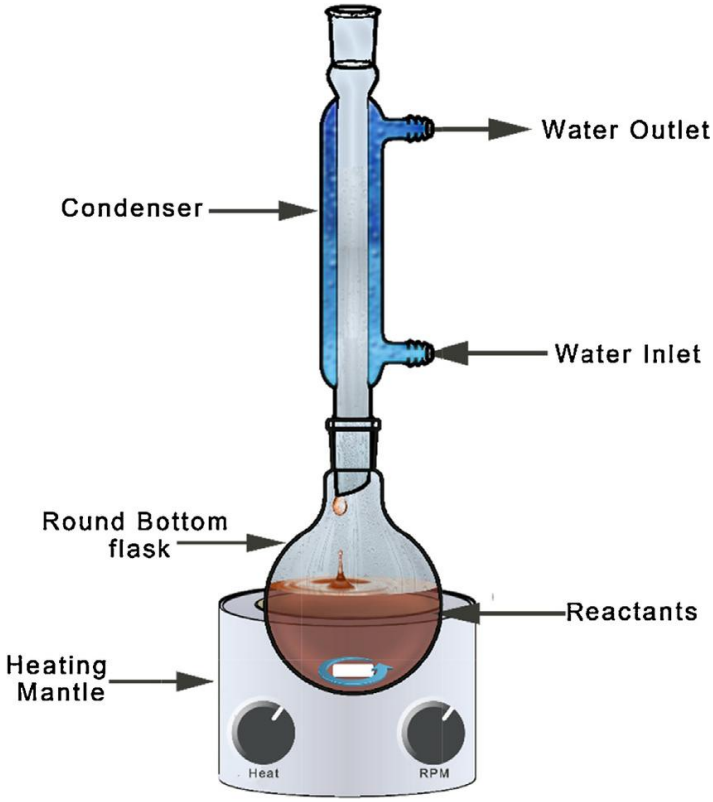
oxidation of the organic matter. The chemical reactions involved in the method are as under:

$2K_2Cr_2O_7 + 8H_2SO_4 \rightarrow 2K_2SO_4 + 2Cr_2(SO_4)_3 + 8H_2O + 3O_2$

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

$Cr_2O_7^{--} + 6Fe^{++} + 14H^{+} \rightarrow 6Fe^{+++} + 2Cr_3+ + 7H_2O$

VIII. Experimental set up used in laboratory



IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	COD flask with reflux condenser	100 ml	1
2	Heating mantle		
3	Pipette	10 ml	1
4	Burette	25 ml	1
5	Conical Flask	250 ml	2
6	Glass beads		

7	Potassium dichromate	Dissolve 12.259 gm of potassium dichromate (dried at 103^{o}C for 24 hours) in distilled water and make up the volume 1 liter.	
8	Sulfuric acid with reagent	Add 10 gm of silver sulphate in 100 ml of concentrated sulfuric acid and keep overnight for dissolution.	100 ml
9	Ferrion indicator	Dissolve 1.485 gm of 1, 10-phenanthroline monohydrate and 695 mg of iron sulphate heptahydrate ($FeSO_4.7H_2O$) in distilled water and diluted up to 100 ml. (This Indicator is readily available in market)	10 ml
10	Mercuric Sulphate		5 gm

X. Precautions to be followed

1. Use the exact volume of sample required for in the procedure. A larger sample will dilute the acid concentration and lower the boiling point in the mixture.
2. Place a safety shield in front of the vessel while heating the flask. In the unlikely event of vial breakage, this precaution will minimize any resulting hazard.
3. Handle sulfuric acid carefully.
4. Wear safety glasses or goggles. When mixing the sample and reagent, hold the vial away from the face and body. A great deal of heat is generated, which can crack even borosilicate glass in some instances.

XI. Procedure

1. Take a reflux flask and place 0.4 gm of mercuric sulphate
2. Add 20 ml of sample.
3. Add 10 ml of concentrated dichromate solution.
4. Place some glass beads in the flask.
5. Add slowly 30 ml of sulfuric acid with reagent.
6. Mix the content thoroughly.
7. Place condenser on the reflux flask and place whole assembly on heater
8. Start heater and reflux for a minimum period for two hours. Add glass beads to avoid bumping of the solution.
9. Cool the content and wash with distilled water.
10. Dilute the sample to make up volume up to 150 ml.
11. Titrate excess dichromate with ferrous ammonium sulphate placed in burette using ferroin indicator.
12. Sharp color changes from blue green to wine red indicate end point.
13. Note down burette reading.
14. Repeat the above procedure using distilled water (blank) in place of sample.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
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XIII. Actual procedure followed

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XIV Precautions followed

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XV. Observations and Calculations

Observation table for Chemical Oxygen Demand.

Sr. No.	Sample details	Volume of sample (ml)	Initial burette reading (ml)	Final burette reading (ml)	Difference (ml)
1	Blank				
2	Waste water				

Quantity of ferrous ammonium sulphate added for blank (A) = ml.

Quantity of ferrous ammonium sulphate added in waste water (B) = ml.

COD = [(A – B) x normality of ferrous ammonium sulphate x 8 x 1000] / Volume of sample

XVI. Results

COD of given water sample = _____ mg/l

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 Describe the importance of glass beads in flask.
2 Write COD limit of effluent for petrochemical industry as per CPCB norms.
3 Explain significance of COD test.
4 Write necessity of condenser in COD test.
5 Explain why water inlet is at the bottom of condenser.

(Space for Answer)

XX. References / Suggestions for further Reading

1. https://camblab.info/wp/index.php/272/
2. https://www.lar.com/products/cod-analysis/cod-chemical-oxygen-demand.html
3. https://www.lar.com/products/cod-analysis/cod-chemical-oxygen-demand.html
4. http://www.envexp.com/technical/method-downloads/cod-method-410
5. https://nptel.ac.in/courses/105105048/M11L13.pdf

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculation and Result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 10: Determine the turbidity of waste water using turbidity meter

I. Practical Significance

Turbidity is an important indicator of the amount of suspended sediment in water, which can have many negative effects on aquatic life. The suspended sediments that cause turbidity can block light to aquatic plants, smother aquatic organisms, and carry contaminants and pathogens, such as lead, mercury, and bacteria. Turbidity describes the clarity of water. Suspended materials in water, such as clay, silt, and algae, reduce water clarity and cause turbidity.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To Test sample of waste water
2. To caliber turbidity meter
3. To observe and record the reading

IV. Relevant Course Outcomes

Test the different properties of water

V. Practical Outcome

Determine turbidity of waste water using turbidity meter.

VI. Relevant Affective domain unrelated Outcome(s)

1. Follow safe practices
2. Practice good housekeeping
3. Work as a leader/a team member

VII. Minimum Theoretical Background

Turbidity often indicates the presence of dispersed and suspended solids like clay, organic matter, silt, algae and other microorganisms which makes the water turbid. . Human activities such as construction, mining, agriculture and high sediment level entering during rainy season increases turbidity of water. The colloidal material which exerts turbidity provides adsorption sites for chemical that may be harmful or cause undesirable tastes and odors and for biological organism that may be harmful. The

turbidity may interfere with light penetration and photo synthetic reaction in streams and lakes. Turbidity increases the load on slow sand filters.

The suspended matter in water which interferes with passage of light is called turbidity. Presence of suspended and colloidal solids particles scatters the part of incidence light. When light is passed through a sample having suspended particles, some of the light is scattered by the particles. The scattering of the light is generally proportional to the turbidity. Turbidity is a measure of the quality of water. A Nephelometric turbidimeter is an instrument for measuring concentration of suspended particulates in a liquid. A Nephelometer measures suspended particulates by employing a light beam (source beam) and a light detector set often at 90° to the source beam. Particle density is then a function of the light reflected into the detector from the particles.

VIII. Experimental set up used in laboratory

IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	Nephlometric turbidity meter	Range: 0-10000NTU, Principle: Nephelometric, Ratio: Full time ON or OFF, Accuracy +/- 2% of reading + 0.01NTU, Resolution: 0.0001NTU	1
2	Sample cell	Standard	4
3	Flask	1000 ml	1
4	Funnel	50 mm	1
5	Hydrazine sulphate		10 gm
6	Hexamethylenetetramine		100 gm
7	Distilled water		2 lit

X. Precautions to be followed

1. Check the electrical connections properly.
2. Do not spill water on light source
3. Clean turbidity meter before using.

XI. Procedure

A. Reagent preparation

1. Dissolve 5 gm Hydrazine sulphate $H_6N_2O_4S$ in distilled water and dilute to 400 ml in a volumetric flask (solution-1).
2. Dissolve 50 g of pure (>99% purity) hexamethylenetetramine ($C_6H_{12}N_4$) in the 500-ml flask containing about 400 ml of ultra-filtered deionized water (solution-2).
3. Pour solution-2 into the 1-liter volumetric flask containing solution-1. Dilute to the mark with ultra-filtered deionized water.
4. Stopper the flask and gently invert several times to mix.
5. Allow the solution to stand for 48 hours at 25 ±1 °C (68 to 72 °F). During this time, the white polymer suspension will develop. The resulting standard is 4000 NTU.
6. Immediately before dilution, invert the flask containing the stock suspension to mix.
7. Dilute the stock suspension before use with ultra-filtered deionized water to achieve a standard of the desired NTU value.
8. Dilution rates for several standard suspensions are listed below.

NTU Value	ml of 4000 NTU stock per liter
400	100
100	25
50	12.5
20	5
10	2.5
4	1
2	0.5

B. Calibration of the apparatus

1. Switch on the equipment and keep it for 30 minutes.
2. Select range depending upon expected turbidity of given sample of water.
3. Set zero of the instrument with turbidity free distilled water.
4. In another sample cell, take standard solution of 400 NTU and adjust the reading 400 NTU value using knob.

C. Operation of instrument

1. Take water sample in sample cell.
2. Fill it upto the mark and wipe with tissue paper.
3. Insert cell in turbidimeter.
4. Note down the reading shown by meter.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
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XIII. Actual procedure followed

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XIV Precautions followed

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XV. Observations and Calculations

Observations for finding out turbidity of water sample

Sr. No	Sample Details	Turbidity (NTU)

XVI. Results

1. Turbidity of water sample -1(_____) is found to be …….. NTU
2. Turbidity of water sample -2(_____) is found to be …….. NTU
3. Turbidity of water sample -3(_____) is found to be …….. NTU

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 List of turbidity limits for different types of waters prescribed by CPCB
2 State the necessity of calibration of turbidity meter.
3 Write the functions of knobs available on turbidity meter.
4 Measure and write the capacity of sample cell.
5 Write maximum storage time of standard turbidity solution.

(**Space for Answer**)

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XX. References / Suggestions for further Reading

1. https://www.researchgate.net/profile/Rajnish_Sharma12/post/Does_anyone_have_any_documented_reference_for_the_calibration_of_turbidity_meters/attachment/59d6231c79197b80779816fd/AS%3A305447184076802%401449835691824/download/Experiment+on+determination+of+turbidity.pdf
2. https://static.fishersci.com/cmsassets/downloads/segment/Scientific/pdf/WaterAnalysis/Method_Turbidity_WW_Orion_Method_AQ4500.pdf
3. https://www.epa.gov/sites/production/files/2015-08/documents/method_180-1_1993.pdf
4. http://www.water-chemistry.in/2010/11/working-principle-of-nephelometric-turbidity-meter/

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculation and result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 11: Measure the appropriate dosage of alum for raw water using jar test method.

I. Practical Significance

Jar testing is a method of simulating a full scale water treatment process, providing system operators a reasonable idea of the way a treatment chemical will behave and operate with a particular type of raw water. Because it mimics full-scale operation, system operators can use jar testing to help determine which treatment chemical will work best with their system's raw water.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To test sample of raw water
2. To observe the change in sample under consideration
3. To record the reading

IV. Relevant Course Outcomes

Test the different properties of waste water

V. Practical Outcome

Measure the appropriate dosage of alum for raw water using jar test method

VI. Relevant Affective domain unrelated Outcome(s)

1.Follow safe practices
2.Practice good housekeeping
3.Work as a leader/a team member

VII. Minimum Theoretical Background

Jar testing entails adjusting the amount of treatment chemicals and the sequence in which they are added to samples of raw water held in jars or beakers. The sample is then stirred so that the formation, development, and settlement of floc can be watched just as it would be in the full scale treatment plant. (Floc forms when treatment chemicals react with material in the raw water and clump together.) The operator then performs a series of tests to compare the effects of different amounts of flocculation agents at different pH values to determine the right size floc for a particular plant. (The right size of floc depends upon the system's filter dimensions and other considerations.)

VIII. Experimental set up used in laboratory

IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	Glass beaker	1000 ml	6
2	Graduating cylinder	1000 ml	1
3	Stirrers	Adjustable speed	6
4	Turbidity meter	Specified in practical. no 10	1
5	Pipette	10 ml	1
6	Alum		10 gm

X. Precautions to be followed

1. Check the electrical connections properly.
2. Do not disturb water in beakers
3. Clean turbidity meter before using.

XI. Procedure

1. Using a 1000 ml (mL) graduated cylinder, add 1,000 mL of raw water to each of the six jar test beakers. Record the temperature, pH, turbidity, and alkalinity of the raw water before beginning.
2. Prepare a stock solution by dissolving 10.0 grams of alum into 1,000 mL distilled water. Each 1.0 mL of this stock solution will equal 10 mg\L (ppm) when added to 1,000 mL of water to be tested.
3. Using the prepared stock solution of alum, dose each beaker with increased amounts of the solution. Start with 1ml solution to first beaker, 1.5 in second, 2 ml in third and so on.

4. After dosing each beaker, turn on the stirrers. Operate the stirrers at a high RPM for 1 minute to simulate the static mixer. Then reduce the speed of the stirrers to match the conditions in the flocculator and allow them to operate for 30 minutes.
5. Observe the floc formation periodically during the 30 minutes.
6. At the end of the 30 minutes turn off the stirrers and allow settling. Most of the settling will be complete after one hour
7. Now, look at the beakers and determine which one has the best results (if any). If no results were noticeable, then increase the dosage using the table above for the next six jars.
8. If none of the beakers appear to have good results, then the procedure needs to be run again using different dosages until the correct dosage is found.
9. Find turbidity in each beaker and note the reading.
10. Plot the graph of Alum dosage vs residual turbidity

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			
4			
5			
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XIII. Actual procedure followed

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XIV Precautions followed

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XV. Observations and Calculations

Sr. No	Alum Dose (mg/l)	Turbidity (NTU)

XVI. Results

Optimum alum dose for given water sample is _____ mg/lit

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 Name various coagulant used for water treatment.
2 Write significance of jar test.
3 Write chemical formula of alum.
4 Write reason for reduction in speed in experiment.
5 State the importance of jar test in design of water treatment plant.

(Space for Answer)

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XX. References / Suggestions for further Reading

1. https://nptel.ac.in/courses/105104102/Lecture%209.htm
2. http://www.nesc.wvu.edu/pdf/dw/publications/ontap/2009_tb/jar_testing_DWFSOM73.pdf
3. https://static1.squarespace.com/static/54e2b7aee4b0902efd671f90/t/5bb672650d92975174ce3260/1538683493717/TSG-T-008+Jar+Testing+Procedure+RevB.pdf
4. http://mimoza.marmara.edu.tr/~kyapsakli/enve201/9_Coagulation-Flocculation-Jar%20Test.pdf.
5.

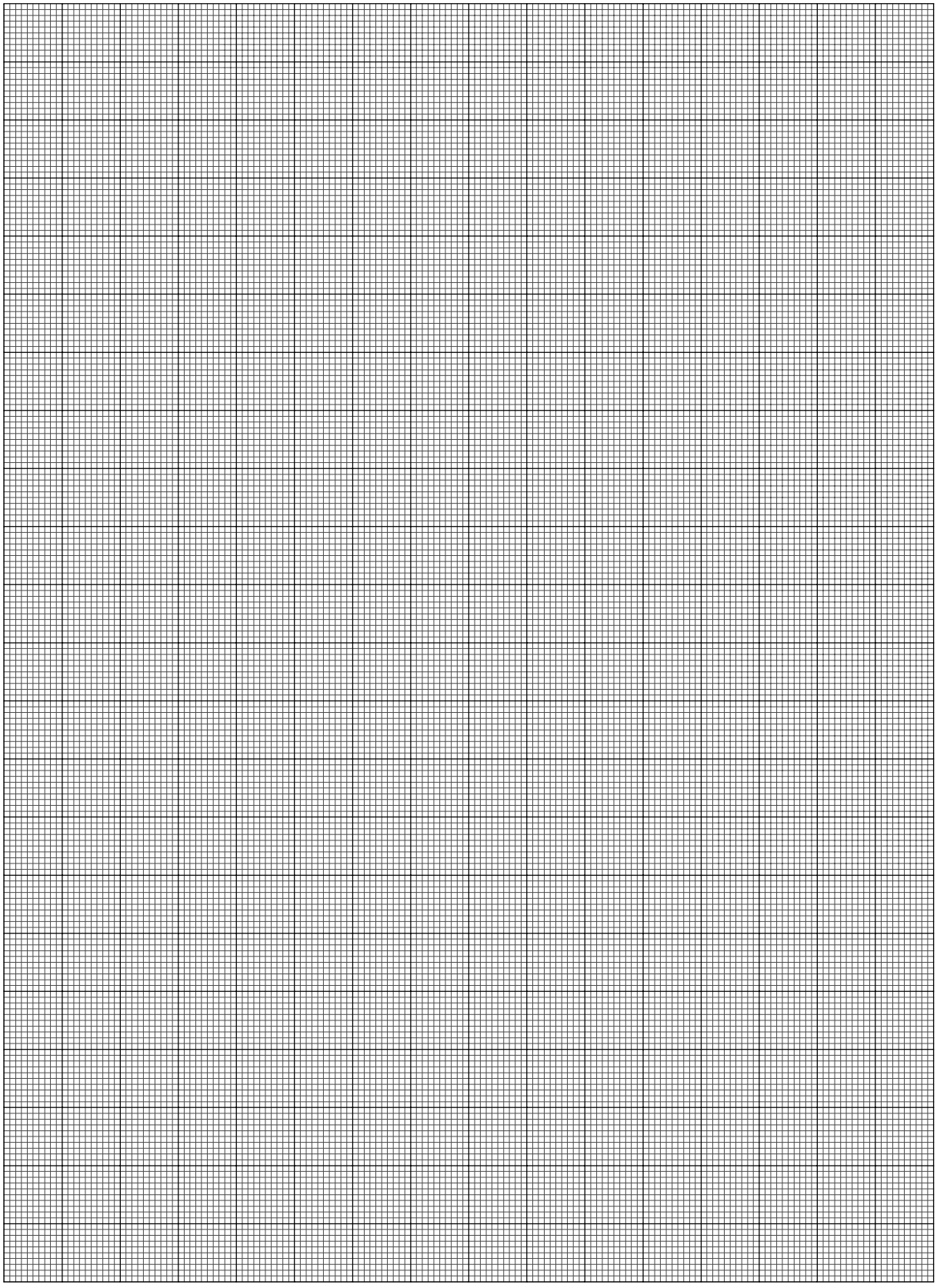
XXI. Assessment Scheme

Performance indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculation and Result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	



Practical No. 12: Determine Sulphate content in waste water

I. Practical Significance

The sulphate content of natural waters is an important consideration in determining their suitability for public and industrial water supplies. The amount of sulphate in waste waters is a factor of concern in determining the magnitude of problems that can arise from reduction of sulphates to hydrogen sulphide. Knowledge of the sulphate content of the sludge or waste fed to digestion units provides a means of estimating the hydrogen sulphide content of the gas produced.The design engineer can determine whether the scrubbing facilities will be needed to remove hydrogen sulphide and size of the units needed.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To Test sample of raw water
2. To observe the change in sample under consideration
3. To record the reading

IV. Relevant Course Outcomes

Test the different properties of waste water

V. Practical Outcome

Determine sulphate content in waste water

VI. Relevant Affective domain unrelated Outcome(s)

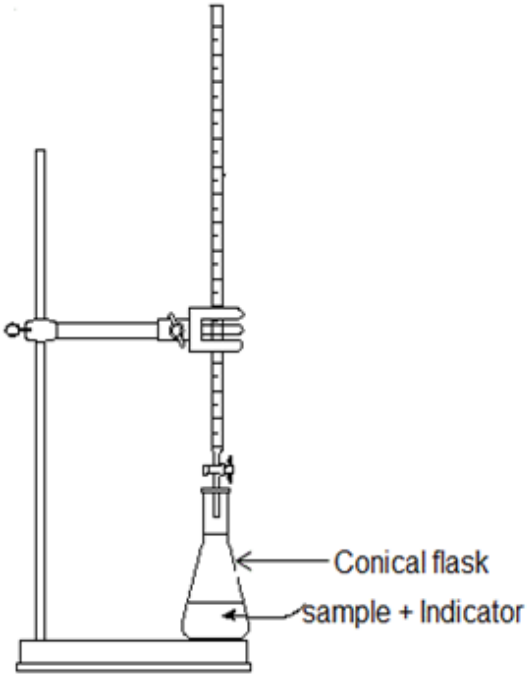
1. Follow safe practices
2. Practice good housekeeping
3. Work as a leader/a team member

VII. Minimum Theoretical Background

Sulphates in natural waters range from a few to thousand milligrams per liter. Excess Na2SO4 and Mg SO_4 should not be present in drinking waters as they became cathartic

action. Higher concentration of sodium sulphate in water can cause malfunctioning of the alimentary canal. So the recommended upper limit is 250mg/l in waters intended for human consumption. In anerobic decomposition of waste waters, sulphates are reduced to Hydrogen sulphides causing abnoxious odours and promote corrosion of sewers. Sulphates are reduced to sulphide in sludge digesters. .

VIII. Experimental set up used in laboratory



IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	Filter Paper	whatman	1
2	Burette	25 ml	1
3	Pipette	10 ml	1
4	Beaker	100 ml	2
5	Hot plate	Variable temperature	1
6	Hydroxylamine chloride	10 gm of $NH_2OH.HCL$ in 100 ml distilled water	10 ml
7	Benzidine hydrochloride	Standard solution	20 ml
8	NaOH	0.05N	1 lit
9	Phenolpthalein Indicator		5 ml

X. Precautions to be followed

1. Check the electrical connections properly.
2. Do not handle chemicals without PPE
3. Pipette out chemicals using rubber sucker

XII. Procedure

1. Take 125 ml of sample in a 400 /500 ml beaker.
2. Add 5 ml of Hydroxylamine chloride and then add 10 ml Benzidine hydrochloride
3. Stir the mixture vigorously and allow the precipitate to settle.
4. Filter the solution and wash the beaker and the filter paper with cold distilled water.
5. Pierce the filter paper in the funnel and wash the precipitate formed on the filter paper to the original beaker with 100 to 150 ml distilled water.
6. Heat the beaker to dissolve the contents for 20 to 30minutes.
7. Add 2 drops of Phenolphthalein Indicator and titrate with 0.05 N NaOH until pink colour is developed

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
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2			
3			
4			
5			
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XIII. Actual procedure followed

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XIV Precautions followed

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XV. Observations and Calculations

Observations table

Sample details	Volume of sample taken (ml)	Initial Burette reading(ml)	Final Burette reading (ml)	ml of NaOH solution used

Concentration of sulphates(mg/l)

$$= \frac{volume\ of\ 0.05\ N\ NaOH * 38.4}{volume\ of\ the\ sample\ taken}$$

XVI. Results

Sulphate content in given sample of water is _____ mg/lit

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 Write necessity of sulphate removal from waste water.
2 List the sources of sulphate in waste water.
3 Write precaution necessary while handling filtrate.
4 Write value of temperature attained during heating of sample.
5 Heat is released or absorbed during preparation of NaOH solution? Write your observation.

(Space for Answer)

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XX. References / Suggestions for further Reading

1 http://www.fao.org/3/t0551e/t0551e03.htm
2 https://ocw.unihe.org/pluginfile.php/462/mod_resource/content/1/Urban_Drainage_and_Sewerage/5_Wet_Weather_and_Dry_Weather_Flow_Characterisation/DWF_characterization/Notes/Wastewater%20characterization.pdf
3 https://www.wateronline.com/doc/a-new-process-for-sulfate-removal-from-indust-0001
4 https://www.youtube.com/watch?v=1dsaz71BB8o

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculation and result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 13: Determine the neutralization point for charcoal treatment of acidic waste water.

I. Practical Significance

Bed of activated carbon is used to remove contaminants and impurities, using chemical adsorption. Each particle, or granule, of carbon provides a large surface area, or pore structure, allowing contaminants the maximum possible exposure to the active sites within the filter media. One gram of activated carbon has a surface area in excess of 3,000 m^2. Activated carbon works via a process called adsorption, whereby pollutant molecules in the fluid to be treated are trapped inside the pore structure of the carbon substrate. Carbon filtering is commonly used for water purification, air filtering and industrial gas processing, for example the removal of siloxanes and hydrogen sulfide from biogas. Active charcoal carbon filters are most effective at removing chlorine, particles such as sediment, volatile organic compounds (VOCs), taste and odor from water.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To Test sample of raw water
2. To observe the change in sample under consideration
3. To record the reading

IV. Relevant Course Outcomes

Test the different properties of waste water

V. Practical Outcome

Determine the neutralization point for charcoal treatment of acidic waste water.

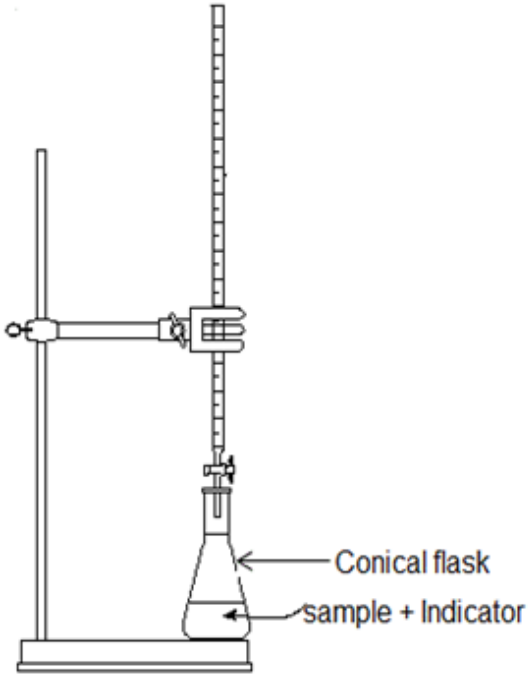
VI. Relevant Affective domain unrelated Outcome(s)

1. Follow safe practices
2. Practice good housekeeping
3. Work as a leader/a team member

VII. Minimum Theoretical Background

Acidity is the quantitative expression of water's capacity to neutralize a strong base to a designated pH and an indicator of how corrosive water is. Acidity can be caused by weak organic acids, such as acetic and tannic acids, and strong mineral acids including sulfuric and hydrochloric acids; however, the most common source of acidity in unpolluted water is carbon dioxide in the form of carbonic acid. Acidity is commonly determined using methyl orange as a color indicator of the pH end point. Because methyl orange undergoes a color change from red to orange at a pH of 3.7, the results of the titration are termed Methyl Orange Acidity. Total acidity includes acidity caused by mineral acids, weak organic acids, and carbon dioxide (in the form of carbonic acid). Acidity determined by titrating to a phenolphthalein end point pH of 8.3 corresponds to the neutralization of carbonic acid to bicarbonate. Because carbon dioxide is the major cause of acidity in natural waters, in most cases the phenolphthalein acidity is equal to the total acidity. Acidity tests can be performed using a pH meter to detect the end points; however, methyl orange acidity and phenolphthalein acidity are the terms used to describe the results. Results of the acidity tests are reported in mg/L $CaCO_3$.

VIII. Experimental set up used in laboratory



IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	Burette	25 ml	1
2	Pipette	10 ml	1
3	Conical Flask	100 ml	2
4	Measuring cylinder	1000 ml	2
5	Magnetic stirrer		1
6	Glass rod		5
7	Sodium thiosulphate solution	0.1 N	100 ml
8	Sodium hydroxide solution	0.02 N	1000 ml
9	Phenolphthalein indicator		5 ml
10	Methyl orange indicator.		5 ml
11	Charcoal		50 gm

X. Precautions to be followed

1. Handle caustic soda carefully.
2. Use safety goggle and hand gloves while handling chemicals.

XIII. Procedure

Part (I):- For the untreated acidic waste water

1. Take 10 ml of given water sample in a conical flask.
2. Add 1 drop of 0.1 N sodium thiosulphate solution to remove the residual chlorine if present.
3. Add 2 drops of Methyl orange indicator. The sample color turns pink.
4. Titrate the solution against 0.02 N NaOH until yellow color appears.
5. Note down the volume of NaOH added (V_1)
6. Add 2 to 3 drops of Phenolphthalein indicator to the same solution in conical flask.
7. Continue the titration against 0.02 N NaOH until sample turns to pink .
8. Note down the total volume of NaOH added (V_2)

Part (II):- For the treated acidic waste water.

1. Tale 100 ml of acidic waste water in a beaker.
2. Add 5/10/15/20 grams of charcoal powder to the beaker containing waste water.
3. Stir the mixture continuously for 30 min. using a glass rod./ magnetic stirrer.
4. Allow the mixture to stand quiescent for 10 min.
5. Filter the mixture by using a funnel. Collect the filtrate in a separate beaker
6. Collect the charcoal on the filter paper.

7. Take 10ml of the filtrate in a conical flask. Add 1 drop of 0.1 N sodium thiosulphate solution to remove the residual chlorine if present.
8. Add 2 drops of Methyl orange indicator. The sample color turns pink.
9. Titrate the solution against 0.02 N NaOH until yellow color appears.
10. Note down the volume of NaOH added (V_1)
11. Add 2 to 3 drops of Phenolphthalein indicator to the same solution in conical flask.
12. Continue the titration against 0.02 N NaOH until sample turns to pink .
13. Note down the total volume of NaOH added(V_2)

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			
4			
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10			
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XIII. Actual procedure followed

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XIV Precautions followed

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XV. Observations and Calculations

Sample details	Volume of sample (ml)	Methyl orange Indicator			Phenolphthalein indicator		
		Initial burette reading (ml)	Final burette reading (ml)	NaOH used V_1 (ml)	Initial burette reading (ml)	Final burette reading (ml)	NaOH used V_2 (ml)

Mineral acidity due to mineral acids (as $CaCO_3$) (mg/l)

$$= \frac{v_1 \ X \ 1000}{ml \ of \ effluent \ sample} =$$

= ----------mg/l or (ppm)

CO_2 acidity due to CO_2 (as $CaCO_3$)(mg/l)

$$= \frac{v_2 \ X \ 1000}{ml \ of \ an \ effluent \ sample} =$$

= ----------mg/l or (ppm)

Total acidity (as $CaCO_3$) = Mineral acidity + CO_2 acidity

= ---------- + ----------

= ----------mg/l or (ppm)

XVI. Results

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 Write the reason for the use of two indicators in titration.
2 Write important property of charcoal.
3 Describe use of sodium thiosulphate in this practical.
4 Write effect of acidity of waste water on equipmnets.
5 List the sources of acidic waste water.

(Space for Answer)

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XX. References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=GjnnK99t4Mc
2. https://www.youtube.com/watch?v=IhEE5LawCkU
3. https://books.google.co.in/books?id=bw34EAcNgz8C&printsec=frontcover&dq=treatment+of+acidic+wastewater&hl=en&sa=X&ved=0ahUKEwiVkLHlrubgAhVMfH0KHb5TDe8Q6AEIKDAA#v=onepage&q=treatment%20of%20acidic%20wastewater&f=false
4. https://inspiredliving.com/cuzn-water-filtration/acid-water-low-pH.htm

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculation and result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 14: Determine the strength of alkaline material in waste water using acid base titration.

I. Practical Significance

Alkalinity is significant in the treatment processes for potable water and wastewater. The alkalinity acts as a pH buffer in coagulation and lime-soda softening of water. In wastewater treatment, alkalinity is an important parameter in determining the amenability of wastes to the treatment process and control of processes such as anaerobic digestion, where bicarbonate alkalinity, total alkalinity and any fraction contributed by volatile acid salts become considerations.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To Test sample of raw water
2. To observe the change in sample during titration.
3. To record the reading

IV. Relevant Course Outcomes

Test the different properties of waste water

V. Practical Outcome

Determine the strength of alkaline material in waste water using acid base titration.

VI. Relevant Affective domain unrelated Outcome(s)

1. Follow safe practices
2. Practice good housekeeping
3. Work as a leader/a team member

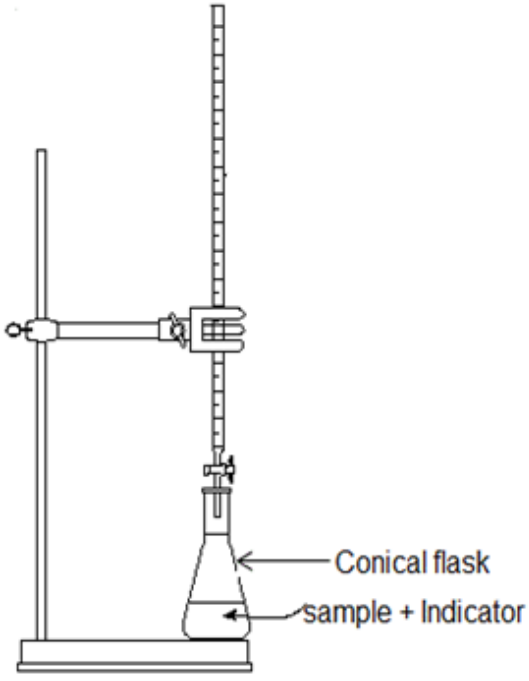
VII. Minimum Theoretical Background

Alkalinity is a measure of the capacity of water to neutralize acids. Alkalinity of water is due to the presence of bicarbonate, carbonate, and hydroxide ions. Salts of weak acids, such as borates, silicates and phosphates, may also contribute. Salts of certain organic

acids may contribute to alkalinity in polluted or anaerobic water, but their contribution usually is negligible. Bicarbonate is the major form of alkalinity. Carbonates and hydroxide may be significant when algal activity is high and in certain industrial water and wastewater, such as boiler water.

The bacteria and other biological entities which play an active role in wastewater treatment are most effective at a neutral to slightly alkaline pH of 7 to 8. In order to maintain these optimal pH conditions for biological activity there must be sufficient alkalinity present in the wastewater to neutralize acids generated by the active biomass during waste treatment. This ability to maintain the proper pH in the wastewater as it undergoes treatment is the reason why alkalinity is so important to the wastewater industry. The standard test for alkalinity measures quantity of acid neutralizing bases and represents this value in milligrams (mg) of $CaCO_3$ equivalents per liter (l) of wastewater. The term mg/l and the term p pm are used interchangeably in the wastewater industry. The amount of alkali that is added during waste treatment is determined by means of this standard test.

VIII. Experimental set up used in laboratory



IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	Burette	25 ml	1
2	Pipette	10 ml	1
3	Conical Flask	100 ml	2
4	Measuring cylinder	1000 ml	2
5	Magnetic stirrer		1
6	Sulfuric Acid solution	0.02 N	1000 ml
7	Sodium thiosulphate solution	0.1 N	100 ml
8	Phenolphthalein indicator		5 ml
9	Methyl orange indicator.		5 ml

X. Precautions to be followed

1. Handle sulfuric acid carefully.
2. Use safety goggle and hand gloves while handling chemicals.

XIV. Procedure

1. Take 100 ml of the given sample in a conical flask.
2. Add one drop of 0.1 N sodium thiosulphate solution to remove the free residual chlorine if present.
3. Add 2 drops of phenolphthalein indicator. The sample turns pink.
4. Rundown 0.02N standard sulphuric acid till the solution turns to colorless.
5. Note down the volume of H_2SO_4added (V_1).
6. Add 2 drops of methyl orange indicator to the same flask till sample turns to yellow.
7. In case pink color does not appear after addition of phenolphthalein continue as above.
8. Note down the total volume of H_2SO_4 added (V_2).

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
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XIII. Actual procedure followed

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XIV Precautions followed

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XV. Observations and Calculations

Sample details	Volume of sample (ml)	Phenolphthalein indicator			Methyl orange Indicator		
		Initial burette reading (ml)	Final burette reading (ml)	H_2SO_4 used (ml)	Initial burette reading (ml)	Final burette reading (ml)	H_2SO_4 used (ml)

1. Phenolphthalein alkalinity (P) (mg/l) as $CaCO_3$

$$= \frac{v_1 X\ normality\ of\ H_2SO_4 X\ 1000\ X50}{volume\ of\ sample\ taken} =$$

= ----------mg/l or (ppm)

2. Total alkalinity (T) as $CaCO_3$ mg/l

$$= \frac{v_2 X\ normality\ of\ H2SO4\ X\ 1000\ X\ 50}{volume\ of\ sample\ taken} =$$

= ----------mg/l or (ppm)

Refer following table for further calculations

Value of P and T	Alkalinity due to		
	OH^-	CO_3^{--}	HCO_3^-
P=0	0	0	T
P < 1/2 T	0	2P	T - 2P
P = 1/2 T	0	2P	0
P > 1/2 T	2P - T	2T – 2P	0
P = T	T	0	0

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XVI. Results

For given sample

Hydroxide alkalinity (mg/l) =

Carbonate alkalinity (mg/l) =

Bicarbonate alkalinity (mg/l) =

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 Write the reason for the use of two indicators in titration.
2 Write significance for the use of sodium thiosulphate solution.
3 Describe the procedure followed for preparing sulfuric acid solution.
4 Write the for the use of white tile during titration.
5 Name the compound causing alkalinity in water.

(Space for Answer)

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XX. References / Suggestions for further Reading

1 https://www.tpomag.com/editorial/2014/05/understanding_alkalinity
2 https://magnesiaspecialties.com/wp-content/uploads/Role-of-Alkalinity-in-Aerobic-Wastewater-Treatment-Plants-MgO-vs-Caustic-Soda1.pdf
3 https://www.epa.gov/sites/production/files/2015- 09/documents/2009_03_13_ estuaries_monitor_chap11.pdf

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculation and result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 15: Determine the density of municipal solid waste

II. Practical Significance

The density of MSW is important for selection of waste collection equipment. Usually density will increase by about 20-25 % during the transport step. Density varies depending on the composition of wastes, being higher in organic wastes and lower in commercial wastes containing mainly paper and cardboard .As transportation cost is important economical factor in MSW treatment it is necessary to calculate density at the source of generation.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To characterize municipal solid waste
2. To segregate municipal solid waste
3. To record the reading

IV. Relevant Course Outcomes

Use land fill and incineration methods for treatment of industrial solid waste

V. Practical Outcome

Determine the density of municipal solid waste

VI. Relevant Affective domain unrelated Outcome(s)

1. Follow safe practices
2. Practice good housekeeping
3. Work as a leader/a team member

VII. Minimum theoretical Background

MSW consists of both materials and products. Materials in MSW include paper and paperboard, yard trimmings, glass, metal, plastics, wood, and food wastes. Each material category (except for food wastes and yard trimmings) is made up of many different products. Products in MSW are grouped into three main categories: (1) durable goods (e.g., appliances), (2) nondurable goods (e.g., newspapers), and (3) containers and packaging. These product categories generally contain each type of MSW material, with

some exceptions. The durable goods category contains no paper and paperboard. The nondurable goods category includes only small amounts of metals and essentially no glass or wood. The containers and packaging category includes only very small amounts of rubber, leather, and textiles. The density of MSW is important for selection of waste collection equipment. Usually density will increase by about 20-25 % during the transport step. Density varies depending on the composition of wastes, being higher in organic wastes and lower in commercial wastes containing mainly paper and cardboard .As transportation cost is important economical factor in MSW treatment it is necessary to calculate density at the source of generation.

VIII. Experimental set up used in laboratory

IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	Beaker	100 ml	10
2	Weighing Balance	1 to 500 gm	1

X. Precautions to be followed

1. Handle digital balance carefully.
2. Use safety goggle and hand gloves while handling MSW.

XVI. Procedure

1. Take 1 kg of Municipal Solid Waste.
2. Segregate the waste and separate paper, plastic, metal, food waste etc.
3. Place each segregated item in separate beaker.
4. Weigh the content in each beaker and note the reading.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
3			

XIII. Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations

Sr. No.	Description	Weight (gm)	Wt % f_i	Typical Density (kg/m^3) D_i	f_iD_i

Average density

$$D_{avg}\left(\sum_{i=1}^{n} f_i D_i\right)$$

Note : Typical density of various material (kg/m^3)
Food waste =290, Yard waste = 240, Paper =85, Plastic = 65, Glass/ceramic =195, Metal =160, Textile =65, Leather =160, stone/bricks =480

XVI. Results

Average density of MSW = _____ kg/m^3

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 List the sources of MSW.
2 Write various characteristics of MSW.
3 Name the act applicable to every municipal authority responsible for collection, segregation, storage, transportation, processing and disposal of municipal solid.
4 Write the name of methods used to dispose MSW.
5 Name the materials having maximum and minimum wt % in your MSW sample.

(space for Answer)

XX. References / Suggestions for further Reading

1. http://cpcb.nic.in/municipal-solid-waste-rules/
2. https://nptel.ac.in/courses/105106056/Municipal_Solid_Waste_Management_Fundamentals_Presentation.pdf
3. https://nptel.ac.in/courses/105106056/Municipal_Solid_Waste_Management_Fundamentals.pdf

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculations and result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No. 16: Determine the density of hazardous waste

I. Practical Significance

A hazardous waste is a special type of waste because it cannot be disposed of by common means like other by-products of our everyday lives. Depending on the physical state of the waste, treatment and solidification processes might be required. Determination of its properties will be helpful for its handling.

II. Relevant Program Outcomes (POs)

PO 2. ***Discipline knowledge:*** *Apply Chemical engineering knowledge to solve industry based Chemical Engineering problems.*
PO 3. ***Experiments and practice:*** *Plan to perform experiments and practices to use the results to solve technical problems related to Chemical engineering.*
PO 4. ***Engineering tools:*** *Apply relevant technologies and Chemical engineering tools with an understanding of the limitations.*

III. Competency and Practical Skills

This practical is expected to develop the following skills for the industry identified competency '***Conserve environment using various pollution control measures'.***

1. To characterize hazardous waste
2. To handle hazardous waste
3. To record the reading

IV. Relevant Course Outcomes

Apply ISO14000 environmental protection norms for chemical industry

V. Practical Outcome

Determine the density of hazardous waste.

VI. Relevant Affective domain unrelated Outcome(s)

1. Follow safe practices
2. Practice good housekeeping
3. Work as a leader/a team member

VII. Minimum Theoretical Background

Hazardous-waste management, the collection, treatment, and disposal of waste material that, when improperly handled, can cause substantial harm to human health and safety or to the environment. Hazardous wastes can take the form of solids, liquids, sludge, or contained gases, and they are generated primarily by chemical production, manufacturing, and other industrial activities. They may cause damage during storage, transportation, treatment, or disposal operations. Improper hazardous-waste storage or disposal frequently contaminates surface and groundwater supplies. People living in homes built near old and abandoned waste disposal sites may be in a particularly

vulnerable position. Hazardous wastes may be found in different physical states such as gaseous, liquids, or solids. A hazardous waste is a special type of waste because it cannot be disposed of by common means like other by-products of our everyday lives. Depending on the physical state of the waste, treatment and solidification processes might be required.

VIII. Experimental set up used in laboratory

IX Resources required

S. No.	Instrumentation/components	Specification	Quantity
1	Sp Gravity bottle	50 ml	1
2	Weighing Balance	1 to 500 gm	1

X. Precautions to be followed

1. Handle digital balance carefully.
2. Use safety goggle and hand gloves while handling hazardous waste.
3. Do not inhale the liquid hazardous waste.

XVII. Procedure

1. Take weight of empty specific gravity bottle (W_1)
2. Fill the bottle with liquid hazardous waste.
3. Weigh the specific gravity bottle with liquid waste (W_2)
4. Record the reading and do the calculation.

XII. Resources used (with major specifications)

S. No.	Instrument /Components	Specification	Quantity
1			
2			
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XIII. Actual procedure followed

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XIV Precautions followed

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XV Observations and Calculations

Weight of empty specific gravity bottle = W_1
Wight of specific gravity bottle with waste = W_2
Weight of hazardous waste = $W_1 - W_2$
Volume of specific gravity bottle = V

Density = Weight of hazardous waste/ Volume of sp gravity bottle

= _____ gm/cc =_____ kg/m^3

XVI. Results

Density of hazardous waste = _____ kg/m^3

XVII. Interpretation of results

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XVIII. Conclusions

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XIX. Practical related Questions

Below given are five sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO

1 List the sources of hazardous waste.
2 Write various characteristics of hazardous waste.
3 Name the rule applicable to management of hazardous waste.
4 List various methods for handling hazardous waste.
5 Define specific gravity.

(Space for Answer)

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XX. References / Suggestions for further Reading

1. https://www.britannica.com/technology/hazardous-waste-management
2. https://www.environment.gov.au/system/files/resources/a16491f5-6697-4f1b-bba0-074963e78957/files/hazardous-waste-unit-conversion-factors.pdf
3. https://www.epa.gov/sites/production/files/201511/documents/2015_hwr_instructions_forms.pdf
4. http://www.mfe.govt.nz/publications/waste/calculation-and-payment-waste-disposal-levy-guidance-waste-disposal-facility-8
5. https://www.epa.gov/sites/production/files/2014-12/documents/k01005.pdf

XXI. Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of Apparatus	20%
2	Observation of correct reading	20%
3	Calculation and result	20%
Product related (10 Marks)		**40%**
4	Interpretation of result & conclusions	20%
5	Answers to practical related questions	20%
Total (25 Marks)		**100 %**

Names of Student Team Members

1. ……
2. ……
3. ……
4. ……

Marks Obtained			Dated signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

List Of Laboratory Manuals Developed by MSBTE

First Semester:

1	Fundamentals of ICT	22001
2	English	22101
3	English Work Book	22101
4	Basic Science (Chemistry)	22102
5	Basic Science (Physics)	22102

Second Semester:

1	Bussiness Communication Using Computers	22009
2	Computer Peripherals & Hardware Maintenace	22013
3	Web Page Design with HTML	22014
4	Applied Science (Chemistry)	22202
5	Applied Science (Physics)	22202
6	Applied Machines	22203
7	Basic Surveying	22205
8	Applied Science (Chemistry)	22211
9	Applied Science (Physics)	22211
10	Fundamental of Electrical Engineering	22212
11	Elements of Electronics	22213
12	Elements of Electrical Engineering	22215
13	Basic Electronics	22216
14	'C' programming Language	22218
15	Basic Electronics	22225
16	Programming in "C"	22226
17	Fundamentals of Chemical Engineering	22231

Third Semester:

1	Applied Multimedia Techniques	22024
2	Advanced Serveying	22301
3	Highway Engineering	22302
4	Mechanics of Structures	22303
5	Building Construction	22304
6	Concrete Technology	22305
7	Strength Of Materials	22306
8	Automobile Engines	22308
9	Automobile Transmission System	22309
10	Mechanical Operations	22313
11	Technology Of Inorganic Chemicals	22314
12	Object Oriented Programming Using C++	22316
13	Data Structure Using 'C'	22317
14	Computer Graphics	22318
15	Database Management System	22319
16	Digital Techniques	22320
17	Principles Of Database	22321
18	Digital Techniques & Microprocessor	22323
19	Electrical Circuits	22324
20	Electrical & Electronic Measurment	22325
21	Fundamental Of Power Electronics	22326
22	Electrical Materials & Wiring Practice	22328
23	Applied Electronics	22329
24	Electrical Circuits & Networks	22330
25	Electronic Measurments & Instrumentation	22333
26	Principles Of Electronics Communication	22334
27	Thermal Engineering	22337
28	Engineering Matrology	22342
29	Mechanical Engineering Materials	22343
30	Theory Of Machines	22344

Fourth Semester:

1	Hydraulics	22401
2	Geo Technical Engineering	22404
3	Chemical Process Instrumentation & Control	22407
4	Fluid Flow Operation	22409
5	Technology Of Organic Chemicals	22410
6	Java Programming	22412
7	GUI Application Development Using VB.net	22034
8	Microprocessor	22415
9	Database Managment	22416
10	Electric Motors And Transformers	22418
11	Industrial Measurements	22420
12	Digital Electronics And Microcontroller Applications	22421
13	Linear Integrated Circuits	22423
14	Microcontroller & Applications	22426
15	Basic Power Electronics	22427
16	Digital Communication Systems	22428
17	Mechanical Engineering Measurments	22443
18	Fluid Mechanics and Machinery	22445
19	Fundamentals Of Mechatronics	22048

Fifth Semester:

1	Design of Steel and RCC Structures	22502
2	Public Health Engineering	22504
3	Heat Transfer Operation	22510
4	Environmental Technology	22511
5	Operating Systems	22516
6	Advanced Java Programming	22517
7	Software Testing	22518
8	Control Systems and PLC's	22531
9	Embedded Systems	22532
10	Mobile and Wireless Communication	22533
11	Industrial Machines	22523
12	Switchgear and Protection	22524
13	Energy Conservation and Audit	22525
14	Power Engineering and Refrigeration	22562
15	Solid Modeling and Additive Manufacturing	22053
16	Guidelines & Assessment Manual for Micro Projects & Industrial Training	22057

Sixth Semester:

1	Solid Modeling	17063
2	Highway Engineering	17602
3	Contracts & Accounts	17603
4	Design of R.C.C. Structures	17604
5	Industrial Fluid Power	17608
6	Design of Machine Elements	17610
7	Automotive Electrical and Electronic Systems	17617
8	Vehicle Systems Maintenance	17618
9	Software Testing	17624
10	Advanced Java Programming	17625
11	Mobile Computing	17632
12	System Programing	17634
13	Testing & Maintenance of Electrical Equipments	17637
14	Power Electronics	17638
15	Illumination Engineering	17639
16	Power System Operation & Control	17643
17	Environmental Technology	17646
18	Mass Transfer Operation	17648
19	Advanced Communication System	17656
20	Mobile Communication	17657
21	Embedded System	17658
22	Process Control System	17663
23	Industrial Automation	17664
24	Industrial Drives	17667
25	Video Engineering	17668
26	Optical Fiber & Mobile Communication	17669
27	Therapeutic Equipment	17671
28	Intensive Care Equipment	17672
29	Medical Imaging Equipment	17673

Pharmacy Lab Manual

First Year:

1	Pharmaceutics - I	0805
2	Pharmaceutical Chemistry - I	0806
3	Pharmacognosy	0807
4	Biochemistry and Clinical Pathology	0808
5	Human Anatomy and Physiology	0809

Second Year:

1	Pharmaceutics - II	0811
2	Pharmaceutical Chemistry - II	0812
3	Pharmacology & Toxicology	0813
4	Hospital and Clinical Pharmacy	0816

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