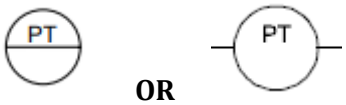
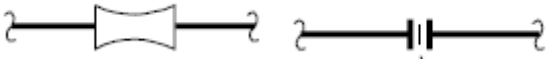
MODEL ANSWER
SUMMER– 18 EXAMINATION

Subject Title:-PROCESS CONTROL SYSTEM **Subject Code:-** 17663

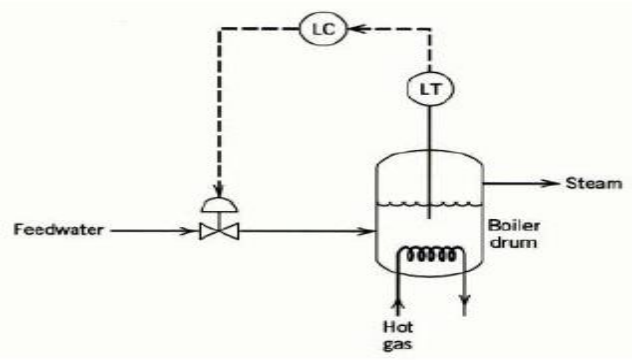
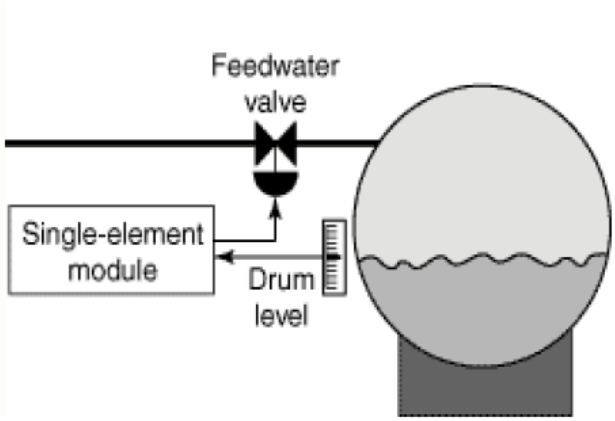
Important Instructions to examiners:

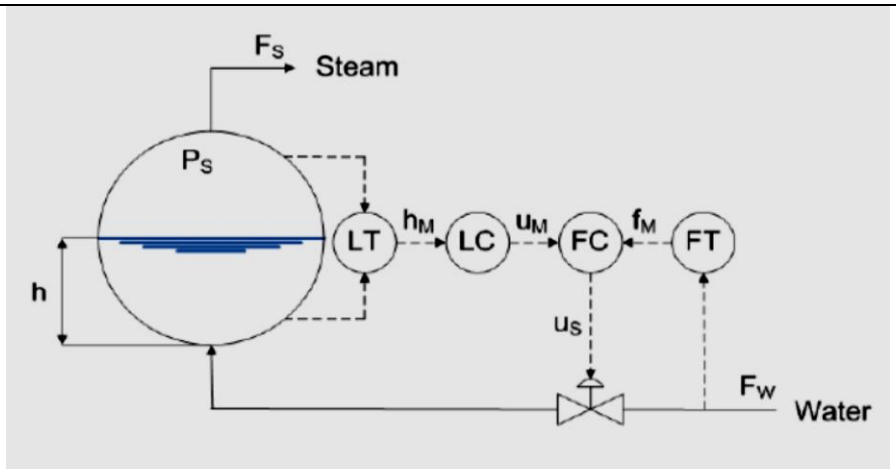
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. No.	Sub Q.N.	Answer	Marking Scheme
Q.1	A)	**Attempt any three of the following :**	12 Marks
	a)	**Draw P and ID symbol for :** **i) Pressure transmitter** **it) Solenoid value** **iii) Orifice meter** **iv) Venturimeter.**	4 Marks
	Ans:	**i) Pressure transmitter**  **OR** **ii) Solenoid valve**  **iii) Orifice** 	1M each

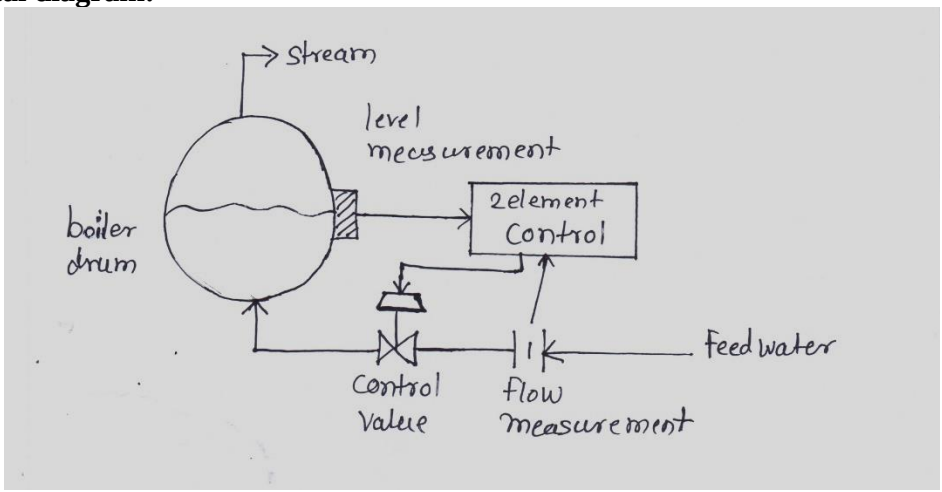
		iv) Venturi  The standard ISA symbols of Venturi and orifice are 	
	b)	**State the need of value positioner.**	**4 Marks**
	Ans:	**Need of valve positioner:** 1) To measure the valve stem position 2) To overcome friction on valve stem through high open loop gain. 3) To increase speed of response when the distance between controller and 4) Valve is large by dead ended controller. 5) To achieve faster response speed. 6) To provide reverse action of signal pressure. 7) Delaying or slowing valve action. 8) Reduces valve hysteresis 9) It can modify valve characteristics	**4 points, 1M each**
	c)	**State selection criteria for DCS system (Four points).**	**4 Marks**
	Ans:	**Selection criteria of DCS:** **1. Nature of Manufacturing and type of product manufactured** • No. of Products manufactured : Single / Multiple • Recipe parameter : Constant or Variable • Procedure : Single or Different • Equipment Utilization : Fixed or Flexible • Frequency of changes to formula & Recipe : Never or Often • Regulatory / Analog loop control • Complex Batch Control **2. The value of the product being manufactured and the cost of downtime** • If the value of the batch is high, either in raw material cost or market value, & the downtime not only results is lost production but potentially dangerous and damaging conditions, the DCS should be selected **3. Factory environment**: : • The environment in process automation can be volatile & dangerous.	**01 Mark for each point (Any 4)**

		• In this scenario, the HMI is a central control room console that provides the only complete "window" into the process, enabling operator to monitor & control the process which are occurring inside pipes & vessels located throughout the plant. **4. Role of operator:** • The DCS plant require an operator to make decision and continuously interact with the process to keep it running. • In fact, operators process knowledge is often critical to operational excellence & keeping the process running optimally. **5. What system performance is required** • The speed of logic execution is a key differentiator between PLC and DCS. While fast scan rates are necessary to be able to effectively control the operations involving motion control, high-speed interlocking, control of motors and drives, he DCS does not have to be that quick. • Control Loops require deterministic Scan execution at speed 100-500ms • System redundancy is often required • Online configuration changes often required • Analog Control – Simple to Advanced PID upto Advanced Process Control- cascade, Split range, Ratio etc. **6. Degree of customization required** • In PLC Powerful Programming languages are typically available to facilitate the creation of custom code from scratch. DCS consists of Pre-engineered solutions consists of standards, templates & extensive libraries. • The highest priority of DCS is to deliver reliability & availability, which often results in a design which trades unlimited functionality for repeatability and dependability.	
	d)	**What is data sheet ? Explain in brief.**	**4 Marks**
	Ans:	**Datasheet:** Data sheet or spec sheet is a document that summarizes the performance and other technical characteristics of a product, machine, component (e.g., an electronic component), material, a subsystem (e.g.a power supply) or software in sufficient detail to be used by a design engineer to integrate the component into a system. **Explanation**:It is one of the documents required for the successful completion of an instrumentation project.Typically, a datasheet is created by the component/subsystem/software manufacturer andbegins with an introductory page describing the rest of the document, followed by listings of specific characteristics, with further information on the connectivity of the devices. In cases where there is relevant source code to include, it is usually attached near the end of the document or separated into another file. Depending on the specific purpose, a datasheet may offer an average value, a typical value, atypical range, engineering tolerances, or a nominal value. The type and source of data are stated on the datasheet. But a technical specification is an explicit set of requirements to be satisfied by a material, product, or service.	**Definition: 2M** **Explanation:2M**

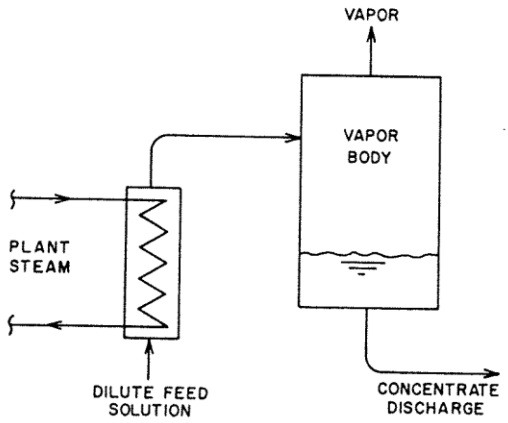
	B)	Attempt any one of the following :	6 Marks
	a)	**Draw physical diagram and P and I diagram for single element and double element boilerprocess control.**	**6 Marks**
	Ans:	**Single-element boiler process:** **P&I Diagram:**  **Physical diagram:**  **Double-element boiler process:** **P&I Diagram:**	**$1\frac{1}{2}$ each**



Physical diagram:

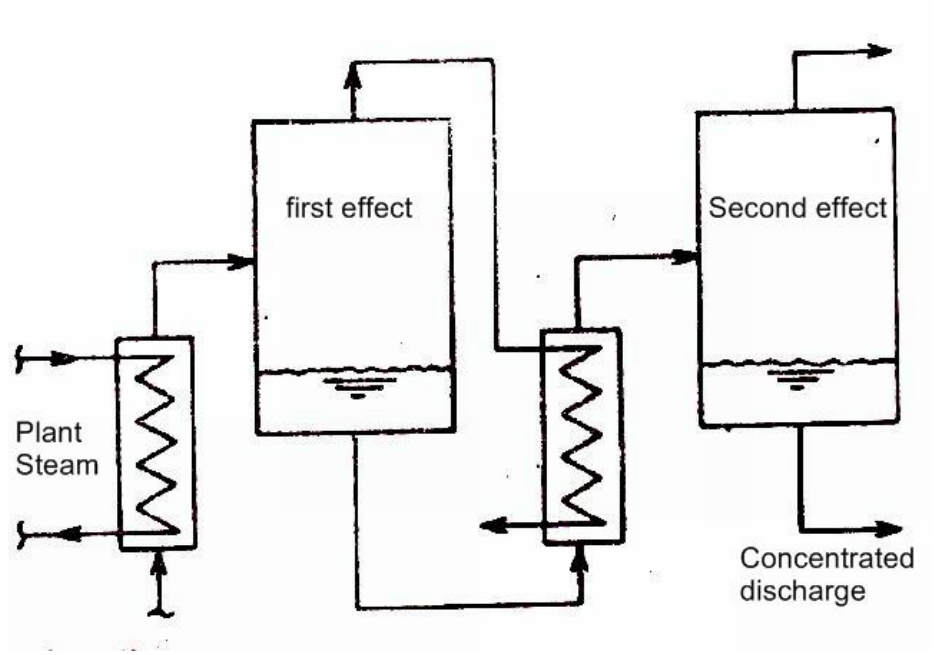


	b)	**Enlist types of Evaporation process. Explain any one with neat diagram.**	**6 Marks**
	Ans:	Evaporation is one of the most important unit operations in food processing and sugar industries. Evaporation process is carried out by two methods- i) Single effect evaporation and ii) Multi-effect evaporation **<u>Single-effect evaporation:</u>** In a single-effect evaporator, steam provides energy for vaporization and the vapor product is condensed and removed from the system. Single-effect evaporation occurs when a dilute solution is contacted only once with a heat source to produce a concentrated solution and pure water vapor discharge.	**Listing:2M** **Diagram:3 M** **Explanation:2M** **(any one to be considered)**

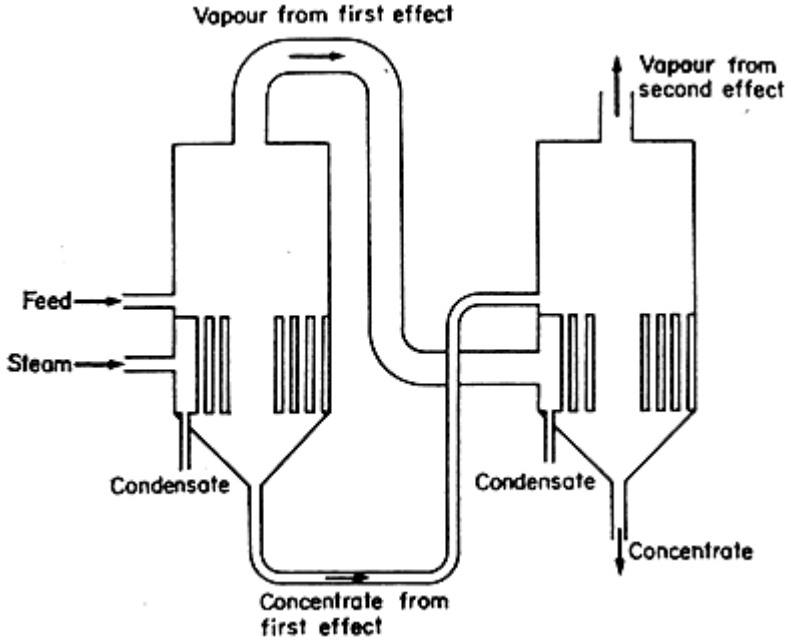
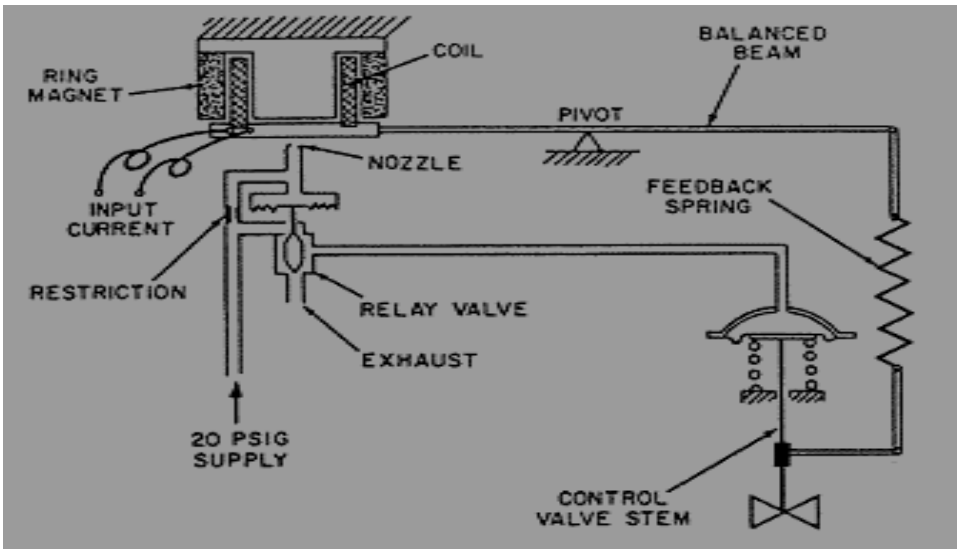


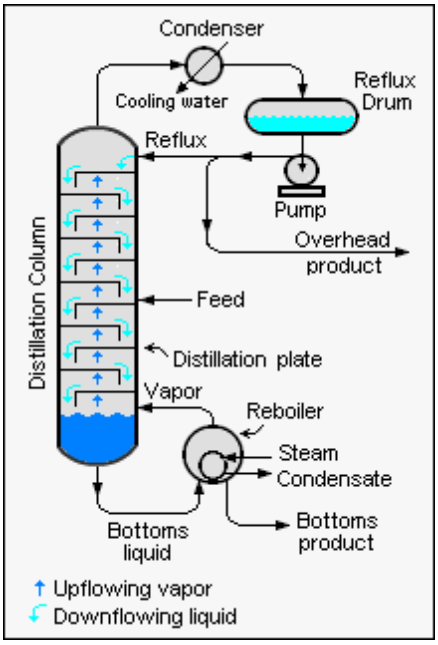
Multiple-effect evaporation:

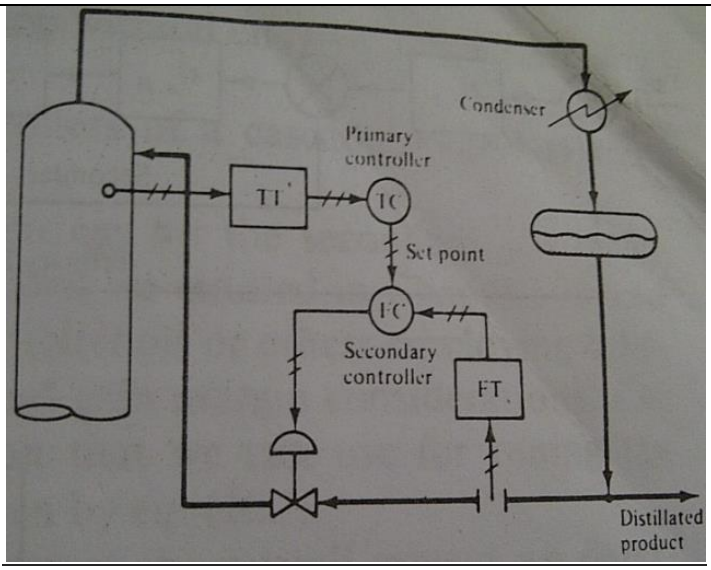
- Multiple-effect evaporations use the vapor generated in one effect as the energy source to an adjacent effect.In a double-effect evaporator, the vapor product off the first effect is used toheat the second vaporization unit. Thus only the first vessel (at the highest pressure) requires an external source of heat.

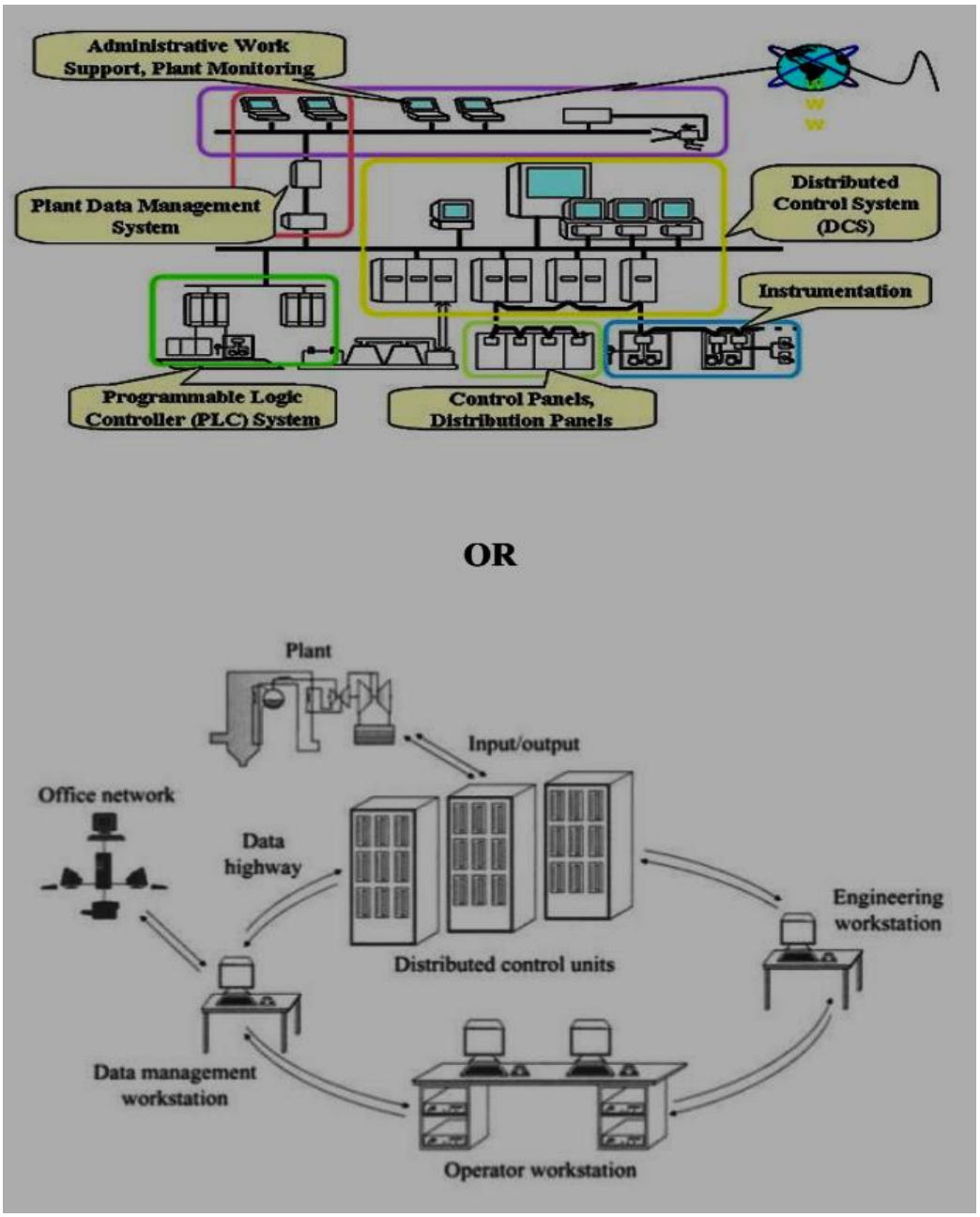


(OR)

			
Q 2		**Attempt any two of the following :**	**16 Marks**
	a)	**Define valve positioner. Draw the neat diagram of electro pneumatic valve positioner. Write its working.**	**8 Marks**
	Ans:	• Definition of valve positioner: The valve positioner is a high gain proportional controller which measures the valve stem position and compares it against its set-point (controller output signal) and if there is a difference, corrects the error by adjusting stem position.  • Electro pneumatic valve positioner has a <u>flapper</u> that compares the motion generated bythe input signal from the controller with the motion generated by the feedback through the linkage connected to the valve stem. • The controller signal of 4-20mA is given to a magnet and coil assembly.	**1 Marks Definition** **3Marks Diagram**

		• One end of a Flapper-nozzle assembly is connected to the magnetic coil. The • other end is connected to the valve stem through the linkage connected to the valve stem. It acts as a feedback. • The controller signal of 4-20mA acts on the magnetic coil which creates a signal in the form of movement of the flapper which is opposed by the feedback through the linkage connected to the valve stem. • The feedback derived from the valve position provides a force to balance the input signal. Thus the desired position is achieved. • A relay valve is attached to the nozzle to provide the supply air to the actuator. Thus the air supply flows to the actuator.	**4Marks Explanation**
	b)	**Describe the working of distillation column with neat diagram. Draw cascade control scheme for any two variables in distillation column.**	**8 Marks**
	Ans:	• Distillation separates a mixture on the basis of difference in relative volatilities, or differences in boiling points, of the components to be separated. • Industrial distillation is performed in large, vertical cylindrical columns known as distillation towers or distillation columns or fractionators • The liquid leaving the column bottom is heated in a reboiler. A reboiler is a special type of heat exchanger used to provide the heat necessary for distillation. Part of this liquid is vaporized and returned into the column. The remaining liquid is taken out as a bottom product, or residue. • The overhead vapour leaving the column from top is sent to a cooler, or condenser, and is collected as a liquid in a receiver, or accumulator or reflux drum. A part of the accumulated liquid is returned to the column as reflux. The remainder is withdrawn as over-head product or distillate.  Cascade control of distillate composition (top product):	**3Marks** **3 Marks**

		 • It is used to regulate the temperature at the top or bottom of the distillation column. • For regulating the temperature of the top of the column, temperature of the overhead output is measured and controlled by TT and TC. This is the primary loop. • Output of TC (primary controller) is given as the set point of the FC. • The flow rate of the distilled product is measured and controlled by FC (secondary controller), whose set point is set by TC. • Thus the secondary loop consists of FT, FC and control valve. This is given back as the reflux flow input to the column. Thus the temperature of the top of the distillation column is regulated. **Note: bottom product also can be considered.**	**2Marks for diagram** **3Marks** **(Explanation is optional)**
	c)	**Draw schematic diagram of DCS in cement industry. Write the steps to control process operation in cement industry.**	**8 Marks**
	Ans:		



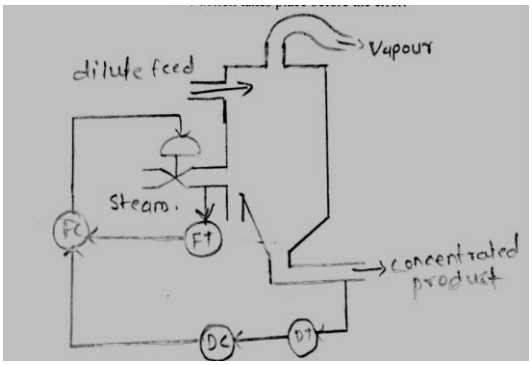
OR

Diagram 4Marks

- A distributed control system (DCS) is a control system for a process where the control elements or modules are distributed throughout the system. It is a multitasking operating system which is user friendly with a data management system. The DCS has capacity for processing large number of I/O points.
- It has a modular system development capacity (expandable) which is easy to use. It has data highway, communication capability and data transmission between separate unites of the data highway which provide very wide band communication.

Explanation 4Marks

Cement industryhas the following units:

		• Crusher section • Raw mill section • kiln and coal mill section • Cement mill section • Packing & dispatch • Each unit will have its own local control room, which are monitored by a central control room. • Raw mill automation is used to control the blending system. • Kiln has optimum control to maintain kiln fuel level, kiln speed, calciner fuel, cooler speed, oxygen content and cooler fan speed. • In packing and dispatch section, automatic bag filling to certain weight and automatic loading in trucks are implemented.	
Q. 3		**Attempt any four of the following :**	**16 Marks**
	a)	**Describe in brief cascade control scheme for evaporation process with neat diagram.**	**4 Marks**
	Ans:	• In the evaporator applications, the product density has to be controlled. • In order to do this, the manipulated variable (steam flow) must be regulated. • The cascade control system has two loop, primary and secondary loops. • The product density is measured by DT, controlled by DC and it's output is given to FC. • The manipulated variable (steam flow) is measured by FT, given to FC which gets its setpoint from DC. • The primary loop consists of DT, DC, and control valve. • The secondary loop consists of FT, FC, control valve • Thus the steam flow rate (manipulated variable) is measured and regulated. • Here the corrective action takes place before the error.  	**Explanation 2 Marks** **Diagram 2Marks**
	b)	**Draw and explain control valve flow characteristics.**	**4 Marks**
	Ans:		

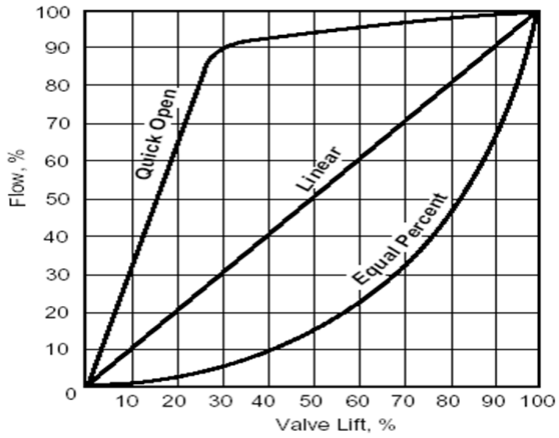


Diagram 2Marks

Quick Opening:
This type of valve is used for full ON / OFF control operation. The valve characteristic shows that relatively small motion of valve stem results in maximum possible flow rate through the valve. It is used when maximum valve capacity must be obtained quickly.

2. Linear –Here flow rate changes linearly with valve travel or stem position

$$\frac{Q}{Q_{max}} = \frac{S}{S_{max}}$$

S is the stem position, Q is the flow rate

3. Equal percentage - this type of valve does not shut off the flow completely in its limit of stem travel. Thus Q_{min} represents the minimum flow when stem is at one limit of its travel. $Q_{max}$is the maximum flow rate. For this valve,

Rangeability R = $\frac{Q_{max}}{Q_{min}}$

- The equal percentage curve shows that the increase in flow rate for a given change in valve opening depends on the extent to which the valve is already open.
- This curve is exponential and is represented by

$$Q = Q_{min}R^{S/S_{max}}$$

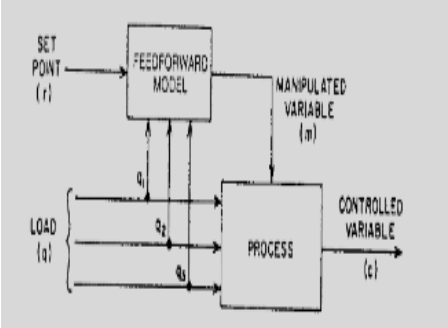
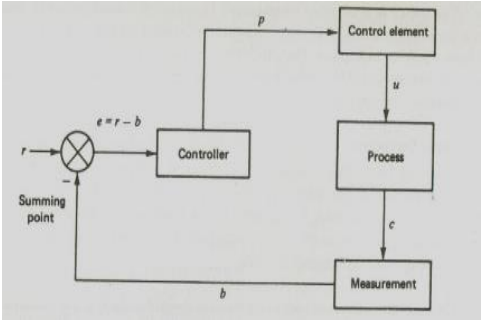
Brief Explanation 2 Marks

c) Compare feed forward control system with feedback control. (Any four pts.) — **4 Marks**

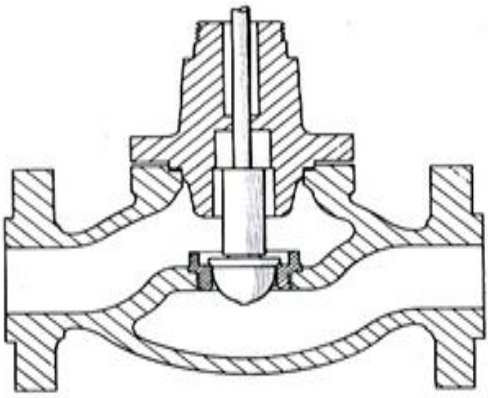
Ans:

No	Feed forward	Feedback
1	Acts before the effect of a disturbance is felt by the system, thus acts in anticipatory manner	Waits until the disturbance affects the system, thus acts in compensatory manner.
2	Good for slow system	Not satisfactory for slow processes

Any 4 points, 1 Marks each

		3	Does not introduce instability in the closed loop response.	Create instability in the closed loop response
		4	Requires identification of all possible disturbances and their direct measurement.	Does not require identification and measurement of any disturbances
		5	Sensitive to modelling errors	Insensitive to modelling errors
		6	Sensitive to process parameter variations	Insensitive to parameter changes
		7	Block diagram: 	Block diagram: 	
	d)	**Explain control net communication method.**		**4 Marks**
	Ans:	• ControlNet is an open industrial control network protocol for real-time industrial automation applications. ControlNet is a member of the CIP (Common Industrial Protocol) network family. ControlNet has good real-time capabilities providing high-speed deterministic transmission for time critical I/O data and messaging data. ControlNet is highly deterministic (the ability to reliably predict when data will be delivered) and repeatable (ensures that transmit times are constant and unaffected by devices connecting to, or leaving, the network) and thus meets critical requirements for synchronized and coordinated real-time motion control applications. • ControlNet was developed by Rockwell Automation and today, it is managed by the ControlNet International User organization. ControlNet products are certified by the ControlNet International user organization, guaranteeing worldwide compatibility It has the built-in support for fully redundant cablesand communication on ControlNet can be strictly scheduled and highly deterministic. These are its features. • ControlNet is standardized in the European standard series EN 50170. It uses coax cables and a transmission speed of 5 Mbit/s. The Media Access method allows multiple controllers to control I/O on the same wire.		**4Marks**
	e)	**Draw and explain the construction of globe valve.**		**4 Marks**
	Ans:	• A globe valve is a type of valve used for regulating flow in a pipeline. It consists of a movable disk-type element and a stationary ring seat in a spherical body.		**Explanation 2 Marks**

- Globe valves are named for <u>their spherical body shape</u> in which the two halves of the body being separated by an internal baffle.
- This has a seat onto which a movable plug can be screwed in to close (or shut) the valve. The plug is also called a disc. The plug is connected to a stem.
- Stem is operated by screw action using a hand wheel in manual valves.
- Automated globe valves use stems which are opened and closed by an actuator assembly.



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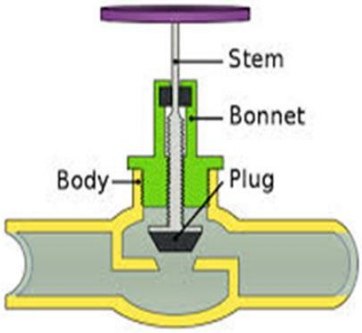

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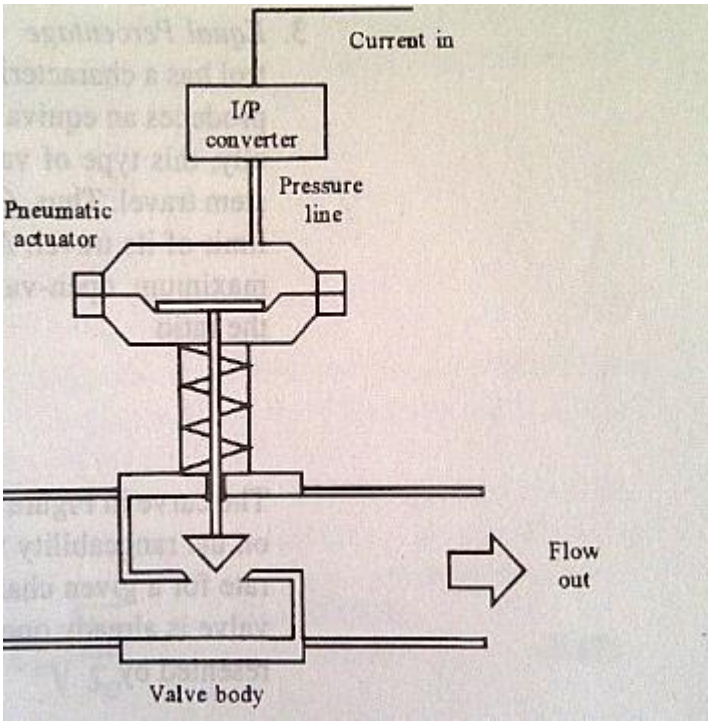
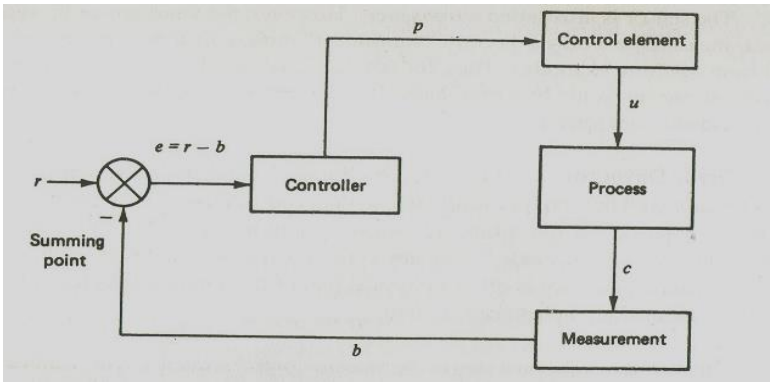
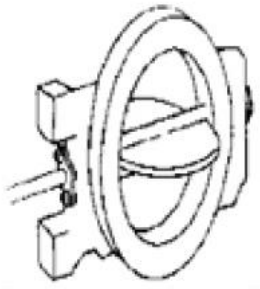
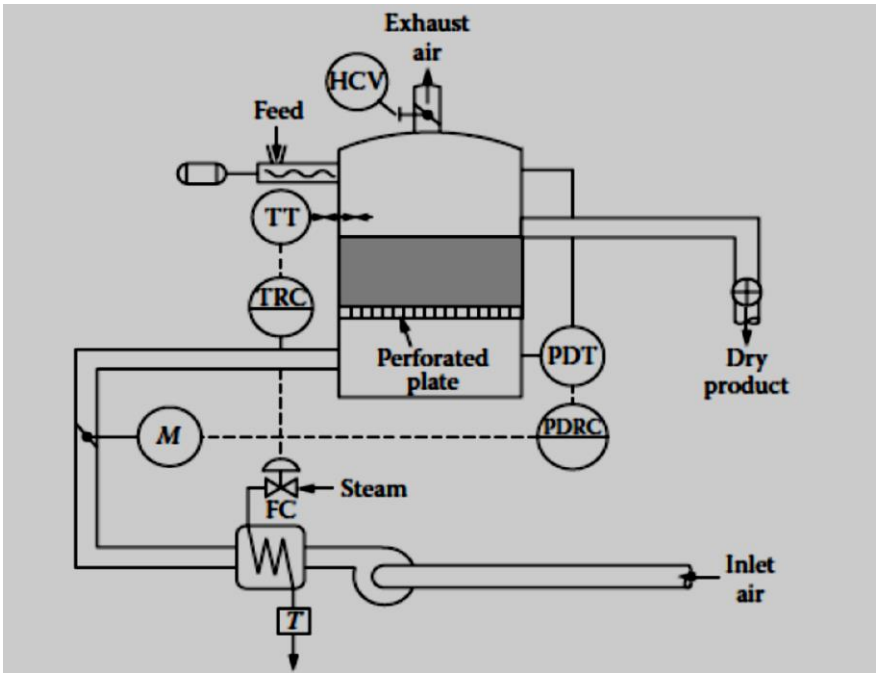


Diagram 2Marks with labeling

Q. 4	A)	Attempt any threeof the following :	12 Marks
	a)	**Draw the block diagram of process control system. Explain it.**	**4 Marks**
	Ans:	**Block diagram:**  The elements of a process control system are 1) Process 2) Measurement &feedback 3) Error detector 4) Controller 5) Final Control Element Controller is the brain of the control system that takes decision to maintain the process variable to its desired value. Mostly the summing point is an integral part of the controller. The error detector outputs an error signal (e = r - b) to the controller, from the reference input(r) and set point (b). Final control element is designed to take action for implementing the decision taken by the controller. Transducer measures and converts non electrical parameter into electrical parameter required for the error detector. The controlled variable is denoted by c, and the measured value by b. the controlled variable set point is marked r. The error detector is a subtracting or summing point that gives an error signal, e= $r \pm b$. The controller uses the error input to determine the output signal p. This has been given to the control element. The control element operates on the process by changing the value of the controlling variable u.	**Diagram:2 M** **Explanation:2M**
	b)	**Explain working of butterfly valve with neat diagram.**	**4 Marks**
	Ans:	 **(OR other suitable diagram)**	

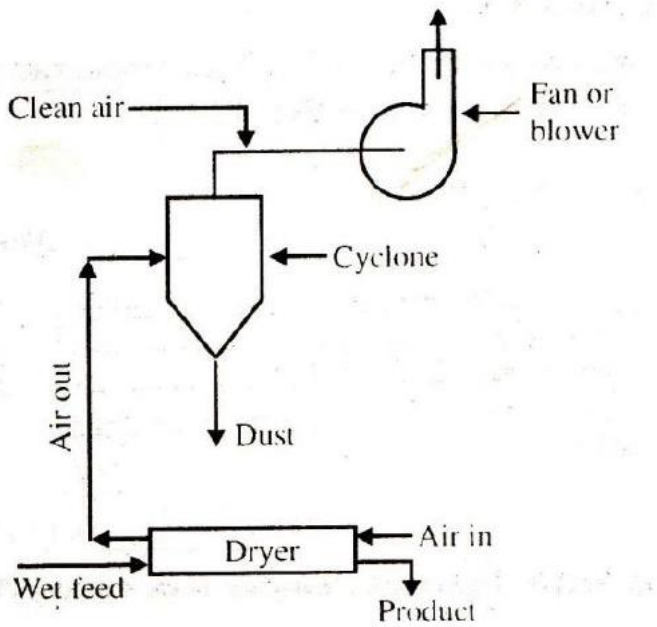
		• In this valve, the plug is in the form of a disc. The "butterfly" is the metal disc mounted on a rod. The disc is positioned in the center of the pipe.A rod connected to an actuator on the outside of the valve is passing through the disc. Rotating the actuator turns the disc either parallel or perpendicular to the flow. • The disc is always present within the flow, therefore a pressure drop is always induced in the flow, regardless of valve position. • A butterfly valve is from a family of valves called quarter-turn valves. In operation, the valve is fully open or closed when the disc is rotated a quarter turn. When the valve is closed, the disc is turned so that it completely blocks off the passageway. When the valve is fully open, the disc is rotated a quarter turn for the passage of the fluid. • Butterfly valves are less costly and lighter in weight, therefore less support is required. It is used for isolating or regulating flow.	**Diagram:2 M** **Explanation:2M**
	c)	**Enlist types of drying processes. Describe any one with neat diagram.**	**4 Marks**
	Ans:	**Types :-** 1) Fluid- Bed Dryer 2) Spray Dryer 3) Direct Fired Rotating Kiln Dryer 4) Double Drum Dryer **OR** 1) Adiabatic and Non-adiabatic Drying 2) Continuous and Batch Drying Continuous Fluid –Bed Dryer **Continuous Fluid–Bed Dryer**: The continuous fluid-bed dryer shown in the following figure. It uses a temperature controller on the air leaving the bed to manipulate the flow of steam to the air heater. A second controller maintains bed density by holding a constant differential pressure across it. Hot air is passed up through the perforated plate, which comes in contact with the falling solid which is to be dried. The dried material is discharged through the side-arm.In this dryer, rapid circulation of the solids means that the average moisture content in the bed is approximately the same as that of the product being discharged..As a consequence, the rate of drying is essentially that of the product. An increase in either feed rate or moisture will lower the outlet-air temperature, causing the controller to increase steam flow to return it to set point. However, the addition of more heat to the air also raises its wet-bulb temperature, thereby raising the level of moisture in the product. Therefore, this system works only on temperature and is not sensitive to humidity.	**Classification -1M** **Diagram-3M** **Description-2M**



OR

Drum Dryers:

The drum dryer is made up of a large, rotating cylindrical tube, usually supported by concrete columns or steel beams. The dryer slopes slightly so that the discharge end is lower than the material feed end in order to convey the material through the dryer under gravity. Material to be dried enters the dryer, and as the dryer rotates, the material is lifted up by a series of internal fins lining the inner wall of the dryer. When the material gets high enough to roll back off the fins, it falls back down to the bottom of the dryer, passing through the hot gas stream as it falls.



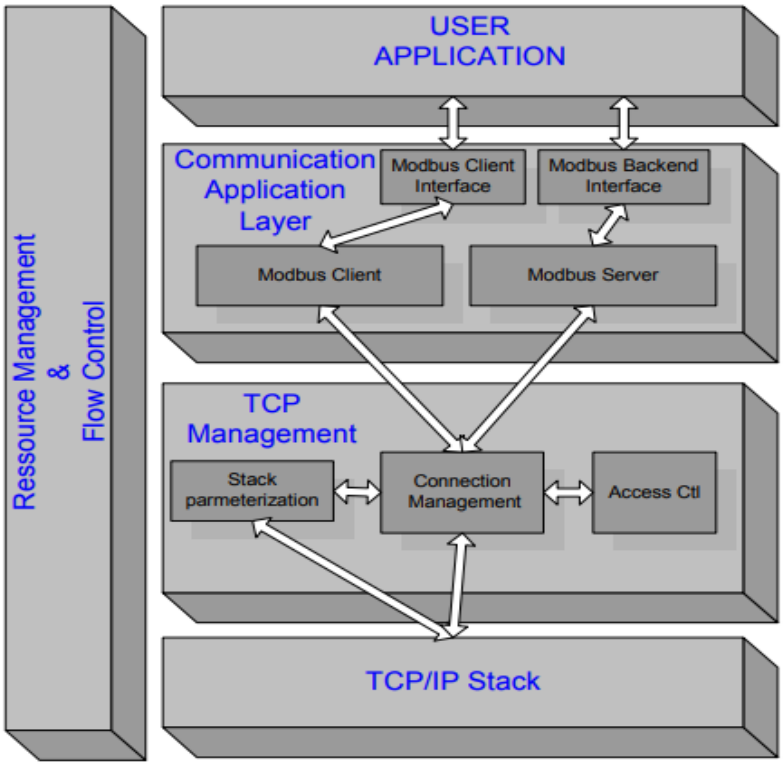
(Any other type with relevant diagram may also be considered)

	d)	**Write the purpose of process flow sheet.**	**4 Marks**
	Ans:	**Process flow diagram:**A process flow diagram (PFD) is a diagram commonly used in chemical and process engineering to indicate the general flow of plant processes and equipment. The PFD displays the relationship between major equipment of a plant facility and does not show minor details such as piping details and designations. Another commonly used term for a PFD is a flowsheet. Process flow diagrams of a single unit process will include the following: • Process piping • Major equipment items • Control valves and other major valves • Connections with other systems • Major bypass and recirculation streams • Operational data (temperature, pressure, mass flow rate, density, etc.), often by stream references to a mass balance. • Process stream names	**4M**
	B)	**Attempt any one of the following :**	**6 Marks**
	a)	**Explain control valve selection and sizing.**	**6 Marks**
	Ans:	**Selection criteria for control Valve:** 1. Body pressure rating: It must be as per the ANSI pressure classes. 2. Temperature considerations: It includes strength of body materials as well as relative thermal expansion of various paths. 3. Material selection: Body materials are to be decided depending on temperature range and erosive qualities of fluid. 4. Flow characteristics: Characteristics may have strong influence on stability of process. Accordingly, choice may be quick opening, linear or equal percentage. 5. Rangeability: Wide rangeability may be required according to the process load change. 6. Pressure drop: Maximum pressure drop a valve can tolerate at fully shut off and partly open or fully open. 7. Cost Vs capacity: For larger lines, over size valves are required and cost increases. **Control valve sizing is done based on the valve coefficient.** • Valve flow coefficient $C_v$is defined as the number of U.S gallons of water per minute that flow through the fully open valve with a pressure differential of 1 psi. • It is the sizing factor for the valve. • $C_v$is the correction factor to the equation $Q = K\sqrt{\Delta p}$ because of the non ideal characteristic of the material that flow. The correction factor allows the selection of proper size of the control valve for the suitable rate of flow for the given application. • $Q = C_v\sqrt{\frac{\Delta p}{S_G}}$ S_G=specific gravity of the liquid • 1 UK gallon= 1.2 US gallon • 1 gallon= 4.55 litres	**Selection criteria-3M** **Sizing estimation: 3M** **Sizing definition and equation-2M,** **Table (1M)**

Valve sizing table:

Valve size (inches)	C_v
1/4	0.3
1/2	3
1	14
$1\frac{1}{2}$	35
2	55
3	108
4	174
6	400
8	725

b)	**Draw the architecture of MOD—BUS and state the function of each block.**	**6 Marks**
Ans:	**MOD-BUS architecture:**	

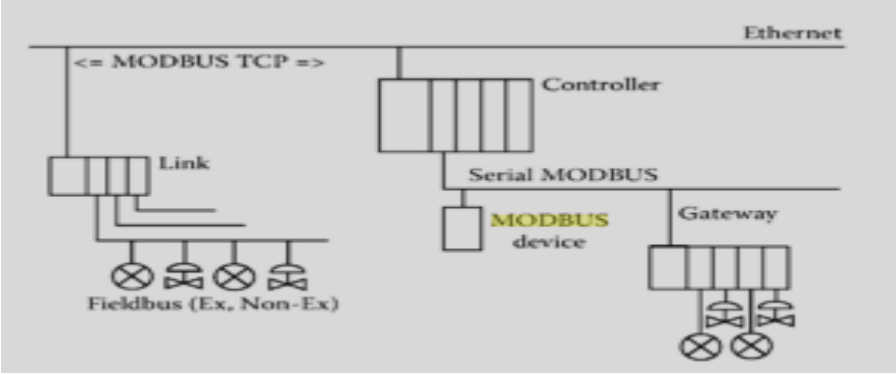
		 MODBUS Protocol is a messaging structure developed by Modicon in 1979, used to establish master-slave/client-server communication between intelligent devices. MODBUS is an application layer messaging protocol, positioned at level 7 of the OSI model,that provides client/server communication between devices connected on different types of buses or networks. • **Communication Application Layer** A MODBUS device may provide a client and/or a server MODBUS interface. A MODBUS backend interface can be provided allowing indirectly the access to user application objects. Four areas can compose this interface: input discrete, output discrete (coils), input registers and output registers. • **TCP Management layer** One of the main functions of the messaging service is to manage communication establishment and ending and to manage the data flow on established TCP connections. • **TCP layer parameterization** Some parameters of the TCP/IP stack can be adjusted to adapt its behaviorlike the data flow control, the address management and the connection management to the product or system constraints. Generally the BSD socket interface is used to manage the TCP connections. • **Connection Management** A communication between a client and server MODBUS Module requires the use of a TCP connection management module. Two possibilities are proposed for the connection management. Either the user application itself manages TCP	**Diagram:3 M Explanation:3M**

connections or the connection management is totally done by this module and therefore it is transparent for the user application.

- **Access Control Module**
  In certain critical contexts, accessibility to internal data of devices must be forbidden for undesirable hosts. That's why a security mode is needed and security process may be implemented if required.
- **TCP/IP Stack layer**
  The TCP/IP stack can be parameterized in order to adapt the data flow control, the address management and the connection management to different constraints specific to a product or to a system. Generally the BSD socket interface is used to manage the TCP connections.
- **Resource management and Data flow control**
  In order to equilibrate inbound and outbound messaging data flow between the MODBUS client and the server, data flow control mechanism is provided in all layers of MODBUS messaging stack. The resource management and flow control module is first based on TCP internal flow control added with some data flow control in the data link layer and also in the user application level.

OR

Typical MOD Bus Architecture

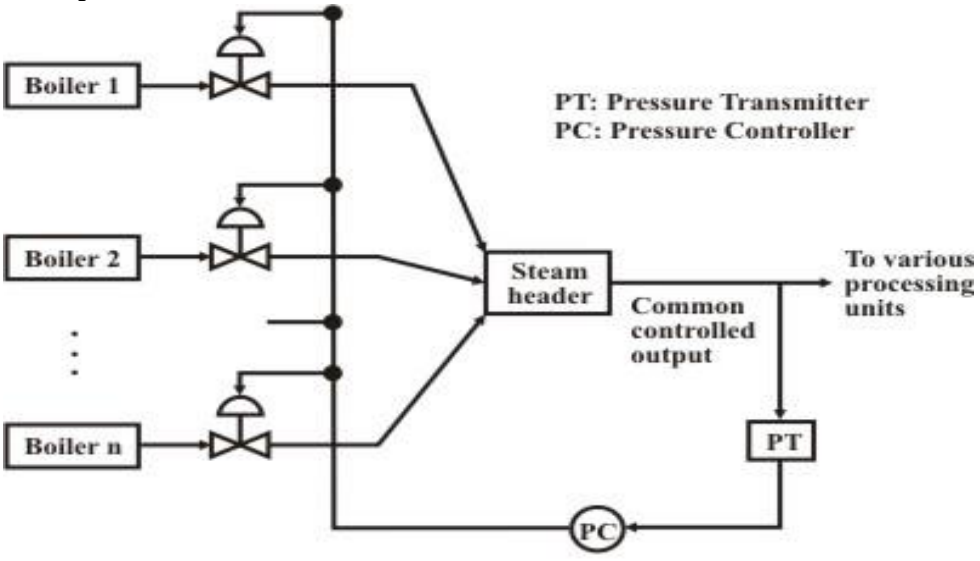


Modbus is transmitted over serial lines between devices. The Mod bus protocol exchanges data in a Master-Slave relationship. Each Slave has a unique address and the data are identified by their location in the slave address register The simplest setup would be a single serial cable connecting the serial ports on two devices, a Master and a Slave.

The data is sent as series of ones and zeroes called bits. Each bit is sent as a voltage. Zeroes are sent as positive voltages and a ones as negative. The bits are sent very quickly. A typical transmission speed is 9600 baud (bits per second).

Certain characteristics of the MOD Bus Protocol are fixed such as frame format, frame sequence, handling of communication errors, exception conditions and functions performed. Other characteristics are user selectable such as transmission medium, baud rate, character parity, no. of stop bits and transmission modes (ASCII or RTU). The contents of the data are also selectable e.g. strings, integers, floating point numbers etc.

Only the master can initiate a transaction. A query and response may involve

		only a single slave or it may be in the form of a broadcast in which case slaves do not answer. The query is contained in a frame that includes the address of the intended receiver, what this slave is to do, data needed to perform the action and a means of checking for errors. The slave checks whether errors have occurred and performs the desired action. After the action is performed , the slave builds the response and returns to the master. The master can send another message to any slave as soon as it receives a valid response or after user selectable time interval The data can be exchanged in two transmission modes: ASCII and RTU. The major difference between the two being the the type of error check performed on the message and the number of characters used. Modbus offers several read, write and test functions, each identified by a code number. They are designed as control commands sensors, actuators, e.g coils, inputs, input registers, holding or output registers, diagnosis and test reports, programs, polling control and reset. For MODBUS TCP the serial frame is simply inserted into the Ethernet data frame.	
Q.5		**Attempt any two of the following :**	**16 Marks**
	a)	**Describe the working of split range control system with example.**	**8 Marks**
	Ans:	• This type of control is used, where there are several manipulated variables, and single output variable. • The coordination among different manipulated variables is carried out by using Split Range Control. • Output of the controller is split and sent to two or more FCEs. • The splitter defines how each FCE is sequenced as the controller output changes from 0 to 100%. • Example:  **Fig. 7 Steam header with split-range control**	**Explanation 3 M** **Diagram for example: 2 M,**

		• In the above example, the steam discharges from several boilers are combined at a steam header. • Overall steam pressure at the header is to be maintained constant through a pressure control loop. • The command from the pressure controller is used for controlling simultaneously the steam flow rates from the boilers in parallel. • There is a single output variable (steam header pressure) while there are a number of manipulating variables (discharge from different boiler) • Thus the output of the controller is split and sent to two or more FCEs	**Explanation 3M**
	b)	**State the role of instrumentation engineer in project engineering.**	**8 Marks**
	Ans:	• Designing and developing new control systems • Testing, maintaining and modifying existing systems • Analyzing data and presenting findings in written reports • Managing operations • Working collaboratively with design engineers, operation engineers, purchasers and other internal staff • Liaising with clients, suppliers, contractors and relevant authorities (e.g. The nuclear decommissioning authority) • Project management within cost and time constrained environments • Understanding and ensuring compliance with relevant health and safety regulations and quality standards • Providing advice and consultancy support • Purchasing equipment • Writing computer software and test procedures • Developing new business proposals	**Any 8, 1M each**
	c)	**Draw the architecture of DCS system. State functions of all components in it.**	**8 Marks**
	Ans:		

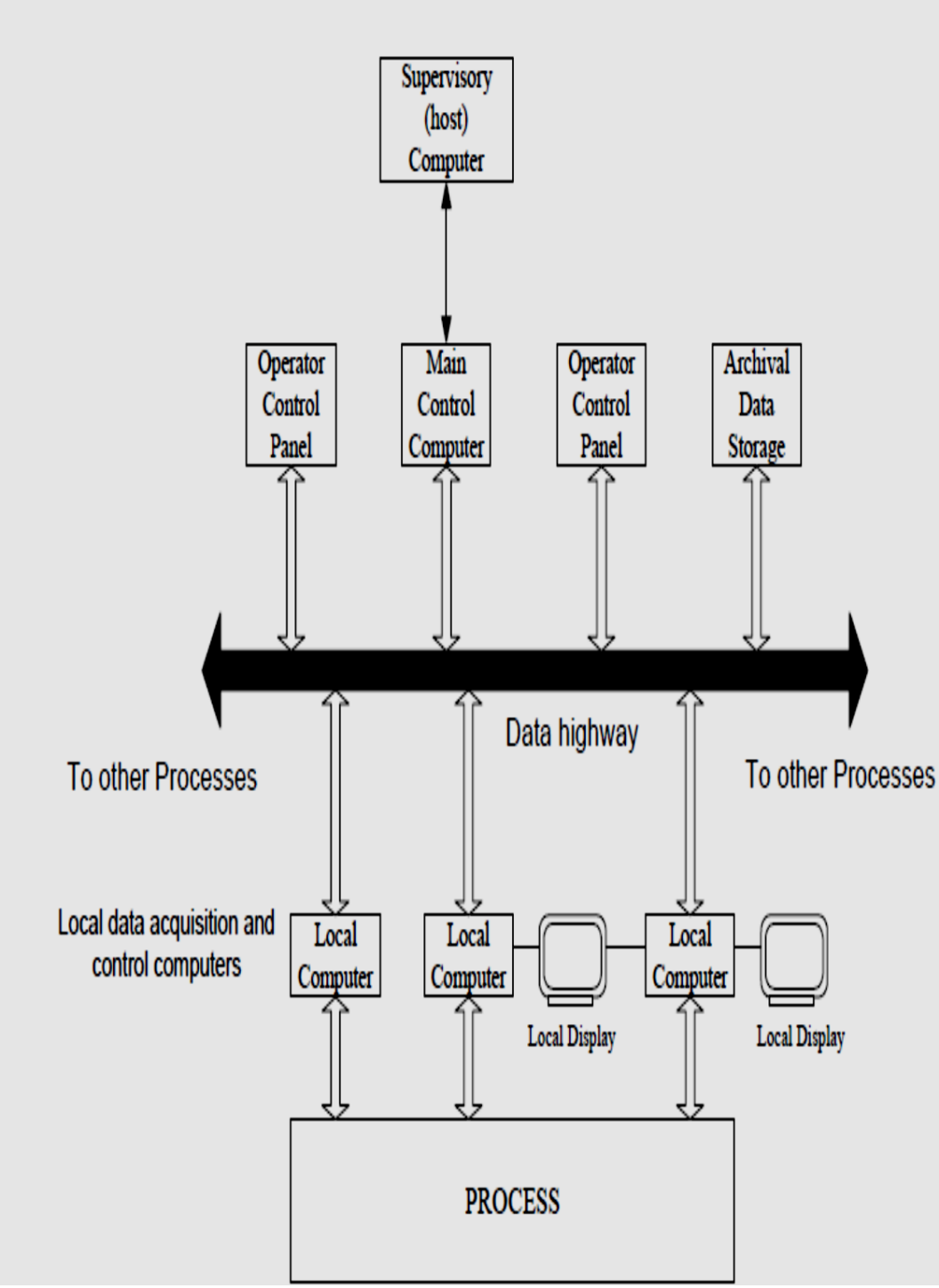


Diagram 4M

OR

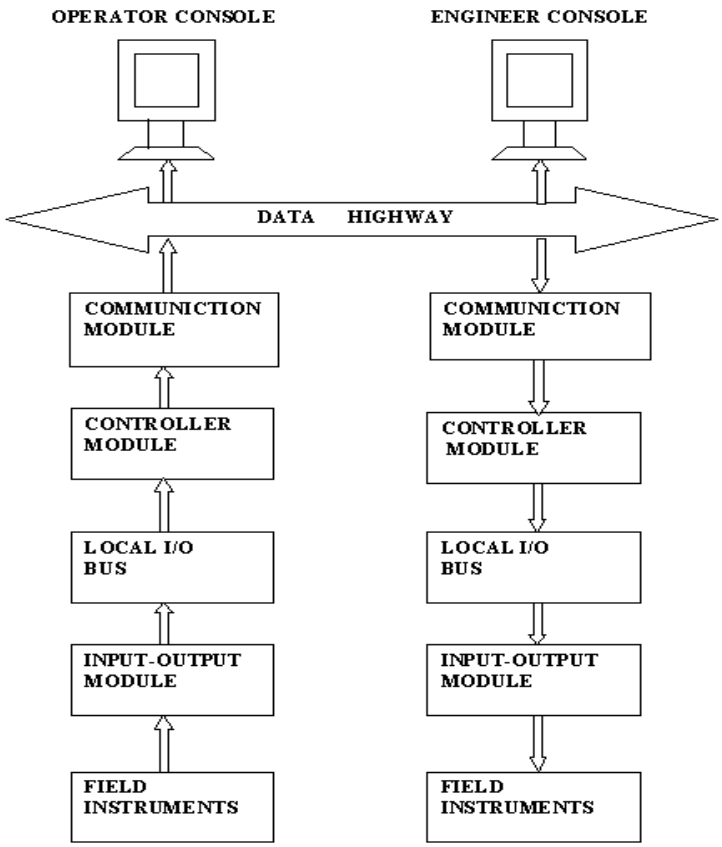


Fig. illustrate the architecture of vertical DCS in terms of functional module.
The modules do not necessarily represent the physical items.

1. Input-output module:-

All these modules are mounted in a single or multirack system connected on common communication highway. I/O modules scan and digitize the process in simple logic. It provides the main interface between DCS and process being controlled. They convert the information provided by process instruments into digital form. They also provide signal filtering.

2. Local I/O bus:-

It provides bridge between I/O and controller module and is restricted in terms of geographical area and data loading. It operates at slower speed than the plant wide data highway communication.

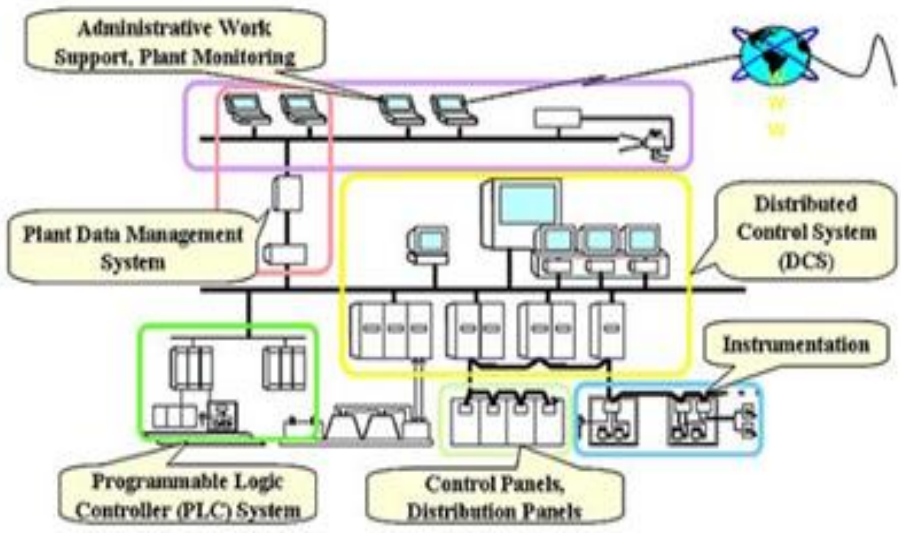
3. Controller module:-

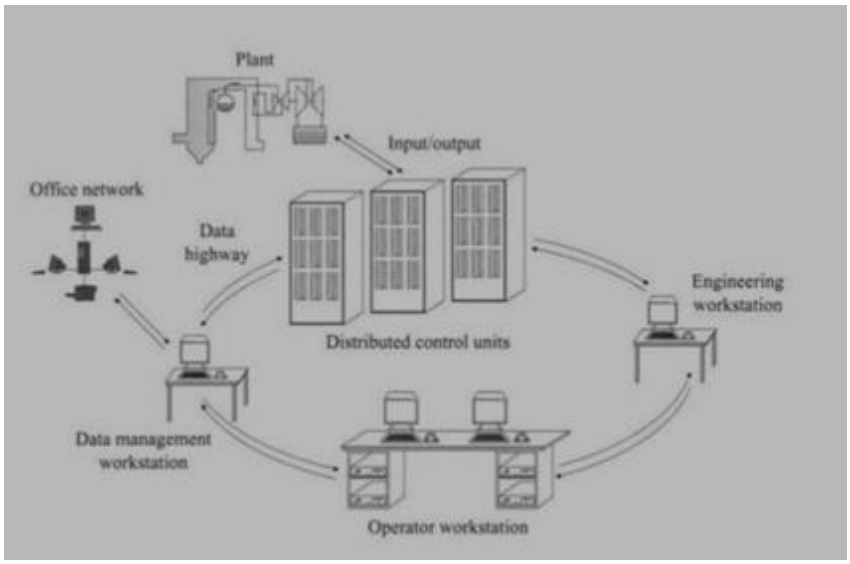
It is the brain of the DCS. It updates field datafrom I/O module and performs control calculation and logic to make the process changes. It also consists of memory, registers and buses, CPU, ROM and RAM. Hence it is microprocessor based device.

4. Communication module:-

It provides communication between data highway and other modules such as controller module and user interfaces. Communication module manages the

Explanation 4 M

		flow of information between the data highway, controller module and user interface. **5. Data highway:-** The data highway is the communication device that allows distribution of the controlling function throughout a large plant area. It is the digital data link that connects the multifunction controllers with the central operator stations. Data highway is microprocessor based module through which the messages and files are transferred.The medium can be coaxial cable or the fiber glass cable. **6. User interface:-** It provides the interface between user and process. It can either operator interface or engineer interface. • Operator Station:- it performs: 1) From operator station, operator can view entire plant/process and can control the process. 2) Controlling the complete process (regulatory and supervisory control);allows configuration of all inputs 3) Alarm display setting. • Engineer Station**:-** it performs following functions: 1) system design and generation of system loop diagram 2) documentation 3) programming 4) system maintenance	
Q.6		**Attempt any four of the following :**	**16 Marks**
	a)	**Explain the role of DCS in thermal power industry.**	**4 Marks**
	Ans:	 **OR**	**Diagram 2 M**



Explanation:

- A distributed control system (DCS) is a control system for a process where the control elements or modules are distributed throughout the system. It is a multitasking operating system which is user friendly with a data management system. The DCS has capacity for processing large number of I/O points.
- It has a modular system development capacity (expandable) which is easy to use. It has data highway, communication capability and data transmission between separate unites of the data highway which provide very wide band communication.

OR

Power plant involves the following activities:
1. Raw Material Transportation and Processing
2. Boiler Combustion (Pulverization of Coal / CFB)
3. Turbine (Steam Turbine and Heat Recovery) Monitoring and Control
4. Generator and Plant Electrical System Monitoring and Control
5. Waste and Exhaust Treatment.

Following major variables are measured and controlled:

- Input variables:

Fuel flow rate, Combustion air, Feed water flow, Steam flow / pressure

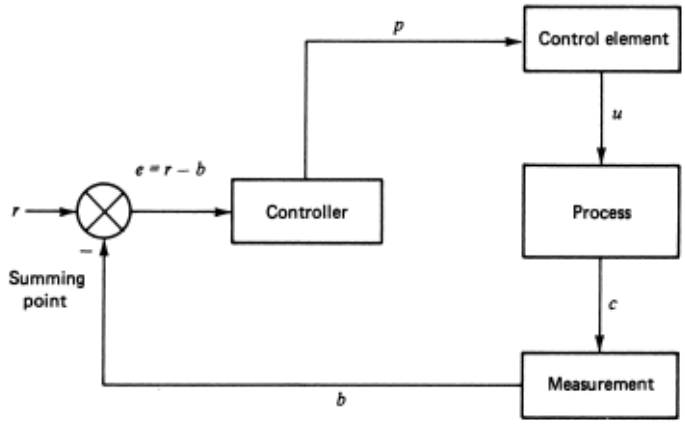
- Control variables:

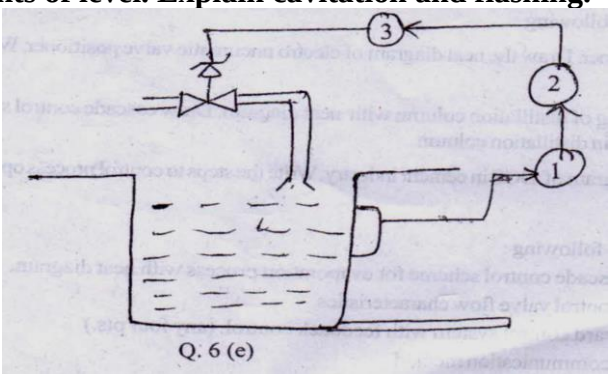
Drum level, Steam pressure, Furnace draft, Waste gases composition.

Above variables are continuously monitored and controlled byDCS and indicated using different DCS displays such as Graphic display, Group display, Trend display, Alarm display, Log and repeat display etc.

Explanation 2 M

	b)	**Find the proper valve size in inches and centimeter for pumping the liquid. Flow rate of 700 gal/min with maximum pressure difference of 65 PSi and liquid specific gravity is 1.3. Findvalve size.**	**4 Marks**

	Ans:	Data given: Q = 700 gal/min, $\Delta P = 65\ psi$ G=1.3 Flow rate $Q = C_V\sqrt{\frac{\Delta P}{G}}$ Therefore$C_V = Q\sqrt{\frac{G}{\Delta P}} = 700\sqrt{\frac{1.3}{65}} = 700\times 0.141 = 98.7$ The required valve size for $C_V = 98.7$ is 3 inches	**4 M**
	c)	**Compare Batch and Continuous process (4 points).**	**4 Marks**
	Ans:	<table><tr><th>No.</th><th>Batch process</th><th>Continuous process</th></tr><tr><td>1</td><td>In this, material is fed to equipment batch wise and then it is processed to obtain finished products.</td><td>In this, material is fed continuously in equipment and is immediately processed and finished product is obtained continuously.</td></tr><tr><td>2</td><td>Raw materials are fed before the start of the operation</td><td>Raw materials are fed continuously throughout the process</td></tr><tr><td>3</td><td>During process operation neither addition of material nor removal of finished product from unit occurs.</td><td>During process operation therate of process output is matched with input material.</td></tr><tr><td>4</td><td>Preferred in small scale production.</td><td>Preferred in large scale production.</td></tr><tr><td>5</td><td>Simple Control system is required.</td><td>More complex control system is required.</td></tr><tr><td>6</td><td>Load change effects are less.</td><td>Load change effects are more</td></tr><tr><td>7</td><td>Series operation</td><td>Parallel operation</td></tr><tr><td>8</td><td>More time is needed for operation</td><td>Less time is needed for operation</td></tr><tr><td>9</td><td>Large installation, therefore cost is more</td><td>Relatively small installation, therefore cost is less</td></tr></table>	**Any 4, 1M each**
	d)	**Draw block diagram of automatic control system. Explain each block.**	**4 Marks**
	Ans:	**Block Diagram of automatic control system:**  **Note: any other relevant diagram can also be considered.**	**02 M diagram**

		Explanation: **1) Process:** A process can consist of a complex assembly of phenomena that relate to some manufacturing sequence. Many variables may be involved in such a process, and it may be desirable to control all these variables at the same time. There are singlevariable processes, in which only one variable is to be controlled, as well as multivariable processes, in which many variables, perhaps interrelated, may require regulation. The process is often also called the plant. **2) Measurement:** a measurement refers to the conversion of the variable into some corresponding analog of the variable, such as a pneumatic pressure, an electrical voltage or current, or a digitally encoded signal. A sensor is a device that performs the initial measurement and energy conversion of a variable into analogous digital, electrical, or pneumatic information. Further transformation or signal conditioning may be required to complete the measurement function. The result of the measurement is a representation of the variable value in some form required by the other elements in the process-control operation. **3) Controller:** The next step in the process-control sequence is to examine the error and determine what action, if any, should be taken. This part of the control system has many names, such as compensator or filter, but controller is the most common. **4) Final Control element:** The final element in the process-control operation is the device that exerts a direct influence on the process; that is, it provides those required changes in the controlled variable to bring it to the setpoint. This element accepts an input from the controller, which is then transformed into some proportional operation performed on the process.	**02 M explanation**
	e)	**Identify the elements of level. Explain cavitation and flashing.**  Q. 6 (e)	**4 Marks**
	Ans:	**1- Level gauge (LG)** **2- Level transmitter (LT)** **3- Level controller (LC)** **<u>Cavitation</u>** is the formation and subsequent collapse of vapour cavities or gas "bubbles" or "voids" in a flowing liquid in a region where the local static pressure of the liquid falls below its vapour pressure. **<u>Flashing</u>** is the formation of vapour cavities or gas "bubbles" or "voids" in a flowing liquid in a region where the local static pressure of the liquid falls below its vapour pressure andthevapour phase continues downstream because the downstream pressure remains at or below the vapour pressure of the liquid.	**2M** **Definition 2 M**