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24 Aug 2019

OFFICE OF PRINCIPAL

STANDARD OPERATING PROCEDURE (SOP)
FOR STANDARDIZATION OF LAB MANUAL

1. In view of standardization of Lab Manual for all departmental Labs in AIT. Committee appointed for same submitted the General Standard Formats which shall be followed for preparation of all Lab Manual from AY 2019 – 20. Standard Operating Procedure (SOP) is framed for same
2. The SOP is for "**STANDARDIZATION OF LAB MANUAL**"
3. This will be effective from current academic year 2019 – 20.
4. This SOP will be reviewed as and when required.

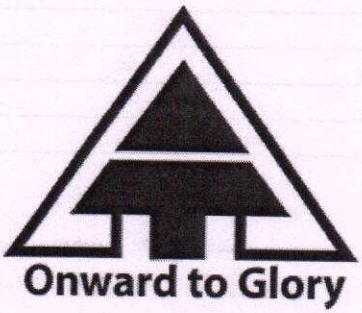
(Dr. B.P. Patil)
Principal

Copy To -

Director Jt Dir	}	for information please.
HOD Mech HOD Comp HOD E&TC HOD IT HOD ASGE	}	for information and needful action please.
HOD IT	-	Publish on AIT Web site
Office Supdt	-	for Office Record

ARMY INSTITUTE OF TECHNOLOGY

LAB MANUAL



Name of Subject	Sample
Department	General
Subject Code	XXXXX
TW/OR/PR	PR
Marks	50
Course (Pattern)	2015
Year	TE
Semester	2

List of Experiments

(As given by SPPU)

Sr. No	Title	Page No
1	Positive Negative Number Count	10
2	Study of IC-74LS83 as a BCD adder	16
3	Kinematic viscosity of liquid	22
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Additional List of Experiments

(Over and above SPPU Syllabus)

Sr. No	Title	Page No
1	To determine hardness of water sample.	26
2		
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Pre-requisite for Lab

Companion Courses	
Code	Subject
XXXX	Machine Learning
XXXX	Data Analytics
XXXX	Natural Language Processing
...	...
Prerequisite Courses/Lab	
Code	Subject
XXXX	Engineering Mathematics
XXXX	Fundamentals of Programming
XXXX	Theory of Computation
....	....

Learning Objectives

Sr. No	Objective
1	To learn the current technologies being used
2	To understand the basic issues and performance requirements
3	...
4	....
...	...

Precautions / Lab Safety Do's and Don'ts/ Lab Etiquettes

Sr. No	Details
1	The use of personal audio or video equipment is prohibited in the laboratory
2	Keep work area neat and free of any unnecessary objects.
3	Always perform the experiments as directed by your instructor.
4	Never work in the laboratory without the supervision of an instructor.
5	
6	
...	

Evaluation Guidelines (Rubrics)

(Similar guidelines pertaining to each subject (lab) shall be used to evaluate **each experiment** performed in the lab)

Grade	Poor	Average	Good	Outstanding
Marks	0-3	4-5	6-8	9-10

Criteria	Grade		Marks
Set-up and Equipment Care	Poor (0-3)	Set-up of equipment is not accurate, help is required with several major details	
	Average (4-5)	Set-up of equipment is generally workable with several details that need refinement	
	Good (6-8)	Set-up of equipment is generally accurate with 1 or 2 small details that need refinement	
	Outstanding (9-10)	All equipments accurately placed	
Following Procedure	Poor (0-3)	Lacks appropriate knowledge of the lab procedures. Often requires help from the teacher to even complete basic procedures	
	Average (4-5)	Demonstrates general knowledge of lab procedures. Requires help from the teacher with some steps in procedures.	
	Good (6-8)	Demonstrates good knowledge of the lab procedures. Will discuss with peers to solve problems in procedures.	
	Outstanding (9-10)	Demonstrates very good knowledge of the lab procedures. Gladly helps other students to follow procedures.	
Data Collection	Poor (0-3)	Measurements are incomplete, inaccurate and imprecise. Observations are incomplete or not included. Symbols, units and significant figures are not included.	
	Average (4-5)	Measurements are somewhat inaccurate and imprecise. Observations are incomplete. There are 3 or more minor errors using symbols, units and significant digits or 2 major errors	
	Good (6-8)	Measurements are mostly accurate. Observations are generally complete. Work is organized. Only 2 or 3 minor errors using symbols, units and significant digits.	
	Outstanding (9-10)	Measurements are both accurate and precise. Observations are very thorough and may	

		recognize possible errors in data collection. Work is neat and organized. Includes appropriate symbols, units and significant digits.	
Analysing and Concluding	Poor (0-3)	Provides limited analysis of the data. Demonstrates limited ability to draw conclusions based on the data.	
	Average (4-5)	Provides some analysis of the data. Demonstrates some ability to draw conclusions based on the data.	
	Good (6-8)	Provides sufficient analysis of the data. Draws valid conclusions based on the data.	
	Outstanding (9-10)	Provides rich analysis of the data. Draws insightful conclusions based on the data.	
Safety	Poor (0-3)	Proper safety precautions are consistently missed. Needs to be reminded often during the lab.	
	Average (4-5)	Proper safety precautions are often missed. Needs to be reminded more than once during the lab.	
	Good (6-8)	Proper safety precautions are generally used. Uses general reminders of safe practices independently.	
	Outstanding (9-10)	Proper safety precautions are consistently used. Consistently thinks ahead to ensure safety. Will often help other students to conduct labs safely.	
Specifications (Computer Program)	Poor (0-3)	The program is producing incorrect results.	
	Average (4-5)	The program produces correct results but does not display them correctly.	
	Good (6-8)	The program works and produces the correct results and displays them correctly. It also meets most of the other specifications.	
	Outstanding (9-10)	The program works and meets all of the specifications.	
Readability (Computer Program)	Poor (0-3)	The code is poorly organized and very difficult to understand.	
	Average (4-5)	The code is readable only by someone who knows what it is supposed to be doing	
	Good (6-8)	The code is fairly easy to understand.	
	Outstanding (9-10)	The code is exceptionally well organized and very easy to follow.	
Reusability	Poor (0-3)	The code is not organized for reusability.	

(Computer Program)	Average (4-5)	Some parts of the code could be reused in other programs.	
	Good (6-8)	Most of the code could be reused in other programs.	
	Outstanding (9-10)	The code could be reused as a whole, or each routine could be reused.	
Documentation (Computer Program)	Poor (0-3)	The documentation is simply comments embedded in the code and does not help the reader understand the code.	
	Average (4-5)	The documentation is simply comments embedded in the code with some simple header comments separating routines	
	Good (6-8)	The documentation consists of embedded comment and some simple header documentation that is somewhat useful in understanding the code.	
	Outstanding (9-10)	The documentation is well written and clearly explains what the code is accomplishing and how.	
Timely submission (Computer Program)	Poor (0-3)	The code was more than 2 weeks overdue.	
	Average (4-5)	The code was within 2 weeks of the due date.	
	Good (6-8)	The program was delivered within a week of the due date.	
	Outstanding (9-10)	The program was delivered on time	
Efficiency (Computer Program)	Poor (0-3)	The code is huge and appears to be patched together.	
	Average (4-5)	The code is brute force and unnecessarily long	
	Good (6-8)	The code is fairly efficient without sacrificing readability and understanding.	
	Outstanding (9-10)	The code is extremely efficient without sacrificing readability and understanding	

Experiment No.1

Title: Positive Negative Number Count

Aim: Write X86/64 ALP to count number of positive and negative numbers from the array

Objectives:

- To understand the concept of sign bit.
- To study and implement the jump and bt instructions to find whether number is positive or negative.

Software/Hardware Required:

Core 2 duo/i3/i5/i7 - 64bit processor

Operating System – ubuntu/Fedora 64bit OS

Assembler: NASM

Editor Used – gedit

Theory:

Explanation:

Positive Numbers and negative numbers:

If the most significant bit of given number is 0 then the number is positive else the number is negative.

Logic: Check MSB of number using BT instruction. BT saves the value of the bit indicated by the base (first operand) and the bit offset (second operand) into the carry flag. Then use JNC instruction to checks the contents of a result of BT instruction. If carry is generated then increment negative count else increment positive count.

Assembler Directives Used:

global

macro

db

dq

.data

.code

.bss

resb

equ

Instructions Used:

BT: Bit Test

JNC: Jump Not Carry

AND: Logical AND

ADD: Addition

External Functions: No external function is used.

Input: An array declared in data segment.

Output: Positive Numbers and Negative numbers count.

Mathematical Model

Let y=F(x) be a solution for the above problem.

Let S be a system such that

s={ x1,x2,x3,x4,x5,x6,x7, y , N}where x1,x2,x3 ,x4,x5,x6,x7 are the inputs to the system

y=Y,Z is the output of system

N is the number of elements in array

Y=F(x) where F function performs counting of positive numbers from x inputs and stores the result in variable Y.

Z=G(x) where G function performs counting of negative numbers from x inputs and stores the result in variable Z.

Deterministic Data analysis

1. If ∃ x(i) such that |X|= 0 return error
2. If ∃x(i) such that |X|≠ 0 then Y=F(X) and Z=G(X) i.e. positive and negative numbers count.

Success State

When function performs successful positive and negative numbers count operation i.e. {Y, Z | X->Y, Z}

End State

When function does not perform positive and negative numbers count operation.

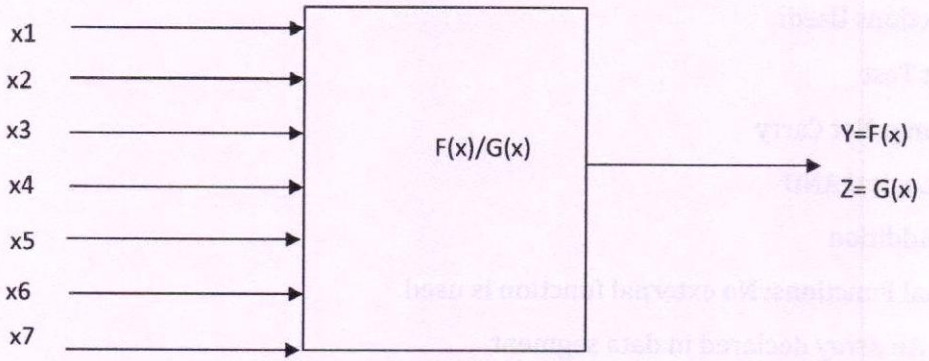


Fig 1.a Block Diagram

State Diagram

In a state diagram

1. q0 state indicates the initial state.
2. q1 state indicates the successful positive and negative numbers count operation.
3. q2 state indicates the unsuccessful operation
4. q3 state indicates the final result.
5. q4 state indicates the termination of operation.

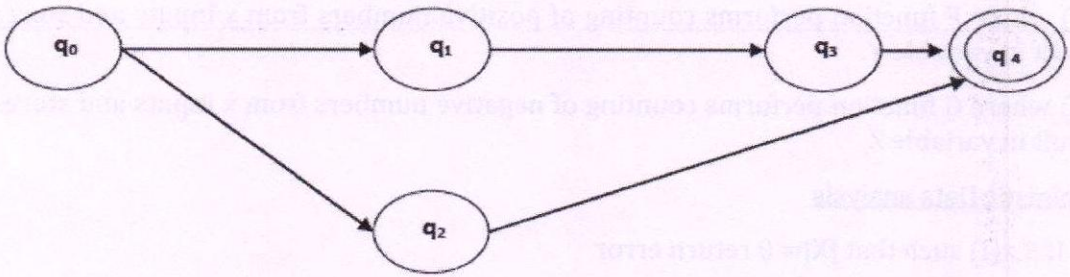


Fig 1.b State Diagram

Flowchart:

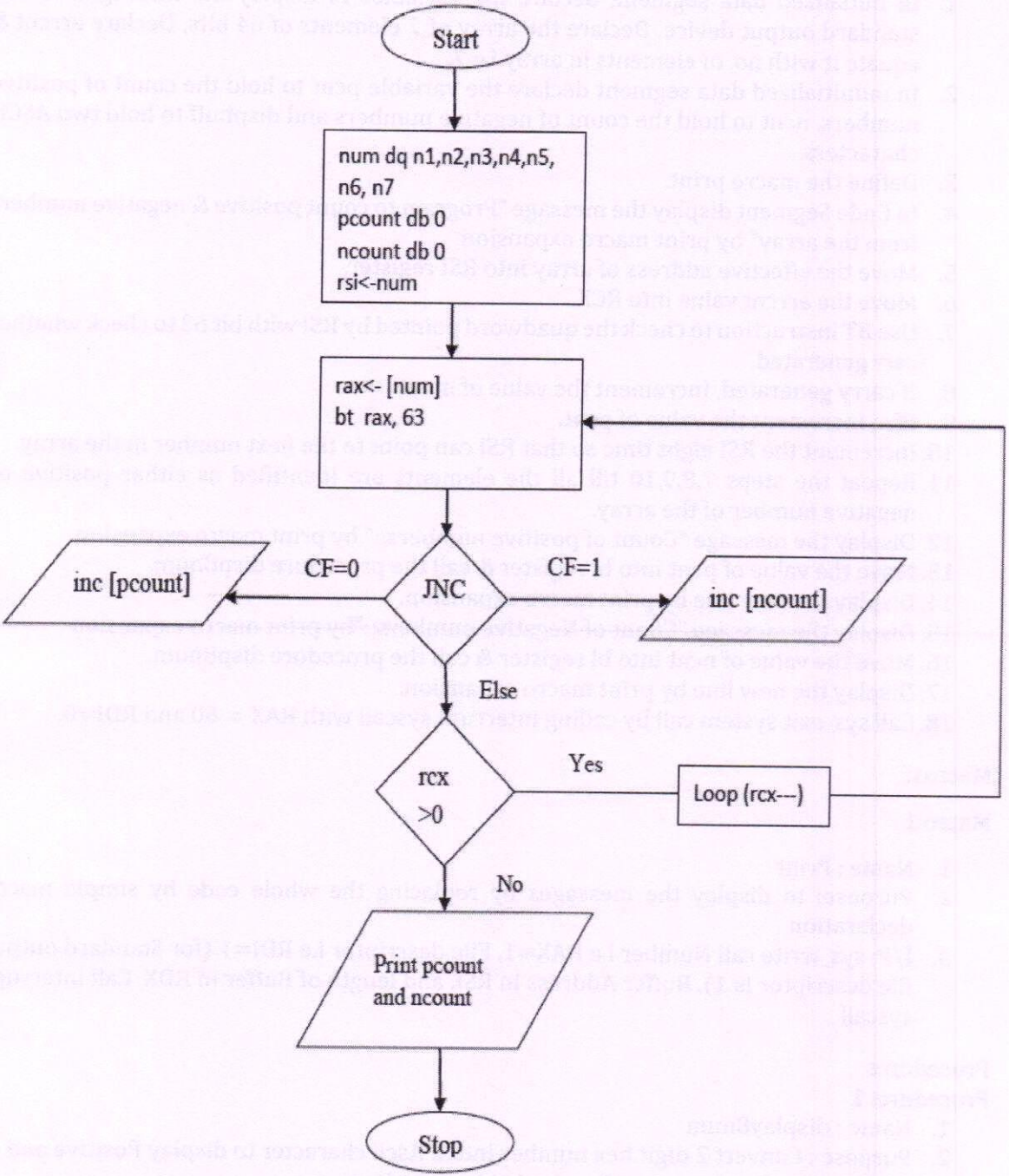


Fig1.c: Flowchart to count number of positive and negative numbers from the array

Main Algorithm:

1. In initialized data segment, declare the variables to display the messages on the standard output device. Declare the array of 7 elements of 64 bits, Declare arrcnt & equate it with no. of elements in array i.e 7.
2. In uninitialized data segment declare the variable pcnt to hold the count of positive numbers, ncnt to hold the count of negative numbers and dispbuff to hold two ASCII characters.
3. Define the macro print.
4. In Code Segment display the message "Program to count positive & negative numbers from the array" by print macro expansion
5. Move the effective address of array into RSI register.
6. Move the arrcnt value into RCX.
7. Use BT instruction to check the quadword pointed by RSI with bit 63 to check whether carr generated.
8. If carry generated, Increment the value of ncnt.
9. Else Increment the value of pcnt.
10. Increment the RSI eight time so that RSI can point to the next number in the array.
11. Repeat the steps 7,8,9,10 till all the elements are identified as either positive or negative number of the array.
12. Display the message "Count of positive numbers::" by print macro expansion
13. Move the value of pcnt into bl register & call the procedure disp8num.
14. Display the new line by print macro expansion.
15. Display the message "Count of Negative numbers::"by print macro expansion
16. Move the value of ncnt into bl register & call the procedure disp8num.
17. Display the new line by print macro expansion.
18. Call sys_exit system call by calling interrupt syscall with RAX = 60 and RDI=0.

Macros:

Macro 1

1. Name : Print
2. Purpose: to display the messages by replacing the whole code by simple macro declaration
3. I/P: sys_write call Number i.e RAX=1, File descriptor i.e RDI=1 (for Standard output file descriptor is 1), Buffer Address in RSI, and length of Buffer in RDX. Call interrupt syscall

Procedures

Procedure: 1

1. Name : display8num
2. Purpose : Convert 2 digit hex number into 2 Ascii character to display Positive and negative number count on Standard output (stdout).
3. I/P : bl=pcnt/ncnt
4. Algorithm for Procedures
    a. Move RSI with effective address of dispbuff.

b. Initialize rcx by 2
c. Rotate the contents of bl to the left side by 4 bits.
d. Move the contents of bl into al
e. And the contents of al with 0fH
f. Compare al with 09h
    i. If al is below or equal then add 30H in al
    ii. Else add 37H in al
g. Move the content of al into memory pointed by RSI
h. Increment RSI
i. Repeat from step c to h until rcx is not equal to 0
j. Expand macro print with the parameters dispbuff & 2.
k. return

References:

- Ray Seyfarth, "Introduction to 64 Bit Intel Assembly Language Programming for Linux", ISBN- 13 : 978-1 466470033, ISBN-10 : 1466470038
- Assembly Language Tutorial [online]: www.tutorialspoint.com
- INTEL 80386 PROGRAMMER'S REFERENCE MANUAL 1986

Frequently Asked Questions

Q. No	Questions	BT	CO
1	What do you mean by initialization of data segment?	2	1
2	Draw and explain EFLAG register.	2	1
3	What is the full form of .bss	1	2,3
4	Define Assembler Directive?	2	2,3
5	What is Assembler?	2	2,3
6	What is System Call?	2	2,3
7	What is Interrupt?	2	2,3
8	Explain bt, inc and jnc instructions with example.	2	2,3
9	Explain Code Segment, Data Segment and Stack Segment.	2	2,3
10	Why we indicate FF as 0FF in program?	3	2,3
11	What is the difference between "Jump" & "Call" instruction?	4	2,3
12	Write down difference between Macro and Procedure.	4	2,3
13	What is the maximum size of the instruction in 8086 and 80386	2	1
14	Which bit is the sign bit of byte, word, double word and quadword data type.	3	2,3
15	How many segment registers present in 80386 microprocessor.	2	1

Guidelines for Students

- The experiments should be completed and get checked by the concerned teacher in the lab on or before the date of submission. After which the experiment will not be signed.

- Every experiment must be included in the file in following format.
  a. **Aim**: In this section write complete objective of the program you are going to make in the lab. This section specifies the complete description of the including problem analysis, input description, method used, fundamental concept and desired output format.
  b. **Theory**: Write brief theory related to practical.
  c. **Algorithm**: Write Algorithm for given task.
  d. **Input**: Write input test data/ or program that are used to test program objective to see whether program is achieving the given objective or not.
  e. **Output**: describe the results in few lines
  f. **Conclusion**: Write complete conclusion whether what the student has learned from this experiment.
  g. **Source Code**: Submit in the form of soft copies.

- Marking criteria.
  a. Experiment completion (Timely)
  b. Lab file (neatness and regularity)
  c. Viva (from time to time)
  d. Mock Practical Exam
  e. Exam (end term): Practical + Viva

Assessment Methodology

- Timely completion of assignment- 2marks
- Program demonstration- 4 marks
- Viva-voce -2 marks
- Timely submission of journal- 2 marks

Experiment No. 2

Title: Study of IC-74LS83 as a BCD adder.

Problem Definition & Aim of Experiment:

1. Design and Implement 1 digit BCD adder using IC-74LS83
2. Design and Implement 4-bit Binary sub tractor using IC-74LS83.

Objective of Experiment:

To understand how both arithmetic operations, addition & subtraction, can be performed by single IC.

Lab Equipments and IC's Used:

Experimental kit, 74LS83, 74LS08, 74LS32, 74LS04

Theory:

A binary adder is a digital circuit that produces the arithmetic sum of two binary numbers. It can be constructed with full adders connected in cascade, with the output carry from each full adder connected to the input carry of next full adder in chain. The augends bits of 'A' and the addend bits of 'B' are designated by subscript numbers from right to left, with subscript 0 denoting the least significant bits. The carries are connected in chain through the full adder. The input carry to the adder is C_0 and it ripples through the full adder to the output carry C_4.

Note: The BIOS in many personal computers stores the date and time in BCD because the MC6818 real-time clock chip used in the original IBM PC AT motherboard provided the time encoded in BCD. This form is easily converted into ASCII for display.

A BCD adder is a circuit that adds two BCD digits and produces a sum digit also in BCD. BCD addition procedure can be summarized as follows,

Operation:

Case1: Sum is less than 9 carry 0.

Output Y is 0. Hence second input to adder is 2 i.e. B3B2B1B0 = 0000

Therefore the o/p of the adder is 1 and adder 2 is same

Case2: Sum is less than 9 carry 1.

In this the carry output of adder is 1is high i.e. 1.Thus correction of six [(0110)2] has to be applied. Thus the o/p Y has to be 1.

Case3: Sum is greater than 9.

Since the sum of the adder is 1 is invalid BCD correction has to be applied.

Thus the o/p has to be 1.

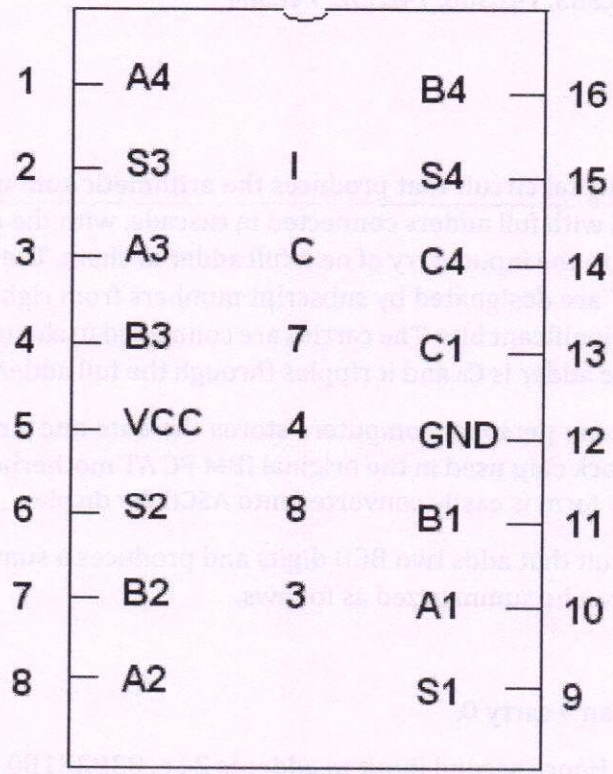
Thus for combinational circuits o/p has to be 1. If the sum is greater than 9 and carry is 1.

$Y = S3\ (S1+S2) + C0$

Thus to implement BCD adder we require:

a. 4 bit binary adder for initial addition.
b. Logic circuits to detect sum greater than 9.
c. One more 4 bit adder to add $(0110)_2$.

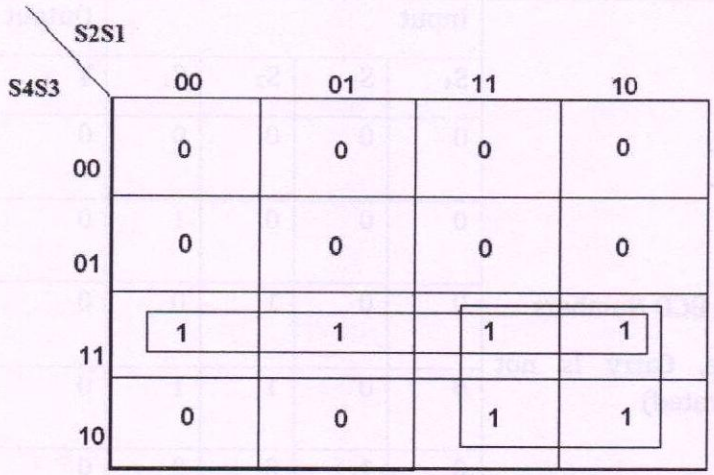
Pin Diagram of IC7483:



Truth Table:

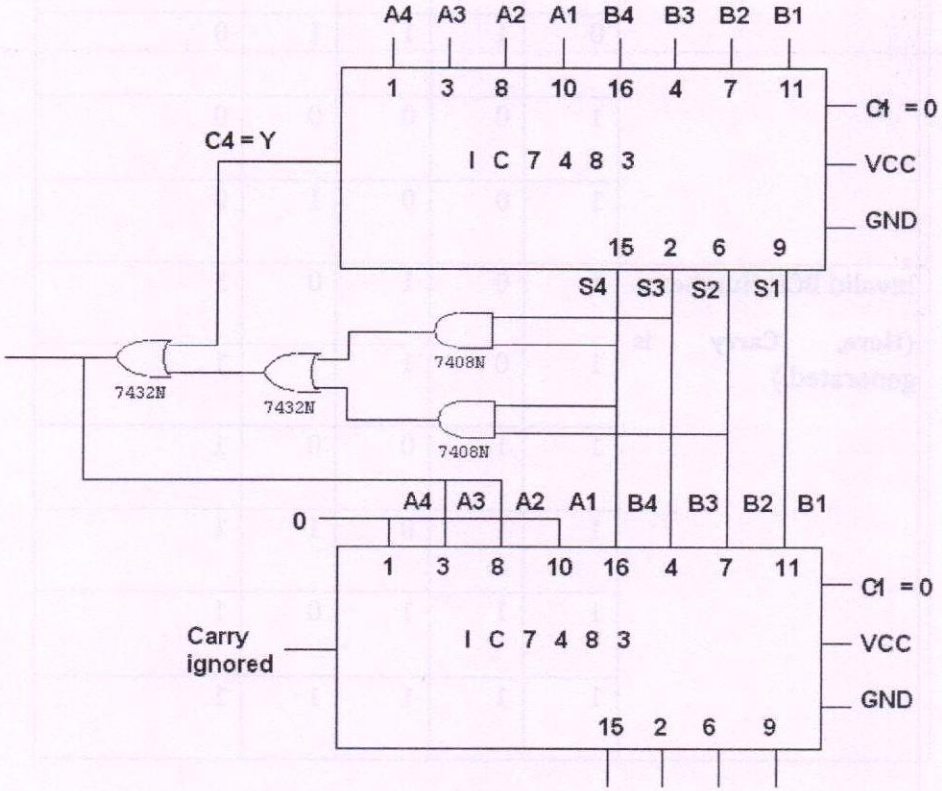
	Input				Output
	S_4	S_3	S_2	S_1	Y
Valid BCD Numbers (Here, Carry is not generated)	0	0	0	0	0
	0	0	0	1	0
	0	0	1	0	0
	0	0	1	1	0
	0	1	0	0	0
	0	1	0	1	0
	0	1	1	0	0
	0	1	1	1	0
	1	0	0	0	0
	1	0	0	1	0
Invalid BCD Numbers (Here, Carry is generated.)	1	0	1	0	1
	1	0	1	1	1
	1	1	0	0	1
	1	1	0	1	1
	1	1	1	0	1
	1	1	1	1	1

K Map for Output Y:



$Y = S_4 S_3 + S_4 S_2$

BCD ADDER DIAGRAM:



Note: C_1 is C_{in} of the First Full Adder of the cascaded arrangement (4 Full adders are cascaded in the IC7483 to add two 4 bit numbers), whereas, C_4 is the C_{out} of the last Full Adder of the cascaded arrangement. Hence, C_1 of both the IC7483 are kept low.

74LS83 as a Binary Subtractor:

Subtraction can be visualized as addition of two numbers. There are numerous ways to perform subtraction viz. 2's Compliment Method, 9's Compliment Method, 10's Compliment Method, etc.

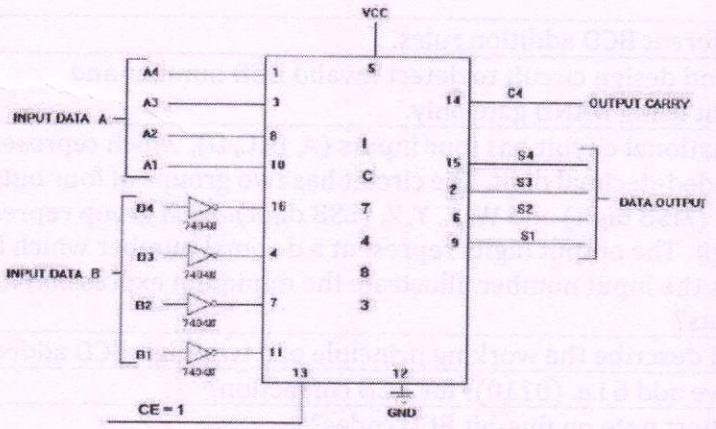
To perform binary subtraction with the adder IC, 2's complement logic is applied. If we want to perform operation (A-B) then in this subtraction A is minuend and B is subtrahend.

PROCEDURE:

1. Take 2's complement of subtrahend.
2. 2's complement=1's complement + 1
3. Add 2's complement of subtrahend in minuend.

The circuit for subtracting A-B consists of an adder with inverters, placed between each data input 'B' and corresponding input of full adder. The input carry Co must be equal to 1 when programming subtraction.

4- bit Binary Subtractor Diagram



Truth Table:

Input data A				Input Data B				Subtraction				
A4	A3	A2	A1	B4	B3	B2	B1	Borrow	S4	S3	S2	S1
1	0	0	0	0	0	1	0	1	0	1	1	0
1	0	0	0	1	0	0	0	1	0	0	0	0
1	0	0	1	0	0	1	1	1	0	1	1	0
0	1	1	1	0	1	0	1	1	0	0	1	0
0	1	1	0	0	0	0	1	1	0	1	0	1

References:

1. Anand Kumar, "Fundamentals of digital circuits" 1st edition, Prentice Hall of India, 2001
2. MykePredko, "Programming and customizing the 8051 microcontroller", Tata McGraw Hill 2003.
3. R.P. Jain , "Modern digital electronics" , 3rd edition , 12th reprint Tata McGraw Hill Publication, 2007.
4. Morris Mano, "Digital Logic and Computer Design" 4th edition, Prentice Hall of India, 2013.

Questions:

S. No	QUESTION	BT Level	CO
1	Write different BCD addition rules.	1	1
2	Discuss and design circuit to detect invalid BCD number and implement using NAND gate only.	1	1
3	A combinational circuit has four inputs (A, B, C, D), which represent a binary coded-decimal digit. The circuit has two groups of four outputs -S, T, U, V (MSB digit) and W, X, Y, Z. (LSB digit). Each group represents a BCD digit. The output digits represent a decimal number which is five times the input number. Illustrate the minimum expression for all the outputs?	3	1
4	Draw and describe the working principle of a two-digit BCD adder.	2	1
5	Why do we add 6 i.e. $(0110)_2$ for BCD correction?	2	2
6	Write a short note on five-bit BCD codes?	2	2

7	**Solve** arithmetic operation indicated below. Follow signed bit notation: i. 001110 + 110010 ii. 101011 - 100110. b) **Explain** the importance of gray code?	3	1
8	**Solve** (3250 - 72532)10 using 10's complement?	3	1
9	In a 32 bit computer, what are the maximum and minimum possible binary numbers? **Convert** these into maximum and minimum possible positive decimal numbers?	2	1
10	**Convert** the octal numbers into binary, decimal, BCD and Hexadecimal numbers (3600)octal,(1200)octal,(0200)octal,(0777)octal.	2	1
11	**Convert** the decimal numbers into binary, BCD and Hexadecimal numbers (3600)d, (1200)d, (0200)d, (0777)d.	2	1
12	Suppose you have a cheque for RS.10000/-.what is the number system used? **Define** base system used and what are the weights of the digits 1,0,0,0,0 and 0 now?	3	1

Guidelines for students:

- The students should verify the truth table.
- Fair diagram should be redrawn with the pencil.
- The conclusion should be written based on the results generated after performing the experiment.

Assessment methodology:

- Each experiment will be accessed out of 10.
- Attending the lab session will carry 01 mark.
- Performing and showing result of the experiment carry 02 marks.
- Submitting the file in the scheduled time will carry 07 marks.

Experiment No. 3

Title: Kinematic viscosity of liquid

Problem Definition and Aim of Experiment: To find kinematic viscosity of liquid and its variation with temperature.

Objective of Experiment

1. To understand of kinematic Viscosity
2. To find out effect of temperature on Kinematic Viscosity

Theory

1. Introduction
   - Definition of viscosity of a liquid
   - Define Dynamic viscosity and kinematic viscosity with equations. Variation of viscosity with temperature.
   - Why do we need to have viscous fluids for lubrication of rubbing surfaces in machinery?
2. Definition
   Kinematic viscosity of a liquid can be determined with the help of a Redwood Viscometer. The variation of viscosity with temperature is given by the formula:

$$\nu = \frac{A.t - B}{t} \qquad (1.1)$$

where ν is the kinematic viscosity in stokes, A and B are constants and 't' is the time in seconds required to collect $50cm^3$ of liquid in the measuring flask.

Experimental Set-up

For finding kinematic viscosity of liquid with variation in temperature, we are using Redwood viscometer as shown in Figure 1.1.

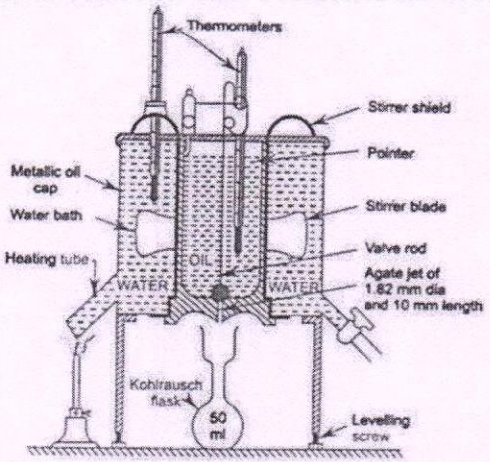


Figure 1.1 Redwood viscometer

Redwood viscometer with its accessories such as a flask, ball valve, heating arrangement, thermometer, stop watch etc.

Procedure

1. Level the viscometer with the help of levelling screws.
2. Fill the water jacket with water and heat it to the desired temperature through the heater and water jacket provided.
3. Close the orifice by means of a ball valve and pour the liquid for which the viscosity is to be determined into the cylinder upto the index mark.
4. Record the temperature of oil. Keep the measuring flask below the orifice.
5. Lift the ball valve and start the stop watch simultaneously. Measure the time in seconds required to collect 50cm^3 of liquid in the measuring flask.
6. Repeat the observation by heating the liquid to various temperatures.

Observation Table

Sr. No.	TEMPERATURE, °C	TIME, t, second	KINEMATIC VISCOSITY, ν, Stokes
1			
2			
3			
4			
5			
6			
7			
8			

Technical Data

- Diameter of cylinder = 47.625 mm
- Height of cylinder = 88.5 mm
- Diameter of the orifice = 1.2 mm
- Length of the orifice = 12 mm

Calculations

1. Kinematic Viscosity, $\nu = \frac{A.t - B}{t}$ (1.1)

where, A = 0.0026 and B = 1.176

Graph

Draw a graph of Kinematic viscosity ν in stokes Vs. Temperature in °C. Ideal Graph of common liquids and gases is shown in Figure 1.2.

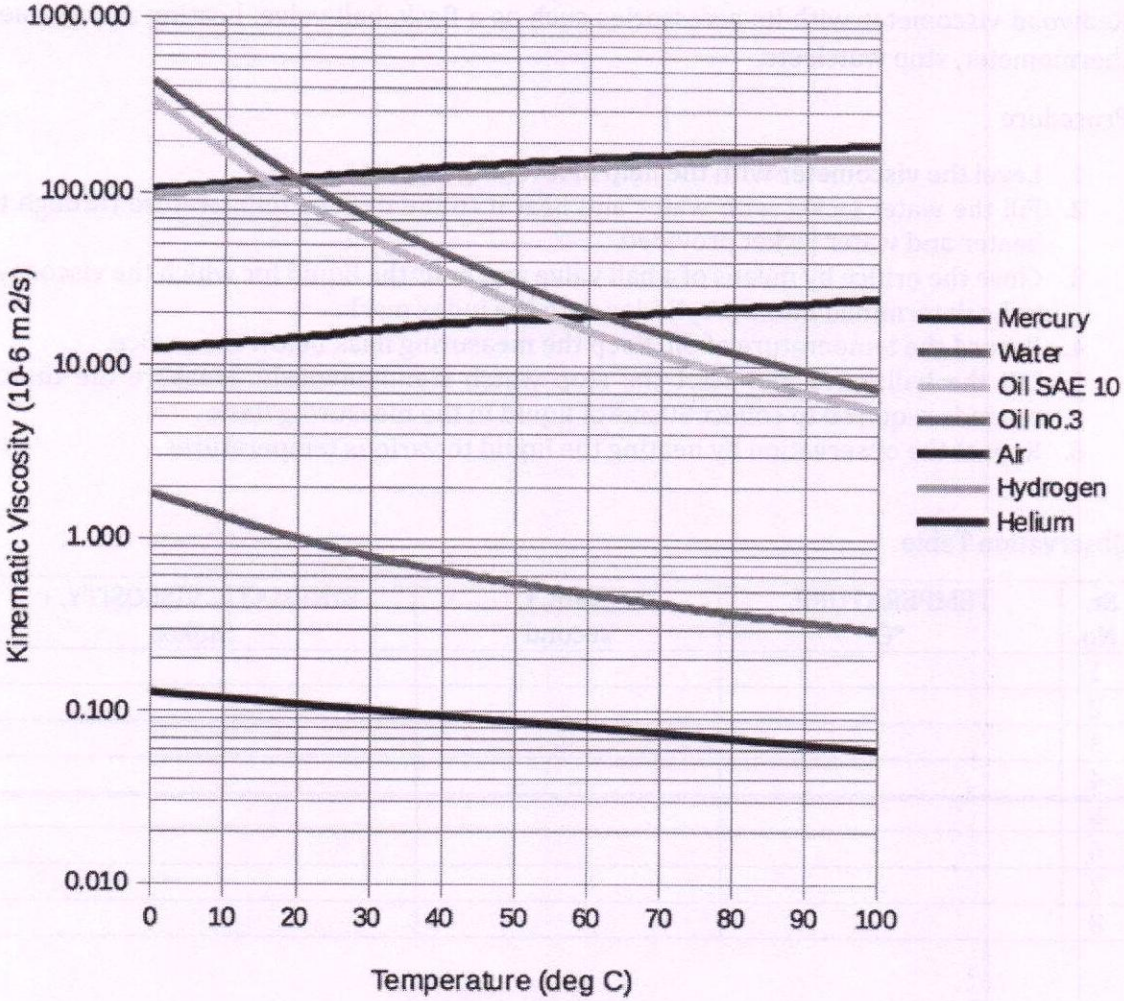


Figure 1.2 Ideal Graph of common liquids and gases

Results / Discussion

Comment on the variation observed in the graph between the Kinematic viscosity and temperature. This method only facilitates a comparison of viscosities of different liquids. The exact value of viscosity of any liquid can however be obtained by comparison with the value of time 't' for liquids of known viscosity.

References

1. Streeter, V. L. and Wylie, E. B., "Fluid Mechanics", McGraw Hill International Book Company, N.Y.
2. Kumar, K. L., "Engineering Fluid Mechanics", Eurasia Publishing House (P) Ltd., Ram Nagar.
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4. Jain, A. K., "Fluid Mechanics", Khanna Publishers, Delhi.
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9. White, F. M., "Fluid Mechanics", McGraw Hill Inc., N.Y.
10. Dr. Bansal, R. K., [2000] "Fluid Mechanics & hydraulics machines", Laxmi Publication Pvt. Ltd., New Delhi.

Questions related to the experiment

Que.	Question	CO	BT
Q1.	Define the following fluid properties: (i) Density, (ii) weight density, (iii) specific volume and (iv) specific gravity of a fluid.	CO1	Level 1
Q2.	Differentiate between: (i) Liquids and gases, (ii) Real fluids and ideal fluids, (iii) Specific weight and specific volume of a fluid.	CO2	Level 2
Q3.	What is the difference between dynamic viscosity and kinematic viscosity? State their units of measurements.	CO2	Level 2
Q4.	Explain the terms: (i) Dynamic viscosity, and (ii) Kinematic viscosity. Give their dimensions.	CO2	Level 2
Q5.	State the Newton's law of viscosity and give examples of its application.	CO1	Level 1
Q6.	Enunciate Newton's law of viscosity. Explain the importance of viscosity in fluid motion. What is the effect of temperature on viscosity of water and that of air?	CO2	Level 2
Q7.	Define Newtonian and Non-Newtonian fluids.	CO1	Level 1

Questions related to the applications of the experiment

Que.	Question	CO	BT
Q1.	If you use highly viscous fluid in your vehicle, what will going to happen?	CO1	Level 4
Q2.	In cold seasons, why car/automobile takes considerable time to start after cranking?	CO2	Level 3

Guidelines for Submission:

- The journal must contain the following related to every experiment:
- Theory related to the experiment
- Apparatus with their detailed specifications
- Schematic, Layout diagram (must be drawn using lead pencil)
- Observation table/ simulation plots/graphs

- Sample calculations for one/two reading
- Result table
- Graph (must be drawn on graph paper using lead pencil)
- Conclusions from the graph/s
- Answers of short questions related to the experiment asked at the end of every experiment in his own language as per his/her understanding
- Relevance of practical/assignment in real life /industry

Assessment Methodology:

- Assessment of submission by student for every experiment will be a continuous assessment for the TW
- Assessment will be based on understanding of theory, attentiveness during practical, and understanding.
- How efficiently the student can do connections to get the results.
- Timely submission of journal.

Experiment No. 4

Title: To determine hardness of water sample.

Problem Definition: Hard water means water containing dissolved salts of calcium and magnesium. High levels of calcium and magnesium salts can affect several organs in our body and cause health problems. One of the harsh effects of hard water is the risk of cardiovascular disease. In steam generation hard water causes boiler's problems like priming, foaming, caustic embrittlement, scales & sludges etc. Water hardness reduces the efficiency of boilers. In electronics industry salts of calcium and magnesium are responsible for additional conductivity which may lead problems in process side. Hard water is totally unfit for drinking and industrial purpose and we have to remove hardness from water.

Aim of Experiment: To determine the total hardness of given water sample by EDTA method

Objectives: (a) To understand the meaning of hardness.

(b) Quantitative analysis of hardness.

Chemicals: 0.01 M EDTA (approx), 0.0___M $ZnSO_4$,, $NH_4OH - NH_4Cl$

Buffer solution, Erichrome Black T (EBT) indicator.

Apparatus: Burette, Conical flask, Volumetric flask

Theory: Hardness is caused by dissolved salts of calcium & magnesium. There are two types of hardness:

1. Temporary hardness – This is caused by the presence of bicarbonate salts of calcium and magnesium. This can be removed by boiling of hard water, which causes the salts to decompose into insoluble carbonates
2. Permanent hardness – This is due to the presence of sulphate, nitrate & chloride salts of calcium and magnesium. These salts are not removed by heating so have to be remove these salts by chemical methods

The total hardness of water includes both temporary and permanent hardness.

To determine the total hardness of water, EDTA method is used. The disodium salt of ethylene diamine tetra acetic acid forms stable metal complexes with calcium and magnesium ions at pH 10.

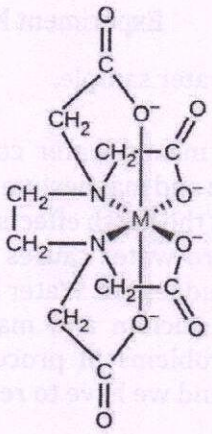

Fig. 1 : Structure of metal-EDTA complex

For the titration Erichrome Black T is used as indicator. At pH 7 -11 it has blue colour. When indicator is added to hard water sample containing both Ca^{++} and Mg^{++}, the magnesium ions form a stable Mg-EBT complex with indicator which is wine red in colour.

When EDTA from burette is added to the hard water sample in conical flask Ca-EDTA complex is first formed. When all Ca^{++} ions are used up, EDTA snatches the Mg^{++} ions from Mg-EBT complex to form Mg-EDTA complex leaving indicator free which is blue in color. This is the endpoint of the titration and the volume of EDTA consumed corresponds to the EDTA required for complexing with the calcium and magnesium ions present in the water sample.

Reaction:

Mg^{++} + EBT ----------> Mg - EBT (wine red complex)

Ca^{++} + EDTA ----------> Ca - EDTA (colorless complex)

EDTA + Mg -EBT ----------> Mg- EDTA + EBT

(Wine red complex) (Colorless) (Blue)

Procedure:

Standardisation of EDTA

1. Fill burette -1, with std.zinc sulphate solution and burette -2, with EDTA solution.
2. From burette -1, take 9 ml of std.zinc sulphate solution into a 250 ml conical flask. To

this add 3-5 ml of buffer solution and 3 drops of Erichrome black-T indicator. Wine red color develops. Titrate this solution against EDTA solution from burette-2, till the colour changes from wine red to blue. This is the end point. Let this burette reading be X_1 ml.

3. Without discarding the above titration mixture, add 1 ml of the std.zinc sulphate solution to it again from burette-1 (total zinc sulphate in the flask is now 10 ml). Wine red color redevelops. Titrate this against EDTA solution from burette-2, till the again colour changes from wine red to blue. Let this burette reading be X_2 ml.

4. To the same flask add 1 more ml of the std. zinc sulphate solution (Total zinc sulphate in the flask is 11 ml) from burette-1. Titrate against EDTA solution from burette-2, till again colour changes from wine red to blue. Let this burette reading be X_3 ml.

5. From these three readings find exact molarity of EDTA solution

Observations:

Standardisation of EDTA

Solution taken in burette-1 : Std. Zinc sulphate

Solution taken in burette-2 : EDTA soln. (approx)

Indicator used : Erichrome Black T

End point : wine red to blue

Reaction: $[Na_2EDTA] + Zn^{+2} \rightarrow [Na_2EDTA(Zn^{+2})complex] + 2H^+$

Observation Table

Burette-1	Std $ZnSO_4$	9 ml	10 ml	11 ml
Burette-2	EDTA	X_1	X_2	X_3

Estimation of Total Hardness:

Repeat the above procedure with given hard water sample in place of std. zinc sulphate solution.

OBSERVATIONS:

Solution taken in burette-1 : hard water sample

Solution taken in burette-2 : EDTA soln.

Indicator used : Erichrome Black T

End point : colour changes wine red to blue

Reaction:

$[Na_2EDTA] + Mg^{+2}/Ca^{+2} \rightarrow [Na_2\ EDTA(Mg^{+2}/Ca^{+2})complex] + 2H^+$

Observation Table

Burette-1	Hard water	9 ml	10 ml	11 ml
Burette-2	EDTA	Y_1	Y_2	Y_3

Reaction:

$[Na_2EDTA] + Mg^{+2}/Ca^{+2} \rightarrow [Na_2\ EDTA(Mg^{+2}/Ca^{+2})complex] + 2H^+$

Calculations:

Standardisation of EDTA

EDTA Vs $ZnSO_4$

$M_1 V_1 = M_2 V_2$

$M_1 \times X_1 = 0.01 \times 9$ (trial 1)

$M_1 = 0.01 \times 9 / X_1$

$M_2 \times X_2 = 0.01 \times 10$ (trial 2)

$M_2 = 0.01 \times 10 / X_2$

$M_3 \times X_3 = 0.01 \times 11$ (trial 3)

$M_3 = 0.01 \times 11 / X_3$

Exact molarity of EDTA $= M_4 = M_1+M_2+M_3 / 3$

$=$ ------ M

To calculate total hardness of water

1000 ml of IM EDTA = 100 gm of $CaCO_3$

1 ml of M_4 M EDTA = 100 X M_4 mg of $CaCO_3$

"Y_1" ml of M_4 M EDTA = 100 x M_4 x Y_1 mg of $CaCO_3$

9 ml of water sample contains 100 x M_4 x Y_1 mg of $CaCO_3$ hardness

hence,1000 ml of water sample contains = 100 x M_4 x Y_1 x 1000 / 9 mg

= -------- A_1 ppm of $CaCO_3$ hardness

Similarly, in trial 2,

1000ml water sample contains = 100 x M_4 x Y_2 x 1000 / 10 mg of $CaCO_3$

= ------ A_2 ppm of $CaCO_3$ hardness

In trial 3,

1000ml water sample contains=100 x M_4 x Y_3 x 1000/11 mg $CaCO_3$

= ------- A_3 ppm of $CaCO_3$ hardness

Total hardness of water sample is = $A_1+A_2+A_3$ / 3

Graph/Chart(Along with ideal/model/graph/charts): (If Applicable) NA

Results :

Molarity of EDTA = ---------- M

Hardness of given water sample = ---------- ppm

Conclusions : (a)Hardness causing salts are present in water sample.

(b) Quantitative analysis of hardness is done by EDTA method.

Data sheet / chart used / data base used / standard specification sheet / application note: (If applicable) NA

References:

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3. G.H. Jeffery, J.Bassett &J. Mendham, R.C. Denney, "Vogels text book of quantitative chemical analysis", 2019.
4. S.S. Dara & S.S. Umare, " A textbook of engg chemistry", 2018 .

Question Bank:

Questions related to the experiments:

Q. No	Question	BT	CO
1	Define hard water & soft water?	1	1
2	Explain hardness of water and its types with examples?	2	2
3	How will you determine the hardness of water by EDTA method? Explain with suitable reactions.	2	2
4	What are problems caused by hard water in different fields?	3	1

Questions related to the applications of the experiments:

Q. No	Question	BT	CO
1	50 ml of a water sample requires 15.9 ml of 0.02M EDTA for titration. 50 ml of same sample after boiling requires 6.4 ml of same EDTA solution. Calculate the temporary and permanent hardness of the water sample.	3	1
2	25 ml of standard hard water containing 1 mg/ml $CaCO_3$ when titrated against EDTA using EBT indicator required 10 ml for the end point. Hence 1ml of EDTA solution reacts with_____ of $CaCO_3$ hardness.	3	2
3	$Ca(HCO_3)_2$ imparts _____ to water	3	1
4	100 ml of water sample requires 18 ml of EDTA solution for the end point with EBT indicator. If 1 ml of EDTA reacts with 1.2 mg of $CaCO_3$ equivalent hardness, calculate the hardness of water sample.	3	1
5	In the determination of hardness of water, why Na_2EDTA is used instead of EDTA ?	3	2

Submission guidelines:

- Students should submit journal on time. Today's experiment is expected to be submitted in the next week during lab hours.
- Observation, diagrams and calculations should be on the plain side of the paper.

Assessment methodology:

- On time submission- 03 marks
- Accuracy of results- 02 marks
- Overall presentation of experiment- 05 marks
- Questions and answers - 05 marks