N6 Chemical Plant Operation

Gateways to Engineering Studies - Chris Brink

HYBRID LEARNING SOLUTIONS

Gateways to Engineering Studies

Chemical Plant Operation N6

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	Assessment / Activity		Multimedia
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	Demonstration/ observation		Presentation/ Lecture
	Did you know?		Read
	Example		Safety
	Experiment		Site visit
	Group work/ discussions, role-play, etc.		Take note of
	In the workplace		Theoretical – questions, reports, case studies, etc.
	Keywords		Think about it

Module 1

Separation Processes

Learning Outcomes

On the completion of this module the student must be able to:

- Describe the following separation processes:
  - Distillation
  - Continuous distillation
  - Condensation
  - Evaporation
  - Vapour-liquid equilibrium
  - Relative volatility
  - Filtration
  - Crystallization
  - Extraction
  - Fractionation
  - Types of fractionation units (towers)
  - Absorption
  - Adsorption
  - Higgins contractor

1.1 Introduction

In a scientific sense, a chemical process is a method or means of somehow changing one or more chemicals or chemical compounds. Such a chemical process can occur by itself or be caused by an outside force, and involves a chemical reaction of some sort.

In an engineering sense, a chemical process is a method intended to be used in manufacturing or on an industrial scale to change the composition of chemicals or materials, usually using technology similar or related to that used in chemical plants or the chemical industry.

1.2 Distillation

It is the separation of components of liquid mixture through stages of heating and cooling until a pure light product is obtained towards the top of the plant and a pure heavy product at the bottom. It can be defined as the separation of the components of a liquid mixture by a process involving partial vaporization.

In general, the vapour evolved is recovered by condensation. There for vapour-liquid separation is done by distillation.

Rectification on the other hand, refers to a single-unit distillation operation in which vaporization occurs in repeated steps to give a much greater over-all separation than could be obtain by one simple distillation.

1.3 Continuous distillation

By continuously feeding a distillation unit with the material to be separated, it is possible to obtain the so-called continuous distillation. In an operation of this type, the unit can be brought to a steady operating condition where the amount of feed exactly equals the amount of material removed and the vapour and liquid concentrations at any point in the unit remain constant.

1.4 Condensation

It is the opposite of evaporation. The movement of the molecules of the vapor decreases as the result of cooling (which is the removal of a quantity of heat). The molecule move nearer to each other and the force of attraction become stronger until eventually a liquid is formed. The heat that is necessary to change the state of a liquid at constant temperature refers to latent heat.

1.5 Evaporation

It takes place as the result of heating which provides the molecules of the liquid with greater molecular movement. These movement increases until the mutual force of attraction the molecules have for each other and the pressure on the liquid are overcome simultaneously and the molecules break away from the mass (liquid).

1.6 Vapour-liquid equilibrium

For mixtures, which follow Raoult's law, the composition of the equilibrium vapours evolved at any temperature from a liquid of known concentration can be calculated by use of the vapour pressures of the pure components at the temperature involved.

Definition: Raoult's Law
A law of thermodynamics established by French physicist François-Marie Raoult in 1882. It states that the vapor pressure of a solvent above a solution is equal to the vapor pressure of the pure solvent at the same temperature scaled by the mole fraction of the solvent present.

However, since most mixtures do not follow Raoult's law. It is usually necessary to determine the equilibrium liquid and vapour compositions experimentally. Raoult's law differs from Dalton's law, which is a gas law and is only applicable to gases.

Definition: Dalton's Law
The law states that the total pressure exerted by the mixture of non-reactive gases is equal to the sum of the partial pressures of individual gases.

1.7 Relative volatility

It may define as the volatility of one component of a liquid mixture divided by the volatility of another component of the liquid mixture. Relative volatilities are commonly expressed with the higher of the two relative volatility should never have a numerical value less than 1.0.

1.8 Filtration

It refers to the removal of wax from wax distillates. The mixture of wax and adhering oil is frozen and allowed to warm slowly so that the oil drains from the cake, purifying the wax.

A typical process application applicable for contact filtration of liquids is as follows and refers to the collection of valuable solutes from solutions, for example:

- Adsorption onto carbon of iodine
- Collection of insulin
- The removal of undesired contaminates
- The adsorption of coloured substances from aqueous sugar solutions
- on to carbon
- Carbon is also used adsorb odorous substances, and
- Grease is adsorbed from dry-cleaning liquids.

1.9 Crystallization

By means of crystallization wax is removed from crude oil or from lubrication oil. There for crystallization is use to separate liquid-solids.

1.10 Extraction

It involves the removal of a component from a liquid by means of the selective solvent action of another liquid.

1.11 Fractionation

Where distillation only produces an overhead and bottom product, fractionation still produces blends between overhead and bottom.

By maintaining the maximum temperature gradient obtained by maximum bottom temperature (without flooding the tower), the purest bottom and top products are obtained.

As the gradient diminishes, the one product is carried over to the next, both at the top and at the bottom. In refining operations using fractionation well none

intermediate distillates are Heavy fuel oils, diesel oils, kerosene, Naphta and gas oils.

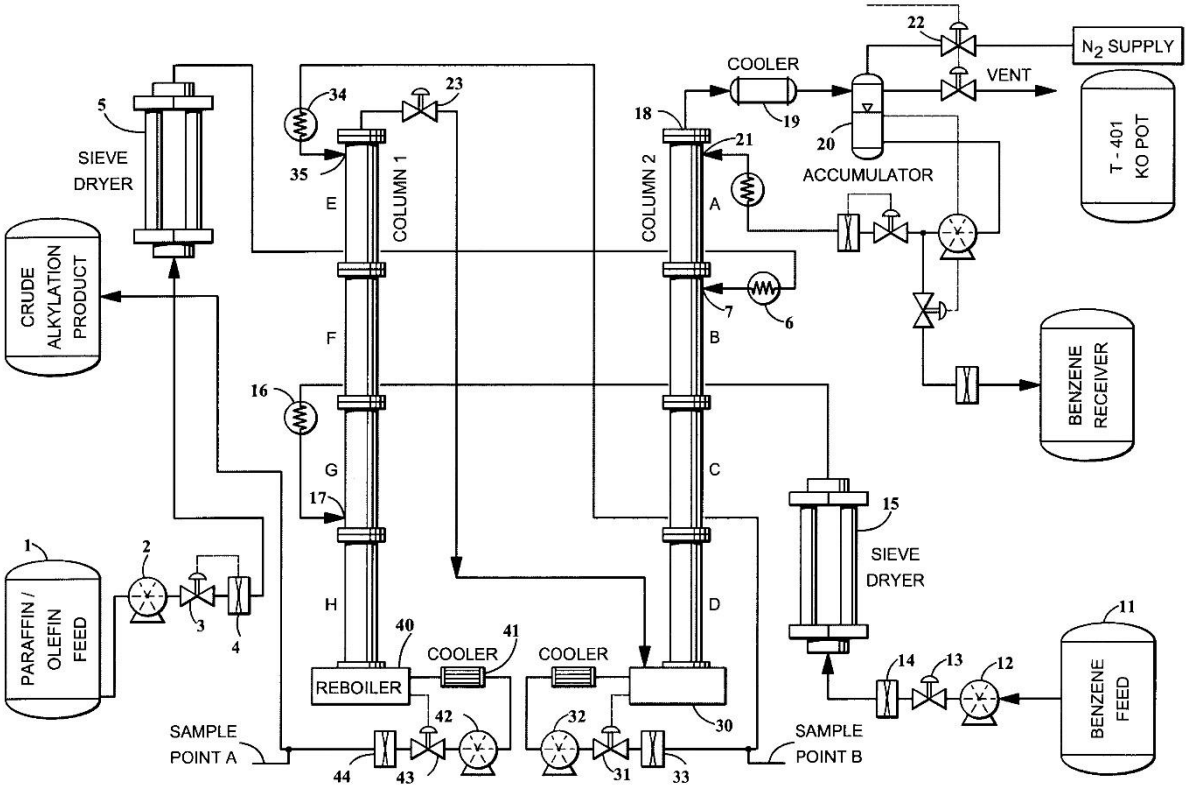


Figure 1.1 Typical fractionation tower / unit

There are mainly four heavy distillates in refining operations using fractionation, namely, heavy mineral oils, heavy flotation oils, waxes and lubricating oils.

1.12 Types of fractionation units (towers)

Fractionation towers can be divided into two main groups accordance with their internal construction namely:

- Clock plate, bubble cap or valve tray units, and
- Packed towers

1.12.1 Valve trays (plates)

These are sieve trays with large (roughly 35-40 mm diameter) variable openings for gas flow. The perforations are covered with movable caps, which rise as the flow rate of gas increases.

At low gas rates and corresponding pressure drop remains low but not as low as that for sieve or bubble cap trays. Tray spacing is usually chosen on the basis of expediency in construction, maintenance, and cost and later checked to be certain that adequate insurance against flooding and excessive entertainment is present.

For special cases where tower height is an important consideration spacing of 15 cm have been used.

For all except the smallest tower diameters 50 cm would seem to be a more workable minimum from the point of view of cleaning the trays.

1.12.2 Bubble plate towers

These are widely used in industry. Distillation columns of this type consist of a series of plates. There are a number of openings in each plate through which the vapours rise.

Each of the openings has an elevated cap on it so that the cap into the liquid on the plate deflects the vapours. The vapours bubble through the liquid where condensation and vaporization occur.

1.12.3 Linde plates

These designs have involved improvements both in the perforation design and the tray arrangements, an alteration in the perforation pattern to influence the flow of liquid.

The slots, distributed throughout the tray, not only reduce the hydraulic gradient in large trays but are also deployed that they influence the direction of liquid flow to eliminate stagnant areas and achieve, as nearly as possible, desirable plug flow of liquid across the trays.

This multiple downspouts are not sealed in the liquid on the tray below; instead the liquid is delivered through slots in the bottom closure to spaces between the downspouts on the tray below. The parallel-flow tray is so designed that the liquid on all trays in the one-half the tower flows from right to left, and on the trays in the other half from left to right.

Such an arrangement approximates the so-called Lewis case and results in an improved Murphree tray efficiency.

- The efficiencies of individual plates in a distillation tower may be reported as Murphree tray/plate efficiencies. This efficiency is defined as the actual vapour enrichment over one plate divided by the theoretical vapour enrichment, which would have been obtained if the liquid on the plate and the vapours leaving the plate had reached equilibrium.

- Downspouts/discharge gutters. The liquid led from the one tray to the next by means of downspouts or down-comers. These may be circular pipes or preferable portions of the tower cross section set aside for liquid which is agitated into a froth on the tray, adequate residence time must be allowed in the downspout to permit disengaging the gas from the liquid, so that only clear liquid enters the tray below.

The downspout must be brought close enough to the tray below the seal into the liquid on that tray thus short-circuits the tray above. Seal pots and seal-pot dams (inlet weirs) may be used, but they are best avoided especially if there is a tendency to accumulate sediment. If they are used, weep holes (small holes through the tray) in the seal pot should be used to facilitate draining the tower on shutdown.

- Weirs. The depth of liquid on the tray required for gas contacting is, maintained by an overflow (outlet) weir. Straight weirs are most common, multiple V-notch weirs maintain a liquid depth, which is less sensitive to variations in liquid flow rate, and consequently also from departure of the tray from levelness, circular pipes used as downspouts, are not recommended.

1.12.4 Counter flow plates/trays

These tray-resembling devices differ from conventional trays in that there are no ordinary downspouts. Liquid and vapour flow counter-currently through the same openings. Trays like trubo-, kitter-, ripple and leva trays are used.

1.12.5 Packed towers

Instead of valve trays and bubble caps, this type of the tower is filed with Raschig (Porcelain) rings, charcoal, grit, etc. This tower is smaller and used for special applications.

The tower packing provide for inter facial surface between liquid and gas. It also possesses desirable fluid-flow characteristics. The packing being chemically inert to fluids being processed. It has structural strength to permit easy handling and installation. It represents low cost.

1.13 Absorption

However note that the gas or vapours to be purified are let in at the bottom of the tower and the absorption medium at the top. If the overhead product has to be further purified, a second smaller tower is used.

It refers to the process in which a substance is taken up (absorbed) by an absorbent. Absorption is defined as the process of absorbing or taking up of gases, fluids. Therefore it is been use for encapsulation separation.

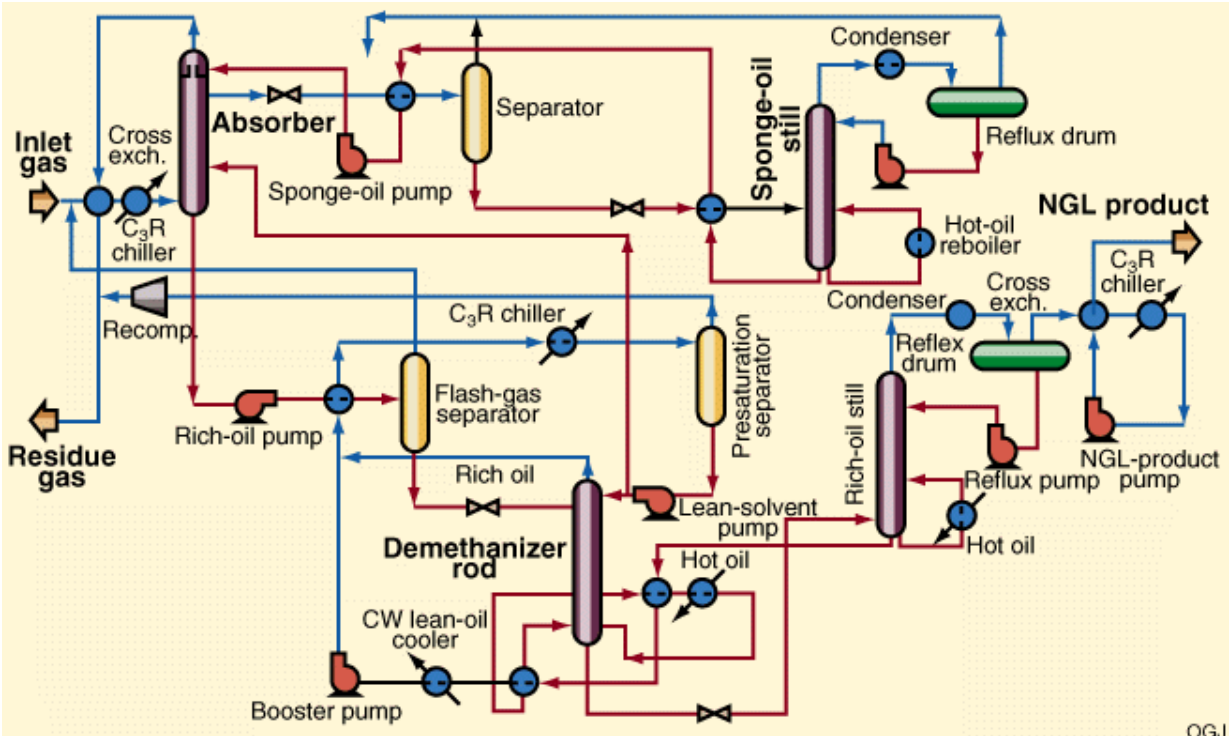


Figure 1.2 Typical Absorption unit

1.14 Adsorption

It refers to a process in which a substance accumulates on the surface of a solid forming a thin film. There for it is been use for separate vapour solids.

Factors contribute to the shape of a breakthrough curve concerning adsorption are as follow:

- The actual rate and mechanism of the adsorption process
- The nature of the adsorption equilibrium
- The fluid velocity
- The concentration of solute in the feed
- The length of the adsorber bed

1.14.1 Fix-bed adsorber

This type is design for vapours at high pressure.

- The gas under pressure enters at the top and ball on a screen helps to distribute the gas.
- The gas moves through the adsorbent and is dried.
- The dried gas leaves the adsorber at the bottom.
- The adsorbent enters at the top and spent adsorbent is removed at the bottom.
- Regeneration fluid moves through the dryer from bottom to top.

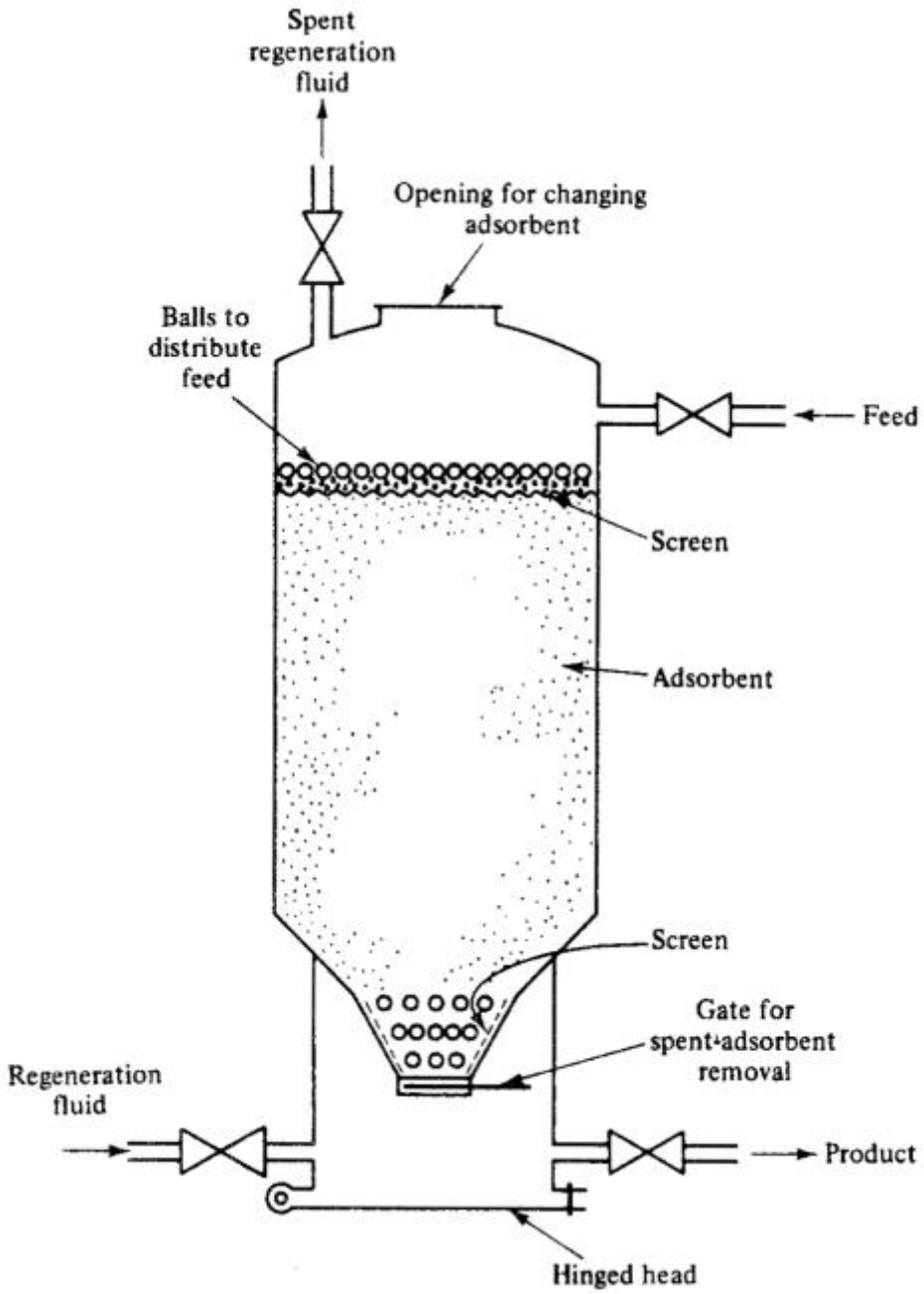


Figure 1.3 Fix-bed adsorber

The method of operation on a fixed bed adsorber through the shape of a breakthrough cure is as follows:

- If the breakthrough curve is steep, the effluent air, substantially free of vapour, may be discharged to the atmosphere until the breakpoint is reached, where upon the influent stream must be diverted to a second absorber while the first is regenerated.
- On the other hand, if the breakthrough curve is flat, so that the breakpoint is a substantial portion of the absorbent remains unsaturated with absorbate, gas may be permitted to flow through a second absorber in series with the first until the carbon in the first is substantially all saturated.
- The influent mixture is then passed through the second and the third absorber in series while the first is generated.

1.15 Higgens contractor

The temporarily stationary upper bed of solids is contracted with liquid flowing downward, so that fluidization does not occur. In the lower bed, the solid is regenerated by an eluting liquid.

After several minutes, the liquid flow is stopped, valves are turned and the liquid-filled piston pump is removed for a period of several seconds, whereupon solid is moved clockwise hydraulically.

With the valves readjusted to their original position, movement of solid is completed and liquid flows are started to complete the cycle.

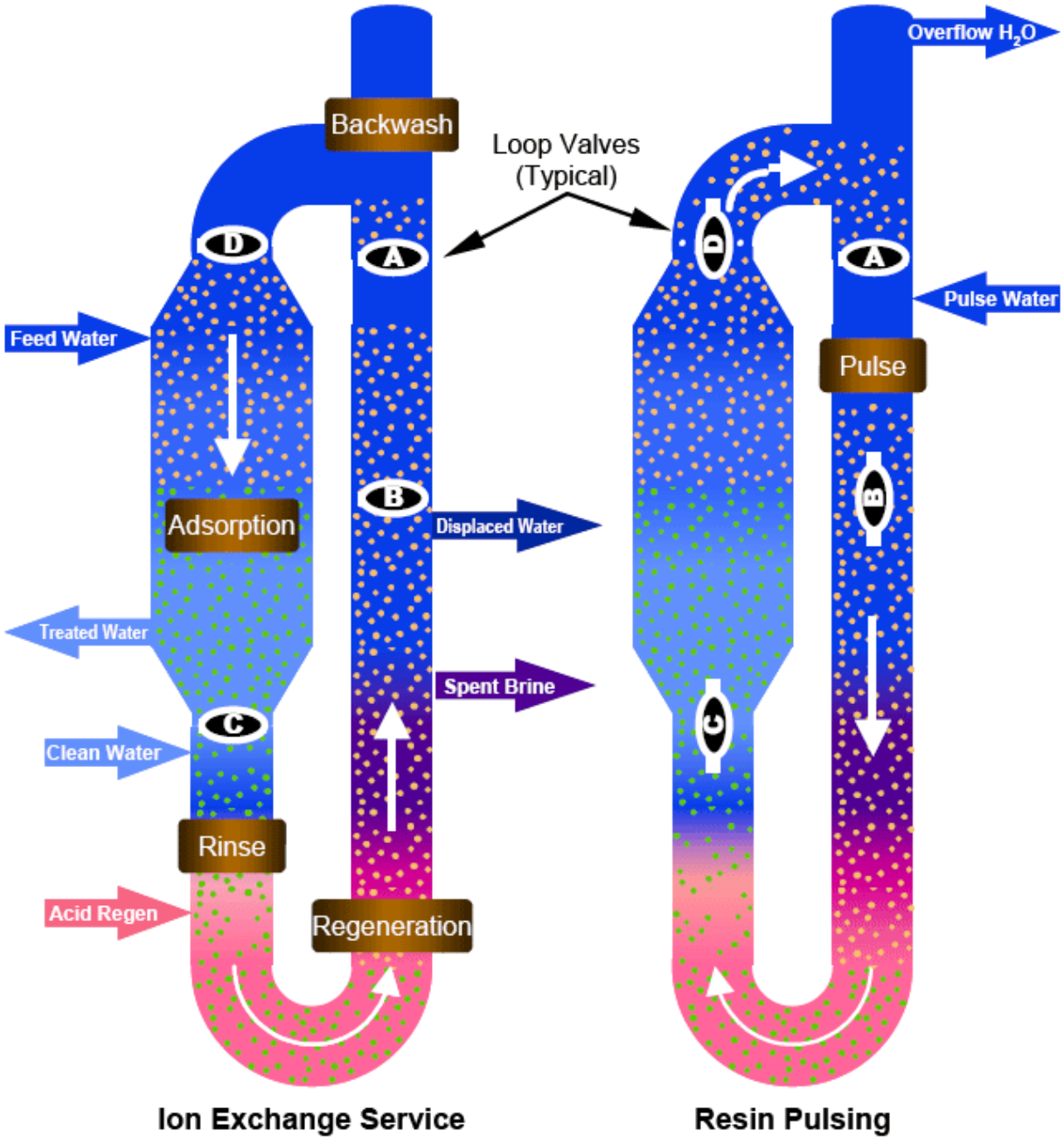


Figure 1.4 Higgins loop produced water purification

Activity 1.1

1. Describe how the shape of a breakthrough curve will influence the method of operating a fix-bed adsorber.
2. Name the unit operations used to separate:
   2.1 Vapour-liquid
   2.2 Liquid-solid
   2.3 Encapsulation
   2.4 Vapour-solid
3. Write brief notes on the contact filtration of liquids.
4. Write brief notes on the design of:
   4.1 Shell and trays
   4.2 Weirs
5. Define the following:
   5.1 Adsorption
   5.2 Absorption
   5.3 Ion exclusion

Self-Check

I am able to:	Yes	No
• Describe the following separation processes:		
o Distillation		
o Continuous distillation		
o Condensation		
o Evaporation		
o Vapour-liquid equilibrium		
o Relative volatility		
o Filtration		
o Crystallization		
o Extraction		
o Fractionation		
o Types of fractionation units (towers)		
o Absorption		
o Adsorption		
o Higgins contractor		
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.		

Module 2

Organic Chemistry

Learning Outcomes

On the completion of this module the student must be able to:

- Describe the following:
  - Polymerisation
  - Liquid and Gas fuels
  - Coal-tar Continuous Distillation
  - Coke Production
  - Producer gas production

2.1 Introduction

Organic chemistry is a sub-discipline of chemistry involving the scientific study of the structure, properties, and reactions of organic compounds and organic materials, ie, matter in its various forms that contain carbon atoms.

The study of structure includes using spectroscopy and other physical and chemical methods to determine the chemical composition and constitution of organic compounds and materials.

The study of properties includes both physical properties and chemical properties, and uses similar methods as well as methods to evaluate chemical reactivity, with the aim to understand the behavior of the organic matter in its pure form, but also in solutions, mixtures, and fabricated forms.

The study of organic reactions includes both their preparation by synthesis or by other means, as well as their subsequent re-activities, both in the laboratory and 'in silico' study.

Definition: 'in silico'

An expression used to mean "performed on computer or via computer simulation." The phrase originated in 1989 as an analogy to the Latin phrases in vivo, in vitro, and in situ, which are commonly used in biology and refer to experiments done in living organisms, outside of living organisms, and where they are found in nature, respectively.

2.2 Polymerisation

When scientists began to investigate the structure of materials like wood, rubber, etc, they found confusing results. Cellulose for example, which is the basic fibrous material of wood, cotton and linen, has been known for a long time and the formula $C_6H_{10}O_5$ was given to it because that is what chemical analysis has shown.

However, other investigations have shown that a molecule of cellulose like Glucose $C_6H_{12}O_6$ is very much greater and initially, it was thought that this cellulose was not a molecule, but a "lump" of hundreds of molecules.

Rubber is another material where the formula was derived more than 100 years ago as C_5H_8 and with later investigations the larger molecule was found which was again thought to be a "lump" of molecules.

The idea of "lumps" was only corrected relatively recently when it was shown that the rubber molecules are actually larger molecules.

Today it is accepted that the type of materials that these useful fibers, ie cellulose, plastic materials, and rubber all consist of large molecules. Their relative size however, gives these molecules the unusual properties that we get in plastics, rubber, and natural fibers.

Therefore the following concepts to distinguish are as follow:

- *Polymerisation*: The link of similar molecules, to joining together of light olefins.
- *Isomerisation*: Alteration of arrangement of the atoms in a molecule without changing the number of atoms.
- *Aromatisation*: The conversion of naphtha's to obtain products of higher octane number.
- *Hydrogenation*: it refers to an addition (of hydrogen to an olefin) reaction that hydrogen undergoes with unsaturated hydrocarbons or other organic compounds, in the presence of a catalyst, at suitable temperature and pressures, eg ethylene to from ethane, carbon monoxide to from methanol and higher alcohol's etc.
- *Cracking*: It is the breaking-up of any hydrocarbon in such a way that carbon-carbon bonds break-up to from new hydrocarbon products.

Example

$C_3H_8 \leftrightarrow C_2H_4 + CH_4$ ------- an olefin and paraffin are formed.

- *Alkylation*: Refer to the combine of lower weight hydrocarbons to from high-octane gasolines and are essentially to reverse of the main reactions that occur during cracking. There for it builds hydrocarbon molecules in the gasoline range that possess high anti-knock qualities.

  Low-molecular weight paraffin's eg iso-butane and olefin's may be united thermally without a catalyst or catalytically using sulfuric acid as alkylating agent. Thus it revere to the union of an olefin with a promatic or paraffin hydrocarbon.

- *Octane number*: Experimentation with pure hydrocarbons revealed that highly branched paraffin's cause less knocking than continuous chain compounds. In fact because of its excellent anti-knock properties, one highly branched chain paraffin, isooctane was chosen as the reference standard in rating gasolines and was assigned an octane number or 100.

  The continuous chain compound n-heptane, which knocks badly, was given an octane number of 0. The octane rating of any given gasoline is equal to the percentage of isooctane in a synthetic iso-octane-n-heptene mixture that produces the same degree of knocking as the gasoline being tested.

  Branched chain paraffin's and unsaturated hydrocarbons, in general, have excellent antiknock properties and therefore high octane numbers. The higher the octane number the more powerfully the fuel and thus more economically.

2.3 Liquid and Gas fuels

Liquid fuel products consist of: water, tar and crude oil while gaseous fuel products consist of: hydrogen, methane, ethylene, carbon monoxide, carbon dioxide, hydrogen sulphide, ammonia and nitrogen.

2.2.1 Liquid fuels

- *Crude Petroleum*: The major source for liquid fuels is crude petroleum. Basically, petroleum is a mixture of many hydrocarbons usually containing impurities such as sulfur and nitrogen compounds and vanadium compounds at some cases.

  Crude oils vary in compounds with respect to the paraffin, naphthalene, and aromatic groups. There for intermediate base crude's refer to crude's that contain large quantities of both paraffinic and naphtenic compounds and furnish medium-grade straight-run gasolines and lubricating oils. Both wax and asphalt are found in these oils.

  The constituents of petroleum are, carbon black, acetylene, methane, ethylene, propylene, butylenes, toluene, xylene, naphthalene and coke.

- *Paraffin base crude's*: These crude's consist primarily of open chain compounds and furnish low-octane number straight-run gasoline and excellent but waxy lubricating oil stocks.

  These crude's consist primarily of:
  - Open-chain compounds
  - Furnish low- octane number straight gasoline
  - Excellent but waxy lubricating.

- *Naphthene base crude's*: These crude's contain a high percentage of cyclic (naphthenic) compounds and furnish relatively high-octane grade straight-run gasoline. The lubricating oil fractions must be solvent-refined. Asphalt is present.

  Naphthalene (Naphta) molecule consists of two benzene rings joined together through two carbon atoms, which are common to both rings.

- *Intermediate base crude's*: These crude's contain large quantities of both paraffinic and naphthenic compounds and furnish medium-grade straight run gasolines and lubricating oils. Both wax and asphalt are found in these oils.

- *The olefin series*: This series is either not present in crude oil or exists in very small quantities. Cracking processes produce large amounts of olefins and have better antiknock properties than normal paraffin. Olefins have poorer properties than highly branched paraffin and aromatics. They are the most important class of compounds chemically derived from petroleum.

- *Naphthalene series*: It has the same empirical formula as the olefin series, but differs in that its members are completely saturated. It is the second most abundantly occurring series of compounds in most crude's.

- Liquid / Liquefied Petroleum Gas (LPG): LPG under a pressure of 5 Bar easily condenses to a liquid meaning that a large mass per volume energy can be stored.

  Liquid can easily vapourise to gas. This comprises C_3 to C_4 hydrocarbons refer to a ± 50% propane/propylene to butane/butylene mixture. LPG is obtained as a by-product in oil refineries. These gases are dissolved in oil, which is refined. This gas type of fuel is widely used in domestic applications and in industries such as glass industries for furnaces.

  LPG comes from the ground as a constituent of wet natural gas or of crude oil or as a by-product from refining.

2.2.2 Natural Gas

It is a by-product from the petroleum industry or in a natural form from the wells, in which case it can be converted to liquid fuels. By-products are normal burned at the refineries, or in European countries piped to be used as household fuels for cooking and heating purposes.

Main gasses used are propane or butane or a mixture of the two natural gas composed of Hydrocarbons of the paraffin series from methane to pentane, carbon dioxide, nitrogen, and sometimes helium.

The purification of natural gas involves the removing of undesirable water and hydrogen sulphate. The Girbotol procedure is used to remove the H_2S.

Water removing (dehydration) methods are:
- Compression
- Treatment with drying substance
- Adsorption and
- Refrigeration

The most important products obtained from natural gas are, methane, ethane, propane, butane, liquid petroleum gas (LPG), natural gasoline, carbon black, hydrogen, helium, fuel and petrochemicals.

2.4 Coal-tar Continuous Distillation

The following products are refining from the process, namely: light oil, carbolic oil, naphthalene oil, creosote or wash oil, residue or anthracene and residuum or pitch.

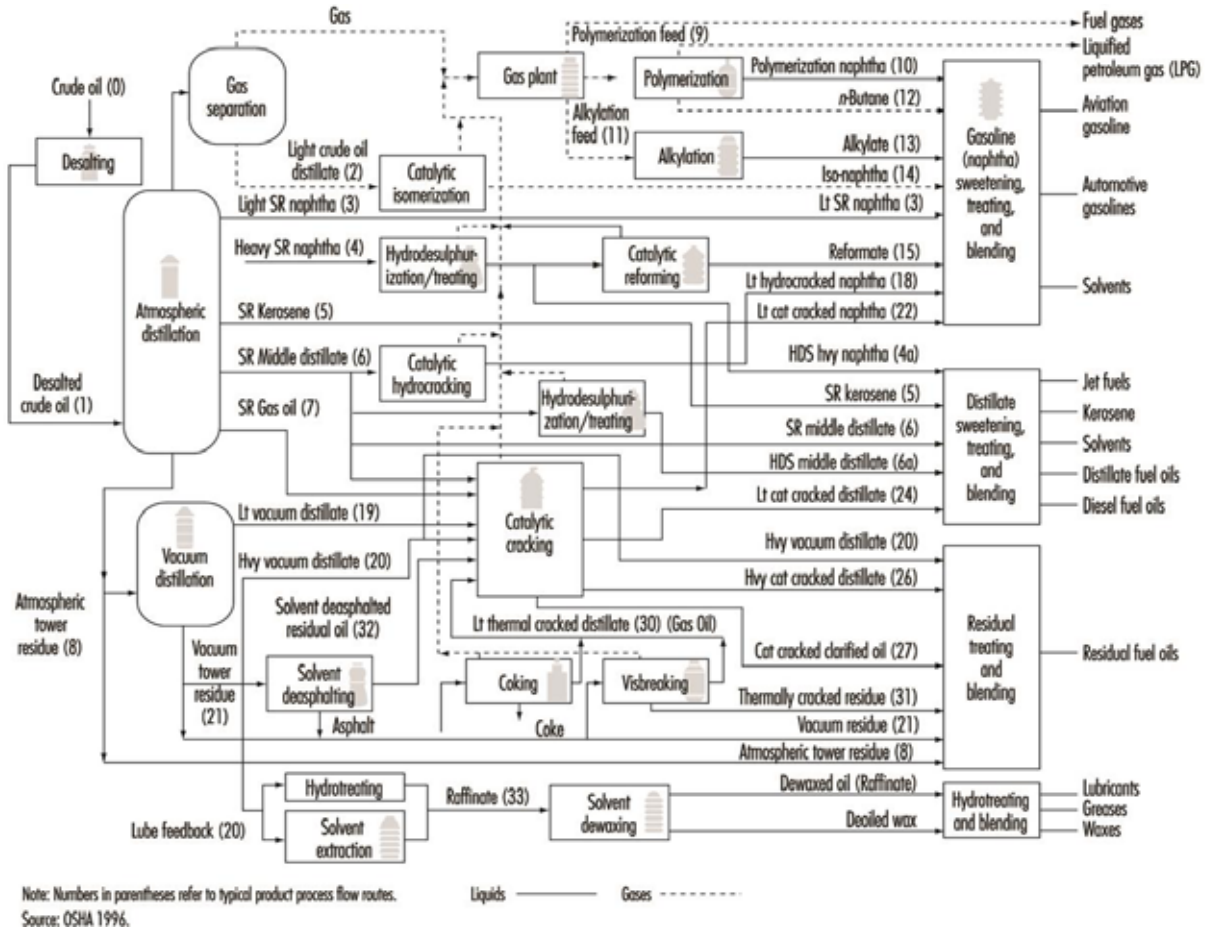


Figure 2.1 A typical continuous distillation flow chart

2.5 Coke Production

The constituents of coal are carbon, hydrogen, oxygen, sulphur, nitrogen, moisture, and ash. Coal originally existed as vegetable matter and this vegetable matter than underwent geological changes, which transformed it to its present state.

Generally speaking, the greater the geological changes the greater will be the percentage of carbon within the coal.

Some of the carbon is combined with other compounds are known as volatile matter as they are driven off as a gas when the coal is heated.

The part of the carbon remaining after the volatile matter is driven off is known as fixed carbon.

Coke is the product from the coal carbonisation process. Coke is mainly use in blast furnace to produce iron out of iron ore (metallurgical coke) and gas producers.

The products that are then producing during a coke production process are coke, gas (CO-gas), tar, ammonium, sulphate and light oils.

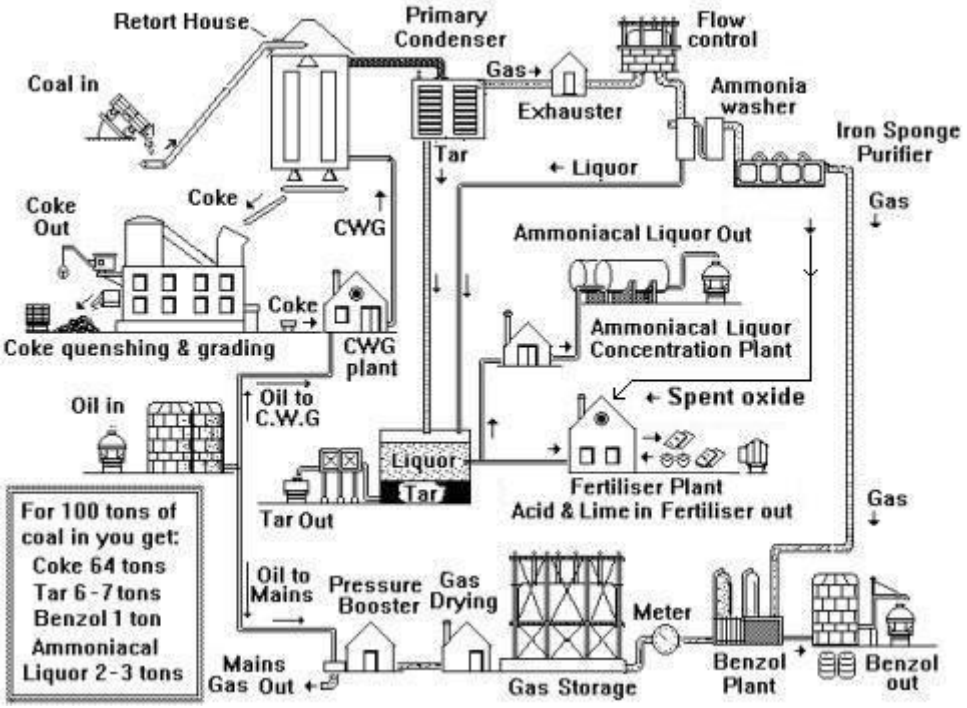


Figure 2.2 A typical coke oven coke plant

Chronological steps of the process as follows:

- Coal is transferred, crushed and screened
- Cole is charged to a hot, empty oven.
- Cole is chemically transformed to coke and volatiles by pyrolysis.
- Hot coke is pushed out of the oven, quenched, and transported.
- Condensable products of distillation are liquefied and collected in the hydraulic main.
- Foul gas is cooled, and tar extracted.
- Ammonia is removed from gas as ammonium sulphate.
- Gas is cooled and subjected to benzol and toluol removal by absorption.
- Hydrogen sulphide is removed.
- Purified gas is metered and transferred to consumers.

2.6 Producer gas production

Step one: Blow (operation involving 30% or 63 sec)
Primary air is admitted at the base of a mechanical generator and is passes up through the fuel bed of coke at a gas-making temperature.

Step two: Blow run (operation involving 9% or 19 sec)
This happen immediately after step one, while the fire temperature is at its peak and the blast gases contains the height percentage of CO. Closing the secondary air valve and the stack valve and allowing the producer gas to bypass through the machine into the wash box accomplish it.

Step three: Up run (operation involving 32% or 67 sec)

Steam is admitted at the base of the generator and passes up through the red-hot coke, forming blue gas. Oil gas is produced by the pyrolysis of the oil in an atmosphere of blue gas and from the radiant heat. The blue and oil gases mix and pass on to the super heater, where the pyrolysis of the gasified oil is completed and the gases are made permanent.

Step four: Back run (operation involving 24% or 51 sec)
Steam is admitted into the top of the riser pipe, passing up the super heater, where it is superheated, down through the carburetor, reacting with any carbon in the generator fuel, finally passing out the bottom of the generator through the cast-ion back-run pipe through the three-way valve into the was box, to the relief holder. Fuel is automatically charged during this portion of the cycle after the back-run and the oil has been shut off.

Step five: Final up run (operation involving 3% or 6 sec)
This puts a blanket of steam between the blue gas in the base of the generator and the air that follows. The carburetor, super heater and riser pipe are already filled with back-up steam.

Step six: Blow purge (operation involving 2% or 4 sec)
This purges the machine of blue gas and steam and produces some CO, all of which is swept through the machine, through the wash box, into the relief holder. This is accomplish by opening the generator air valve prior to opening the stock valve, which releases the products of combustion to atmosphere.

Activity 2.1

1. Define the following reactions:
   1.1 Isomerisation
   1.2 Polymerisation
2. Write brief notes on each of the following crudes:
   2.1 Intermediate base
   2.2 Naphthene base
3. What is natural gas composed of?

Self-Check

I am able to:	Yes	No
• Describe the following:		
o Polymerisation		
o Liquid and Gas fuels		
o Coal-tar Continuous Distillation		
o Coke Production		

o Producer gas production		
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.		

Module 3

Inorganic Chemistry

Learning Outcomes

On the completion of this module the student must be able to:

- Describe:
  - Acids
  - Bases
  - Salts
- Describe the production of:
  - Caustic soda
  - Chlorine
  - Aluminium sulphate

3.1 Introduction

Inorganic chemistry is the study of the synthesis and behavior of inorganic and organometallic compounds. This field covers all chemical compounds except the myriad organic compounds (carbon based compounds, usually containing C-H bonds), which are the subjects of organic chemistry.

It has applications in every aspect of the chemical industry, including catalysis, materials science, pigments, surfactants, coatings, medicine, fuel, and agriculture.

3.2 Acids, Bases and Salts

3.2.1 Acids

An acid is a substance that increases the concentration of hydrogen ions I hydronium ions (H+) in an aqueous solution or which is able to donate protons to another substance. When an acid dissolves in water, it breaks up (dissociates) into small particles, called ions. This is tile reason wily acids are so corrosively.

3.2.2 Bases

Bases are substances, which also ionise when dissolved in water but they from hydroxide ions (OHl A reaction of an acid and a base is known as protolysis. This is the reaction during which protons are transferred in water. Weak bases refer to $CaCO_3$ and Na_2CO_3 (carbonates) and the strong bases refer to the NaOH, $Ca(OH)_2$ and KOH (hydroxides).

3.2.3 Salts

A salt is formed when an acid reacts with a base. Salts are crystalline substances at normal temperatures and have high melting points. The crystals are brittle and crumble quite easily when hit with a hard object. While salts in the crystalline state they do not conduct electricity, but when it is in solutions it conduct electricity and are called electrolytes.

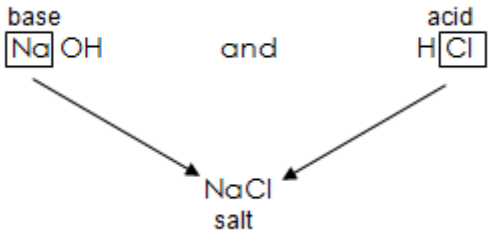


Figure 3.1

3.2.4 PH concept

The pH is defined as the logarithm of the reciprocal of the hydronium ion concentration, or pH = -log $[H^+]$. Thus the pH value of a dilute solution can now be easily calculated if $[H^+(aq)]$ is known.

For a neutral solution we know that $[H^+(aq)] = 10^{-7}$ mol.dm^{-3}

pH = -log $[H^+]$
= -log 10^{-7}
= -(-7)
= **7** ---------- H_2O is neutral

A pH change of 1 pH value represents a ten-fold change in hydrogen ion concentration.

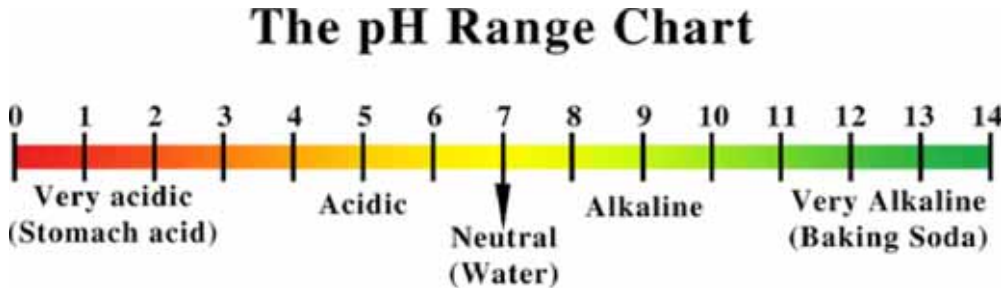


Figure 3.2

Strong acids ionise almost completely in solution and from a high concentration of hydrogen ions.

Weak acids ionise only partially in solution and from a low concentration of hydrogen ions.

3.2.5 Ion Exchange

This process is used on a large scale by industries to soften hard water.

Positively charged ions (cations) will exchange with positive ions, eg $Ca^{+2} + Na_2R \Rightarrow Na_2R + CaCl_2$.

"R" represents the residual material of the Zeolite which can be regenerated by contact with a solution of salt, eg $CaR + 2NaCl \Rightarrow Na_2R + CaCl_2$.

The rate of ion exchange depends upon rates of the following individual processes:

- Diffusion of ions from the bulk of the liquid to the internal surface of an exchanger particle.
- Inward diffusion of ions through the solid to the internal surface of an exchange of the ions.
- Outward diffusion of the released ions to the surface of the solid.
- Diffusion of the released ions from the surface of the solid to the bulk of the liquid.

3.2.6 Ion Exclusion

A resin is pre-saturated with the same ions as in a solution. It can then reject ions in such a solution but at the same time absorb non-ionic organic substances such as glycerine, and the like, which may also be in the solution. Tile organic matter can later be washed from the resin in an ion-free state.

3.3 Production of Caustic Soda.

3.3.1 Preparation of Caustic Soda (NaOH) by means of electrolysis

This method using a mercury cathode. In the mercury cell, continuously fed brine is partly decomposed in one compartment (called the electrolyser) between a graphite anode and a moving mercury cathode, forming chlorine gas at the anode and sodium amalgam at the cathode.

The reactions are: $2NaHg + 2H_2O \rightarrow 2NaOH + H_2 + Hg$; the sodium amalgam flows continuously to a second compartment where it becomes the anode to a short-circuited iron or graphite cathode in an electrolyte of NaOH-solution.

Purified water is fed to the cell counter current to the sodium amalgam; hydrogen gas is formed, and the NaOH increases to 40% or 50%. The reaction is as follows: $2NaHg + 2H_2O \rightarrow 2NaOH + H_2 + Hg$.

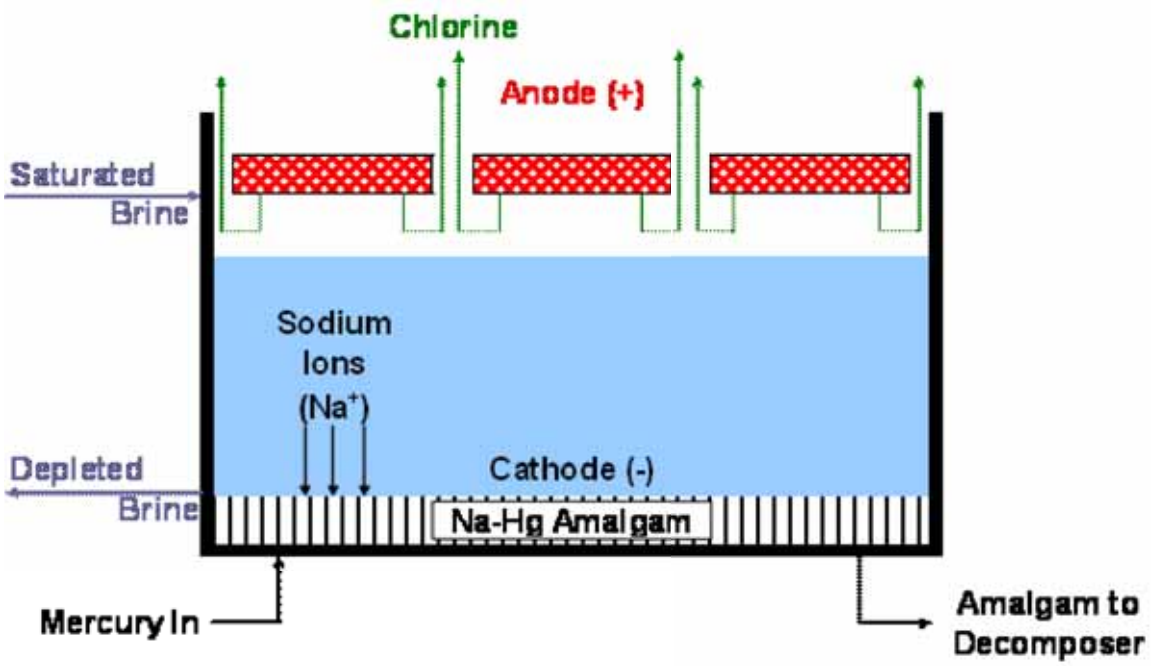


Figure 3.3 A typical mercury cell

3.3.2 Preparation of Caustic Soda (NaOH) by means of a caustic cell

Chorological steps of tile process as follow:

- Firstly brine purification, then
- Brine electrolysis.
- Then follow the evaporation and salt separation, til en
- Follow the fine evaporation.
- Then you get the finishing of caustic in the pots, which the special purification of caustic after then take place.

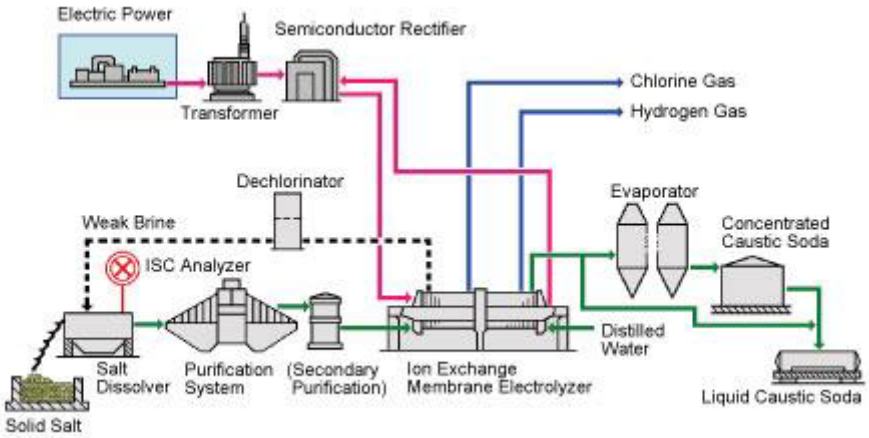


Figure 3.4 A typical flowchart

3.4 Production of Chlorine

3.4.1 Chlorine cell

The production of Chorine (Cl_2) is a by-product from the production of Caustic Soda and there for it refer to the same process as 3.3.

3.5 Production of Aluminium Sulphate. (Dorr procedure)

The preparation of aluminium sulphate can be follow accordance the following reaction eg $2NH_{3(gas)} + H_2SO_{4\ Lq)} \rightarrow (NH_4)_2SO_{4\ (Sol)}$

Chronological steps of the process as follow:

- Aluminium sulphate is made by reacting bauxite with sulphuric acid.
- The bauxite is grounded and conveyed to storage bins.
- Reactions occur in lead line tanks, where reactants are mixed by agitators and heated with steam.
- Reactors are operated in series.
- Into the last rector barium sulphide is added to reduce ferric sulphate to the ferrous state and to precipitate iron.
- Mixture from reactors sent through thickeners, which remove undissolved matter and wash waste to remove all alum.
- The clarified fluid is concentrated and poured into flat pans, where it is cooled and solidified.

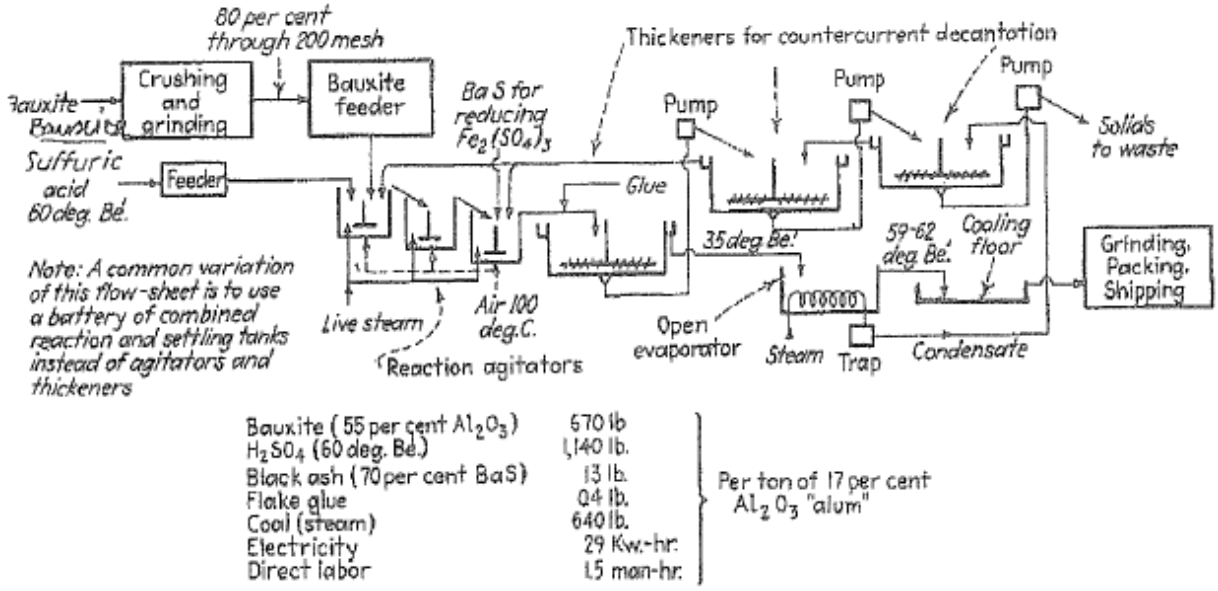


Figure 3.5 A typical flow chart

Activity 3.1

1. Write brief explanatory notes on each of the following steps in the preparation of caustic soda using a diaphragm cell:
2. Define the *law of intermediate metals*.
3. Draw a flow chart for the diaphragm caustic soda cell and name the main steps in the process.

	**Self-Check**		
I am able to:		**Yes**	**No**
• Describe:			
o Acids			
o Bases			
o Salts			
• Describe the production of:			
o Caustic soda			
o Chlorine			
o Aluminium sulphate			
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.			

Module 4

Pressure Measurement

Learning Outcomes
On the completion of this module the student must be able to:

- Describe the different kinds of pressure gauges and their:
  - Occurrence
  - Properties
  - Preparation and
  - Uses
- Describe the following tubes:
  - Helical
  - Spiral
  - C Bourdon tube
- Describe the diaphragm meter
- Describe the McLeod vacuum motor

4.1 Introduction

Process control is the regulation of an industrial process, which is possibly to simplify the actions by using instruments for process control like computers. Process control refers there for to manage process variables with applicable instrumentation.

Process variables refer to the physical quantity that can be measured and can change eg speed, pressure, flow, volume or temperature.

Process variables all so refers to the physical quality that can be measured and can change eg pH measuring to determine if a particular fluid is an acid or an alkaline, density and viscosity measurers of a particular fluid.

Measuring one or more process variables and regulating the process according to the measurement controls a modern industrial.

Measuring instruments consist of three parts, namely:

- *The Primary measuring element*: Also called sensory element that is in contract with the variables being measured and detects the change, for example the electrodes of a pH meter. It is of most important for controlling conditions that these elements are sensitive to react fast on process changes

measured. Should the element by reluctant, any change will after a time delay, be adjusted with accompanying delays.

- *Transfer element*: This element transfers the change, which was detected, to the next element known as the indicating element. An example of a transfer element is the hair tube connected to a pressure gauge.
- *The Indicating element*: Also called secondary element and reacts to the change that was detected and transferred, for example the Bourdon type of pressure meter, which indicated the pressure on a calibrated scale.

4.2 Pressure measurement

Pressure is force exerted, per unit area, and can be caused by a liquid contained in a vessel, or by gases and is measure in Newton per m^2 (Pascal).

However it is necessary to understand absolute pressure conditions and refer to the following definition.

	Definition: Absolute Pressure Gauge- plus atmospheric pressure eg when atmospheric pressure is measured in gauge pressure, it is 0 kPa. Atmospheric pressure at sea level is 101,32 kPa.

4.3 Different kinds of pressure gauges

- Helical -, spiral -, C Bourdon tube,
- Diaphragm type,

Mc Leod vacuum motor,

- Thermo type vacuum meter, and
- The resistance meter.

4.3.1 Helical-, spiral-, C Bourdon tube

The French inventor Bourdon, who in 1849 discovered that a bent flat tube tends to straighten when pressure is applied within the tube. Since this discovering the Bourdon tube is successfully used as indicating element.

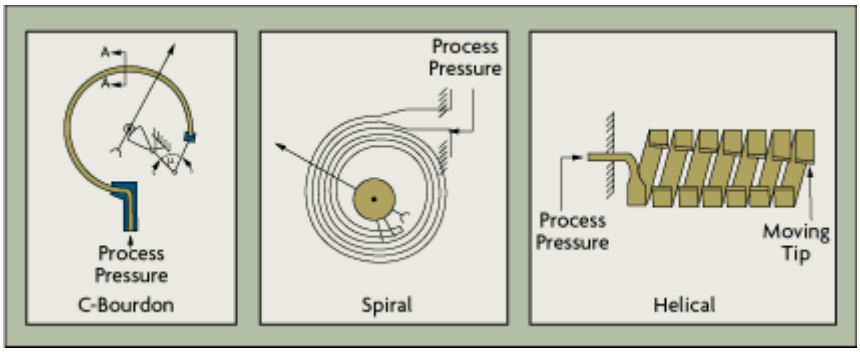


Figure 4.1 Bourdon tubes

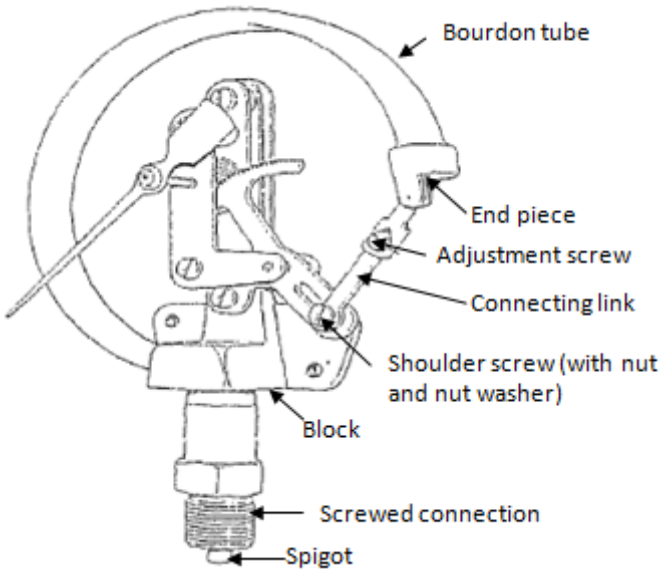


Figure 4.2 Base-frame of bourdon gauge

Operation:
The Bourdon tube consists of a tube of oval section bent in a circular arc. One end of the tube is sealed and attached to the mechanism, which operates the pointer. The other end of the tube is open for the application of pressure is has to measure.

The internal pressure tends to straighten out the tube. The resulting movement of the face end of the tube causes the pointer to move over the scale.

The following kinds of Bourdon tubes are applicable if the fluid have no corrosion problems concerning pressure conditions:

- 1 - 70 bars: Solid phosphor bronze
- 1 - 350 bars: Solid heat-treated beryllium copper
- 70 - 6 000 bar: Solid alloy steel tubes

4.4 Diaphragm meter

Diaphragms are very popular when it comes to the measurement of pressure differences.

The diaphragm box consists of a cylindrical box with an elastic strong metal or rubber diaphragm disc across its open end. The diaphragm box is suspended in the tank rises the pressure on the diaphragm increases and the diaphragm moves. This compresses the air within the closed system.

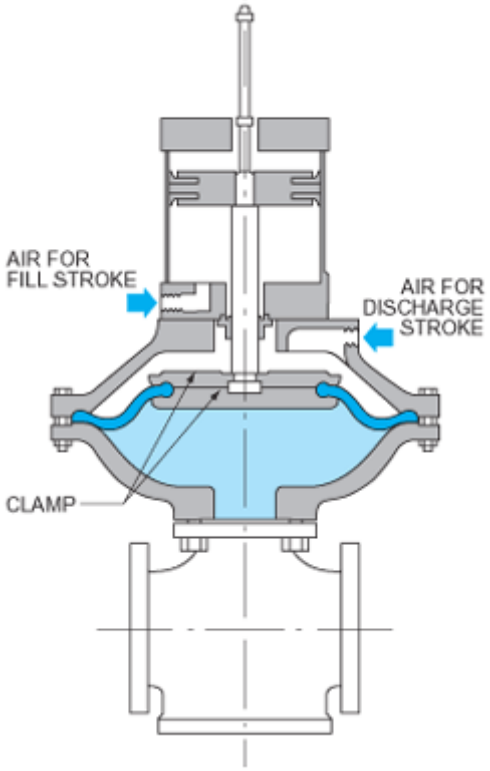


Figure 4.3 Diaphragm meter

The increased air pressure is transmitted by the capillary tube to the pressure-measuring portion of the instrument, which may be an indicator or a recorder.

4.5 Me Leod vacuum motor

Operation:

Gas from the system whose pressure is required enters the gauge through "B" and fills the tubes down to the level of the mercury reservoir. The reservoir "G" is then raised, cutting off the gas present in the bulb "H" and compressing it into the capillary extension, which lies along the scale "S".

The mercury rises faster in the left-hand limb, and my be made to stand at any height in the tube "A" and of the closed capillary must be the same to avoid differences of pressure arising from capillary depression of the mercury in the narrow tube.

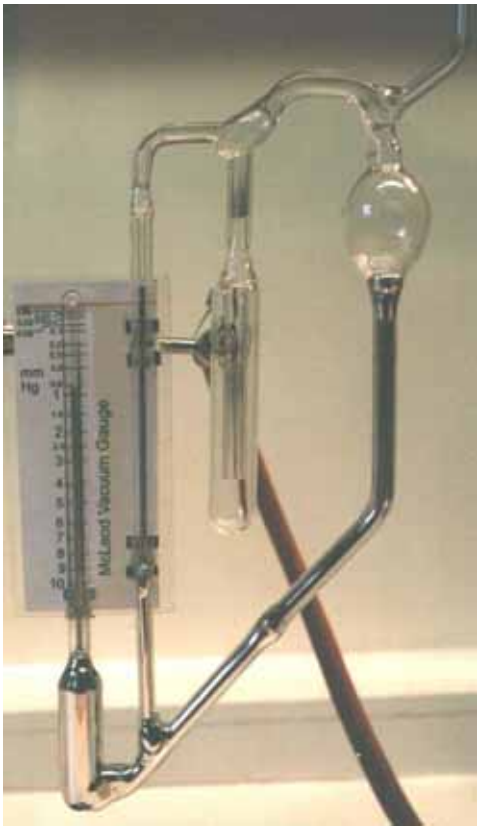


Figure 4.4 McLeod vacuum gauge

	Activity 4.1

1. Sketch a Bourdon gauge and describe its operation.
2. Discuss the operation and uses of a diaphragm meter.
3. Explain how the McLeod vacuum motor is used.
4. Sketch the Helical gauge and describe its operation.

	Self-Check

I am able to:	**Yes**	**No**
• Describe the different kinds of pressure gauges and their:		
o Occurrence		
o Properties		
o Preparation and		
o Uses		
• Describe the following tubes:		
o Helical		
o Spiral		
o C Bourdon tube		
• Describe the diaphragm meter		
• Describe the McLeod vacuum motor		

If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.

Module 5

Temperature Measurement

Learning Outcomes
On the completion of this module the student must be able to:

- Describe the different kinds of temperature gauges and instruments
  - Filled system (mercury- in - steel thermometer)
  - Pressure type
  - Expansion type
  - Thermocouple
  - Pyrometer
  - Resistance thermometers

5.1 Introduction

Temperature is a measure of the heat energy of a body or substance and is measured by means of various thermometers and is measure in Fahrenheit (°F), Celsius (°C), Kelvin (K) and Rankine.

The Rankine scale is the equivalent of the thermodynamic Kelvin scale, but expressed in terms of Fahrenheit degrees. Thus, the temperature of the triple point of water on the Rankine scale, corresponding to 273,16 K, is very nearly 491,69° Rankine.

Celsius designated the ice point as 0°C and the steam point as 100°C at sea level atmospheric pressure which is 101,32 kPa.

However it is necessary to understand absolute temperature conditions which, refer to the Kelvin scale and is the fraction 1/273,16 of the thermodynamic temperature of the triple point of water.

The triple point is realized when ice, water and water vapour is in equilibrium. It is the sole defining fixed point of the thermodynamic Kelvin scale and has the assigned value 273,16 K.

Definition: Absolute temperature
The temperature read on the Kelvin scale where the melting point of ice is 273,16 Kelvin, which is equal to 0°C at sea level.

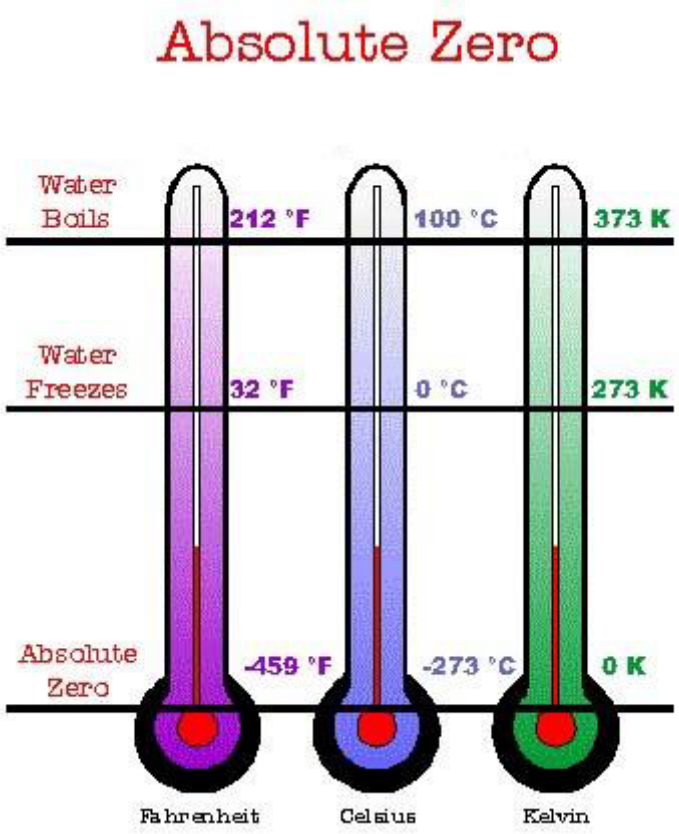


Figure 5.1 Thermometers compare Fahrenheit, Celcius and Kelvin scales

Worked Example 5.1

Convert the following:
a) 10°C to Kelvin
b) 263 K to °C

Solution:
a) 10°C to Kelvin
= 273 + 10
= 283 K

b) 263 K to °C
= 263 - 273
= -10 °C

5.2 Different kinds of temperature gauges / instruments

- Filled system

- Pressure type
- Expansion type
- Thermocouple
- Potentiometer I Pyrometer
- Resistance type

5.3 Filled system (mercury- in- steel thermometer)

Operation

When the temperature rises, the mercury in the bulb expands more than the bulb so that some mercury is driven through the capillary tube into the Bourdon tube. As the temperature continue to rise, increasing amounts of mercury will be driven into the Bourdon tube, causing it to uncurl.

One end of the Bourdon tube is fixed, while the motion of the other end is communicated to the pointer or pen arm.

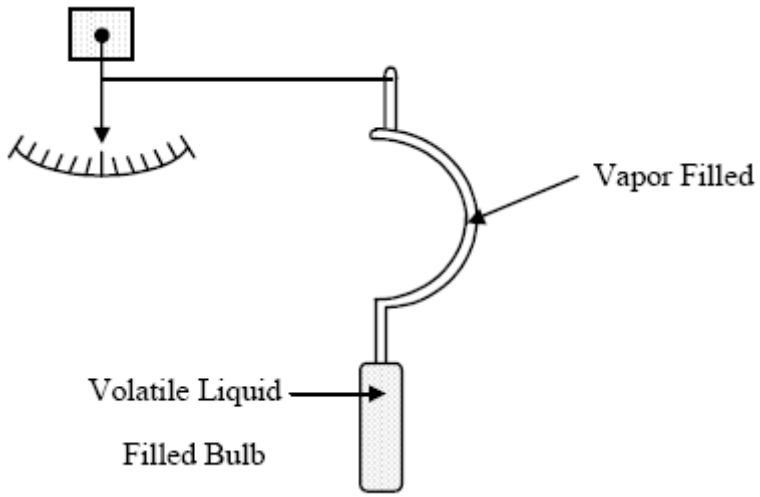


Figure 5.2

Advantages

- Fundamental simplicity of the system allows rugged construction, minimizing the possibility of damage or failure in shipment, installation, and use. The amount of upkeep is generally minor.
- Simplicity of the system allows inexpensive design.
- As used in the process industries, sensitivity, response time, and accuracy are generally the equal of any other temperature measuring instrument available.
- The capillary allows considerable separation between the point of measurement and the point of indication. It is usually more economical to employ transducers for signal transmission of 30,48 m (100 ft) or more.
- The measuring system is selfcontained. It does not need auxiliary power unless it is combined with a pneumatic or an electric transmission system.
- The system can be designed to deliver significant power if necessary to drive indicating or controller mechanisms, including valves.

Disadvantages / Limitations

- The bulb size may be too large to fit the available space.
- The performance characteristics vary considerably with the type of filling fluid, and the user must be certain that he does not misapply a particular type of system.
- The maximum temperature is more limited than that in some electrical measuring systems.
- In case of system failure, the entire unit must be replaced or repaired.
- Separation of sensing and indicating elements may be limited to 10 to 100 meter depending on other characteristics, such as filling liquid and accuracy requirements.

5.4 Pressure type

Based on Charles' law

When the temperature of a gas change, but the volume of the gas remains the same, the pressures of the gas will also proportionally changes.

A sealed unit consisting of a Bourdon tube element, connected to a hair tube which, in turn, is connected to a hollow metal ball, filled with a gas or liquid or vapour which expands when the temperature increase and the pressure is applied to the Bourdon tube.

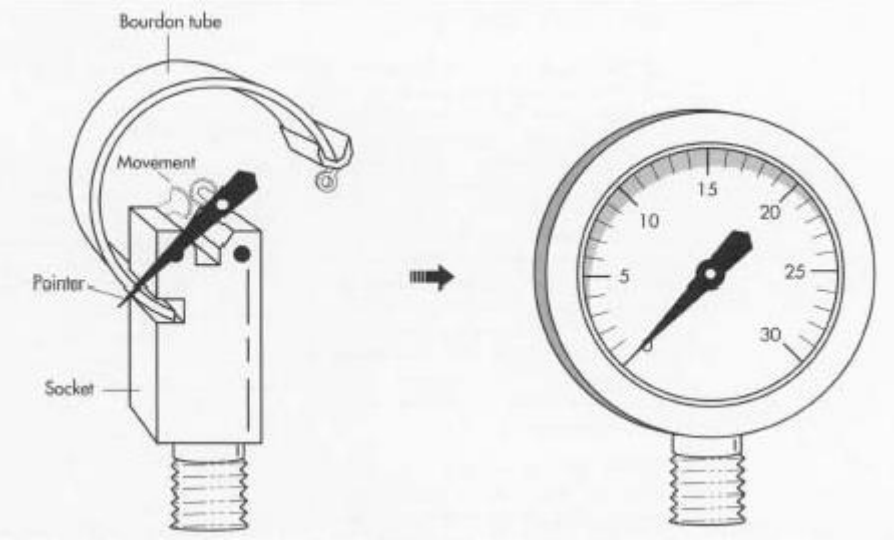


Figure 5.3

A gear mechanism conveys the movement to a scale, which is marked off in °C or Kelvin.

5.5 Expansion type

Bimetal Thermometers

Linear Expansion also known as bimetal strip, refers to the degree of expansion of a metal is proportional to the temperature. When two strips, each of a

different type of metal, with different coefficient of expansion is secured to each other that will be an indication of the temperature of the strip reflected.

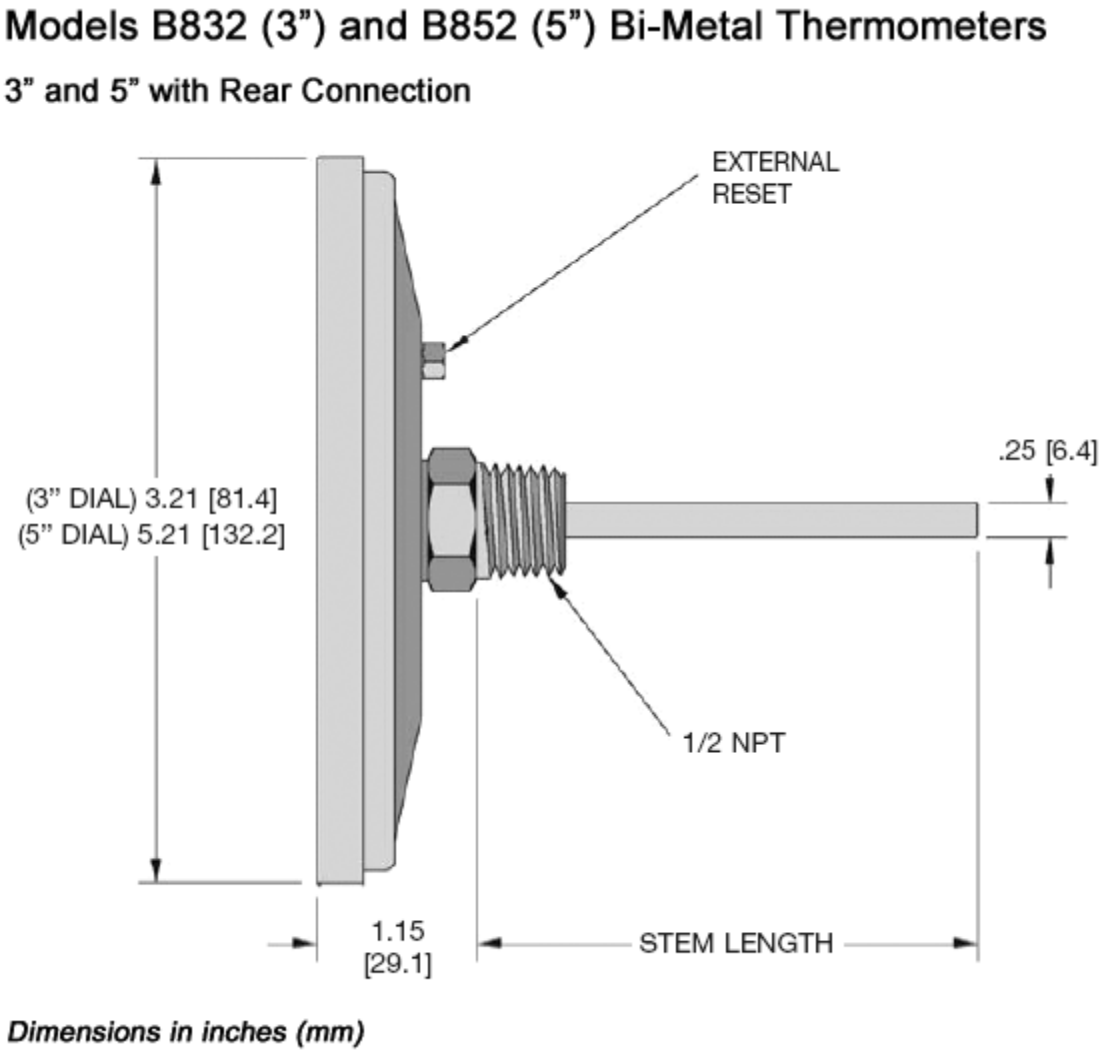


Figure 5.4 Bimetal thermometers for the measurement of temperature of environment

One end of the strip is fixed and the other allowed moving freely as a result of the bending. The free moving end is connected to a gear mechanism which causes a pointer to move indicate the temperature on a suitable scale.

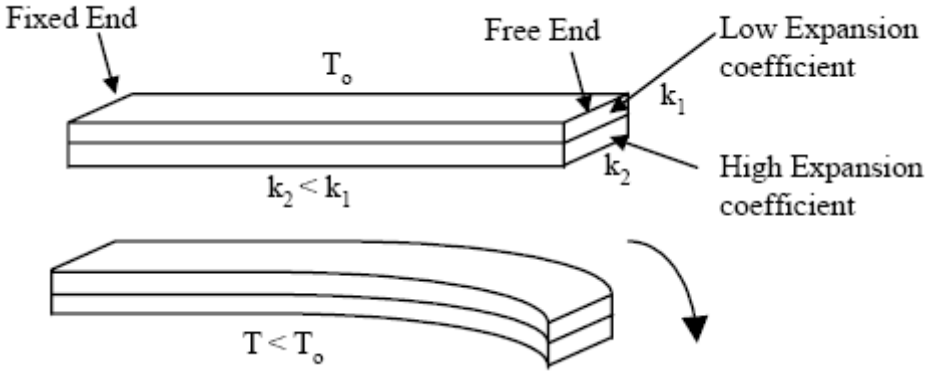


Figure 5.5 Principles of bimetal thermometers

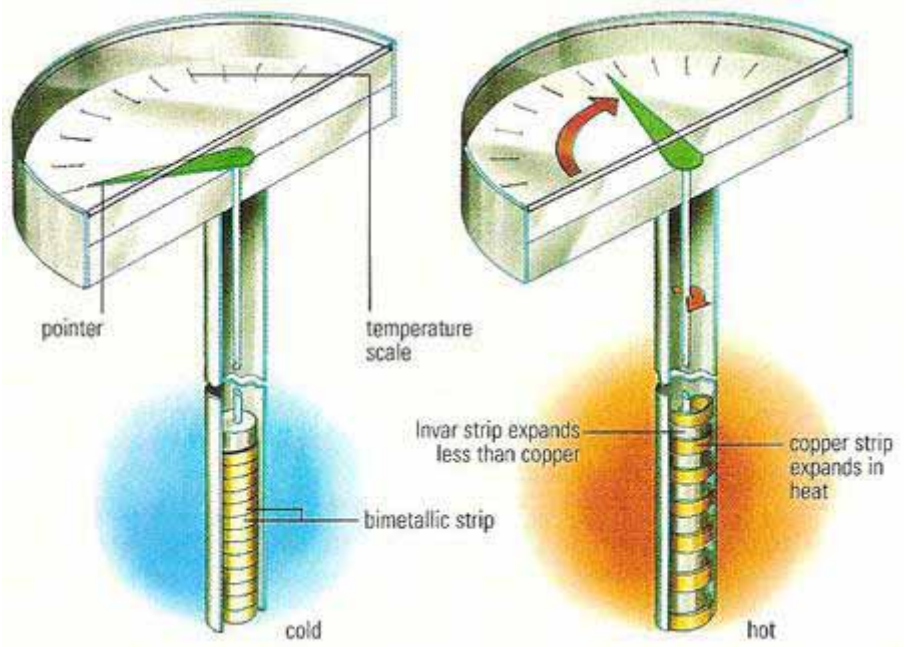


Figure 5.6 Bimetal thermometer for the measurement of temperature of environment

5.6 Thermocouple

When two different types of metal wires (conductors) eg copper and iron are connected at the ends, forming an electric circuit, an electromotive force (emf measured in milli-volts) is set up in the circuit and a small current flows if the two joins are at different temperatures.

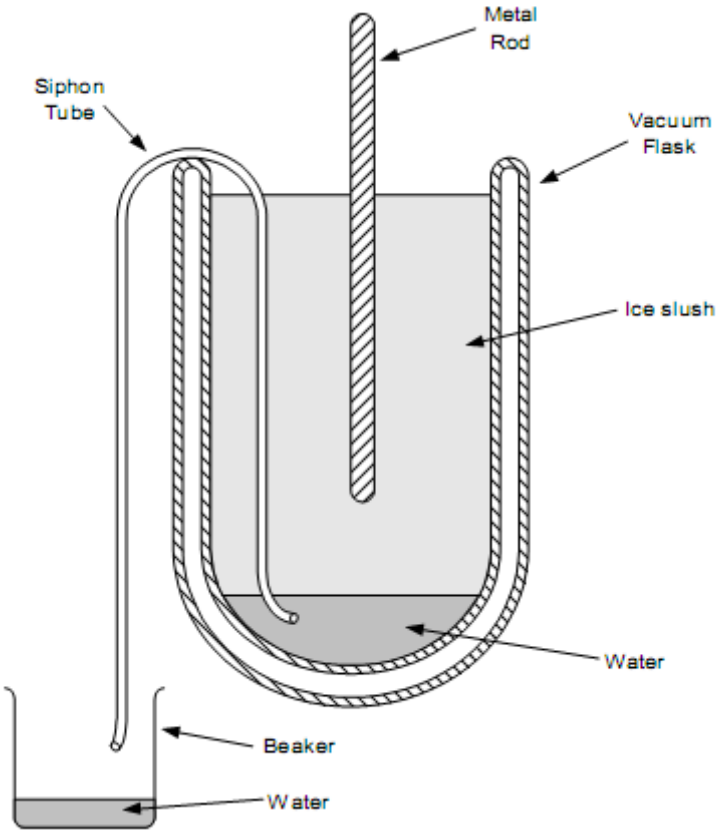


Figure 5.7 Thermocouple ice point

The emf is proportional to the difference in temperature between the two joins. The larger the difference in temperature, the larger the emf. The container with the ice water is the cold connection and is at constant temperature.

Pending on the temperature difference between the two connections the emk measured will be an indication of the temperature at tile hot connection.

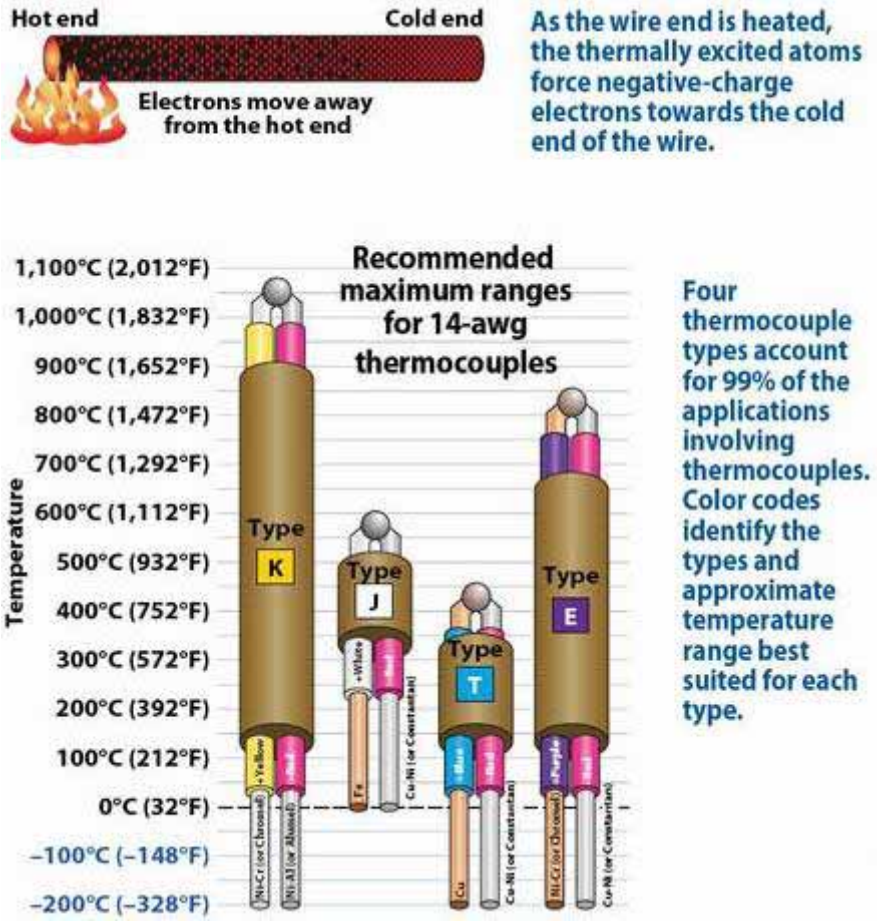


Figure 5.8

5.8 Pyrometer

Operation

They may be divided into two groups. In the first group, the light of a given wavelength from the hot body is optically matched with the light from a constant comparison lamp in the instrument by means of an optical wedge or polarizing system.

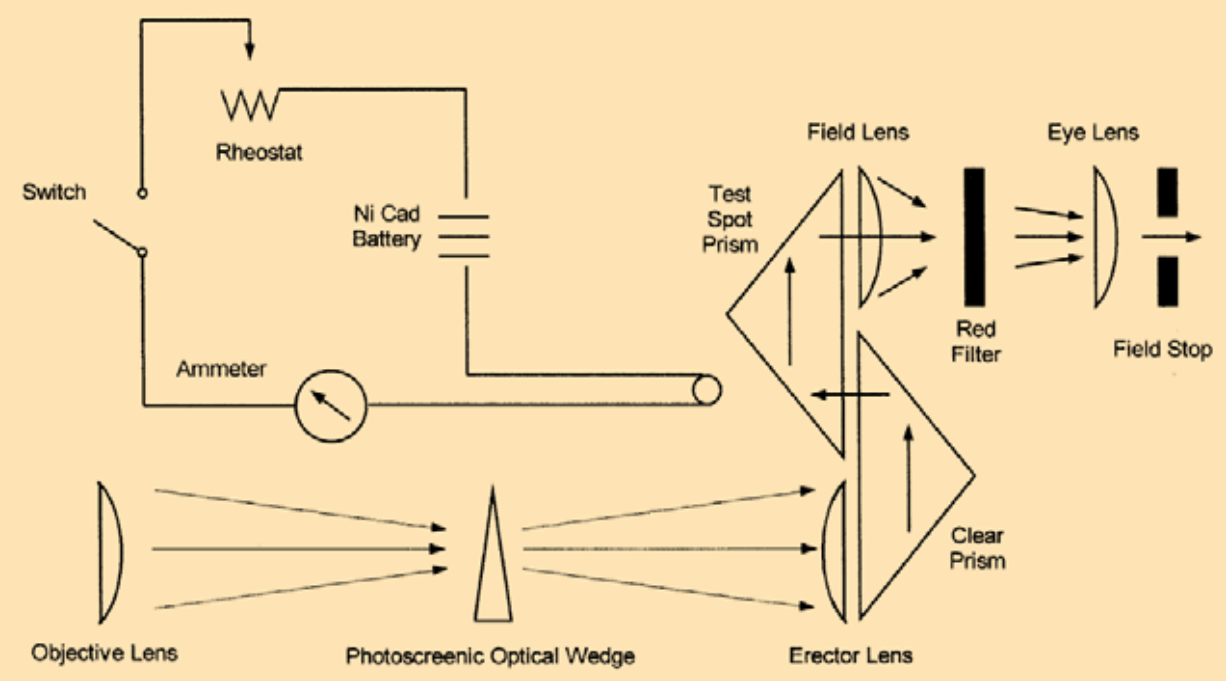


Figure 5.9 Optical wedge type pyrometer

In the second group, which has now become by far the most popular, the brightness of the light from the calibrated comparison lamp is varied to match the light from the hot body.

The brightness of the lamp is judged to be the same as that of the source when it merges into the image of the source. The instrument is therefore known as the disappearing Filament Pyrometer.

5.10 Resistance thermometers

This type is depending on the principle that the resistance of a metal conductor electricity / current change with temperature change.

The temperature - resistance - ratio is constant enough that the resistance measuring can be transform to temperature.

The temperature sensitive element is a wire spiral consists of a high resistant against heat and is made normally of nickel or platinum.

The resistance thermometer is very accurate and can be use to measure small temperature areas.

The Wheatstone Bridge is a convenient accurate piece of equipment in measuring resistance.

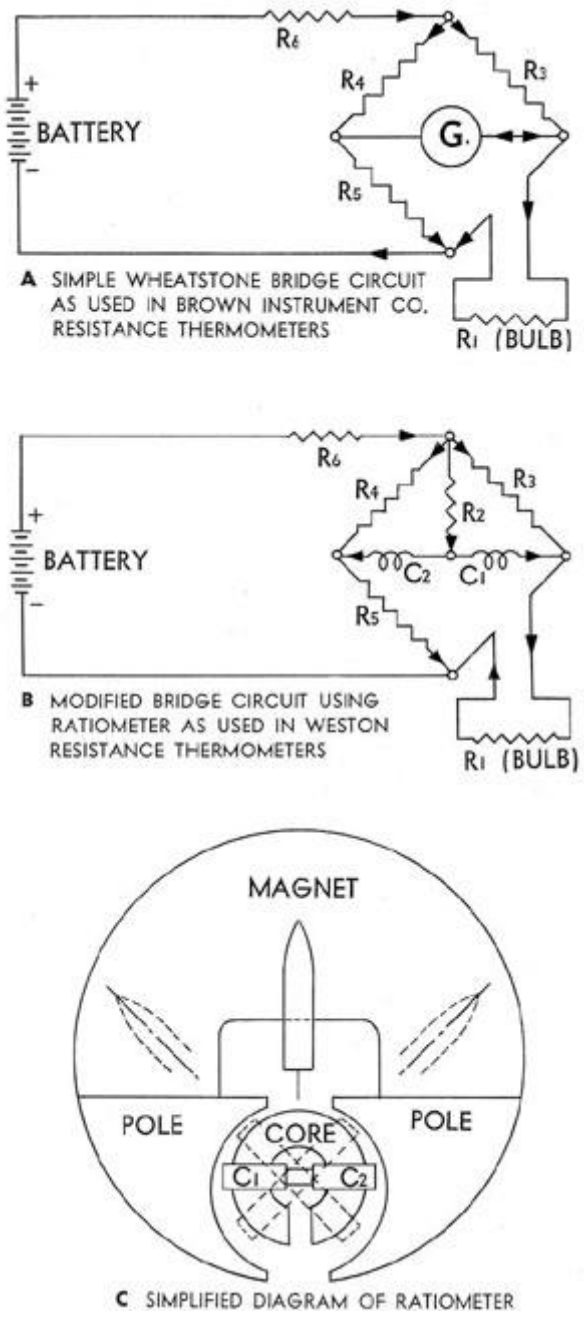


Figure 5.10 Resistance thermometers

Activity 5.1

1. Discuss the advantages and limitations of filled-system thermometers.
2. Give the advantages and disadvantages of the filled system (mercury–in-steel thermometer).
3. Sketch a thermocouple and explain describe its use.
4. What is a pyrometer?
5. How are resistance thermometers used?

	Self-Check		
I am able to:		**Yes**	**No**
• Describe the different kinds of temperature gauges and instruments			
o Filled system (mercury- in - steel thermometer)			
o Pressure type			
o Expansion type			
o Thermocouple			
o Pyrometer			
o Resistance thermometers			
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.			

Module 6

Flow Measurement

Learning Outcomes
On the completion of this module the student must be able to:

- Describe the following:
  - Positive displacement meters
  - Primary measuring flow meters
  - Secondary measuring flow meters

6.1 Introduction

The principle on which the flow meter works boils down to 'when a liquid flows in a pipe and the cross section changes then the velocity of the liquid changes and then the pressure of the liquid changes accordingly'.

The meter that causes the difference in pressure is called the primary flow meter or primary element and the meter used to measure the difference in pressure over the primary element is called the secondary flow meter or element.

6.2 Positive displacement meters

These meters measure the actual quantity of liquid flowing through the meter, and through the gear mechanisms, a counting apparatus rotates, which indicates the quantity.

The principle of the measurement is that as the liquid flows through the meter it moves a measuring element which seals off the measuring chamber into a series of measuring element which seals off the measuring chamber into a series of measuring element moves, these compartments each holding a definite volume.

As the measuring element moves, these compartments are successfully filled and emptied. Thus for each complete cycle of the measuring element, a fixed quantity of liquid is permitted to pass from the inlet to the outlet of the meter.

A film of the measured liquid provides the seal between the measuring element and the measuring chamber. The number of cycles of the measuring element is indicated by means of a pointer moving over a dial.

The following displacement type meters are well used in the chemical industry:

- reciprocating piston
- Rotating or oscillating piston
- Rotating disc
- Mutating disc
- Fluted spiral rotor
- Sliding vane
- Oval gear
- Rotating vane (turbine)
- Screw (helical) type

6.2.1 Rotating Vane (turbine) Type

The liquid stream drives a blade wheel, which rotates freely close to the walls of the meter.

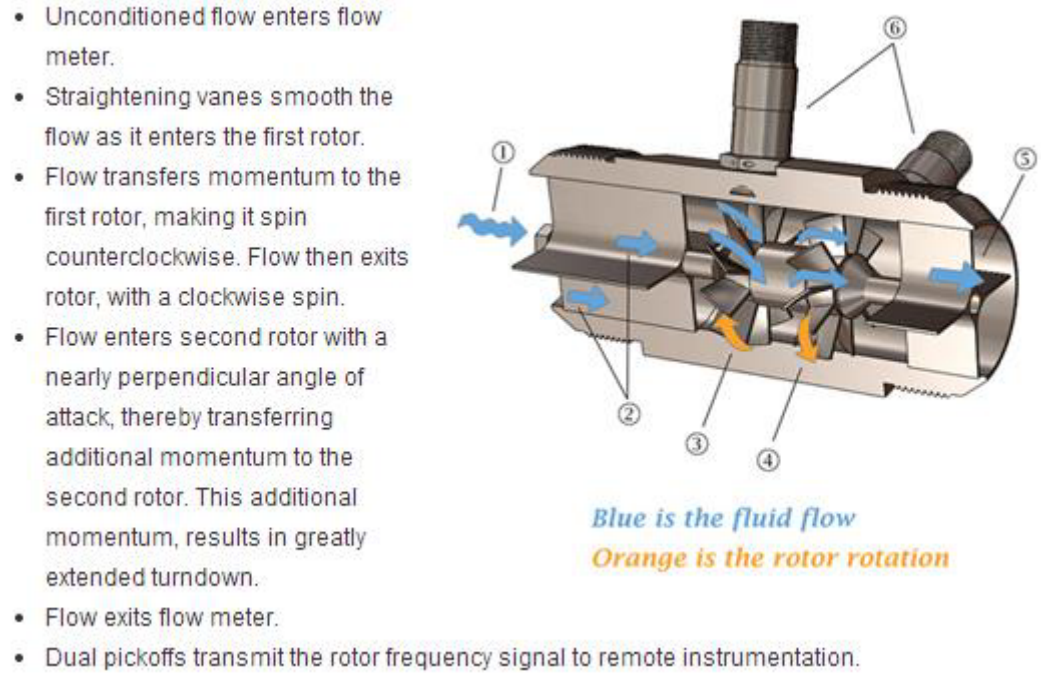


Figure 6.1 Dual rotor turbine concept

The displaced volume between the blades is known and the number of rotations is registered as the volumetric quantity.

6.2.2 Screw (Helical) Type

On the same principles of a windmill the liquid flowing through the meter causes the screw to rotate.

The rotation of the screw indicates, with the aid of a gear and counting mechanism the volumetric quantities.

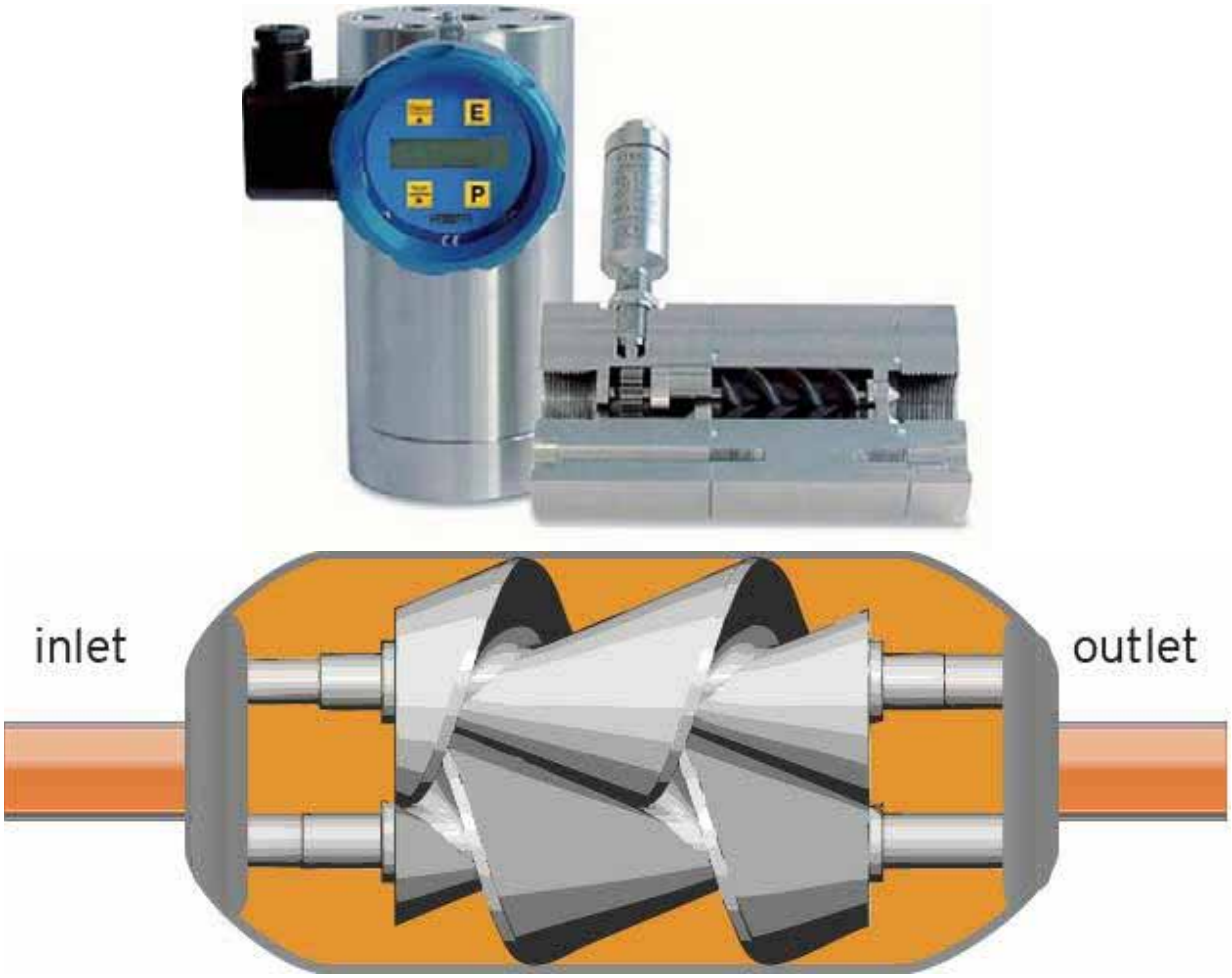


Figure 6.2 Screw (helical) type of meter

These meters should always be handled with care. It may be mounted in any attitude but for maximum meter range ability it should be mounted with the rotor axis horizontal.

The flow should be in the direction shown on the body. In order to reduce the risk of vaporization in the meter, the meter should be installed downstream of the pump so that the liquid passes through at a pressure well above its vapour pressure.

It is necessary to provide a straight pipe section of 10 pipe diameters upstream of the meter and 5 pipe diameters downstream.

The following errors are common using these applications as follows:

- The size of the clearances between the measuring element and the measuring chamber.

- The magnitude of the torque required to drive the meter register.

- The viscosity of the measured liquid. Increase in the viscosity of the measured liquid will increase the pressure drop across the measuring element but this is more than compensated for by the reduction of flow through the clearances for a given pressure drop.

  Thus, the error decreases with increase of viscosity at both low and high flow rates. The frangibility, or rage of flows for which the meter error is less than a specified value will therefore increase with increase of viscosity. Typical performance data for a film sealed positive displacement meters is shown.

  The meter factor defined as the ratio of the actual quantity passed to the volume indicated by the meter is plotted against the percentage of the rated flow.

6.3 Primary measuring flow meters

6.3.1 Orifice plates

These consist of flat-machined metal discs with a hole in the middle. They are mounted between two flanges in the pipe for measurement purposes.

Note:
There is a considerable permanent loss of pressure to (down stream from) the orifice plate.

Suitable points, depending on the characteristics of the pipe system, are chosen for the pressure difference meter and flow rate can be measured.

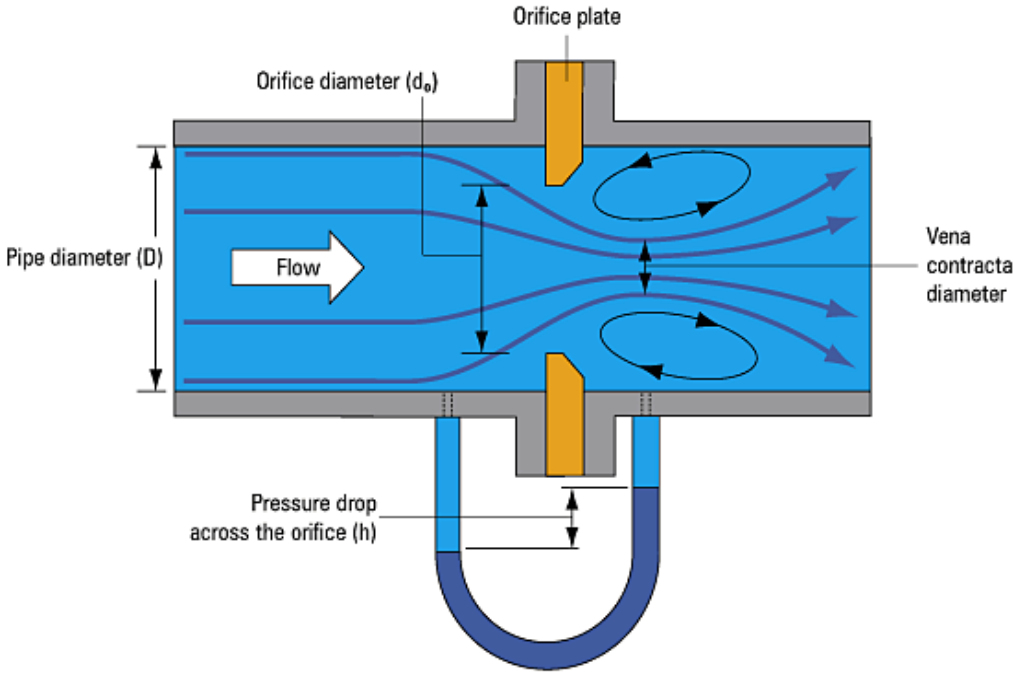


Figure 6.3 Installed orifice

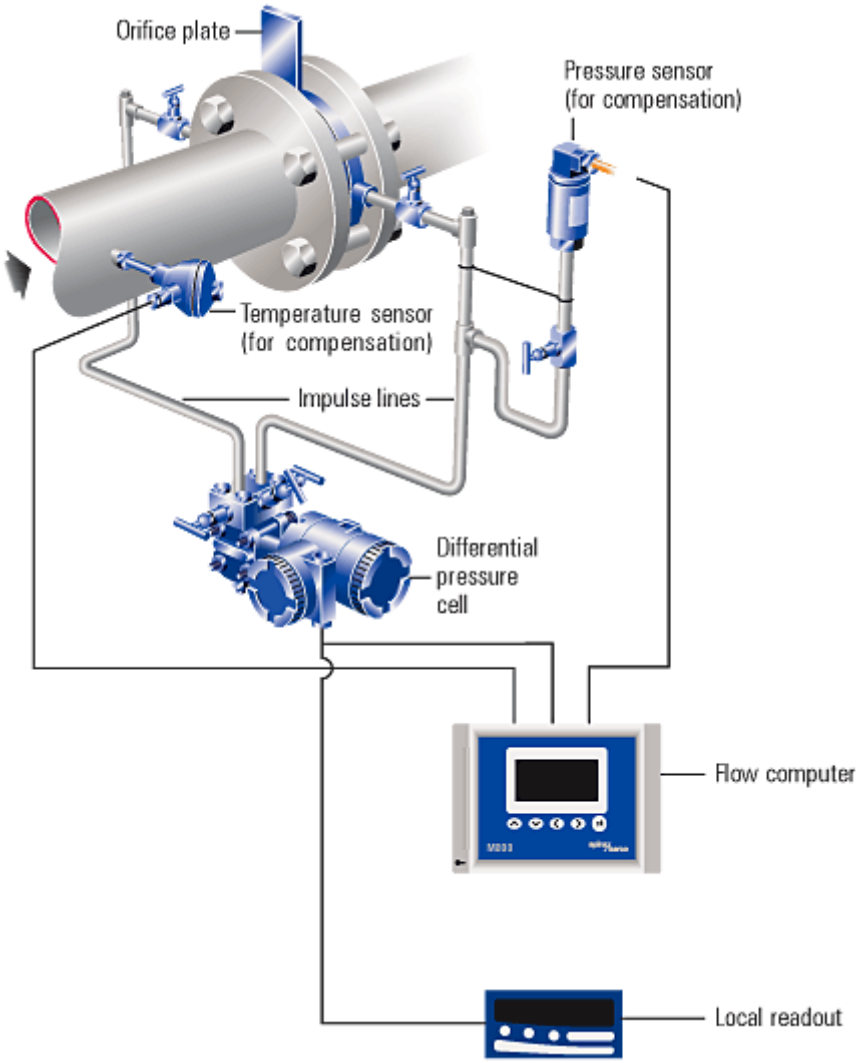


Figure 6.4 Orifice plate flow meter installation

It is essential to measure the pipe into which the plate is being inserted.

During installation and use, nothing must be allowed to damage the sharp upstream edge if the orifice. The upstream face should be smooth for a diameter of at least twice that of the bore, and be flat to within 2 %of the pipe diameter, when the plate is clamped between the flanges.

When the plate is in use, on extraneous matter must be allowed to collect on or near the orifice plate.

Where gases containing tar and other similar substances have to be metered, arrangements are usually made to remove their deposits with a blast of high pressure steam.

When the plate is being installed, gaskets, usually 1 to 6 mm thick and graphited on the side to the plate, are used between the plate and the flanges.

The gaskets must never extend into the pipe and should be cut to size when they are being installed. When the flange bolts are being tightened care must be taken to see that a uniform pressure is maintained all round the plate, so that the danger of buckling the plate is eliminated.

Great care must be taken to see that the orifice is concentric with the pipe, particularly when it has a high orifice ratio.

Care must also be taken with the pressure holes. After drilling the inside edge of the hole should be rounded off slightly with a reamer or file to be sure that no burrs exist.

Bleed holes should always provided in orifice plates. In liquid flow measurement the hole should be at the top to allow gas, which would otherwise be trapped by the plate, to pass on with the liquid.

In gas and steam flows measurement the hole should be at the bottom to allow liquids to pass.

6.3.2 Venturi tube

This type consists of a short tapered part and a long tapered part, of which the two constricted ends are connected by means of a short tube, which is the cone. The whole apparatus is attached to the pipe by means of flanges.

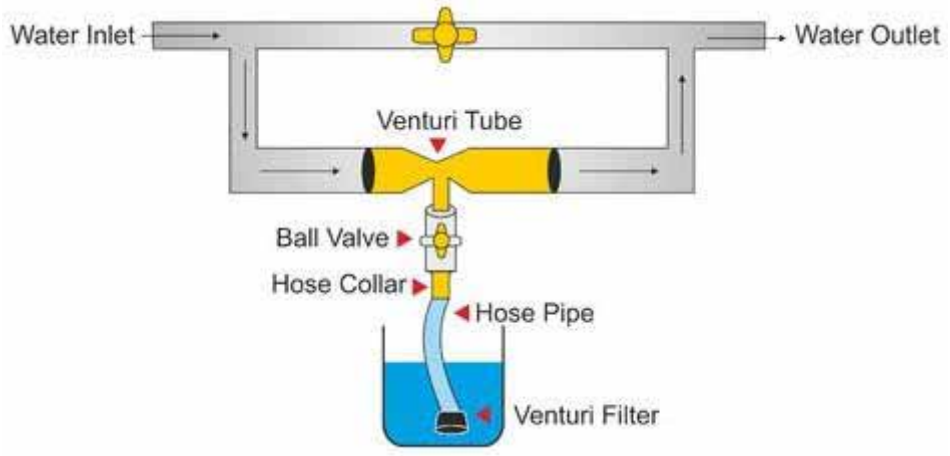


Figure 6.5 Venturi tube

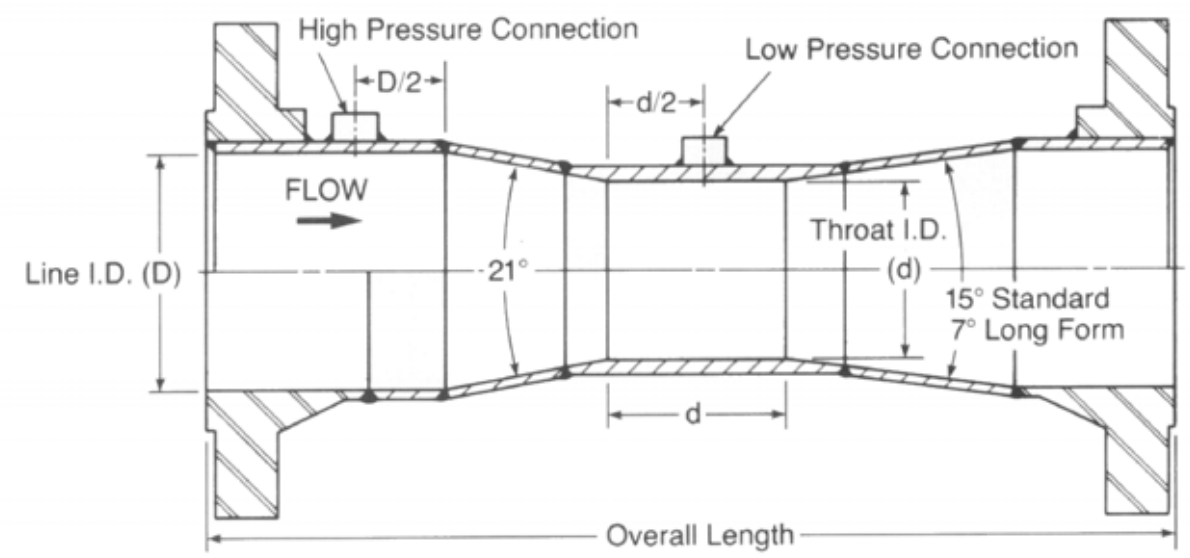


Figure 6.6 Flow diagram of a venturi tube

Advantages

- If carefully made and calibrated, it gives the most accurate reading.
- Does not wear easily.
- Dirt or deposits are not kept behind.
- Pressure loss across the meter is less than in the case of the orifice plate.

Disadvantages

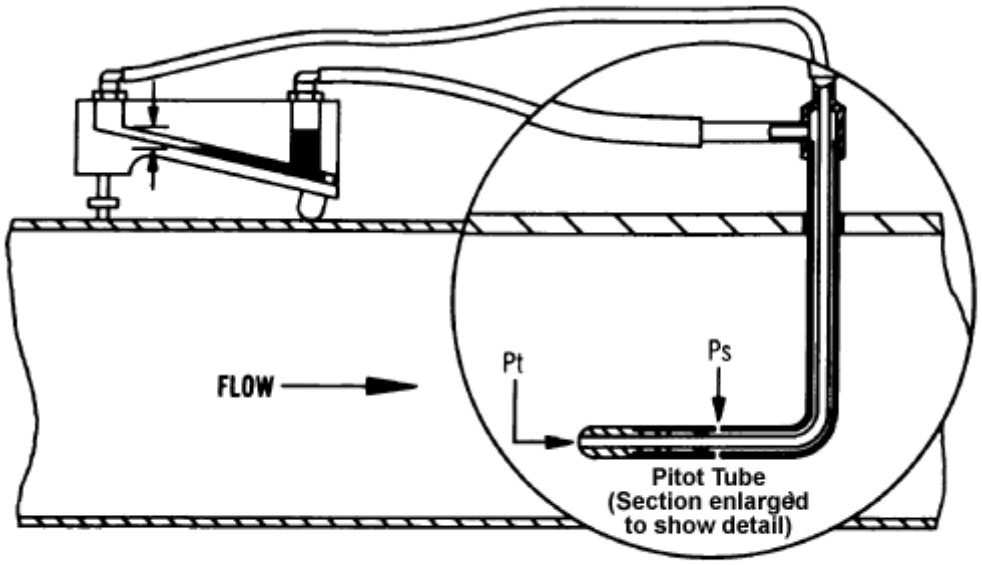
- Due to the size and shape, it is more difficult to install than a orifice plate.
- Accurate machining is essential and the characteristics of each of the tubes have to be determined experimentally. Sharp corners and ridges affect the flow.
- The cost of the tube is higher than that of the orifice plate.

6.3.3 The Pitot tube

It has been said that the pressure of a liquid in a pipe will increase when the velocity thereof is reduced. Thus a high pressure will build up when an obstruction, even in the shape of a squarely bent tube with its opening against the direction of flow is placed in the pipe.

The kinetic energy of the liquid is converted or transformed into pressure energy.

The difference between the pressure of the liquid against the wall of the pipe (static pressure) and the velocity pressure (kinetic pressure) gives an indication of the flow rate.



Pitot Tube senses total and static pressure.
Manometer measures velocity pressure –
(Difference between total and static pressures).

Figure 6.7 A simple pitot tube installed

Advantages

- It is cheaper than most other.
- It is easier to replace.
- It gives a very small pressure loss and
- Depending on the type of liquid, any type of metal tube can be used.

Disadvantages

- The tube I pipe blocks up easily if the liquid contains solids.
- The high-pressure tube must be placed exactly parallel in the pipe
- otherwise it will affect the reading.

6.4 Secondary measuring flow meters

6.4.1 Rotameter

It is an indicating element and operates as follows:
The internal cross-sectional area of the tube changes as the tube tapers and the flow is determined as follows:

- The tapered tube is mounted vertically in the line with the wide side up.
- The tube is graded, that is a scale is affixed to it and a small weight or heavy float is lifted by the liquid stream to a position where the downward pressure of the float balance the upward pressure of the liquid.
- The reading is then taken on the scale, directly opposite to the float.

The rotameter requires very little servicing. Deposits on the float or taper-tube can be seen when the taper-tube is made of glass, or in the sight glass.

Deposits are removed by flushing the rotameter with suitable washing liquid. Sensitively can be tested by tested by noticing its response to small changes in flow.

Periodically rotameter should be dismantled clean and checked for corrosion and wear.

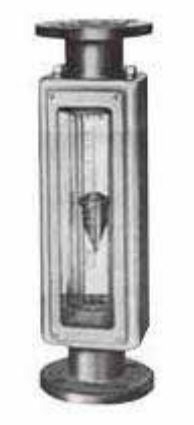


Figure 6.8 Glass body of the controllable area meter

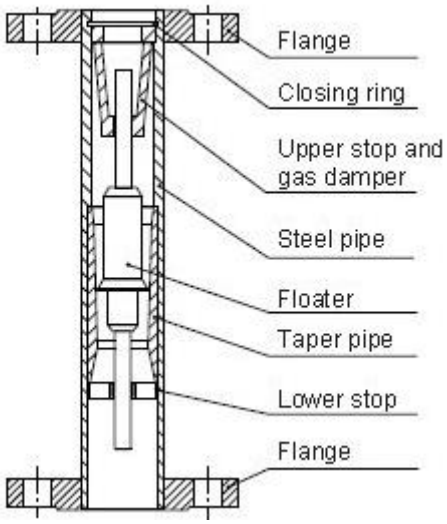


Figure 6.9 Rotameter with metal tube

6.4.2 Chain-balance-plummet hydrometer

S = Sampling chamber
L = Linear variable transformer
P = Plummet with metal core supporting chains "C"
R = Resistance thermometer bulb

Operation

The displacer or plummet is counter balanced by the weight of the plummet and platinum-iridium calibrating chain. The plummet is so weighted that, at the middle of the density indicating range, it will support half the weight of the chain with the reference points supporting the other half.

As the density of the liquid increases, the increased buoyancy of the plummet causes it to rise. In rising, the plummet will take up greater potion of the weight of the chain.

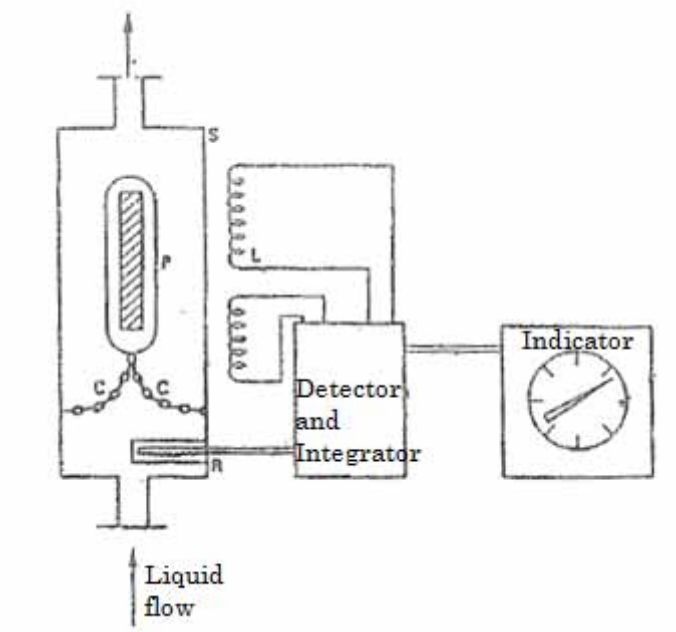


Figure 6.10

It continues to rise until the increased po1iion of the plummet is reduced and the plummet will sink so that the reference points take a greater portion of the weight of the chain.

It will continue to rise until the increased portion of the plummet is reduced and the plummet will sink so that the reference points take a greater potion of the weight of the chain.

It will continue to sink until equilibrium is again. Thus for each value of the density with the range of the plummet-chain assembly, the plummet will take up a definite position which is a measure of tile density of the liquid.

The plummet contains a ferromagnetic core, which alters the inductance between the primary winding the two opposed halves of the secondary winding of a differential transformer as the plummet rises or falls.

Activity 6.1

1. Write brief notes on *positive displacement meters*.
2. Discuss the precautionary steps which should be taken when installing and using orifice plates.
3.

	**Self-Check**		
I am able to:		**Yes**	**No**
• Describe the following:			
o Positive displacement meters			
o Primary measuring flow meters			
o Secondary measuring flow meters			
If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.			

Module 7

Level Measurement

Learning Outcomes
On the completion of this module the student must be able to:

- Describe the sight glass
- Describe measurement by means of pressure difference

7.1 Introduction

In industrial applications where fluids or bulk material are used, storage tanks or silos are used for processing or storing media. Sensors are used to detect levels. Even critical process conditions such as emptying a hydraulic tank or the unintentional overspill of a tank are monitored using level sensors

7.2 The Sight-Glass

There are a large variety of shapes and types of sight-glasses on the market, the most important being the tube and window type.

Figure 7.1 Tube type of sight glass

When clear, transparent liquids are measured, it is sometimes difficult to see the level in the tube and, consequently, a small float is introduced into the tube. This floats on the liquid and makes it easier to take the readings.

These types of applications are suitable for high-pressure equipment like steam drums.

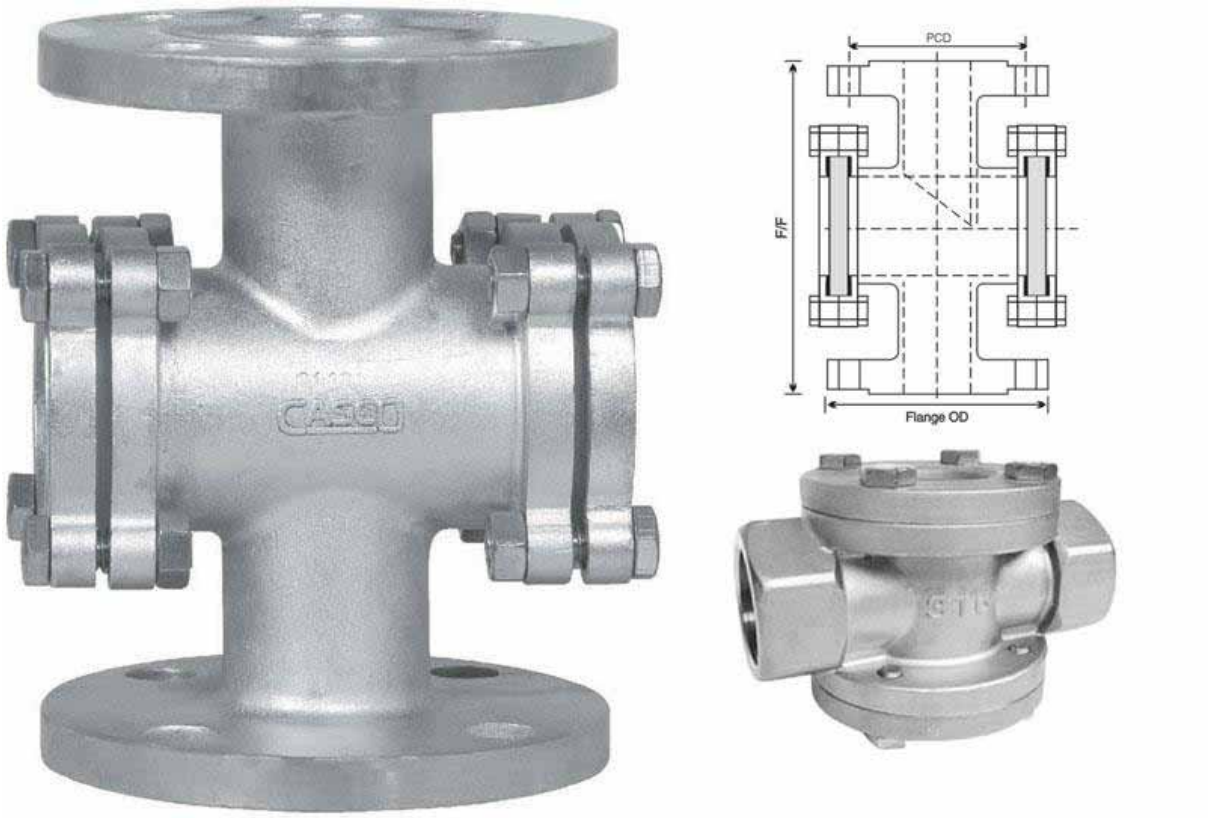


Figure 7.2 Window type of sight glass

7.3 Measurement by Means of Pressure Difference

It is well known that the pressure of a column of liquid exerts, depends on the density of the liquid and the height of the column refer to $P = p \times g \times h$.

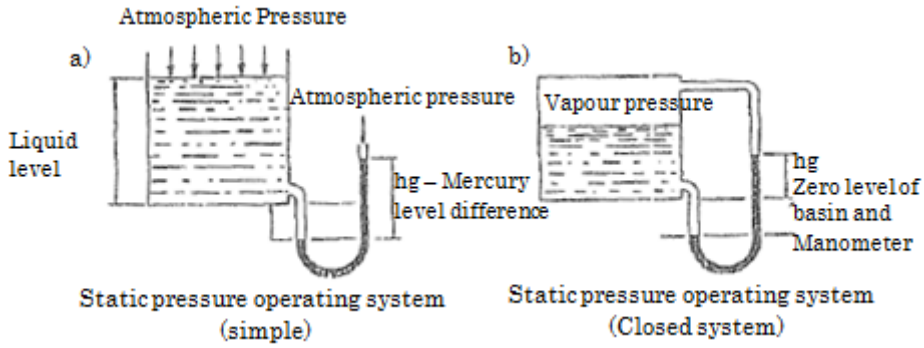


Figure 7.3 Measuring of level by means of manometers

In the container shown in **Figure 7.3a** both the legs are open to atmosphere refer to the manometer. The container in **Figure 7.3b** is under pressure vapour pressure of the liquid. The one leg of the manometer is then connected to this pressure at the top so that the pressure acts on both legs and thus cancels it.

7.3.1 Gas-bubble meter type determining liquid level in a close tank

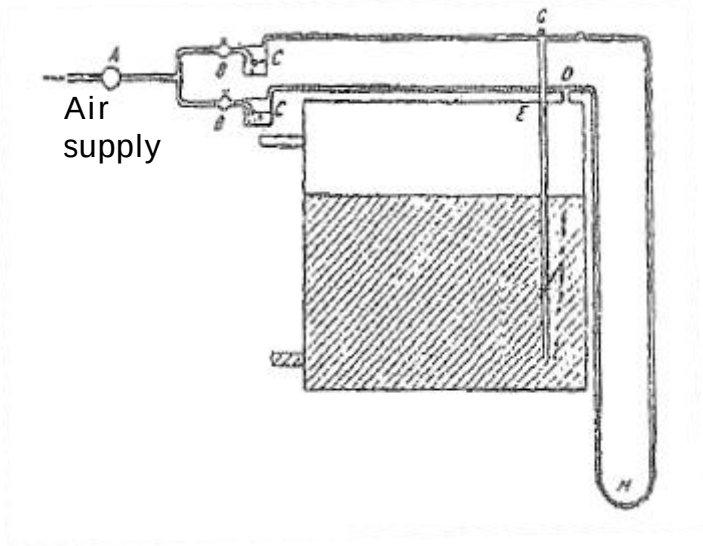


Figure 7.4

A = Reducing valve
B.B = Needle valves
C.C =Bubblers
M = Manometer
G = Clean-out plug

The pressure in the standpipe will build up until it is equal to that due to the liquid above the level of the bottom of the pipe.

If the flow of gas is small, say, 60 bubbles per minute, a pressure of gas equal to that in the standpipe will be applied to the liquid level indicator and the recorder. They will, therefore, give an indication depending up the pressure due to the depth of the liquid in the tank and so indicate the level.

7.3.2 Diaphragm depth meter system type

The diaphragm box consists of a cylindrical box with a rubber diaphragm across its open end. The diaphragm box is suspended in the tank well above the sediment level.

When the level of the liquid in the tank rise, the pressure on the diaphragm increases, and the diaphragm moves. This compresses the air within the closed system.

The capillary tube to the pressure-measuring portion of the instrument transmits the increased air pressure, which may be an indicator or a recorder.

7.3.3 Operation of the gas purge system

Purging gas is blown through a standpipe, which goes down almost to the bottom of the tank. The pressure in the pipe will build up until it is equal to that of the liquid above the level of the bottom of the standpipe.

If the flow of gas is small, pressure of gas equal to that in the standpipe will be applied to the liquid level indicator and recorder.

Activity 7.1

1. Write brief explanatory notes on the force balance system for the measure of levels.
2. Explain how you would determine the level of a liquid in a closed tank with the aid of a gas-bubble type of meter.

Self-Check

I am able to:	Yes	No
• Describe the sight glass		
• Describe measurement by means of pressure difference		

If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.

Module 8

Quality Measurement

Learning Outcomes
On the completion of this module the student must be able to:

- Describe how to determine viscosity
- Describe the use of:
  - The hydrogen electrode
  - Reference electrodes

8.1 Introduction

Accurate and repeatable measurements are vital to the successful operation of a chemical process - to deliver consistent product while minimizing costs. Today, the vast majority of installed gas and steam flow measurements in most chemical plants use differential pressure-based (DP) flow meters.

Although the DP flow meter is well established and capable of better than 1% flow accuracy and repeatability in a laboratory, most experienced users expect no better than 3-7% in the "real world" - even with a well-installed and maintained meter. This being the case, opportunity exists to improve plant operation by improving these existing DP flow measurement points.

8.1.1 How Can Better Flow Measurement Improve Chemical Plant Operation?

In the broadest sense, the measurement of flow in a Chemical process can be grouped into three categories:

- Process Control
- Custody Transfer
- Monitoring

All three categories provide some economic benefit from reduced flow measurement uncertainty.

- Process Control
  There are numerous flow measurements made throughout any chemical process – for example: Feed flow to reactors, flow into and out of separators or distillation columns, flow through heat exchangers, into and out of tanks, jacketed steam and cooling water flows, etc.

While the specific impact depends on the given application, as a general example, consider a feed flow to a reactor or distillation column. If the flow is mis-measured by 3% too low, not only will costs increase due to excess raw material being used - this unaccounted variability contributes directly to the variability of the resultant product and may lead to sub-optimal operation. This variability will impact downstream processes and further reduce end product quality and process efficiency.

- Custody Transfer
  While custody transfer measurements are uncommon in Chemical plants (as opposed to oil & gas or district heating applications), each measurement typically has very high economic value.

  For example, steam may be produced by a joint venture between two or more plants, and then sold back to the two plants. As another example, most plants install a flow meter to check the billing from the natural gas supplier.

  Many plants also employ "pseudo" custody transfer applications, in which the utilities and other plant units are treated as separate business entities to evaluate performance – in these cases, any transfer of steam, compressed air or other fluid can be considered as "pseudo-custody".

  In these applications, a reduction in flow uncertainty is random, which means that any error has an equal probability of resulting in over-billing or under-billing. However, large uncertainties lead to disagreement between the billing and check meters, leading eventually to billing disputes, expensive flow audits, and ultimately claims for retroactive compensation.

- Monitoring
  Most flow measurements in a Chemical plant are for monitoring only. While not used directly for control, these measurements are used to detect problems and make off-line decisions that impact the efficiency of the plant:

  – efficiency calculations: Which unit needs maintenance, which should be shut down when demand is light, etc
  – mass, energy and steam balances
  – leak detection and cost allocation

  While a reduction in flow uncertainty in a monitoring application will not provide direct savings, it can lead to better decisions. While difficult to quantify, upgrading the wrong process or overlooking a leak due to poor measurement can have real economic costs.

  While absolute accuracy is key for custody transfer, in the vast majority of chemical plant applications repeatability is key. For this reason, this paper will focus on improving repeatability.

8.2 Determined Viscosity

A ball with a specific mass is dropped in a glass tube filled with liquid. The time taken for the ball to reach the bottom of the tube is measured. This is then the viscosity of the liquid, in other words the longer the time taken the 30 higher the viscosity.

Viscosity is measured in poise or stokes, and the Saybolt-, Redwood-, and Engler scales are normally use, using the rotating bowl or vane instruments.

Hagen-Poiseuille law: Hagen (Germany) and Poiseuille (France) described viscosity as the ratio of shear stress versus shear rate at the wall of a capillary tube. Positive displacement meters are frequently used in oil and water undertakings for accounting purposes.

Definition: Hagen-Poiseuille law
This law states that the flow rate is proportional to the pressure difference between the ends of the pipe and the fourth power of its radius.

8.3 Hydrogen electrode

If a simple voltaic cell, hydrogen is used as one electrode, the potential difference attained between the electrodes will, if everything else is kept the same, be a function of the concentration of the hydrogen electrode.

A hydrogen electrode consists of a platinum plate or wire covered with platinum black. When hydrogen is bubbled over such an electrode it is absorbed into its surface and the electrode behaves as a hydrogen electrode.

It can be shown that the potential attained by a hydrogen electrode is related to the pH value, e.g. the standard or normal hydrogen ion activity, and this solution is hydrochloric acid having a concentration of 1,228 mol/dm.

8.4 Reference electrodes

In order to complete the electrical circuit a second contact with the tested solution is required. The potential difference developed at this second point of contact must be constant.

It should be independent of temperature changes (or vary in a known manner), be independent of the pH value of the solution, and remain stable over long periods if the potential difference produced at the measuring electrode is to be accurately measured.

Activity 8.1

1. Name and describe TWO instruments that are used for measuring viscosity.
2. Describe how to determine viscosity.
3. Describe the use of:

(a) The hydrogen electrode

(b) Reference electrodes

Self-Check

I am able to:	**Yes**	**No**
• Describe how to determine viscosity		
• Describe the use of:		
o The hydrogen electrode		
o Reference electrodes		

If you have answered 'no' to any of the outcomes listed above, then speak to your facilitator for guidance and further development.

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2013

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

3 April 2013 (X-Paper)
09:00 – 12:00

Candidates will require drawing instruments, pens and a ruler.

This question paper consists of 5 pages.

TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Sketches must be large, neat and fully labelled.
5. Write neatly and legibly

QUESTION 1 SEPARATION THEORY

1.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only ~true' or 'false' next to the question number (1.1.1-1.1.5) in the ANSWER BOOK.

1.1.1 There is no difference between continuous distillation and rectification.

1.1.2 Crystallization is used to separate one liquid from another one.

1.1.3 Packed towers are classified as fractionation towers.

1.1.4 Adsorption is used to separate vapour from solids.

1.1.5 Fixed-bed absorbers are designed to be used for vapours at high pressure.

(5 x 1) (5)

1.2 Write brief clarifying notes on:

1.2.1 The volatility of a component in a liquid mixture, which follows Raoul's law

1.2.2 Relative volatility

1.2.3 Rectification

(3 x 3) (9)

1.3 State FIVE characteristics tower packing should offer. (5)

1.4 Sketch a labelled, typical absorption unit that refines gas using absorption oil. (6)

[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true! or 'false' next to the question number (2.1.1-2.1.5) in the ANSWER BOOK.

2.1.1 The linking of similar molecules by joining together light olefins refers to polymerisation.

2.1.2 Aromatisation is the conversion of naphthalene to obtain products of a lower octane number.

2.1.3 An example of a cracking reaction is:
$C_3H_8 \rightarrow C_2H_6 + H_2 + CO$

2.1.4 Liquid fuel products can consist of water and crude oil, while gaseous fuel products consist of carbon monoxide and nitrogen.

2.1.5 LPG is only obtained as a byproduct from refineries.

(5 x 1) (5)

2.2 Explain each of the following:

2.2.1 Paraffin-based crude (2)

2.2.2 Intermediary based crude (2)

2.2.3 Alkylation (1)

2.3 List THREE heavy distillates in refining operations using fractionation. (3)

2.4 Describe the purification process of natural gas. (6)

2.5 Discuss the step-by-step decomposition of coal. (6)

[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.1.1-3.1.5) in the ANSWER BOOK.

3.1.1 A salt is formed when an acid reacts with a base.

3.1.2 A pH value of 0 refers to a strong alkali.

3.1.3 A pH value of 7 for water is neutral.

3.1.4 Ion exchange is used on a large scale by industries to soften rain water.

3.1.5 The zeolite process refers to ion exchange.

(5 x 1) (5)

3.2 Write brief explanatory notes on each of the following steps in preparation of caustic soda using a diaphragm cell:

3.2.1 Brine purification (3)

3.2.2 Evaporation and salt separation (2)

3.3 Draw a fully labelled flowchart for the preparation of NaOH by means of a caustic cell. (15)

[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 Indicate whether the following statements are TRUE or FALSE. Choose the

answer and write only 'true' or 'false' next to the question number (4.1.1-4.1.5) in the ANSWER BOOK.

4.1.1 Process variables refer to measuring the physical quantity but not to measuring the physical quality.

4.1.2 The electrodes of a pH meter are an example of a primary measuring element.

4.1.3 Absolute pressure refers to gauge pressure.

4.1.4 10ºC is equal to -283 Kelvin.

4.1.5 A screw type of flow meter refers to a positive displacement meter.

(5 x 1) (5)

4.2 Write brief clarifying notes explaining Kelvin as temperature scale. (3)

4.3.1 List SIX instruments that can measure temperature. (6 x ½) (3)

4.3.2 List SIX instruments that can measure pressure. (6 x ½) (3)

4.4 Sketch and describe the operation of a chain-balanced plummet hydrometer. (9)

4.5 Briefly explain the *hydrogen electrode* as quality measuring instrument. (2)

[25]

TOTAL: 100

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2013

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

This marking guidelines consists of 7 pages.

QUESTION 1 SEPARATION THEORY

1.1.1 False

1.1.2 False

1.1.3 True

1.1.4 True

1.1.5 True (5)

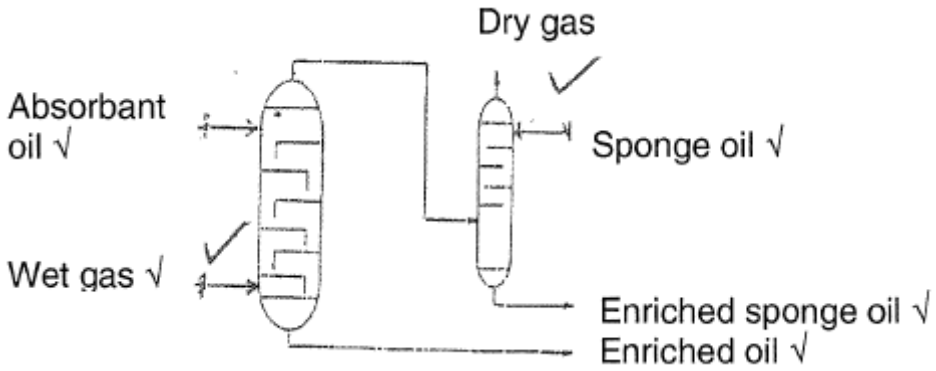
1.2.1 Volatility of a Component. (3)
The volatility of a component in a liquid mixture, which follows Raoult's law, must be equal to the vapour pressure of that component in pure state.

1.2.2 Relative volatility. (3)
It may be defined as the volatility of one component of the liquid mixture divided by the volatility of another component of the liquid mixture.

1.2.3 3 Rectification (3)
It may be defined as a single-unit distillation operation in which vaporization occurs in repeated steps to give a much greater overall separation than could be obtained by one simple distillation.

1.3 Characteristics tower packing should offer (5)
- Provide for large interfacial surface between liquid and gas
- Possess desirable fluid-flow characteristics
- Be chemically inert to fluids being processed
- Have structural strength to permit easy handling and installation
- Represent low cost

1.4 (6)



[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1.1 True

2.1.2 False

2.1.3 False

2.1.4 True

2.1.5 False

(5 x 1) (5)

2.2.1 Paraffin-based crude

This crude consists primarily of open-chain compounds and furnishes low octane-number straight-run gasoline and excellent but waxy lubricating oil stocks. (2)

2.2.2 Intermediary based crude
This crude consists of large quantities of both paraffinic and naphthenic compounds and furnishes medium grade straight-run gasoline and lubricating oils. Both wax and asphalt are found in these oils. (2)

2.2.3 Alkylation
This is the binding of an olefin with an aromatic or paraffin hydrocarbon. (1)

2.3 Heavy distillates
- Heavy mineral oils
- Heavy flotation oils
- Waxes
- Lubricating oils (Any 3 x 1) (3)

2.4 Purification of natural gas
Four important methods are employed for the dehydration of gas namely compression, treatment with drying substances, absorption and refrigeration. A plant for water removal by compression consists of a gas compressor, followed by a cooling system to remove the water vapour condensation. The treatment of gas with drying substances has found widespread usage in this country. The agents employed for this purpose are activated alumina and bauxite, silica gel, sulfuric acid, glycerin and a concentrated solution of calcium chloride or sodium thiocyanate. Passing it over refrigerated coils may also dehydrate gas. The Girbotol procedure is used to remove the H_2S. (6)

2.5 Decomposition of coal
- Step 1: As the temperature is raised the aliphatic 'carbon to carbon' bonds are the first to break.
- Step 2: 'Carbon to hydrogen linkages' are severed next as the temperature of 600 ºC is approached and exceeded.
- Step 3: The decompositions during carbonisation are essential reactions affecting the elimination of hetero cycle complexes and progressive aromatisation.
- Step 4: The average molecular weights of the volatile intermediate products constantly decrease as the temperature of carbonisation rises. This decrease is marked by the evolution of water, carbon monoxide, hydrogen, methane and other hydrocarbons.

- Step 5: Final decomposition is at a maximum between 600 °C and 800 °C. (6)

[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1.1 True

3.1.2 False

3.1.3 True

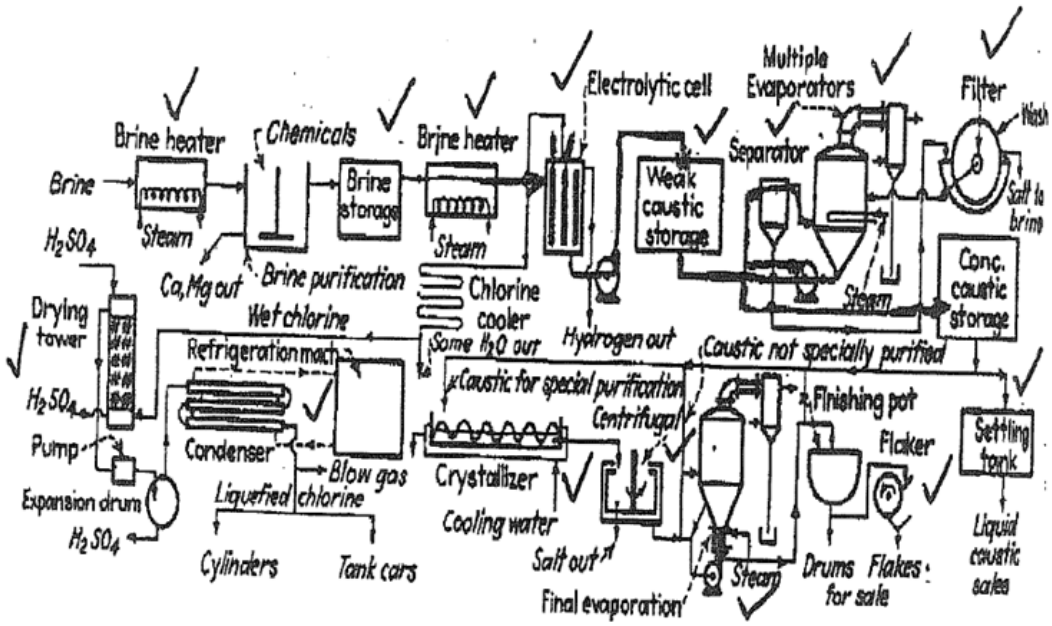
3.1.4 False

3.1.5 True (5)

3.2.1 Brine purification
To make a purer caustic soda and to lessen clogging of the cell diaphragm with a consequent increase, purification of the NaCl solution of calcium, ions and magnesium compounds is practiced, using soda ash with some caustic soda. Sometimes sulphates are removed with BaCl or the hot brine is treated with hydroxyl and carbonate ions. The clear brine is neutralised with hydrochloric acid. (3)

3.2.2 Evaporation and salt separation
NaOH solution is evaporated in a double or triple effect evaporator with salt separators and then passes through a settler and washing filter. The salt so recorded is again made into charging brine. (2)

3.3



(15)

[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1.1 False

4.1.2 True

4.1.3 False

4.1.4 False

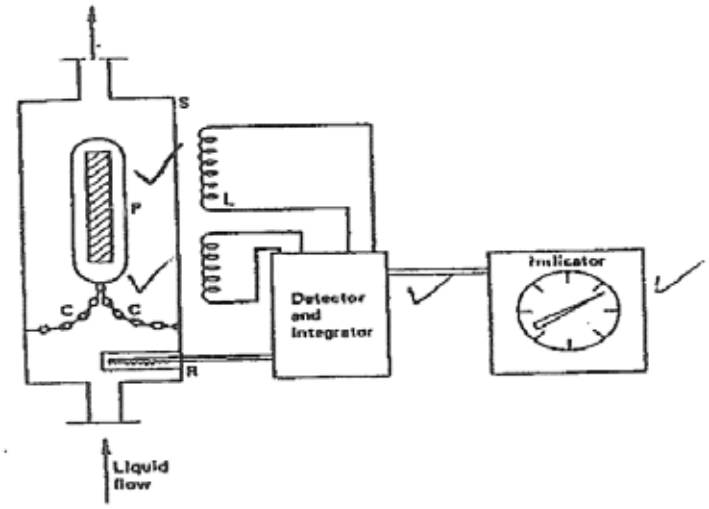
4.1.5 True (5)

4.2 Kelvin scale
The Kelvin scale is a fraction 1/273,16 of the thermodynamic temperature of the triple point of water.
The triple point is realised when ice, water and water vapour are in equilibrium. It is the sole defining fixed point of the thermodynamic Kelvin scale and has the assigned value 273,16 K. (3)

4.3.1 Temperature measuring instruments
- Helical type Bourdon tube
- Spiral type
- Bourdon tube (filled systems)
- Pyrometer
- Resistance thermometer
- Thermocouple
- Potentiometer (Any SIX correct answers) (6 x ½) (3)

4.3.2 Pressure measuring instruments
- McLeod vacuum gauge
- Bourdon tube
- Barometer
- Manometer
- Helical type
- Resistance type (Any SIX correct answers) (6 x ½) (3)

4.4 Chain-balanced plummet hydrometer:



S = Sampling chamber
L = Linear variable transformer
P = Plummet with metal core supporting chains 'C'
R = Resistance thermometer bulb (4)

Operation.
The displacer or plummet is counterbalanced by the weight of the plummet and platinum-iridium calibrating chain. The plummet is so weighted that, at the middle of the density indicating range, it will support half the weight of the chain with the reference points supporting the other half.
As the density of the liquid increases, the increased buoyancy of the plummet causes it to rise. In rising, the plummet will take up the greater portion of the weight of the chain.
It continues to rise until the increased portion of the plummet is reduced and the plummet will sink so that the reference points take a greater portion of the weight of the chain.
The plummet will continue to sink until equilibrium is gained. Thus for each value of density within the range of the plummet-chain assembly, the plummet will take up a definite position which is a measure of the density of the liquid.
The plummet contains a ferromagnetic core, which alters the inductance between the primary winding and the two opposed halves of the secondary winding of a differential transformer as the plummet rises or falls.
(5)

4.5 Hydrogen electrode
A hydrogen electrode consists of a platinum plate or wire covered with platinum black. When hydrogen is bubbled over such an electrode it is absorbed into its surface and the electrode behaves as a hydrogen electrode. It can be shown that the potential attained by a hydrogen electrode is related to the particular pH value. (2)

[25]

TOTAL: 100

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NOVEMBER 2012

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

9 November 2012 (X-Paper)
09:00 – 12:00

REQUIREMENTS:

Drawing instruments, pens and a ruler.

This question paper consists of 5 pages.

TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Sketches must be large, neat and fully labelled.
5. Write neatly and legibly

QUESTION 1 SEPARATION THEORY

1.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 1true1 or 'false1 next to the question number (1.1.1 - 1.1.5) in the ANSWER BOOK.

1.1.1 Continuous distillation refers to a single-unit distillation operation. (1)

1.1.2 The purpose of filtration is also to remove undesired contaminants. (1)

1.1.3 Extraction is not the same as filtration. (1)

1.1.4 Raschig (porcelain) rings are used in absorption towers to purify gas. (1)

1.1.5 A fix-bed absorber is designed to process vapours at high pressure. (1)

1.2 Write brief clarifying notes on each of the following operations applied in oil refining:

1.2.1 Vapour-liquid equilibrium (3)

1.2.2 Distillation (2)

1.3 Discuss the following parts of distillation and fractionation columns:

1.3.1 Valve trays (6)

1.3.2 Counter-flow trays (3)

1.3.3 Discharge gutters (6)

[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (2.1.1 - 2.1.5) in the ANSWER BOOK.

2.1.1 lsomerisation refers to the alteration of arrangement of the atoms in a molecule changing the number of atoms. (1)

2.1.2 Hydrogenation refers to an addition reaction that hydrogen undergoes with saturated hydrocarbons. (1)

2.1.3 Alkylation refers to the combination of lower-weight hydrocarbons to form high-octane gasolines. (1)

2.1.4 Crude oils vary in compounds with respect to the paraffin, naphthalene and aromatic groups. (1)

2.1.5 LPG is only obtained as a by-product of refineries. (1)

2.2 Describe the purification process of natural gas. (5)

2.3 Explain in detail step by step, the production of producer gas from coke as fuel source. Also state the operating time involving every step. (15)
[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.1.1 - 3.1.5) in the ANSWER BOOK.

3.1.1 A base is a substance which ionises when it dissolves in water and forms H+. (1)

3.1.2 A salt forms when an acid reacts with a base. (1)

3.1.3 A strong acid equals a pH of 14. (1)

3.1.4 During the production of caustic soda Ci2 is produced as a byproduct. (1)

3.1.5 Industries use the ion exchange process to produce distilled water. (1)

3.2 Define the concept pH and explain the difference between a strong acid and a weak acid. · (5)

3.3 Draw a labelled flowchart for the preparation of NaOH by means of a caustic cell. (15)
[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true• or 'false' next to the question number (4.1.1 - 4.1.5) in the ANSWER BOOK.

4.1.1 Process variables refer to physical quantity and quality that can be measured. (1)

4.1.2 The atmospheric pressure inland is as high as 101 ,32 kPa. (1)

4.1.3 The resistance type meter can be used to measure pressure and temperature (1)

4.1.4 263 K equals 10 ºC. (1)

4.1.5 A hydrogen electrode is used to measure pH. (1)

4.2 Discuss the precautionary measures that should be taken during installation of an orifice plate disk. (11)

4.3 Sketch and describe the operation of a chain-balance-plummet hydrometer. (9)
[25]

TOTAL: 100

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NOVEMBER 2012

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

This marking guidelines consists of 7 pages.

QUESTION 1 SEPARATION THEORY

1.1.1 False (1)

1.1.2 True (1)

1.1.3 True (1)

1.1.4 False (1)

1.1.5 True (1)

1.2.1 Vapour-liquid equilibrium.
For mixtures, which follow Raoult's law, the composition of the equilibrium vapours evolved at any temperature from a liquid of known concentration can be calculated by use of the vapour pressures of the pure components at the temperature involved. However, since most mixtures do not follow Raoult's law, it is usually necessary to determine the equilibrium liquid and vapour compositions experimentally. (3)

1.2.2 Distillation.
It is the separation of components of liquid mixture through stages of heating and cooling until a pure light product is obtained towards the top of the plant and a pure heavy product at the bottom. (2)

1.3.1 Valve trays
Valve trays are sieve trays with large (roughly 35-40 mm diameter) variable openings for gas flow. The perforations are covered with movable caps, which rise as the flow rate of gas increases. At low gas rates and corresponding pressure drop it remains low but not as low as that for sieve or bubble cap trays.
Tray spacing is usually chosen on the basis of expediency in construction, maintenance, and cost and later checked to be certain that adequate insurance against flooding and excessive entertainment is present. For special cases where tower height is an important consideration spacing of 15 cm has been used. For all except the smallest tower diameters 50 cm would seem to be a more workable minimum from the point of view of cleaning the trays. (6)

1.3.2 Counter flow trays
These tray-resembling devices differ from conventional trays in that there are no ordinary downspouts. Liquid and vapour flow counter-currently through the same openings. Trays like trubo-, kitter-, ripple and leva trays are used. (3)

1.3.3 Discharge gutters.
The liquid is led from the one tray to the next by means of downspouts or down-comers. These may be circular pipes or preferable portions of the tower cross-section set aside for liquid which is agitated into a froth on the tray, adequate residence time must be allowed in the downspout to permit

disengaging the gas from the liquid, so that only clear liquid enters the tray below.
The downspout must be brought close enough to the tray below the seal into the liquid on that tray thus short-circuits the tray above. Seal pots and seal-pot dams (inlet weirs) may be used, but they are best avoided especially if there is a tendency to accumulate sediment. If they are used, weep holes (small holes through the tray) in the seal pot should be used to facilitate draining the tower on shutdown (6)

[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1.1 False (1)

2.1.2 False (1)

2.1.3 True (1)

2.1.4 True (1)

2.1.5 False (1)

2.2 Purification of natural gas.
Four important methods are employed for the dehydration of the gas namely: compression, treatment with drying substances, absorption and refrigeration.
A plant for water removal by compression consists of a gas compressor, followed by a cooling system to remove the water vapour condensation.
The treatment of gas with drying substances has found widespread usage in this country. The agents employed for this purpose are activated alumina and bauxite, silica gel, sulfuric acid, glycerin and concentrated solution of calcium chloride or sodium thiocyanate.
Passing it over refrigerated coils may also dehydrate gas.
The Girbotol procedure is used to remove the H_2S. (5)

2.3 Production of producer gas. (NB. ½ point per correct answer)

Step one: Blow (operation involving 30% or 63 sec.)
Primary air is admitted at the base of a mechanical generator and is passed up through the fuel bed of coke at a gas-making temperature.

Step two: Blow run (operation involving 9% or 19 sec.)
This happens immediately after step one, while the fire temperature is at its peak and the blast gases contain the height percentage of CO.
Closing the secondary air valve and the stack valve and allowing the producer gas to bypass through the machine into the wash box accomplish it.

Step three: Up run (operation involving 32% or 67 sec.)
Steam is admitted at the base of the generator and passes up through the red-hot coke, forming blue gas. Oil gas is produced by the pyrolysis of the oil in an atmosphere of blue gas and from the radiant heat.

The blue and oil gases mix and pass on to the super heater, where the pyrolysis of the gasified oil is completed and the gases are made permanent.

Step four: Back run (operation involving 24% or 51 sec.)
Steam is admitted into the top of the riser pipe, passing up the super heater, where it is superheated, down through the carburetor, reacting with any carbon in the generator fuel, finally passing out the bottom of the generator through the cast-ion back-run pipe through the three-way valve into the wash box, to the relief holder. Fuel is automatically charged during this portion of the cycle after the back-run and the oil has been shut off.

Step five: Final up run (operation involving 3% or 6 sec.)
This puts a blanket of steam between the blue gas in the base of the generator and the air that follows. The carburetor, super heater and riser pipe are already filled with back-up steam.

Step six: Blow purge (operation involving 2% or 4 sec.)
This purges the machine of blue gas and steam and produces some CO, all of which is swept through the machine, through the wash box, into the relief holder. This is accomplish by opening the generator air valve prior to opening the stock valve, which releases the products of combustion to atmosphere.

(15)
[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1.1 False (1)

3.1.2 True (1)

3.1.3 False (1)

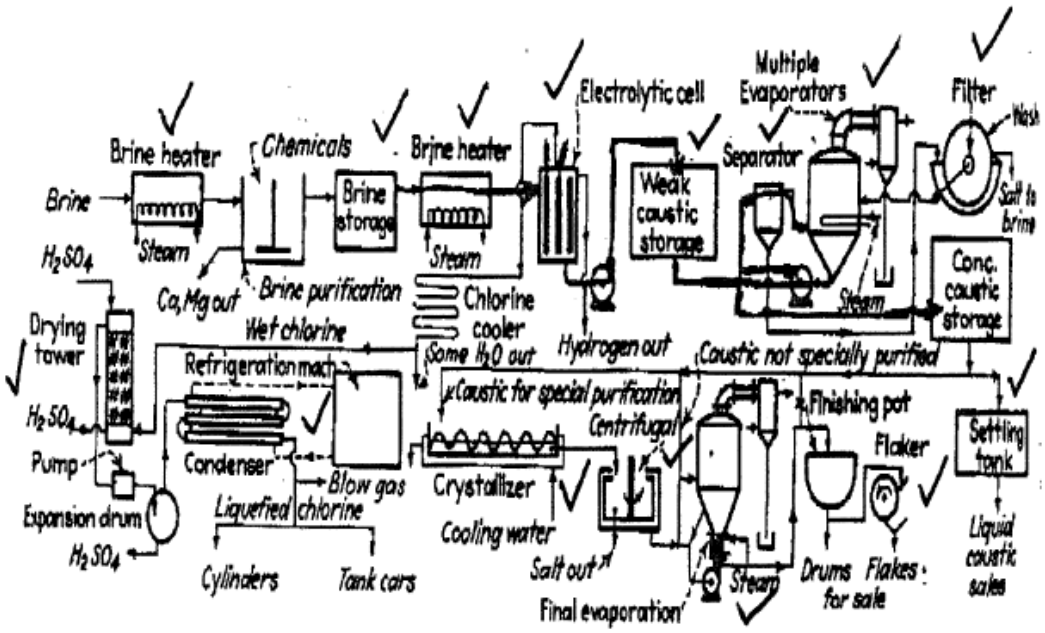
3.1.4 True (1)

3.1.5 False (1)

3.2 PH concept.
The pH is defined as the logarithm of the reciprocal of the hydronium ion concentration, or pH =-log $[H^+]$. Thus the pH value of a dilute solution can now be easily calculated if [H+ (aq)] is known.
Strong acid: ionise almost completely in solution and form a high concentration of hydrogen ions.
Weak acid: ionise only partially in solution and form a low concentration

of hydrogen ions. (5)

3.3 NaOH Plant



(15)

[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1.1 True (1)

4.1.2 False (1)

4.1.3 True (1)

4.1.4 False (1)

4.1.5 True (1)

4.2 <u>Orifice plate precautionary measures</u>

During installation and use, nothing must be allowed to damage the sharp upstream edge of the orifice. For this reason, the plate should never be cleaned with emery cloth, owing to the danger of rounding the sharp edge of the orifice. The upstream face should be smooth for a diameter of at least twice that of the bore, and be flat to within 2 % of the pipe diameter, when the plate is clamped between the flanges.

When the plate is in use, no extraneous matter must be allowed to collect on or near the orifice plate.

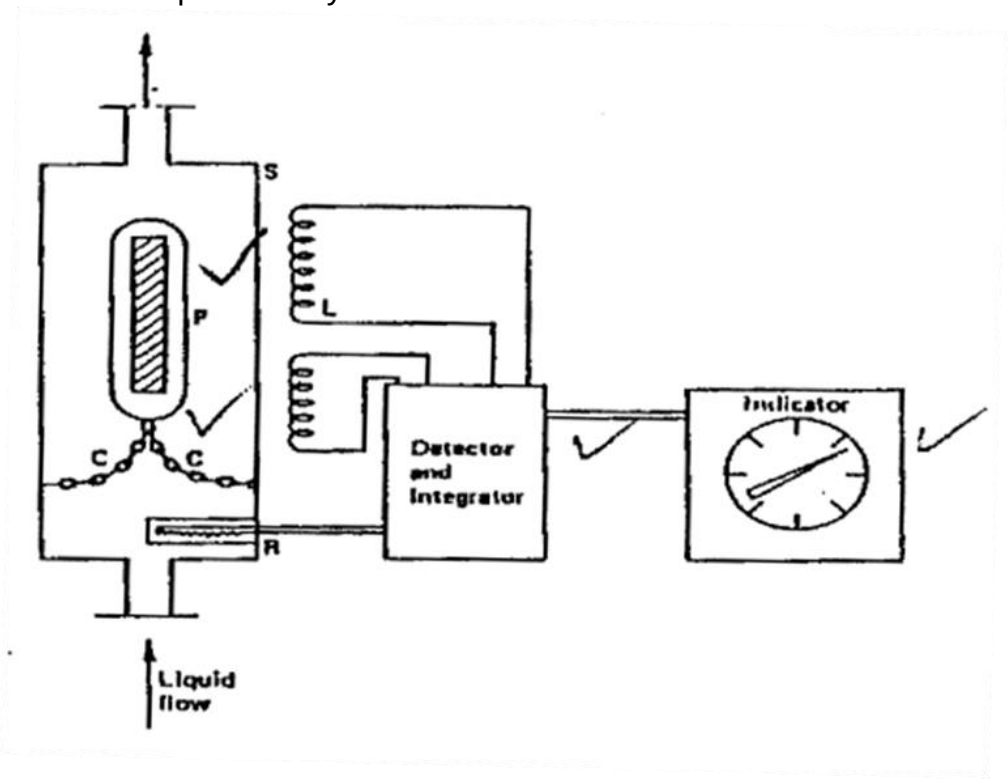
Where gases containing tar and other similar substances have to be metered, arrangements are usually made to remove their deposits with a blast of high-pressure steam.

When the plate is being installed, gaskets, usually 1 to 6 mm thick and graphite on the side to the plate are used between the plate and the flanges.

The gaskets must never extend into the pipe and should be cut to size

when they are being installed.
When the flange bolts are being tightened care must be taken to see that a uniform pressure is maintained all round the plate, so that the danger of buckling the plate is eliminated.
Great care must be taken to see that the orifice is concentric with the pipe, particularly when it has a high orifice ratio.
Care must also be taken with the pressure holes. After drilling the inside edge of the hole should be rounded off slightly with a reamer or file to be sure that no burrs exist.
Bleed holes should always be provided in orifice plates. In liquid flow measurement the hole should be at the top to allow gas, which would otherwise be trapped by the plate, to pass on with the liquid.
In gas and steam flows measurement the hole should be at the bottom to allow liquids to pass . (11)

4.3 Chain-balance-plummet hydrometer:



Operation.
The displacer or plummet is counter balanced by the weight of the plummet and platinum-iridium calibrating chain. The plummet is so weighted that, at the middle of the density indicating range, it will support half the weight of the chain with the reference points supporting the other half.
As the density of the liquid increases, the increased buoyancy of the plummet causes it to rise. In rising, the plummet will take up greater portion of the weight of the chain.
It continues to rise until the increased portion of the plummet is reduced and the plummet will sink so that the reference points take a greater portion of the weight of the chain.
It will continue to sink until equilibrium is gained. Thus for each value of the

density within the range of the plummet-chain assembly, the plummet will take up a definite position which is a measure of the density of the liquid. The plummet contains a ferromagnetic core, which alters the inductance between the primary winding and the two opposed halves of the secondary winding of a differential transformer as the plummet rises or falls. (9)

[25]

TOTAL: 100

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

AUGUST 2012

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

20 July 2012 (X-Paper)
09:00 – 12:00

Candidates will require drawing instruments, pens and a ruler.

This question paper consists of 5 pages.

TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Sketches must be large, neat and fully labelled.
5. Write neatly and legibly

QUESTION 1 SEPARATION THEORY

1.1 Indicate whether the following statements are TRUE or FALSE. Write only 1true' or 'false' next to the question number (1.1.1 - 1.1.5) in the ANSWER BOOK.

1.1.1 Rectification refers to a single-unit distillation operation. (1)

1.1.2 Condensation occurs when the movement of liquid molecules decreases as a result of cooling. (1)

1.1.3 Extraction is removal of a component from a liquid by means of another liquid. (1)

1.1.4 Distillation produces only an overhead and a bottom product. (1)

1.1.5 A fixed-bed adsorbent is designed for vapours at low pressure. (1)

1.2 Briefly explain each of the following as applied in oil refining:

1.2.1 Relative volatility (2)

1.2.2 Absorption (3)

1.3 Briefly explain each of the following:

1.3.1 Shell and trays (3)

1.3.2 Weirs (3)

1.4 Use a sketch to illustrate the operation of a Higgens contractor. (9)

[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1 Indicate whether the following statements are TRUE or FALSE. Write only 'true' or 'false' next to the question number (2.1.1 - 2.1.5) in the ANSWER BOOK.

2.1.1 The linkage of similar molecules refers to olefins isomerisation. (1)

2.1.2 Hydrogenation refers to an addition reaction that hydrogen undergoes with saturated hydrocarbons. (1)

2.1.3 Crude oils vary in compounds with respect to the paraffin, naphthalene and aromatic groups. (1)

2.1.4 An example of a cracking reaction is:
$C_3H_8 \leftrightarrow C_2H_4 + CH_4$ (1)

2.1.5 LPG is only obtained as a by-product from refineries. (1)

2.2 Explain the composition of each of the following crude oils:

2.2.1 Paraffin-based crude (2)

2.2.2 Naphtha-based crude (3)

2.2.3 Intermediate-based crude (2)

2.3 Draw a labelled flowchart of a coal-tar continuous distillation plant and list the products of the procedure. (13)
[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Indicate whether the following statements are TRUE or FALSE. Write only •true' or 'false' next to the question number (3.1.1 - 3.1.5) in the ANSWER BOOK.

3.1.1 When a salt reacts with an acid a base will be formed. (1)

3.1.2 A pH of zero is a strong alkali. (1)

3.1.3 A strong acid ionises almost completely in solution and forms a high concentration of hydrogen ions. (1)

3.1.4 $CaCO_3$ refers to a weak base and KOH to a strong base. (1)

3.1.5 When salts are in a crystal state they do conduct electricity. (1)

3.2 Briefly explain the term acid and also refer to the difference between a strong and weak acid. (7)

3.3 Explain what is meant by ion exclusion. (3)

3.4 Write brief, explanatory notes on the principles and the rate of ion exchange. (10)
[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 Indicate whether the following statements are TRUE or FALSE. Write only 'true• or 'false• next to the question number (4.1.1 - 4.1.5) in the ANSWER BOOK.

4.1.1 The indicating element receives the change detected by the primary measuring element. (1)

4.1.2 If the gauge pressure at sea level equals zero kPa then the absolute pressure is 101 132 kPa. (1)

4.1.3 A Bourdon tube cannot be used to measure temperature. (1)

4.1.4 27 ºC equals 300, 16 degrees Kelvin. (1)

4.1.5 A disadvantage of Venturi tubes is that they wear out easily. (1)

4.2 Write brief explanatory notes on the following:

4.2.1 Inductance-bridge hydrometer (4)

4.2.2 The forced-balance system for the measuring of levels (6)

4.3 List SIX instruments that can be used to measure temperature and SIX instruments that measure pressure. (6)

4.4 With the aid of an appropriate example, discuss the purpose of the transfer and indicating measuring elements as part of an instrument. (4)

[25]

TOTAL: 100

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

AUGUST 2012

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

This marking guideline consists of 8 pages.

QUESTION 1 SEPARATION THEORY

1.1.1 True (1)

1.1.2 False (1)

1.1.3 True (1)

1.1.4 True (1)

1.1.5 False (1)

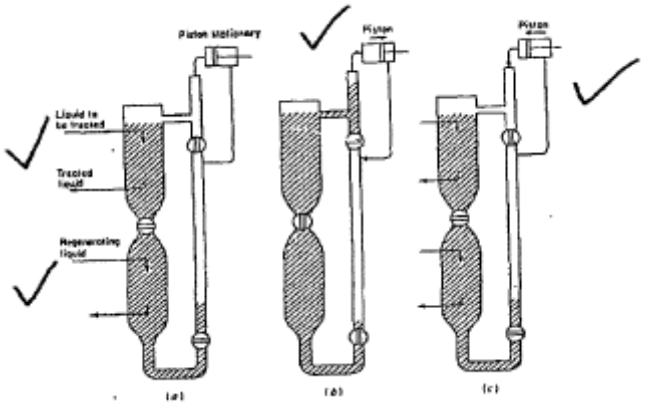
1.2.1 Relative volatility
It may define as the volatility of one component of a liquid mixture divided by the volatility of another component of the liquid mixture. Relative volatilities are commonly expressed with the higher of the two relative volatility should never have a numerical value less than 1.0 (2)

1.2.2 Absorption
Is widely employed in the recovery of natural gasoline from well gas and vapours given off by storage tanks. Absorption also obtains light hydrocarbons from many refining processes. The solvent oil may be heavy gasoline, kerosene, or even heavier oils. Fractionating or steam stripping removes the absorbed products. (3)

1.3.1 Shell and trays
The trays are usually made of metal sheets, of special alloys if necessary, thickness governed by the anticipated corrosion rate. The trays must be stiffened and supported and must be fastened to the shell to prevent movement, with allowance for thermal expansion. The tower may be made of any number of materials. Glass, glass-lined metal, carbon, and plastics, even wood but most frequently metals are used. (3)

1.3.2 Weirs
The depth of liquid on the tray required for gas contacting is, maintained by an overflow (outlet) weir. Straight weirs are most common, multiple V-notch weirs maintain a liquid depth, which is less sensitive to variations in liquid flow rate, and consequently also from departure of the tray from levelness. In order to ensure reasonably uniform distribution of liquid flow on a singly-pass tray, weir length of 60 to 70% of the tower diameter is used. (3)

1.4 Higgens contractor
Sketch



(4)

Operation

The temporarily stationary upper bed of solids is contracted with liquid flowing downward, so that fluidization does not occur. In the lower bed, an eluting liquid regenerates the solid. After several minutes, the liquid flow is stopped, valves are turned as shown in figure "b" and the liquid-filled piston pump is removed as shown for a period of several seconds, were upon solid is moved clockwise hydraulically. In figure "c" with the valves readjusted to their original position, movement of solid is completed and liquid flows are started to complete the cycle. (5)

[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1.1 False (1)

2.1.2 False (1)

2.1.3 True (1)

2.1.4 True (1)

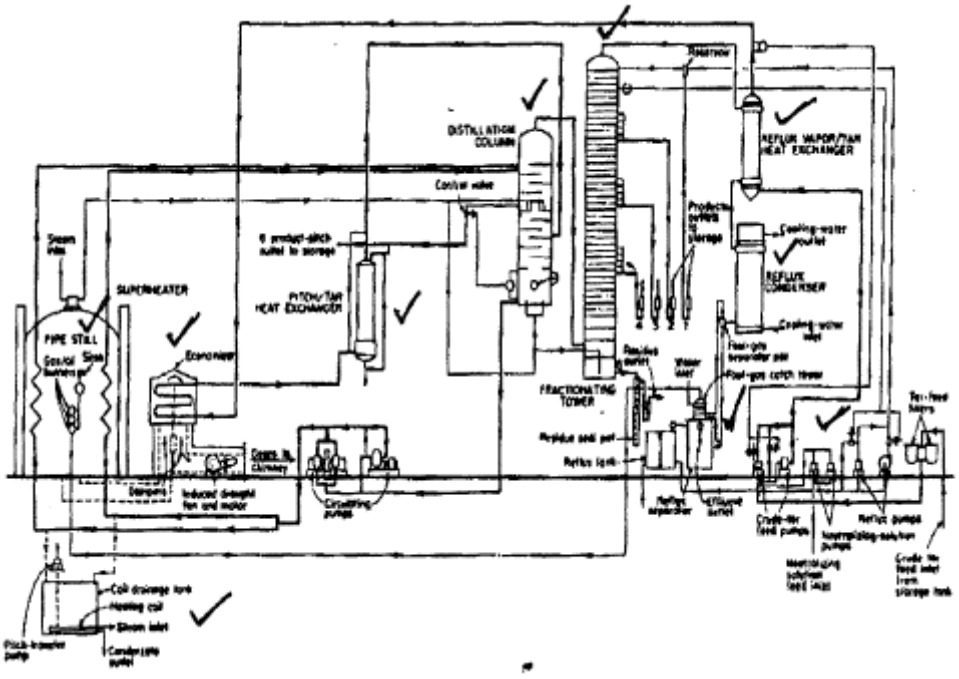
2.1.5 False (1)

2.2.1 Paraffin base crude.
These crude's consist primarily of open-chain compounds and furnish low-octane number straight-run gasoline and excellent but waxy lubricating oil stocks. (2)

2.2.2 Naphthene base crude.
These crude's contain a high percentage of cyclic (naphthenic) compounds and furnish relatively high-octane grade straight-run gasoline. The lubricating-oil fractions must be solvent- refined. Asphalt is present (3)

2.2.3 Intermediate base crude.
These crude's contain large quantities of both paraffinic and naphthenic compounds and furnish medium-grade straight run gasolines and lubricating oils. Both wax and asphalt are found in these oils. (2)

2.3 Coal-tar continuous distillation.



Products:
Light oil, carbolic oil, naphthalene oil, creosote or wash oil, residue anthracite and pitch. (13)
[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1.1 False (1)

3.1.2 False (1)

3.1.3 True (1)

3.1.4 True (1)

3.1.5 False (1)

3.2 Acids:
An acid is a substance that increases the concentration of hydrogen ions / hydronium ions (H+) in an aqueous solution or which is able to donate protons to another substance. When an acid dissolves in water, it breaks up (dissociates) into small particles, called ions. This is the reason why acids are so corrosively.

Strong acids ionise almost completely in solution and. from a high concentration of hydrogen ions.

Weak acids ionise only partially in solution and from a low concentration of hydrogen ions. (7)

3.3 Ion Exclusion

A resin is pre-saturated with the same ions as in a solution. It can then rejections in such a solution but at the same time absorb non-ionic organic substances such as glycerin, and the like, which may also be in the solution. The organic matter can later be washed from the resin in an ion-~ free state. (3)

3.4 Ion exchange.

Positively charged ions (cations) of a solution, which are capable of diffusing through the pores, will exchange with the positive ions (Na+) of such a mineral, which is therefore called a cat-ion exchanger.

eg Ca^{2+} $Na_2R \Rightarrow Na_2R + CaCl_2$

Where "R" represents the residual material of the Zeolite. In this manner "hard" water containing Ca++ can be softened by contact with Zeolite, the less objectionable Na^+ replacing the Ca^{++} in solution and the latter becoming immobilized in the solid. The reaction is reversible, and after saturation with Ca the Zeolite can be regenerated by contact with a solution of salt.

Eg $CaR + 2NaCl \Rightarrow Na_2R + CaCl_2$

The rate of ion exchange depends upon rates of the following individual processes:

- Diffusion of ions from the bulk of the liquid to the internal surface of an exchanger particle.
- Inward diffusion of ions through the solid to the internal surface of an exchange of the ion.
- Outward diffusion of the released ions to the surface of the solid.
- Diffusion of the released ions from the surface of the solid to the bulk of the liquid. (10)

[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1.1 True (1)

4.1.2 True (1)

4.1.3 False (1)

4.1.4 True (1)

4.1.5 False (1)

4.2.1 Inductance-bridge hydrometer.

In this instrument the level of the measured liquid is held constant at an overflow tube. A glass hydrometer either rises or falls in the liquid as the specific gravity varies. The lower end of the hydrometer supports an armature

in an inductance coil. A similar coil in the recording instrument duplicates any movement of this armature. With this system, the temperature of the liquid is usually recorded along with the value of specific
gravity, so that corrections can be made. (4)

4.2.2 The force balance system for the measure of levels.
It consists of a stainless steel diaphragm and a sensing unit. If the pressure on the diaphragm increases, the diaphragm will move towards the sensing unit and cause the baffle to move towards the bleed nozzle. This restricts the escape of air to the atmosphere, so that the air pressure behind the diaphragm builds up until it again balances the pressure due to the liquid.

When the pressure falls, the diaphragm moves away from the sensing unit and an increased amount of air is allowed to escape to the atmosphere. The pressure behind the diaphragm therefore falls, until it again balance the pressure due to the liquid. The air pressure behind connection to an indicator or recorder, which shows the level of the tank contents. (6)

4.3 Temperature instruments. (Anv SIX correct answers)
- Helical type Bourdon tube
- Spiral type
- Bourdon tube (filled systems)
- Pyrometer
- Resistance thermometer
- Thermocouple
- Potentiometer

Pressure instruments.
- Mc Leod vacuum gauge
- Bourdon tube
- Barometer
- Manometer
- Helical type
- Resistance type

(6)

4.4 Transfer element.
This element transfers the change, which was detected, to the next element known as the indicating element. An example of a transfer element is the hair tube connected to a pressure gauge.

The Indicating element.
Also called secondary element and reacts to the change that was detected and transferred, for example the Bourdon type of pressure meter, which indicated the pressure on a calibrated scale. (4)

[25]

TOTAL: 100

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2012

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

3 April 2012 (X-Paper)
09:00 – 12:00

Candidates will require drawing instruments, pens and a ruler.

This question paper consists of 5 pages.

TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Sketches must be large, neat and fully labelled.
5. 100 marks = 100%
6. Write neatly and legibly

QUESTION 1 SEPARATION THEORY

1.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (1.1.1 - 1.1.5) in the ANSWER BOOK.

1.1.1 Raoult's law concerning equilibrium vapours differs from Dalton's law which is a gas law. (1)

1.1.2 Extraction refers to the removal of a gas from a liquid. (1)

1.1.3 Charcoal can be used as filling material in a pack tower pending the application. (1)

1.1.4 Crystallization is used to separate gas from liquids. (1)

1.1.5 A fix-bed absorber is designed for vapours at high pressure. (1)

1.2 Define each of the following:

1.2.1 Distillation (3)

1.2.2 Relative volatility (2)

1.2.3 Murphree-plate efficiency (3)

1.3 Discuss the following parts of distillation and fractionation columns:

1.3.1 Discharge gutters (6)

1.3.2 Linde plates (6)

[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (2.1.1 - 2.1.5) in the ANSWER BOOK.

2.1.1 Polymerisation and isomerisation refer to the same concept. (1)

2.1.2 Aromatisation is the conversion of naphtha to obtain products of a higher octane number. (1)

2.1.3 Paraffin base crude consists of no waxy lubricating components. (1)

2.1.4 Tar products are a by-product from the coke production process. (1)

2.1.5 Coke is mainly produced as a fuel for steam boilers. (1)

2.2 Explain each of the following concerning crude oil:

2.2.1 The olefin series (3)

2.2.2 The naphthalene series (2)

2.3 Explain, with the aid of an example, the following terms:

2.3.1 Cracking (2)

2.3.2 Hydrogenation (3)

2.4 Define the following reactions:

2.4.1 Isomerisation (2)

2.4.2 Aromatisation (1)

2.5 Briefly discuss liquid petroleum gas as fuel. (7)
[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.1.1 - 3.1.5) in the ANSWER BOOK.

3.1.1 A salt is formed when an acid reacts with a base. (1)

3.1.2 A pH 13 indicates a strong acid. (1)

3.1.3 $pH = -\log[H^+]$ (1)

3.1.4 The production of Ct2 is a by-product from the production of NaOH (1)

3.1.5 NaCl is a strong acid. (1)

3.2 Write brief, explanatory notes on each of the following steps in the preparation of caustic soda using a diaphragm cell:

3.2.1 Brine purification . (4)

3.2.2 Evaporation and salt separation (2)

3.2.3 Special purification of caustic soda (4)

3.3 Write brief, explanatory notes on the principles and the rate of ion exchange. (10)
[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true• or 'false' next to the question number (4.1.1 - 4.1.5) in the ANSWER BOOK.

4.1.1 Volume is an example of a physical quality. (1)

4.1.2 Process variables refer to physical quantity and physical quality. (1)

4.1.3 The indicating element sends the change measured to the transfer element. (1)

4.1.4 273,16 Kelvin equals 0 °C. (1)

4.1.5 It is difficult to replace a Pitot tube. (1)

4.2 Sketch and describe the operation of a mercury-in-steel thermometer. (9)

4.3 Briefly explain each of the following:

4.3.1 The law of intermediate metals (4)

4.3.2 Inductance-bridge hydrometer (4)

4.3.3 The Hagen-Poiseuille law (3)

[25]

TOTAL: 100

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2012

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

This marking guidelines consists of 6 pages.

QUESTION 1 SEPARATION THEORY

1.1.1 True (1)

1.1.2 False (1)

1.1.3 True (1)

1.1.4 False (1)

1.1.5 True (1)

1.2.1 Distillation

It may define as the separation of the components of a liquid mixture by a process involving partial vaporization. In general, the vapour evolved is recovered by condensation. Therefore vapour-liquid separation is done by distillation. (3)

1.2.2 Relative volatility

It may define as the volatility of one component of a liquid mixture divided by the volatility of another component of the liquid mixture. (2)

1.2.3 Murphree plate efficiency

The efficiencies of individual plates in a distillation tower may be reported as Murphree tray/plate efficiencies. This efficiency is defined as the actual vapour enrichment over one plate divided by the theoretical vapour enrichment, which would have been obtained if the liquid on the plate and the vapours leaving the plate had reached equilibrium. (3)

1.3.1 Discharge gutters

The liquid led from the one tray to the next by means of downspouts· or down-comers. These may be circular pipes or preferable portions of the tower cross section set aside for liquid which is agitated into a froth on the tray, adequate residence time must be allowed in the downspout to permit
disengaging the gas from the liquid, so that only clear liquid enters the tray below. The downspout must be brought close enough to the tray below the seal into the liquid on that tray thus short-circuits the tray above. Seal pots and seal-pot dams (inlet weirs) may be used, but they are best avoided especially if there is a tendency to accumulate sediment. If they are used,
weep holes (small holes through the tray) in the seal pot should be used to facilitate draining the tower on shutdown. (6)

1.3.2 Linde plates

These designs have involved improvements both in the perforation design and the tray arrangements, an alteration in the perforation pattern to influence the flow of liquid. The slots, distributed throughout the tray, not only reduce the hydraulic gradient in large trays but are also deployed that they influence the direction of liquid flow to eliminate stagnant areas and
achieve, as nearly as possible, desirable plug flow of liquid across the trays. This multiple downspouts .Yare not sealed in the liquid on the tray below;

instead the liquid is delivered through slots in the bottom closure to spaces between the downspouts on the tray below. The parallel-flow tray is so designed that the liquid on all trays in the one-half the tower flows from right to left, and on the trays in the other half from left to right. (6)

[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1.1 False (1)

2.1.2 True (1)

2.1.3 False (1)

2.1.4 True (1)

2.1.5 False (1)

2.2.1 The olefin series
This series is either not present in crude oil or exit in very small quantities. Cracking processes produce large amounts of olefins and have better antiknock properties than normal paraffin. Olefins have poorer properties than highly branched paraffin and aromatics. They are the most important class of compounds chemically derived from petroleum. (3)

2.2.2 The naphthalene series
It has the same empirical formula as the olefin series, but differs in that its members are completely saturated. These crude's contain high percentage of cyclic compounds and famish relatively high-octane-number straight-run gasoline. (2)

2.3.1 Cracking
It is the breaking-up of any hydrocarbon in such a way that carbon-carbon bonds break-up to from new hydrocarbon products.
Example: $C_3H_8 \leftrightarrow C_2H_4 + CH_4$ ---------- an olefin and paraffin are formed. (2)

2.3.2 Hydrogenation
It refers to an addition (of hydrogen to an olefin) reaction that hydrogen undergoes with unsaturated hydrocarbons or other organic compounds, in the presence of a catalyst, at suitable temperature and pressures, eg ethylene to from ethane, carbon monoxide to from methanol and higher alcohol's etc. (3)

2.4.1 Isomerisation
Alteration of arrangement of the atoms in a molecule without changing the number of atoms. (2)

2.4.2 Aromatisation
The conversion of naphtha's to obtain products of higher octane number. (1)

2.5 Liquid petroleum gas

LPG under a pressure of 5 Bar easily condenses to a liquid meaning that a large mass per volume energy can be stored. Liquid can easily vapourise to gas. This comprises C_3 to C_4 hydrocarbons refer to a $\pm$ 50% propane/propylene to butane/butalene mixture. LPG is obtained as a byproduct in oil refineries. These gases are dissolved in oil, which is refined. This gas type of fuel is widely used in domestic applications and in industries such as glass industries for furnaces. LPG comes from the ground as a constituent of wet natural gas or of crude oil or as a byproduct from refining. (7)

[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1.1 True (1)

3.1.2 False (1)

3.1.3 True (1)

3.1.4 True (1)

3.1.5 False (1)

3.2.1 Brine purification

To make a purer caustic soda and to lessen clogging of the cell diaphragm with a consequent in crease, purification of the NaCl solution of calcium, ions and magnesium compounds is practiced, using soda ash with some caustic soda. Sometimes sulphates are removed with BaCl or the hot brine is treated with hydroxyl and carbonate ions. The clear brine is neutralized with hydrochloric acid. (4)

3.2.2 Evaporation and salt separation

NaOH solution is evaporated in a double or triple effect evaporator with salt separators and then passes through a settler and washing filter. The salt so recorded is again made into. charging brine. (2)

3.2.3 Special purification of caustic soda

Some of the troublesome impurities in 50% caustic are colloidal iron, NaCl and NaClO. The iron is often removed by treating the caustic with calcium carbonate. The chlorate may be removed by allowing the caustic to drop -1 through a column of 50% aqueous ammonic solution. (4)

3.3 Ion exchange

Positively charged ions (cations) of a solution, which are capable of diffusing through the pores, will exchange with the positive ions (Na^+) of such a mineral, which is therefore called a cat-ion exchanger.

eg $CaR + 2NaCl \Rightarrow Na_2R + CaCl_2$

Where "R" represents the residual material of the Zeolite. In this manner “hard" water containing Ca^{++} can be softened by contact with Zeolite, the less

objectionable Na^+ replacing the Ca^{++} in solution and the latter becoming immobilized in the solid. The reaction is reversible, and after saturation with Ca the Zeolite can be regenerated. by contact with a solution of salt,

eg $CaR + 2NaCl \Rightarrow Na_2R + CaCl_2$

The rate of ion exchange depends upon rates of the following individual processes:

- Diffusion of ions from the bulk of the liquid to the internal surface of an exchanger particle.
- Inward diffusion of ions through the solid to the internal surface of an exchange of the ions.
- Outward diffusion of the released ions to the surface of the solid.
- Diffusion of the released ions from the surface of the solid to the bulk of the liquid. (10)

[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1.1 False (1)

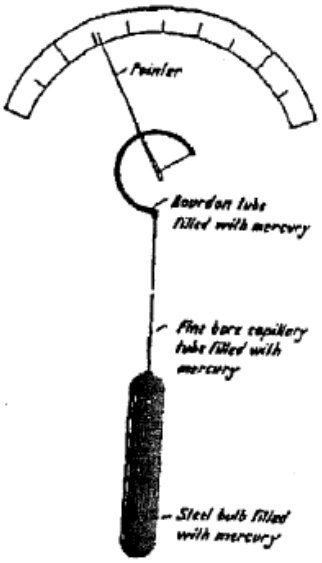
4.1.2 True (1)

4.1.3 False (1)

4.1.4 True (1)

4.1.5 False (1)

4.2 Mercury-in-steel thermometer
Sketch



(4)

Operation
When the temperature rises, the mercury in the bulb expands more than the bulb so that some mercury is driven through the capillary tube into the

Bourdon tube. As the temperature continue to rise, increasing amounts of mercury will be driven into the Bourdon tube, causing it to uncurl. One end of the Bourdon tube is fixed, while the motion of the other end is communicated to the pointer or pen arm. (5)

4.3.1 Law of intermediate metals

In a thermo-electric circuit composed of two metals "A" and "B" with junctions at temperatures t_1 and t_2 respectively, emf is not altered if one or both the junctions are opened and one or more other metals are interposed between the metals "A" and "B", provided that all the junctions by which the single junction at temperature t_1 may be replaced are kept t_1 and all those by which the junction at temperature t_2 may be replaced are kept at t_2. (4)

4.3.2 Inductance- bridge hydrometers

In this instrument the level of the measured liquid is held constant at an overflow tube. A glass hydrometer either rises or falls in the liquid as the specific gravity varies. The lower end of the hydrometer supports an armature in an inductance coil, a similar coil in the recording instrument duplicates any movement of this armature. With this system, the temperature of the liquid is usually recorder along with the value of specific gravity, so that corrections can be made. (4)

4.3.3 Hagen- Poiseulle law

Hagen (Germany) and Poiseulle (France) described viscosity as the ratio of shear stress versus shear rate at the wall of a capillary tube. Positive displacement meters are frequently used in oil and water undertakings for accounting purposes. (3)

[25]

TOTAL: 100

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

AUGUST 2011

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

21 July 2012 (X-Paper)
09:00 – 12:00

Candidates will require drawing instruments, pens and a ruler.

This question paper consists of 5 pages.

TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Sketches must be large, neat and fully labelled.
4. Number the answers according to the numbering system used in this question paper.
5. Write neatly and legibly.

QUESTION 1 SEPARATION THEORY

1.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (1.1.1 - 1.1.5) in the ANSWER BOOK.

1.1.1 Condensation is the opposite of evaporation. (1)

1.1.2 Crystallization is used to separate liquids in solids. (1)

1.1.3 Valve plates are sieve plates with small variable openings for gas flow. (1)

1.1.4 Packed towers can be filed with porcelain rings or charcoal. (1)

1.1.5 During the absorption process the absorption medium enters the tower at the bottom to purify the gas or vapours. (1)

1.2 Write brief notes on the following:

1.2.1 The volatility of a component in a liquid mixture which follows Raoult's law (2)

1.2.2 Rectification (3)

1.3 Discuss the following parts of distillation and fractionation columns:

1.3.1 Bubble-cap plates (3)

1.3.2 Linde plates (6)

1.4 Sketch a neat, labelled fix-bed adsorber. (6)

QUESTION 2 ORGANIC CHEMISTRY

2.1 2.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (2.1.1 - 2.1.5) in the ANSWER BOOK.

2.1.1 lsomerisation refers to the alteration, re-arrangement of the atoms in a molecule by changing the number of atoms. (1)

2.1.2 Hydrogenation refers to an addition reaction that undergoes with saturated hydrocarbons. (1)

2.1.3 Alkylation refers to the combining of lower weight hydrocarbons to form high-octane gasolines. (1)

2.1.4 Crude oils vary in compounds with respect to the paraffin, naphthalene and aromatic groups. (1)

2.1.5 The purification of natural gas involves the removing of undesirable H_2O and H_2S. (1)

2.2 Briefly discuss liquid petroleum gas as a fuel. (7)

2.3 Draw a fully labelled flow chart of a coal-tar continuous distillation plant and list the products of procedure. (13)
[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (3.1.1 - 3.1.5) in the ANSWER BOOK.

3.1.1 When an acid dissolves in water, it breaks up into small particles called cations. (1)

3.1.2 $CaCO_3$ refers to weak bases and KOH to strong bases. (1)

3.1.3 When salts are in a crystal state they can conduct electricity. (1)

3.1.4 A pH change of 1 pH value represents a hundred-fold change in hydrogen ion concentration. (1)

3.1.5 A weak acid ionizes partially in a solution. (1)

3.2 Write brief, explanatory notes on the preparation steps concerning special purification of caustic soda using a diaphragm cell. (3)

3.3 Describe the preparation of caustic soda by means of electrolysis. Using a mercury cathode. (7)

3.4 Write brief, explanatory notes on the principles and the rate of ion exchange. (10)
[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'true' or 'false' next to the question number (4.1.1 - 4.1.5) in the ANSWER BOOK.

4.1.1 Process variables refer to the measuring of physical quantity and quality. (1)

4.1.2 The hair tube connected to a pressure gauge is an example of a primary measuring element. (1)

4.1.3 Absolute pressure refers to atmospheric pressure. (1)

4.1.4 Temperature measures the heat energy of a body. (1)

4.1.5 The advantage of a Venturi tube is that it does not wear easily. (1)

4.2 Sketch and describe the operation of a chain-balance-plummet hydrometer. (9)

4.3 Name SIX instruments for measuring temperature. (3)

4.4 Briefly discuss positive displacement meters. (8)

[25]

TOTAL: 100

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

AUGUST 2011

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

QUESTION 1 SEPARATION THEORY

1.1.1 True (1)

1.1.2 True (1)

1.1.3 False (1)

1.1.4 True (1)

1.1.5 False (1)

1.2.1 Raoult's law
The volatility of a component in a liquid mixture which, follows Raoult's law, must be equal to the vapour pressure of that component in the pure state. (2)

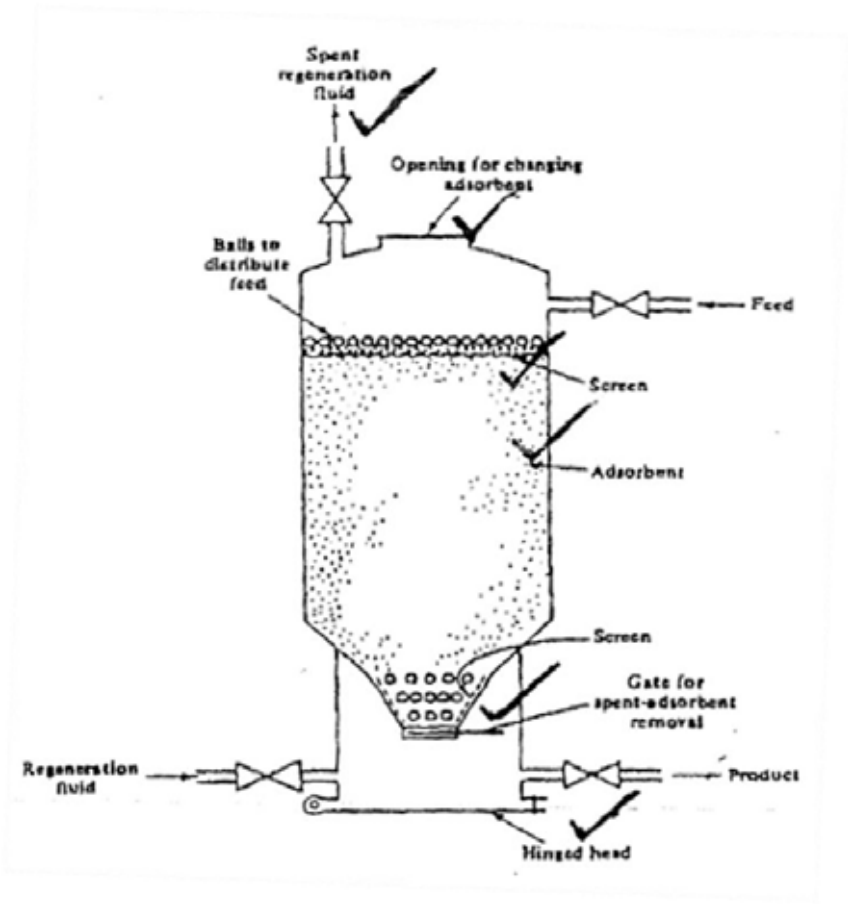
1.2.2 Rectification
It may be defined as a single-unit distillation operation in which vaporization occurs in repeated steps to give a much greater over-all separation that could be obtained by one simple distillation. (3)

1.3.1 Bubble-cap plates
Towers are widely used in industry. Distillation columns of this type consist of a series of plates. There are a number of openings in each plate through which the vapors rise. Each of the openings has an elevated cap on it so that the cap into the liquid on the plate deflects the vapors.
The vapors bubble through the liquid where condensation and vaporization occur. (3)

1.3.2 Linde plates
These designs have involved improvements both in the perforation design and the tray arrangements, an alteration in the perforation pattern to influence the flow of liquid. The slots, distributed throughout the tray, not only reduce the hydraulic gradient in large trays but are also deployed that they influence the direction of liquid flow to eliminate stagnant areas and achieve, as nearly as possible, desirable plug flow of liquid across the trays.

This multiple downspouts are not sealed in the liquid on the tray below; instead the liquid is delivered through slots in the bottom closure to spaces between the downspouts on the tray below. The parallel-flow tray is so designed that the liquid on all trays in the one-half the tower flows from right to left, and on the trays in the other half from left to right. (6)

1.4 Fix-bed adsorber



(6)
[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1.1 False (1)

2.1.2 False (1)

2.1.3 True (1)

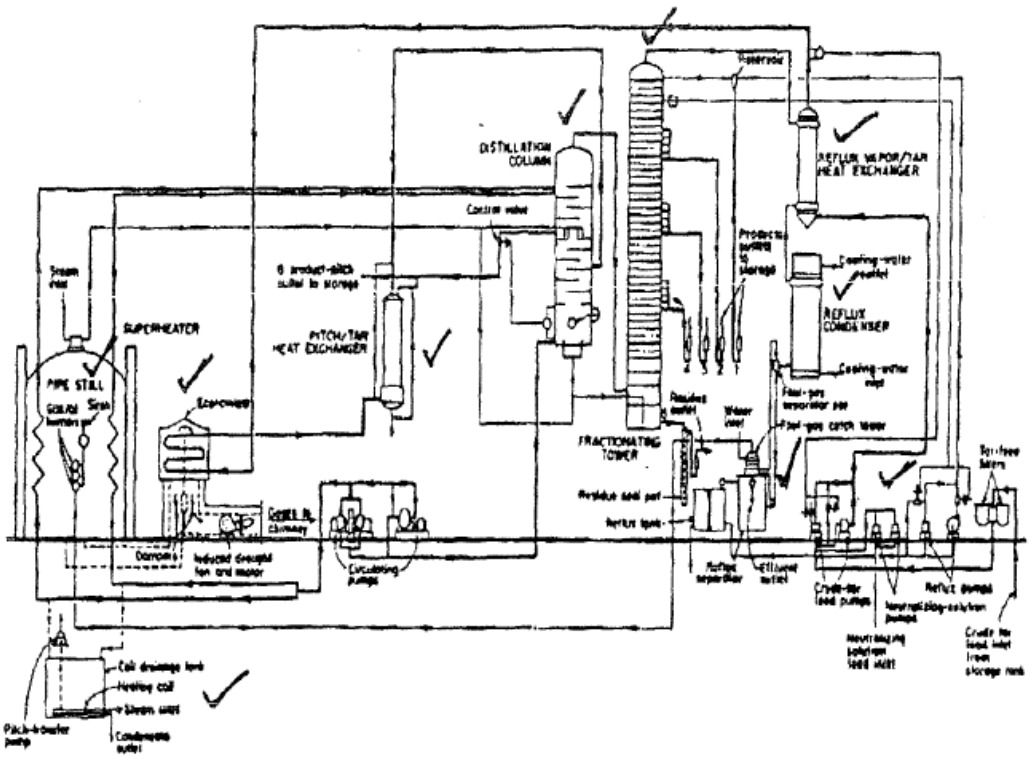
2.1.4 True (1)

2.1.5 True (1)

2.2 Liquid petroleum gas

LPG under a pressure of 5 Bar easily condenses to a liquid meaning that a large mass per volume energy can be stored. Liquid can easily vapourise to gas. This comprises C_3 to C_4 hydrocarbons refer to a $\pm$ 50% propane/propylene to butane/butalene mixture. LPG is obtained as a by-product in oil refineries. These gases are dissolved in oil, which is refined. This gas type of fuel is widely used in domestic applications and in industries as glass industries for furnaces. LPG comes from the ground as a constituent of wet natural gas or of crude oil or as a by-product from refining. (7)

2.3 Coal-tar continuous distillation.



(10)

Products: Light oil, carbolic oil, naphthalene oil, creosote or wash oil, residue anthracite and pitch. (3)

[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1.1 False (1)

3.1.2 True (1)

3.1.3 False (1)

3.1.4 False (1)

3.1.5 True (1)

3.2 Special purification of caustic soda

Some of the troublesome impurities in 50% caustic are colloidal iron, NaCl and NaClO. The iron is often removed by treating the caustic with calcium carbonate. The chlorate may be removed by allowing the caustic to drop through a column of 50% aqueous ammonic solution. (3)

3.3 Preparation of Caustic Soda (NaOH) by means of electrolysis:

This method using a mercury cathode. In the mercury cell, continuously fed brine is partly decomposed in one compartment (called the electrolyser) betvveen a graphite anode and a moving mercury cathode, forming chlorine) gas at the anode and sodium amalgam at the cathode.

The reactions are: $2NaHg + 2H_2O \rightarrow 2NaOH + H_2 + Hg$ the sodium amalgam flows continuously to a second compartment where it becomes the anode to a short-circuited iron or graphite cathode in an electrolyte of NaOH-solution. (7)
Purified water is fed to the cell counter) current to the sodium amalgam; hydrogen gas is formed, and the NaOH increases to 40% or 50%.

3.4 <u>Ion exchange.</u> (10)
Positively charged ions (cations) of a solution, which are capable of diffusing through the pores, will exchange with the positive ions (Na+) of such a mineral, which is therefore called a cat-ion exchanger.

eg $Ca^{2+} + Na_2R \Rightarrow Na_2R + CaCl_2$

Where "R" represents the residual material of the Zeolite. In this manner "hard" water containing Ca^{++} can be softened by contact with Zeolite, the less objectionable Na^+ replacing the Ca^{++} in solution and the latter becoming immobilized in the solid. The reaction is reversible, and after saturation with Ca the Zeolite can be regenerated by contact with a solution of salt,

eg $CaR + 2NaCl \Rightarrow Na_2R + CaCl_2$

The rate of ion exchange depends upon rates of the following individual processes:
- Diffusion of ions from the bulk of the liquid to the internal surface of an exchanger particle.
- Inward diffusion of ions through the solid to the internal surface of an exchange of the ions.
- Outward diffusion of the released ions to the surface of the solid.
- Diffusion of the released ions from the surface of the solid to the bulk of the liquid.

[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1.1 True (1)

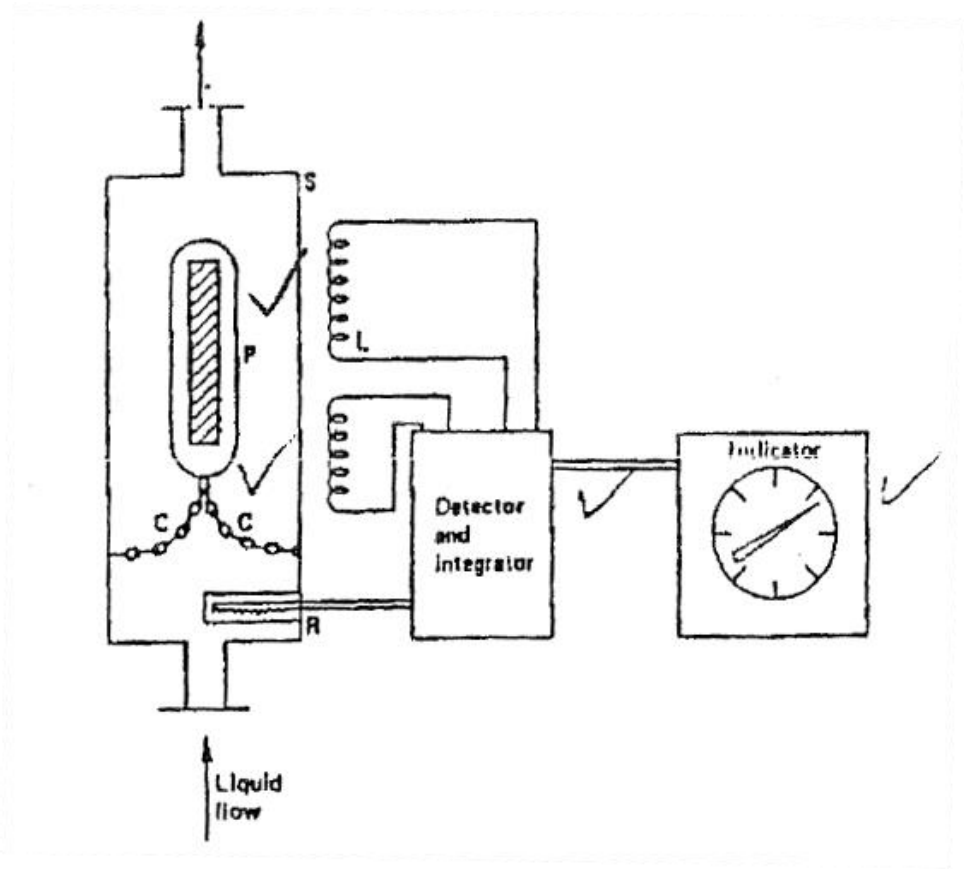
4.1.2 False (1)

4.1.3 False (1)

4.1.4 True (1)

4.1.5 True (1)

4.2 Chain-balance-plummet hydrometer:



(4)

S = Sampling chamber
L = Linear variable transformer
P = Plummet with metal core supporting chains "C"
R = Resistance thermometer bulb

(5)

Operation.

The displacer or plummet is counter balanced by the weight of the plummet and platinum-iridium calibrating chain. The plummet is so weighted that, at the middle of the density indicating range, it will support half the weight of the chain with the reference points supporting the other half.

As the density of the liquid increases, the increased buoyancy of the plummet causes it to rise. In rising, the plummet will take up greater potion of the weight of the chain.

It continues to rise until the increased portion of the plummet is reduced and the plummet will sink so that the reference points take a greater portion of the weight of the chain.

It will continue to rise until the increased portion of the plummet is reduced and the plummet will sink so that the reference points take a greater potion of the weight of the chain. It will continue to sink until equilibrium is again.

Thus for each value of the density with the range of the plummet chain assembly, the plummet will take up a definite position which is a measure of the density of the liquid.

The plummet contains a ferromagnetic core, which alters the inductance between the primary winding the two opposed halves of the secondary winding of a differential transformer as the plummet rises or falls.

4.3 SIX instruments for measuring temperature
Filled system ; Pressure type
Expansion type ; Thermocouple
Potentiometer I Pyrometer ; Resistance type (3)

4.4 Positive displacement meters (8)
The principle of the measurement is that as the liquid flows through the meter it moves a measuring element which seals off the measuring chamber into a series of measuring element which seals off the measuring chamber
into a series of measuring element moves, these compartments each holding a definite volume.

As the measuring element moves, these compartments are successfully filled and emptied. Thus for each complete cycle of the measuring element, a fixed quantity of liquid is permitted to pass from the inlet to the outlet of the meter.

A film of the measured liquid provides the seal between the measuring element and the measuring chamber. The number of cycles of the measuring element is indicated by means of a pointer moving over a dial, a digital totaliser or some other form of register, driven from the measuring element through an adjustable gearing. This gearing ratio is adjusted during calibration so that the difference between the indicated and the actual quantity flowing is a minimum over the whole of the meters rated capacity.

[25]

TOTAL (100)

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2011

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

5 April 2011 (X-Paper)
09:00 – 12:00

REQUIREMENTS:

Candidates will require drawing instruments, pens and a ruler.

This question paper consists of 5 pages.

TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Sketches must be large, neat and fully labelled.
5. 100 marks: 100%.
6. Write neatly and legibly.

QUESTION 1

1.1 Indicate whether the following statements are TRUE or FALSE. Write only •true' or 'false' next to the question number (1.1.1 - 1.1.5) in the ANSWER BOOK.

1.1.1 Rectification refers to a single-unit distillation process in which vaporisation occurs in repeated steps. (1)

1.1.2 Raoult's law does not differ from Dalton's law, which is a gas law applicable to gases. (1)

1.1.3 Crystallization is used to separate crude oil from water. (1)

1.1.4 Packed towers are classified as fractionation towers. (1)

1.1.5 Adsorption is used to separate vapour from solids (1)

1.2 Define the following:

1.2.1 Distillation (3)

1.2.2 Relative volatility (2)

1.3 Write brief, clarifying notes on the following:

1.3.1 Shell and trays (3)

1.3.2 Weirs (3)

1.4 Use a sketch to describe the operation of a Higgens contractor. (9)

[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1 Indicate whether the following statements are TRUE or FALSE. Write only 'true' or 'false' next to the question number (2.1.1 - 2.1.5) in the ANSWER BOOK.

2.1.1 The links of similar molecules, to joining together of light olefins refer to polymerisation. (1)

2.1.2 Aromatisation is the· conversion of naphthalene to obtain products of a lower octane number. (1)

2.1.3 An example of a cracking reaction is:
$C_3H_8 \leftrightarrow C_2H_4 + CH_4$ (1)

2.1.4 Liquid fuel products can consist of water and crude oil, while gaseous fuel products can consist of carbon monoxide and nitrogen. (1)

2.1.5 LPG is only obtained as a by- product from refineries. (1)

2.2 Explain the following concerning crude oil:

2.2.1 The olefin series (3)

2.2.2 The naphthalene series (2)

2.3 Explain in detail, step by step, the production of producer gas from coke as fuel source. Also state the operating time involving every step. (15)
[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Indicate whether the following statements are TRUE or FALSE. Write only 'true' or 'false' next to the question number (3.1.1 - 3.1.5) in the ANSWER BOOK.

3.1.1 A salt is formed when an acid reacts with a base (1)

3.1.2 A pH value of 0 refers to a strong acid (1)

3.1.3 A pH value of 8 refers to a strong alkali (1)

3.1.4 Ion exchange is used on a large scale by industries to soften rain water. (1)

3.1.5 The Zeolite process refers to ion exchange. (1)

3.2 Explain the term *ion exclusion*. (3)

3.3 Use a flow chart for the manufacture of aluminium sulphate by the Dorr procedure to give a chronological description of the process. Give also the applicable chemical reaction. (12)

3.4 Write brief, explanatory notes on each of the following steps in the preparation of caustic soda using a diaphragm cell:

3.4.1 Brine purification (3)

3.4.2 Evaporation and salt separation (2)
[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 Indicate whether the following statements are TRUE or FALSE. Write only 'true' or 'false' next to the question number (4.1.1 - 4.1.5) in the ANSWER BOOK.

4.1.1 Process variables refer to the physical quantity that can be measured but not to the physical quality to be measured. (1)

4.1.2 The electrodes of a pH meter are an example of a primary measuring element. (1)

4.1.3 Absolute pressure refers to gauge pressure. (1)

4.1.4 10 ºC is equal to 283 Kelvin. (1)

4.1.5 A screw type of flow meter refers to a positive displacement meter. (1)

4.2 Describe, with the aid of a labelled sketch the operation of a 'C'- Bourbon tube. (9)

4.3 Briefly explain the following:

4.3.1 The law of intermediate metals (4)

4.3.2 Inductance- bridge hydrometer (4)

4.3.3 The Hagen- Poiseuille law (3)

[25]

TOTAL: 100

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2011

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

This marking guidelines consists of 7 pages.

QUESTION 1 SEPARATION THEORY

1.1 True or False

1.1.1 True (1)

1.1.2 False (1)

1.1.3 False (1)

1.1.4 True (1)

1.1.5 True (1)

1.2

1.2.1 Distillation
It may define as the separation of the components of a liquid mixture by a process involving partial vaporization. In general, the vapour evolved is recovered by condensation. There for vapour-liquid separation is done by distillation. (3)

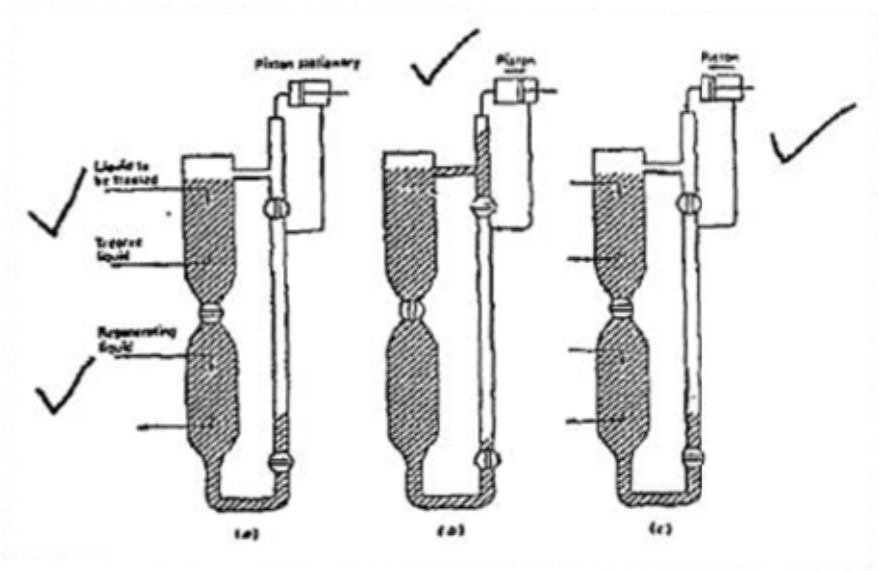
1.2.2 Relative volatility
It may define as the volatility of one component of a liquid mixture divided by the volatility of another component of the liquid mixture. (2)

1.3.1 Shell and trays
The trays are usually made of metal, sheets, of special alloys if necessary, thickness governed by the anticipated corrosion rate. The trays must be stiffened and supported and must be fastened to the shell to prevent movement, with allowance for thermal expansion. The tower may be made of any number of materials. Glass, glass-lined metal, carbon, and plastics, even wood but most frequently metals are used. (3)

1.3.2 Weirs
The depth of liquid on the tray required for gas contacting is, maintained by an overflow (outlet) weir. Straight weirs are most common, multiple notch weirs maintain a liquid depth, which is less sensitive to variations in liquid flow rate, and consequently also from departure of the tray from levelness.

In order to ensure reasonably uniform distribution of liquid flow on a singly-pass tray, weir length of 60 to 70% of the tower diameter is used. (3)

1.4 Higgens contractor
Sketch.



(9)

Operation

The temporarily stationary upper bed of solids is contracted with liquid flowing downward, so that fluidization does not occur. In the lower bed, an eluting liquid regenerates the solid. After several minutes, the liquid flow is stopped, valves are turned as shown in figure "b" and the liquid-filled piston pump is removed as shown for a period of several seconds, were upon solid is moved clockwise hydraulically. In figure "c" with the valves re-adjusted to their original position, movement of solid is completed and liquid flows are started to complete the cycle.

[25]

QUESTION 2 ORGANIC CHEMISTRY

2.1 True or False

2.1.1 True (1)

2.1.2 False (1)

2.1.3 True (1)

2.1.4 True (1)

2.1.5 False (1)

2.2.1 The olefin series.

This series is either not present in crude oil or exit in very small quantities. Cracking processes produce large amounts of olefins and have better antiknock properties than normal paraffin. Olefins have poorer properties than highly branched paraffin and aromatics. They are the most important class of compounds chemically derived from petroleum. (3)

2.2.2 The naphthalene series.
It has the same empirical formula as the olefin series, but differs in that its members are completely saturated. These crude's contain high percentage of cyclic compounds and famish relatively high-octane-number straight-run gasoline. (2)

2.3 Production of producer gas. (NB. ½ point per correct answer)
Step one: Blow (operation involving 30% or 63 sec.) (15)
Primary air is admitted at the base of a mechanical generator and is passes up through the fuel bed of coke at a gas-making temperature.

Step two: Blow run (operation involving 9% or 19 sec.)
This happen immediately after step one, while the fire temperature is at its peak and the blast gases contains the height percentage of CO. Closing the secondary air valve and the stack valve and allowing the producer gas to bypass through the machine into the wash box accomplish it.

Step three: Up run (operation involving 32% or 67 sec.)
Steam Is admitted at the base of the generator and passes up through the red-hot coke, forming blue gas. Oil gas is produced by the pyrolysis of the oil in an atmosphere of blue gas and from the radiant heat. The blue and oil gases mix and pass on to the super heater, where the pyrolysis of the gasified oil is completed and the gases are made permanent.

Step four: Back run (operation involving 24% or 51 sec.)
Steam is admitted into the top of the riser pipe, passing up the super heater, where it is superheated, down through the carburetor, reacting with any carbon in the generator fuel, finally passing out the bottom of the generator through the cast-ion back-run pipe through the three-way .valve into the was box, to the relief holder. Fuel is automatically charged during this portion of the cycle after the back-run and the oil has been shut off.

Step five: Final up run (operation involving 3% or 6 sec.)
This puts a blanket of steam between the blue gas in the base of the generator and the air that follows. The carburetor, super heater and riser pipe are already filled with back-up steam.

Step six: Blow purge (operation involving 2% or 4 sec.)
This purges the machine of blue gas and steam and produces some CO, all of which is swept through the machine, through the wash box, into the relief holder. This is accomplished by opening the generator air valve prior to opening the stock valve, which releases the products of combustion to atmosphere.

[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1 True or False

3.1.1 True (1)

3.1.2 True (1)

3.1.3 False (1)

3.1.4 False (1)

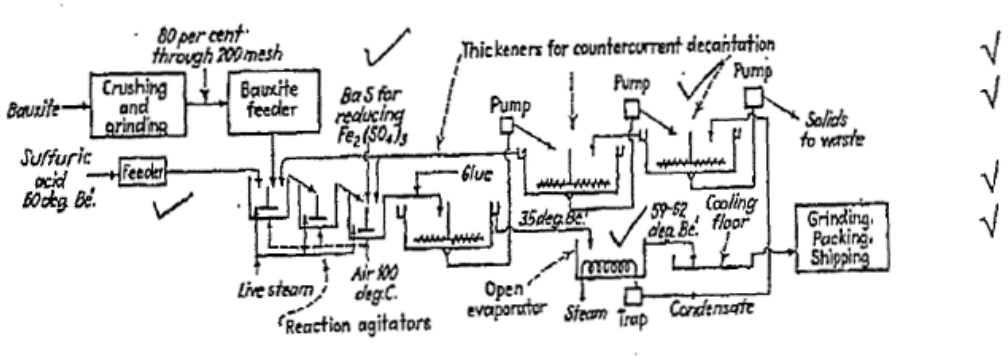
3.1.5 True (1)

3.2 Ion Exclusion

A resin is pre-saturated with the same ions as in a solution. It can then reject ions in such a solution but at the same time absorb non-ionic organic substances such as glycerin, and the like, which may also be in the solution. The organic matter can later be washed from the resin in an ion-free state. (3)

3.3 Dorr procedure: Production of Aluminium Sulphate

Flow chart



(4)

Applicable Chemical reaction:

$2NH_{3\ (gas)} + H_2SO_{4\ Lq)} \rightarrow (NH_4)_2SO_{4\ (Sol)}$ (1)

Chronological steps of the process as follow:

- Aluminium sulphate is made by reacting bauxite with sulphuric acid.
- The bauxite is grounded and conveyed to storage bins.
- Reactions occur in lead line tanks, where reactants are mixed by agitators and heated with steam.
- Reactors are operated in series.
- Into the last rector barium sulphide is added to reduce ferric sulphate to the ferrous state and to precipitate iron.
- Mixture from reactors sent through thickeners, which remove un-dissolved matter and wash waste to remove all alum.
- The clarified fluid is concentrated and poured into flat pans, where it is cooled and solidified. (7)

3.4

3.4.1 Brine purification

To make a purer caustic soda and to lessen clogging of the cell diaphragm with a consequent in crease, purification of the NaCl solution of calcium, ions and magnesium compounds is practiced, using soda ash with some caustic soda. Sometimes sulphates are removed with BaCl or the hot brine is treated with hydroxyl and carbonate ions. The clear brine is neutralized with hydrochloric acid. (3)

3.4.2 Evaporation and salt separation

NaOH solution is evaporated in a double or triple effect evaporator with salt separators and then passes through a settler and washing filter. The salt so recorded is again made into charging brine. (2)

[25]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 True or False

4.1.1 False (1)

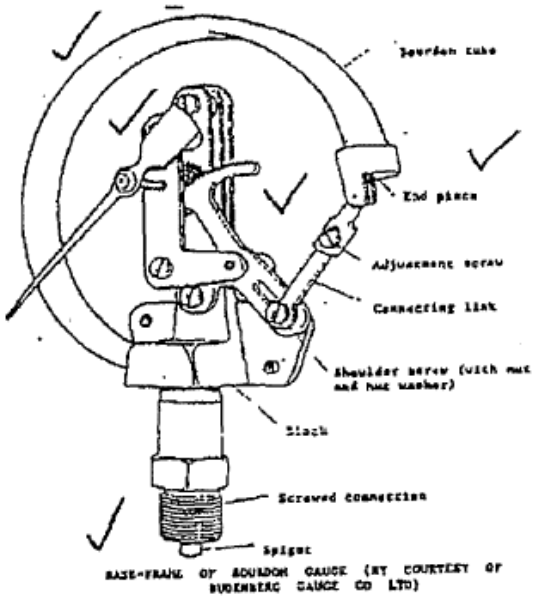
4.1.2 True (1)

4.1.3 False (1)

4.1.4 True (1)

4.1.5 True (1)

4.2 'C'- Bourbon tube
Sketch



BASE-FRAME OF BOURDON GAUGE (BY COURTESY OF BUDENBERG GAUGE CO LTD)

(5)

Operation:
In its simplest from the Bourdon tube consists of a tube of oval section bent in a circular arc. One end of the tube is sealed and attached by a light linkwork to the mechanism, which operates the pointer. The other end of the tube is fixed and is open for the application of pressure is has to measure. The internal pressure tends to straighten out the tube. The resulting movement of the face end of the tube causes the pointer to move over the scale.

(4)

4.3.1 Law of intermediate metals
In a thermo-electric circuit composed of two metals "A" and "B" with junctions at temperatures t_1 and t_2 respectively, emf is not altered if one or both the junctions are opened and one or more other metals are interposed between the metals "A" and "B", provided that all the junctions by which the single junction at temperature t_1 may be replaced are kept t_1, and all those by which the junction at temperature t_2 may be replaced are kept at t_2 made. (4)

4.3.2 Inductance- bridge hydrometers
In this instrument the level of the measured liquid is held constant at an overflow tube. A glass hydrometer either rises or falls in the liquid as the specific gravity varies. The lower end of the hydrometer supports an armature in an inductance coil, a similar coil in the recording instrument duplicates any movement of this armature. With this system, the temperature of the liquid is usually recorder along with the value of specific gravity, so that corrections can be made. (4)

4.3.3 Hagen- Poiseuille law
Hagen (Germany) and Poiseuille (France) described viscosity as the ratio of shear stress versus shear rate at the wall of a capillary tube. Positive displacement meters are frequently used in oil and water undertakings for accounting purposes. (3)

[25]

TOTAL: 100

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NOVEMBER 2010

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

11 November 2010 (X-Paper)
09:00 – 12:00

Candidates will require drawing instruments, pens and a ruler.

This question paper consists of 4 pages.

TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Sketches must be large, neat and fully labelled.
5. 100 marks: 100%
6. Write neatly and legibly.

QUESTION 1 DISTILLATION, ABSORPTION AND ADSORPTION

1.1 Write brief, clarifying notes on each of the following operations applied in oil refining:

1.1.1 Continuous distillation (3)

1.1.2 Relative volatility (2)

1.1.3 Absorption (3)

1.2 Discuss the following parts of distillation and fractionation columns:

1.2.1 Bubble-cap plates (3)

1.2.2 Linde plates (6)

1.2.3 Weirs (3)
[20]

QUESTION 2 ORGANIC CHEMISTRY

2.1 Define the following reactions

2.1.1 lsomerisation (2)

2.1.2 Aromatisation (1)

2.2 Briefly explain the alkylation of hydrocarbons. (4)

2.3 Briefly discuss crude petroleum oil as liquid fuel. (5)

2.4 Describe the purification process of natural gas. (5)

2.5 Draw a labelled flowchart procedure of a typical coke oven plant and list the products of procedure. (18)
[35]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Define the concept pH and explain the difference between a strong acid and a weak acid. (6)

3.2 Define or explain ion exclusion. (4)
[10]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 With the aid of an applicable example, discuss the purpose of the primary measuring element as part of an instrument. (4)

4.2 With the aid of a sketch, explain the operation of optical pyrometers. (6)

4.3 Sketch a rotating, vane type, positive displacement meter and describe the operation of such flow meter. (8)

4.4 Sketch and describe the operation of a chain-balance-plummet hydrometer. (9)

4.5 Explain, with the aid of a sketch, how you will determine the level of a liquid in a closed tank, with the aid of a gas-bubble type of meter. (6)

4.6 Explain briefly the hydrogen electrode as quality measure instrument. (2)

[35]

TOTAL: 100

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NOVEMBER 2010

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

QUESTION 1 DISTILLATION, ABSORPTION AND ADSORPTION

1.1.1 Continuous distillation
By continuously feeding a distillation unit with the material to be separated, it is possible to obtain the so-called continuous distillation. In an operation of this type, the unit can be brought to a steady operating condition where the amount of feed exactly equals the amount of material removed and the vapor and liquid concentrations at any point in the unit remain constant. (3)

1.1.2 Relative volatility
It may define as the volatility of one component of a liquid mixture divided by the volatility of another component of the liquid mixture. Relative volatilities are .. commonly expressed with. the. higher of the two relative. -
volatility should never have a numerical value less than 1.0 (2)

1.1.3 Absorption
Is widely employed in the recovery of natural gasoline from well gas and vapors given off by storage tanks.
Absorption also obtains light hydrocarbons from many refining processes. The solvent oil may be heavy gasoline, kerosene or even heavier oils. Fractionating or steam stripping removes the absorbed products. (3)

1.2.1 Bubble-cap plates
Towers are widely used in industry. Distillation columns of this type consist of a series of plates. There are a number of openings in each plate through which the vapors rise. Each of the openings has an elevated cap on it so that the cap into the liquid on the plate deflects the vapors.
The vapors bubble through the liquid where condensation and vaporization occur. (3)

1.2.2 Linde plates
These designs have involved improvements both in the perforation design and the tray arrangements, an alteration in the perforation pattern to influence the flow of liquid. The slots, distributed throughout the tray, not only reduce the hydraulic gradient in large trays but are also deployed that they influence the direction of liquid flow to eliminate stagnant areas and achieve, as nearly as possible, desirable plug flow of liquid across the trays.

This multiple downspouts are not sealed in the liquid on the tray below; instead the liquid is delivered through slots in the bottom closure to spaces between the downspouts on the tray below. The parallel-flow tray is so designed that the liquid on all trays in the one-half the tower flows from right to left, and on the trays in the other half from left to right. (6)

1.2.3 Weirs.
The depth of liquid on the tray required for gas contacting is, maintained by an overflow (outlet) weir. Straight weirs are most common, multiple notch weirs maintain a liquid depth, which is less sensitive to variations in liquid flow rate, and consequently also from departure of the tray
from levelness, circular pipes used as downspouts, are not

recommended. (3)
[20]

QUESTION 2 ORGANIC CHEMISTRY

2.1.1 lsomerisation.
Alteration of arrangement of the atoms in a molecule without changing the number of atoms. (2)

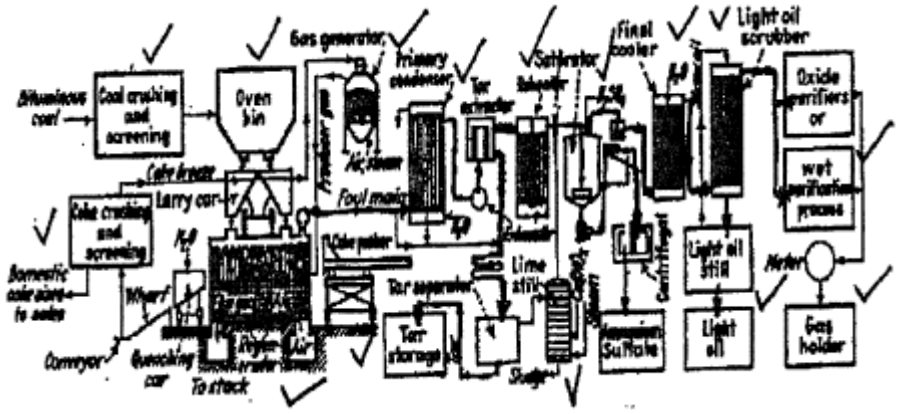
2.1.2 Aromatisation.
The conversion of naphtha's to obtain products of higher octane number. (1)

2.2 Alkylation.
Refer to the combine of lower weight hydrocarbons to from high-octane gasoline and are essentially to reverse of the main reactions that occur during cracking. There for it builds hydrocarbon molecules in the gasoline range that possess high anti-knock qualities. Low-molecular weight paraffin's
eg iso-butane and olefin's may be united thermally without a catalyst or catalytically using sulfuric acid as alkylating agent. Thus it revere to the union of an olefin with a promatic or paraffin hydrocarbon. (4)

2.3 Crude petroleum oil.
The major source for liquid fuels is crude petroleum. Basically, petroleum is a mixture of many hydrocarbons usually containing impurities such as sulfur and nitrogen compounds and vanadium compounds at some cases.
Crude oils vary in compounds with respect to the paraffin, naphthalene, and aromatic groups. There for intermediate base crude's refer to crude's that contain large quantities of both paraffinic and naphtenic compounds and furnish medium-grade straight-run gasoline's and lubricating oils.
Both wax and asphalt are found in these oils. (5)

2.4 Purification of natural gas.
Four important methods are employed for the dehydration of the gas namely: compression treatment with drying substances, absorption and refrigeration.
A plant for water removal by compression consists of a gas compressor, followed by a cooling system to remove the water vapor condensation.
The treatment of gas with drying substances has found widespread usage in this country. The agents employed for this purpose are activated alumina and bauxite1 silica gel, sulfuric acid, glycerin and concentrated solution of
calcium chloride or sodium thiocyanate. Passing it over refrigerated coils may also dehydrate gas.
The Girbotol procedure is used to remove the H_2S.
(5)

2.5 A typical coke oven coke plant



(15)

(3)

Products: Gas, coke, tar, ammonium, sulphate and light oil.

[35]

QUESTION 3 INORGANIC CHEMISTRY

3.1 PH concept.
The pH is defined as the logarithm of the reciprocal of hydronium ion concentration, or pH = -log $[H^+]$. Thus the pH value of a dilute solution can now be easily calculated .if $[H^+ (aq)]$ is known.
Strong acid: ionise almost completely in solution and from a high concentration of hydrogen ions.
Weak acid: ionise only partially in solution and from a low concentration of hydrogen ions. (6)

3.2 Ion Exclusion.
A resin is pre-saturated with the same ions as in a solution. It can then reject ions in such a solution but at the same time absorb non-ionic organic substances such as glycerin, and the like, which may also be in the solution.
The organic matter can later be washed from the resin in an ion-free state.

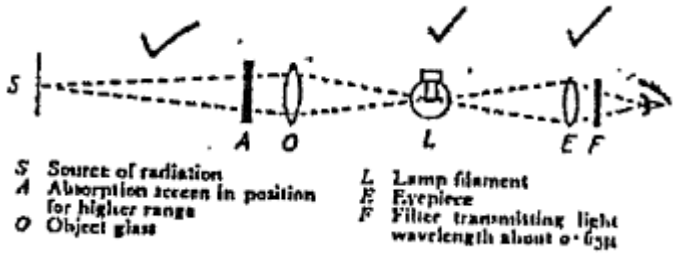
(4)
[10]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 The Primary measuring element
Also called sensory element that is in contract with the variables being measured and detects the change, for example the electrodes of a pH meter. It is of most important for controlling conditions that these elements are sensitive to react fast on process changes measured.
Should the element by reluctant, any change will after a time delay, be adjusted with accompanying delays. (4)

4.2 Optical Pyrometers.
Sketch

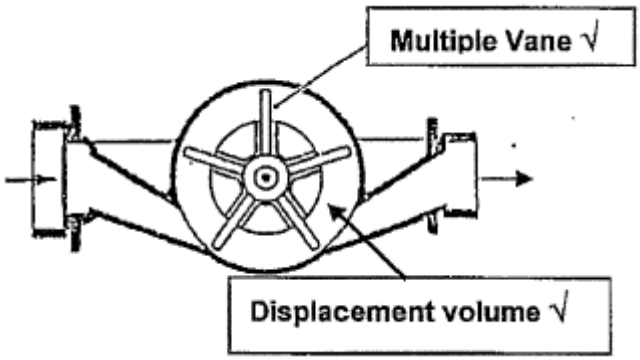
(6)



Operation.
They may be divided into two groups. In the first group, the light of a given wavelength from the hot body is optically matched with the light from a constant comparison lamp in the instrument by means of an optical wedge or polarizing system.

In the second group, which has now become by far the most popular, the brightness of the light from the calibrated comparison lamp is varied to match the light from the hot body. The brightness of the lamp is judged to be the same as that of the source when it merges into the image of the source. The instrument is therefore known as the disappearing Filament Pyrometer.

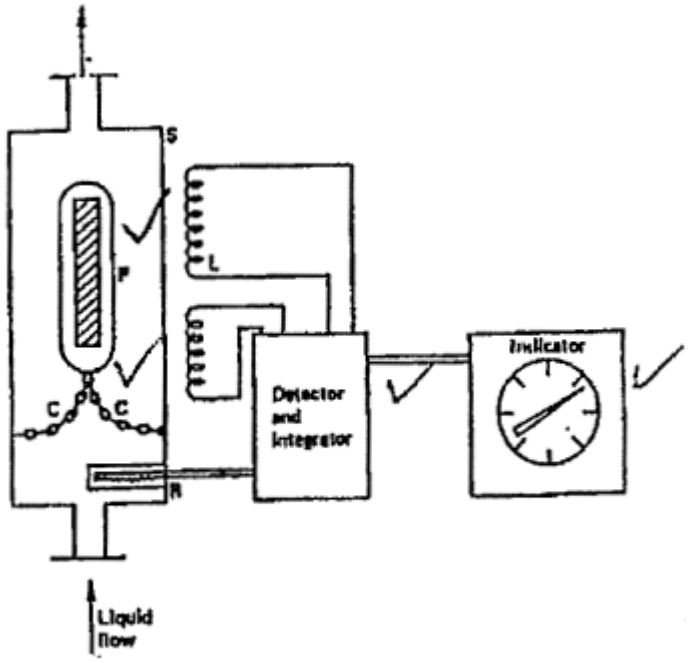
4.3 Rotating vane type positive displacement meter.



(8)

Operation.
The principle of the measurement is that as the liquid flows through the meter it moves a measuring element which seals off the measuring chamber into a series of measuring element which seals off the measuring chamber
into a series of measuring element moves, these compartments each holding a definite volume. As the measuring element moves, these compartments are successfully filled and emptied. Thus for each complete
cycle of the measuring element, a fixed quantity of liquid is permitted to pass from the inlet to the outlet of the meter.
A film of the measured liquid provides the seal between the measuring element and the measuring chamber. The number of cycles of the measuring element is indicated by means of a pointer moving over a dial.

4.4 Chain-balance-plummet hydrometer:



(4)

S = Sampling chamber
L = Linear variable transformer
P = Plummet with metal core supporting chains “C”
R = Resistance thermometer bulb

Operation. (5)

The displacer or plummet is counter balanced by the weight of the plummet and platinum-iridium calibrating chain. The plummet is so weighted that, at the middle of the density indicating range, it will support half the weight of the chain with the reference points supporting the other half.

As the density of the liquid increases, the increased buoyancy of the plummet causes it to rise. In rising, the plummet will take up greater potion of the weight of the chain.

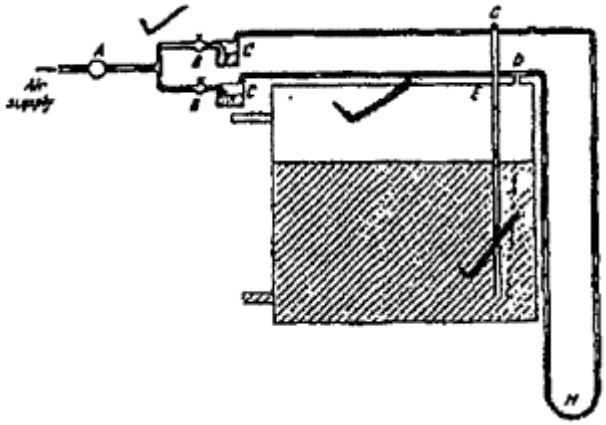
It continues to rise until the increased portion of the plummet is reduced and the plummet will sink so that the reference points take a greater portion of the weight of the chain.

It will continue to rise until the increased portion of the plummet is reduced and the plummet will sink so that the reference points take a greater potion of the weight of the chain. It will continue to sink until equilibrium is again.

Thus for each value of the density with the range of the plummet chain assembly, the plummet will take up a definite position which is a measure of the density of the liquid.

The plummet contains a ferromagnetic core, which alters the inductance between the primary winding the two opposed halves of the secondary winding of a differential transformer as the plummet rises or falls.

4.5 Gas-bubble meter type determining liquid level in a close tank.



(3)

A = Reducing valve
B.B = Needle valves
C.C = Bubblers
M =Manometer
G = Clean-out plug

Explanation
The pressure in the standpipe will build up until it is equal to that due to the liquid above the level of the bottom of the pipe. (3)

If the flow of gas is small, say, 60 bubbles per minute, a pressure of gas equal to that in the standpipe will be applied to the liquid level indicator and the recorder.

They will, therefore, give an indication depending up the pressure due to the depth of the liquid in the tank and so indicate the level.

4.6 Hydrogen electrode. (2)
A hydrogen electrode consists of a platinum plate or wire covered with platinum black. When hydrogen is bubbled over such an electrode it is absorbed into its surface and the electrode behaves as a hydrogen· electrode. It can be shown that the potential attained by a hydrogen electrode is related to the pH value.

[35]
TOTAL: 100

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

AUGUST 2010

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

22 July 2010 (X-Paper)
09:00 – 12:00

Candidates will require drawing instruments, pens and a ruler.

This question paper consists of 3 pages.

TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Sketches must be large, neat and fully labelled.
5. Write neatly and legibly

QUESTION 1 DISTILLATION, ABSORPTION AND ADSORPTION

1.1 Write brief, clarifying notes on each of the following operations applied in oil refining:

1.1.1 Vapour-liquid equilibrium (3)

1.1.2 Murphree-plate efficiency (3)

1.1.3 Distillation (2)

1.2 Discuss the following parts of distillation and fractionation columns:

1.2.1 Discharge gutters (6)

1.2.2 Linde plates (6)
[20]

QUESTION 2 ORGANIC CHEMISTRY

2.1 Explain, with the aid of an example, the following terms:

2.1.1 Cracking (2)

2.1.2 Hydrogenation (3)

2.2 Explain each of the following concerning crude oil:

2.2.1 The olefin series (3)

2.2.2 The naphthalene series (2)

2.3 Explain in detail, step by step, the production of producer gas from coke as fuel source. Also state the operating time involving every step. (15)
[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Briefly explain the term acid and also refer to the difference between strong and weak acid. (7)

3.2 Draw a fully labelled flowchart preparing NaOH by means of a caustic cell. (15)
[22]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 Name THREE parts, of which a measuring instrument consists of, and give an applicable example of each part. (3)

4.2 Sketch a labelled installed orifice plate to measure flow and discuss the precautionary measures that should be taken during installation. (15)

4.3 Name SIX types of instruments that can be used to measure temperature and SIX instruments that can be used to measure pressure. (6)

4.4 Describe, with the aid of a labelled sketch, the operation of a C-Bourdon tube. (9)

[33]

TOTAL: 100

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

AUGUST 2010

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

This marking guidelines consists of 6 pages.

QUESTION 1 DISTILLATION, ABSORPTION AND ADSORPTION

1.1.1 Vapour -liquid equilibrium.
For mixtures, which follow Raoult's law, the composition of the equilibrium vapours evolved at any temperature from a liquid of known concentration can be calculated by use of the vapour pressures of the pure components at the temperature involved. However, since most mixtures do not follow Raoult's law. It is usually determine the necessary to equilibrium liquid and vapour compositions experimentally. (3)

1.1.2 Murphree-plate efficiency
The efficiencies of individual plates in a distillation tower may be reported as Murphree tray/plate efficiencies. This efficiency is defined as the actual vapour enrichment over one plate divided by the theoretical vapour enrichment, which would have been obtained if the liquid on the plate and the vapours leaving the plate had reached equilibrium. (3)

1.1.3 Distillation.
It is the separation of components of liquid mixture through stages of heating and cooling until a pure light product is obtained towards the top of the plant and a pure heavy product at the bottom. (2)

1.2.1 Discharge gutters.
The liquid led from the one tray to the next by means of downspouts or down-comers. These may be circular pipes or preferable portions of the tower cross section set aside for liquid which is agitated into a froth on the tray, adequate residence time must be allowed in the downspout to permit disengaging the gas from the liquid, so that only clear liquid enters the tray below.

The downspout must be brought close enough to the tray below the seal into the liquid on that tray thus short-circuits the tray above. Seal pots and seal-pot dams (inlet weirs) may be used, but they are best avoided especially if there is a tendency to accumulate sediment. If they are used, weep holes (small holes through the tray) in the seal pot should be used to facilitate draining the tower on shutdown.

(6)

1.2.2 Linde plates.
These designs have involved improvements both in the perforation design and the tray arrangements, an alteration in the perforation pattern to influence the flow of liquid. The slots, distributed throughout the tray, not only reduce the hydraulic gradient in large trays but are also deployed that they influence the direction of liquid flow to eliminate stagnant areas and achieve, as nearly as possible, desirable plug flow of liquid across the trays.

This multiple downspouts are not sealed in the liquid on the tray below; instead the liquid is delivered through slots in the bottom closure to spaces between the downspouts on the tray below. The parallel-flow tray is so designed that the liquid on all trays in the one-half the tower flows from right to left, and on the trays in the other half from left to right. (6)

[20]

QUESTION 2 ORGANIC CHEMISTRY

2.1

2.1.1 Cracking.
It is the breaking-up of any hydrocarbon in such a way that carbon-carbon bonds break-up to from new hydrocarbon products.

Example: $C_3H_8 \leftrightarrow C_2H_4 + CH_4$ -------an olefin and paraffin are formed. (2)

2.1.2 Hvdrogenation.
It refers to an addition (of hydrogen to an olefin) reaction that hydrogen undergoes with unsaturated hydrocarbons or other organic compounds, in the presence of a catalyst, at suitable temperature and pressures, eg ethylene to from ethane, carbon monoxide, to from methanol and higher alcohol's etc. (3)

2.2.1 The olefin series.
This series is either not present in crude oil or exit in very small quantities. Cracking processes produce large amounts of olefins and have better antiknock properties than normal paraffin. Olefins have poorer properties than highly branched paraffin and aromatics. They are the most important class of compounds chemically derived from petroleum. (3)

2.2.2 The naphthalene series.
It has the same empirical formula as the olefin series, but differs in that its members are completely saturated. These crude's contain high percentage of cyclic compounds and famish relatively high-octane-number straight-run gasoline. (2)

2.3 Production of producer gas. (NB. ½ point per correct answer)
Step one: Blow (operation involving 30% or 63 sec.)
Primary air is admitted at the base of a mechanical generator and is passes up through the fuel bed of coke at a gas-making temperature.

Step two: Blow run (operation involving 9% or 19 sec.)
This happen immediately after step one, while the fire temperature is at its peak and the blast gases contains the height percentage of CO. Closing the secondary air valve and the stack valve and allowing the producer gas to bypass through the machine into the wash box accomplish it.

Step three: Up run (operation involving 32% or 67 sec.)

Steam Is admitted at the base of the generator and passes up through the red-hot coke, forming blue gas. Oil gas is produced by the pyrolysis of the oil in an atmosphere of blue gas and from the radiant heat. The blue and oil gases mix and pass on to the super heater, where the pyrolysis of the gasified oil is completed and the gases are made permanent.

Step four: Back run (operation involving 24% or 51 sec.)
Steam is admitted into the top of the riser pipe, passing up the super heater, where it is superheated, down through the carburetor, reacting with any carbon in the generator fuel, finally passing out the bottom of the generator through the cast-ion back-run pipe through the three-way .valve into the was box, to the relief holder. Fuel is automatically charged during this portion of the cycle after the back-run and the oil has been shut off.

Step five: Final up run (operation involving 3% or 6 sec.)
This puts a blanket of steam between the blue gas in the base of the generator and the air that follows. The carburetor, super heater and riser pipe are already filled with back-up steam.

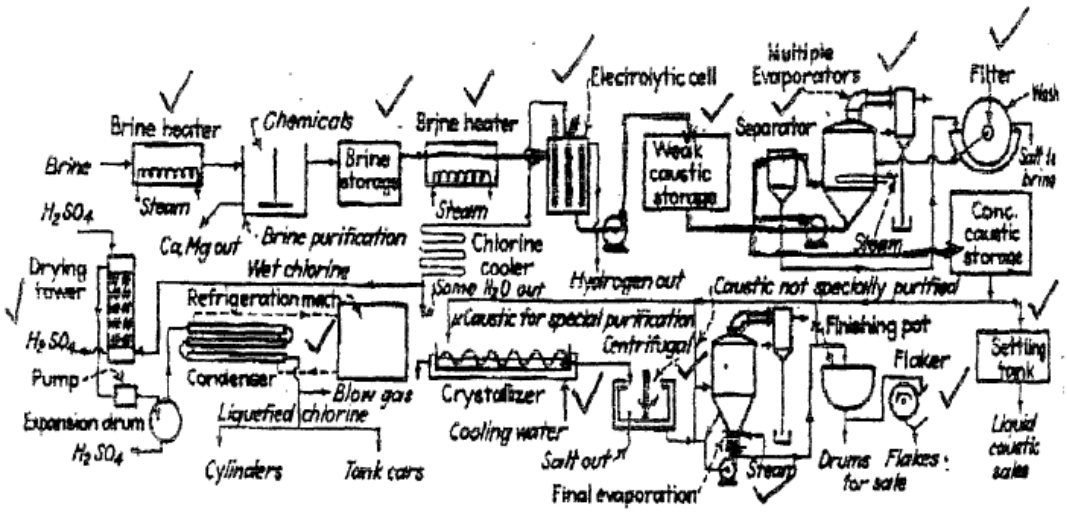
Step six: Blow purge (operation involving 2% or 4 sec.)
This purges the machine of blue gas and steam and produces some CO, all of which is swept through the machine, through the wash box, into the relief holder. This is accomplished by opening the generator air valve prior to opening the stock valve, which releases the products of combustion to atmosphere. (15)

[25]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Acids:
An acid is a substance that increases the concentration of hydrogen ions / hydronium ions (H^+) in an aqueous solution or which is able to donate protons to another substance. When an acid dissolves in water, it breaks up (dissociates) into small particles, called ions. This is the reason why acids are so corrosively.
Strong acids ionise almost completely in solution and from a high concentration of hydrogen ions.
Weak acids ionise only partially in solution and from a low concentration of hydrogen ions. (7)

3.2 NaOH Plant



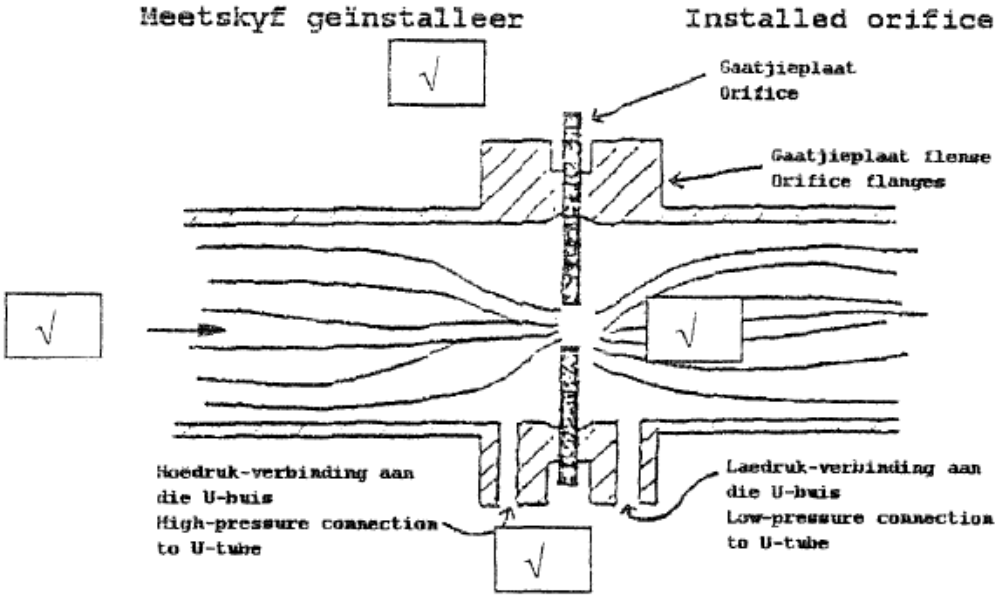
(15)
[22]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 Parts of a measuring instruments

1. Primary measuring element e.g. electrodes of a pH meter.
2. Transfer element e.g. hair tube connected to a pressure gauge.
3. Indicating element e.g. Bourdon type of pressure meter, which indicated the pressure on a calibrated scale. (3)

4.2 Orifice plate Sketch



(4)

Precautionary measures

During installation and use, nothing must be allowed to damage the sharp upstream edge if the orifice. For this reason, the plate should never be cleaned with emery cloth, owing the danger of rounding the sharp edge of the orifice. The upstream face should be smooth for a diameter of at least twice that of the bore, and be flat to within 2 % of the pipe diameter, when the plate is clamped between the flanges.

When the plate is in use, on extraneous matter must be allowed to collect on or near the orifice plate.

Where gases containing tar and other similar substances have to be metered, arrangements are usually made to remove their deposits with a blast of high-pressure steam.

When the plate is being installed, gaskets, usually 1 to 6 mm thick and graphite on the side to the plate are used between the plate and the flanges.

The gaskets must never extend into the pipe and should be cut to size when they are being installed.

When the flange bolts are being tightened care must be taken to see that a uniform pressure is maintained all round the plate, so that the danger of buckling the plate is eliminated.

Great care must be taken to see that the orifice is concentric with the pipe, particularly when it has a high orifice ratio.

Care must also be taken with the pressure holes. After drilling the inside edge of the hole should be rounded off slightly with a reamer or file to be sure that no burrs exist.

Bleed holes should always provided in orifice plates. In liquid flow measurement the hole should be at the top to allow gas, which would otherwise be trapped by the plate, to pass on with the liquid.

In gas and steam flows measurement the hole should be at the bottom to allow liquids to pass. (11)

4.3 Temperature instruments. (Anv SIX correct answers)

- Helical type Bourdon tube
- Spiral type
- Bourdon tube (filled systems)
- Pyrometer
- Resistance thermometer
- Thermocouple
- Potentiometer (3)

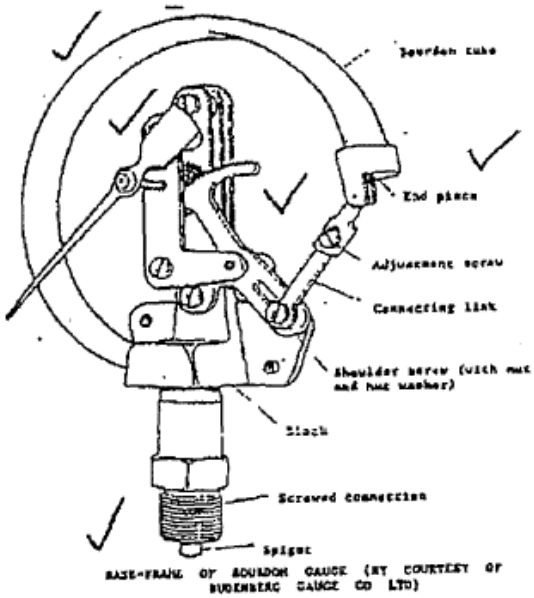
Pressure instruments.

- Mc Leod vacuum gauge
- Bourdon tube
- Barometer
- Manometer
- Helical type (3)

Resistance type

4.4 'C'- Bourbon tube

Sketch (5)



BASE-FRAME OF BOURDON GAUGE (BY COURTESY OF BUDENBERG GAUGE CO LTD)

Operation:
In its simplest from the Bourdon tube consists of a tube of oval section bent in a circular arc. One end of the tube is sealed and attached by a light linkwork to the mechanism, which operates the pointer. The other end of the tube is fixed and is open for the application of pressure is has to measure. The internal pressure tends to straighten out the tube. The resulting movement of the face end of the tube causes the pointer to move over the scale.

(4)
[33]

TOTAL: 100

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2010

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

8 April 2011 (X-Paper)
09:00 – 12:00

This question paper consists of 3 pages.

TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Sketches must be large, neat and fully labelled.
5. 100 marks = 100%.
6. Write neatly and legibly

QUESTION 1 DISTILLATION, ABSORPTION AND ADSORPTION

1.1 Write brief, clarifying notes on each of the following operations as applied in oil refining:

1.1.1 Extraction (2)

1.1.2 Crystallisation (2)

1.1.3 Filtration (2)

1.2 Discuss the following parts of distillation and fractionation columns:

1.2.1 Valve trays (6)

1.2.2 Counter flow trays (2)

1.3 Draw a neat, labelled fix-bed adsorber. (6)
[20]

QUESTION 2 ORGANIC CHEMISTRY

2.1 Explain each of the following crude oils:

2.1.1 Paraffin base crude oil (2)

2.1.2 Naphtha base crude oil (3)

2.1.3 Intermediate base crude oil (2)

2.2 Briefly discuss liquid petroleum gas fuel. (7)

2.3 Draw a labelled flow chart of a coal-tar continuous distillation plant and list the products of the procedure. (13)
[27]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Briefly explain the term bases and also refer to the difference between strong and weak bases. (4)

3.2 Write brief, explanatory notes on each of the following steps in the preparation of caustic soda using a diaphragm cell:

3.2.1 Brine purification (3)

3.2.2 Special purification of caustic soda (3)

3.3 Write brief, explanatory notes on the principles and the rate of ion exchange. (10)
[20]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1	Discuss, with the aid of an applicable example the purpose of the transfer and indicating measuring elements as part of an instrument.	(4)
4.2	State the advantages and disadvantages of filled-system thermometers.	(11)
4.3	Write brief, explanatory notes on the following:	
4.3.1	Inductance-bridge hydrometer	(4)
4.3.2	The force balance system for the measure of levels	(6)
4.4	Sketch and describe the operation of a mercury-in-steel thermometer.	(8)

[33]

TOTAL: 100

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2010

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

This marking guidelines consists of 7 pages.

QUESTION 1 DISTILLATION, ABSORPTION AND ADSORPTION

1.1.1 Extraction
It involves the removal of a component from a liquid by means of the selective solvent action of another liquid and is important for the production of e.g. benzene, toluene etc. (2)

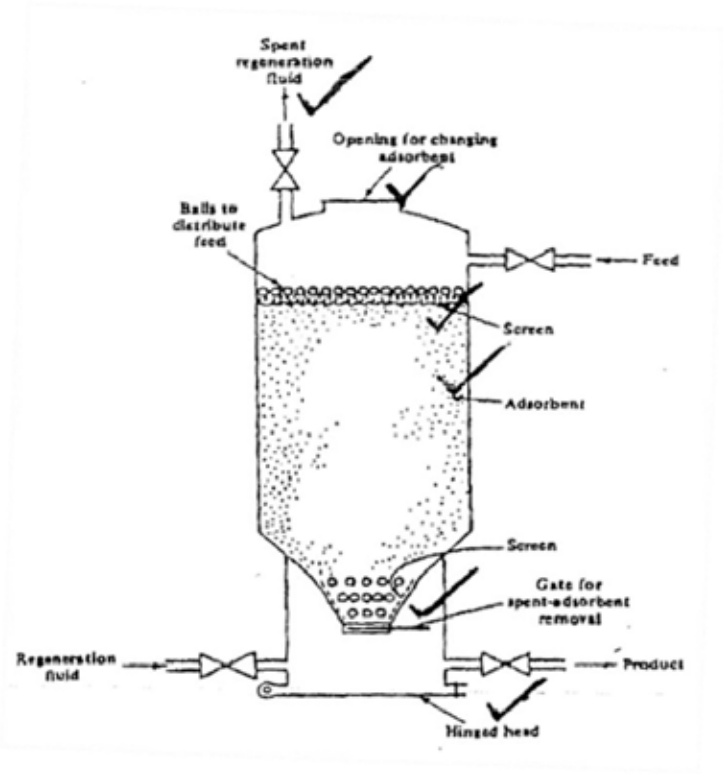
1.1.2 Crystallisation
By means of crystallization wax is removed from crude oil or from lubrication oil to yield crystalline and microcrystalline waxes of low oil content. (2)

1.1.3 Filtration
Is the usual method for removal of wax from wax distillates. The mixture of wax and adhering oil obtained from the press is frozen and allowed to warm slowly so that the oil drains (sweats) from the cake, thus further purifying the wax. (2)

1.2.1 Valve trays
Valve trays are sieve trays with large (roughly 35-40 mm diameter) variable openings for gas flow. The perforations are covered with movable caps, which rise as the flow rate of gas increases. At low gas rates and corresponding pressure drop it remains low but not as low as that for sieve or bubble cap trays.
Tray spacing is usually chosen on the basis of expediency in construction, maintenance, and cost and later checked to be certain that adequate insurance against flooding and excessive entertainment is present. For special cases where tower height is an important consideration spacing of 15 cm has been used. For all except the smallest tower diameters 50 cm would seem to be a more workable minimum from the point of view of cleaning the trays. (6)

1.2.2 Counter flow trays
These tray-resembling devices differ from conventional trays in that there are no ordinary downspouts. Liquid and vapour flow counter-currently through the same openings. Trays like trubo-, kitter-, ripple and leva trays are used. (2)

1.3 Fix-bed adsorber (6)



[20]

QUESTION 2 ORGANIC CHEMISTRY

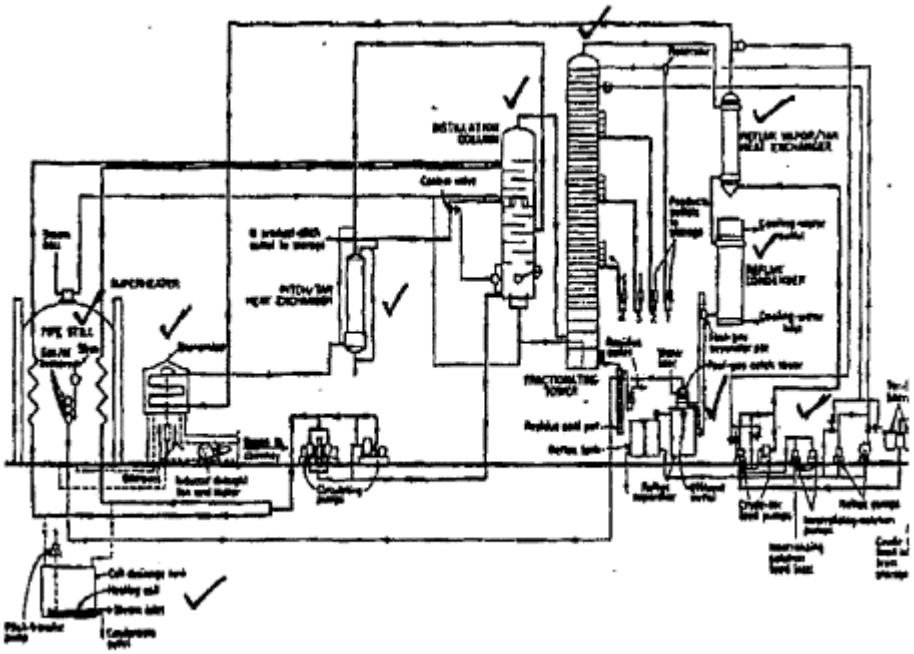
2.1.1 Paraffin base crude.
These crude's consist primarily of open-chain compounds and furnish low-octane number straight-run gasoline and excellent but waxy lubricating oil stocks. (2)

2.1.2 Naphthene base crude.
These crude's contain a high percentage of cyclic (naphthenic) compounds and furnish relatively high-octane grade straight-run gasoline. The lubricating-oil fractions must be so/vent-refined. Asphalt is present. (3)

2.1.3 Intermediate base crude.
These crude's contain large quantities of both paraffinic and naphthenic compounds and furnish medium-grade straight run gasolines and lubricating oils. Both wax and asphalt are found in these oils. (2)

2.2 Liquid petroleum gas
LPG under a pressure of 5 Bar easily condenses to a liquid meaning that a large mass per volume energy can be stored. Liquid can easily vapourise to gas. This comprises C_3 to C_4 hydrocarbons refer to a $\pm$ 50% propane/propylene to butane/butalene mixture. LPG is obtained as a by-product in oil refineries. These gases are dissolved in oil, which is refined. This gas type of fuel is widely used in domestic applications and in industries such as glass industries for furnaces. LPG comes from the ground as a constituent of wet natural gas or of crude oil or as a by-product from refining. (7)

2.3 Coal-tar continuous distillation.



(10)

Products: Light oil, carbolic oil, naphthalene oil, creosote or wash oil, residue anthracite and pitch. (3)

[27]

QUESTION 3 INORGANIC CHEMISTRY

3.1 Bases:
Bases are substances, which also ionise when dissolved in water but they from hydroxide ions (OH). This is the reaction during which protons are transferred in water.
Weak bases refer to $CaCO_3$ and Na_2CO_3 (carbonates) and the strong bases refer to the NaOH, $Ca(OH)_2$ and KOH (hydroxides) (4)

3.2.1 Brine purification
To make a purer caustic soda and to lessen clogging of the cell diaphragm with a consequent increase, purification of the NaCl solution of calcium, ions and magnesium compounds is practiced, using soda ash with some caustic soda. Sometimes sulphates are removed with BaCl or the hot brine is treated with hydroxyl and carbonate ions. The clear brine is neutralised with hydrochloric acid. (3)

3.2.2 Special purification of caustic soda
Some of the troublesome impurities in 50% caustic are colloidal iron, Nace and Naceo. The iron is often removed by treating the caustic with calcium carbonate. The chlorate may be removed by allowing the caustic to drop -1 through a column of 50% aqueous ammonic solution. (3)

3.3 Ion exchange

Positively charged ions (cations) of a solution, which are capable of diffusing through the pores, will exchange with the positive ions (Na^+) of such a mineral, which is therefore called a cat-ion exchanger.
eg $Ca^{2+} + Na_2R \Rightarrow Na_2R + CaCl_2$

Where "R" represents the residual material of the Zeolite. In this manner “hard" water containing Ca^{++} can be softened by contact with Zeolite, the less objectionable Na^+ replacing the Ca^{++} in solution and the latter becoming immobilized in the solid. The reaction is reversible, and after saturation with Ca the Zeolite can be regenerated. by contact with a solution of salt,

eg $CaR + 2NaCl \Rightarrow Na_2R + CaCl_2$

The rate of ion exchange depends upon rates of the following individual processes:

- Diffusion of ions from the bulk of the liquid to the internal surface of an exchanger particle.
- Inward diffusion of ions through the solid to the internal surface of an exchange of the ions.
- Outward diffusion of the released ions to the surface of the solid.
- Diffusion of the released ions from the surface of the solid to the bulk of the liquid. (10)

[20]

QUESTION 4 PROCESS-CONTROL INSTRUMENTATION

4.1 Transfer element.
This element transfers the change, which was detected, to the next element known as the indicating element. An example of a transfer element is the hair tube connected to a pressure gauge. (4)

The Indicating element.
Also called secondary element and reacts to the change that was detected and transferred, for example the Bourdon type of pressure meter, which indicated the pressure on a calibrated scale.

4.2 Advantages and disadvantages of filled-system thermometers.
Advantages.

- Fundamental simplicity of the system allows rugged construction, minimizing the possibility of damage or failure in shipment, installation1 and use. The amount of upkeep is generally minor.
- Simplicity of the system allows inexpensive design.
- As used in the process industries, sensitivity, response time and accuracy are generally the equal of any other temperature measuring instruments available.
- The capillary allows considerable separation between the point of measurement and the point of indication. It is usually more economical to employ transducers for signal transmission of 30 meter or more.

- The measuring system is self-contained. It does not need auxiliary power unless it is combined with a pneumatic or an electric transmission system.
- The system can be design to deliver significant power if necessary to drive indicating or controller mechanisms, including valves.

Disadvantages.

- The bulb size may be too large to fit the available space.
- The performance characteristics vary considerably with the type of filling fluid, and user must be certain that he does not misapply a particular type system.
- The maximum temperature is more limited than that in some electric measuring systems.
- In case of system failure, the entire unit must be replaced or repaired some large users have found it practicable to set up repair facilities.
- Separation of sensing and indicating elements may be limited to 10 to 12 meter, depending on other characteristics, such as filling liquid and accuracy requirements. (11)

4.3.1 Inductance-bridge hydrometer.

In this instrument the level of the measured liquid is held constant at an overflow tube. A glass hydrometer either rises or falls in the liquid as the specific gravity varies.

The lower end of the hydrometer supports an armature in an inductance coil. A similar coil in the recording instrument duplicates any movement of this armature.

With this system, the temperature of the liquid is usually recorded along with the value of specific gravity, so that corrections can be made. (4)

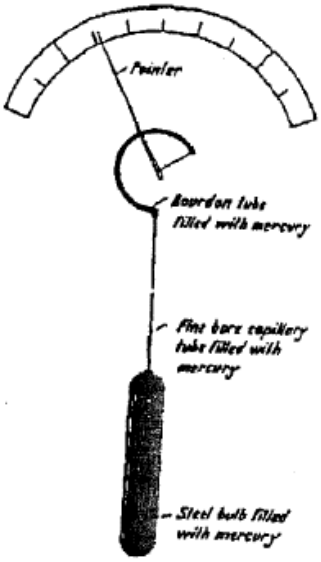
4.3.2 The force balance system for the measure of levels.

It consists of a stainless steel diaphragm and a sensing unit. If the pressure on the diaphragm increases, the diaphragm will move towards the sensing unit and cause the baffle to move towards the bleed nozzle. This restricts the escape of air to the atmosphere, so that the air pressure behind the diaphragm builds up until it again balances the pressure due to the liquid. When the pressure falls, the diaphragm moves away from the sensing unit and an increased amount of air is allowed to escape to the atmosphere. The pressure behind the diaphragm therefore falls, until it again balance the pressure due to the liquid.

The air pressure behind connection to an indicator or recorder, which shows the level of the tank contents (6)

4.4 Mercury-in-steel thermometer

Sketch



Operation

When the temperature rises, the mercury in the bulb expands more than the bulb so that some mercury is driven through the capillary tube into the Bourdon tube. As the temperature continue to rise, increasing amounts of mercury will be driven into the Bourdon tube, causing it to uncurl. One end of the Bourdon tube is fixed, while the motion of the other end is communicated to the pointer or pen arm. (8)

[33]

TOTAL: 100

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NOVEMBER 2009

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

12 November 2009 (X-Paper)
09:00 – 12:00

This question paper consists of 4 pages.

TIME: 3 HOURS
MARKS: 200

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Write neatly and legibly

QUESTION 1

1.1 Give brief explanatory notes on:

1.1.1 The principles of ion exchange (10)

1.1.2 The rate of ion exchange (5)

1.2 Give brief notes on the contact filtration of liquids. (8)

1.3 Name the constituents of petroleum. (7)

1.4 Which are the most important products obtained from natural gas? (6)

1.5 Name the unit operations used to separate:

1.5.1 Vapour-liquid

1.5.2 Liquid-solid

1.5.3 Encapsulation

1.5.4 Vapour-solid (4)

[40]

QUESTION 2

2.1 In high temperature carbonisation of coal the yield of gaseous products is larger than the yield of liquid products.

Name the following:

2.1.1 The liquid products

2.1.2 The gaseous products (7)

2.2 Define each of the following:

2.2.1 Paraffin base crude (4)

2.2.2 Intermediate base crudes (5)

2.2.3 Naphthene base crudes (4)

2.2.4 Polymerisation (4)

2.2.5 Alkylation (4)

2.2.6 lsomerisation (4)

2.3 Discuss the step-by-step decomposition of coal. (8)

[40]

QUESTION 3

3.1 Define distillation. (5)

3.2 Write brief notes on:

3.2.1 The volatility of a component in a liquid mixture which follows Raoult's law (5)

3.2.2 Relative volatility (5)

3.2.3 Rectification (5)

3.3 State FIVE characteristics of tower packing. (7)

3.4 Write brief notes on the design of:

3.4.1 Shell and trays (6)

3.4.2 Weirs (7)

[25]

QUESTION 4

4.1.1 Define the law of intermediate metals. (4)

4.1.2 Describe the importance of this law on the application of thermocouples. (4)

4.2 Use a flow chart of the manufacture of aluminium sulphate by the Dorr procedure to give a chronological description of the process. (15)

4.3 Name FOUR temperature scales. (4)

4.4 Use a sketch to describe the operation of a mercury-in-steel thermometer. (10)

4.5 Name THREE viscosity scales. (3)

[40]

QUESTION 5

Briefly explain the following:

5.1 Inductance-bridge hydrometers (8)

5.2 Hagen-Poiseuille law (5)

5.3	Positive displacement meters	(11)
5.4	The force balance system for level measurement	(8)
5.5	The hydrogen electrode for the measurement of pH	(8)
		[40]

TOTAL: 200

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NOVEMBER 2009

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

QUESTION 1

1.1.1 Positively charged ions (cations) of a solution, which are capable of diffusing through the pores, will exchange with the Na+ ions of such a mineral, which is therefore called a cat-ion exchanger.

eg $Ca^{2+} + Na_2R \Rightarrow CaR + Na^{++}$

Where "R" represents the residual material of the Zeolite. In this manner "hard" water containing Ca_{2+} can be softened by contact with Zeolite, the less objectionable Na^{+} replacing the Ca_2 in solution and the latter becoming immobilized in the solid. The reaction is reversible, and after saturation with Ca^{2+} the Zeolite can be regenerated by contact with a solution of salt,

eg $CaR + 2NaCl \Rightarrow Na_2R + CaCl_2$ (10)

1.1.2 The rate of ion exchange depends, as in ordinary adsorption, upon rates of the following individual processes:

- Diffusion of ions form the bulk of the liquid to the external surface of an exchanger particle.
- Inward diffusion of ions through the solid to the site of exchange.
- Exchange of the ions.
- Outward diffusion of the released ions to the surface of the solid, and
- Diffusion of the released ions from the surface of the solid to the bulk of the liquid. (5)

1.2 Typical process applications include:

collection of valuable solutes from solutions eg.

- adsorption onto carbon of iodine
- collection of insulin
- the removal of undesired contaminates
- the adsorption of coloured substances from aqueous sugar solutions onto carbon (8)
- carbon is also used adsorb odorous substances
- grease is adsorbed from dry-cleaning liquids

1.3 Carbon black, acetylene, methane, ethylene, propylene, butylenes, toluene, xylene, naphthalene, coke. (7)

1.4 Fuel, natural gasoline, LPG, carbon black, helium, hydrogen and petrochemicals. (6)

1.5.1 distillation

1.5.2 crystallization

1.5.3 adsorption

1.5.4 adsorption (4)

[40]

QUESTION 2

2.1.1 Liquid products: Water, tar, crude oil (3)

2.1.2 Gaseous products: Hydrogen, methane, ethylene, carbon monoxide, carbon dioxide, hydrogen sulphide, ammonia and nitrogen (4)

2.2.1 Paraffin base:
These crude consist primarily of open-chain compounds and furnish low octane-number straight-run gasoline and excellent but waxy lubricating oil stocks. (4)

2.2.2 Intermediate base:
These crude contain large quantities of both paraffinic and naphtenic compounds and furnish medium grade straight-run gasolines and lubricating oils. Both wax and asphalt are found in these oils. (5)

2.2.3 Naphtene base:
These crude contain a high percentage of cyclic (naphthenic) compounds and furnish relatively high octane-number straight-run gasoline! The lubricating oil fractions must be solvent-refined. Asphalt is present. (4)

2.2.4 Polymerization:
The linking of similar molecules, the joining together of light olefins. (4)

2.2.5 Alkylation:
The union of an olefin with an aromatic or paraffinic hydrocarbon. (4)

2.2.6 Isomerization:
Alteration of the arrangement of the atoms in the molecule without changing the number of atoms. (4)

2.3 As the temperature is raised, the aliphatic “carbon to carbon" bonds are the first to break. (8)
"Carbon to hydrogen linkages" are severed next as the temperature of 600 ºC is approached and exceeded.
The decompositions during carbonization are essentially reactions effecting the elimination of hetero cycle complexes and progressive aromatization.
The average molecular weights of the volatile intermediate products constantly decrease as the temperature of carbonization rises. This decrease is marked by the evolution of water, carbon monoxide, hydrogen, methane, and other hydrocarbons.
Final decompositions are at a maximum between 600 and 800 ºC.

[40]

QUESTION 3

3.1 Distillation may be defined as the separation of the components of a liquid mixture by process involving partial vaporization. In general, the vapour evolved is recovered by condensation. (5)

3.2.1 The volatility of a component in a liquid mixture which follows Raoult's Law, must be equal to the vapour pressure of that component in the pure state. (5)

3.2.2 Relative volatility may be defined as the volatility of one component of the liquid mixture divide by the volatility of another component of the liquid mixture. (5)

3.2.3 Rectification may be defined as a single unit distillation operation in which vaporization occurs in repeated steps tog give a much greater overall separation that could be obtained by one simple distillation. (5)

3.3 Provide for large interfacial surface between liquid and gas
Possess desirable fluid-flow characteristics
Be chemically inert to fluids being processed
Have structural strength to permit easy handling and installation (7)
Represent low cost

3.4.1 The trays are usually made of metal sheets, of special alloys if necessary, the thickness governed by the anticipated corrosion rate. The trays must be stiffened and supported and must be fastened to the shell to prevent movement with allowance for thermal expansion. The tower may be made of any number of materials. Glass, glass-lined metal, carbon, plastics, even wood but most frequently metals are used. (6)

3.4.2 The depth of the liquid on the tray required for gas contracting is maintained by an overflow outlet weir.
Straight weirs are most common; multiple v-notch weirs maintain a liquid depth which is less sensitive to variations in liquid flow rate consequently also from departure of the tray from level ness. In order to ensure reasonably uniform distribution of liquid flow on a singly-pass tray, a weir length of 60 to 80 percent of the tower diameter is used. (7)

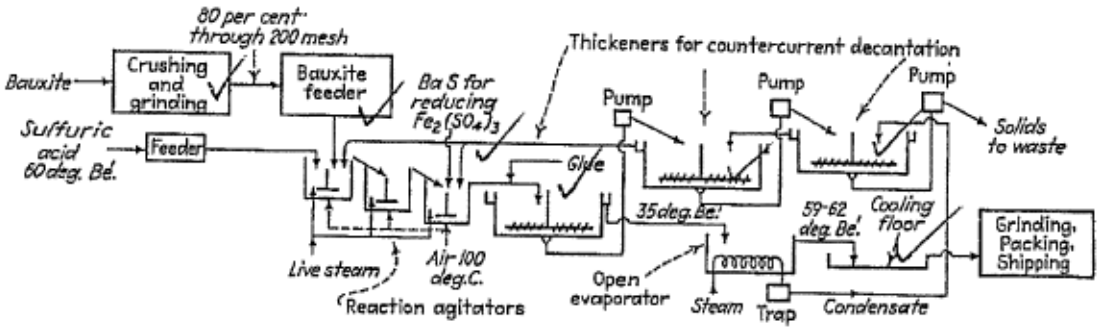
[25]

QUESTION 4

4.1.1 Law of intermediate metals.
In a thermo-electric circuit composed of two metals A and B with junctions at temperatures t_1 and t_2 respectively, the emf is not altered if one or both the junctions are opened and one or more other metals are interposed between the metals A and B, provided that all the junctions by which the single junction at temperature t_1 may be reduced are kept t_1, and all those by which the junction at temperature t_2 may be replaced are kept at t_2. (4)

4.1.2 This law has a very important bearing on the application of thermo-couples to temperature measurement, for it means that, provided all the apparatus for measuring the thermo-electric emf, connected in the circuit at the cold junction, is kept at the same temperature, the presence of any number of junctions of different metals will not affect the total emf in the circuit. It also means that if another metal is introduced into the hot junction for calibration purposes it does not affect the thermo-electric emf provided it is all at the temperature of the hot junction. (4)

4.2



The bauxite is ground and conveyed to storage bins.

The reaction occurs in lead-lined sinks, where the reactants are thoroughly mixed and heated with the aid of agitators and live steam. These reactors are operated in series.

Into the last reactor barium sulphide is added in the form of black ash to reduce ferric sulphate to the ferrous state and to precipitate the iron.

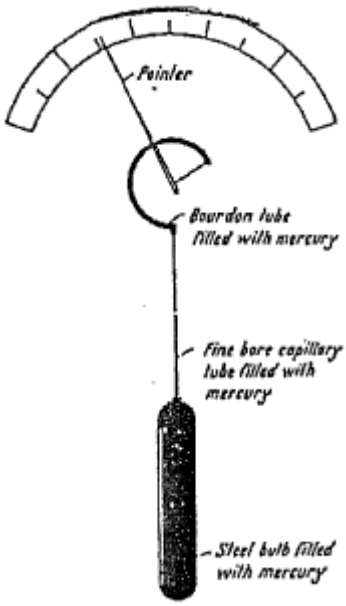
The mixture from the reactors is sent through a series of thickeners, which remove un-dissolved matter so that it will contain practically no alum.

The clarified aluminium sulphate solution is concentrated in an open, steam-coil-heated evaporator.

The concentrated liquid is poured into flat pans, where it is cooled and completely solidified. (15)

4.3 Reaumer-; Celsius-, Kelvin-, Rankine-. (4)

4.4



When the temperature rises, the mercury in the bulb expands more than the bulb so that some mercury is driven through the capillary tube into the Bourdon tube. As the temperature continues to rise, increasing amounts of mercury will be driven up into the Bourdon tube, causing it to uncurl. One end of the Bourdon tube is fixed while the other end is communicated to the pointer or pen arm. (10)

4.5 Saybolt-; Redwood-; Engler-. (3)

[40]

QUESTION 5

5.1 Inductance-Bridge Hydrometer. In this instrument the level of the measured liquid is held constant at an overflow tube. A glass hydrometer either rises or falls in the liquid as the specific gravity varies.
The lower end of the hydrometer supports an armature in an inductance coil, any movement of this armature is duplicated by a similar coil in the recording instrument. With this system, the temperature of the liquid is usually recorder along with the value of specific gravity, so that corrections can be made.
(8)

5.2 Hagen-Poiseuille Law. Hagen (Germany) and Poiseuille (France) described viscosity as the ratio of shear stress versus shear rate at the wall of a capillary tube. Positive displacement meters are frequently used in oil and water undertakings for accounting purposes. (5)

5.3 The principle of the measurement is that as the liquid flows through the meter it moves a measuring element which seals off the measuring chamber into a series of measuring compartments each holding a definite volume. As the measuring element moves these compartments are successfully filled and emptied. Thus for each complete cycle of the measuring element, a fixed

quantity of liquid is permitted to pass form the inlet to the outlet of the meter. The seal between the measuring element and the measuring chamber is provided by a film of the measure liquid. The number of cycles is indicated by means of a pointer moving over a dial, digital totaliser or some other form of register , driven from the measuring element through an adjustable gearing. This gearing ratio is adjusted during calibration so that the difference between the indicated and the actual quantity flowing is a minimum over the whole of the meters' rated capacity. (11)

5.4 It consists of a stainless steel diaphragm a sensing unit. If the pressure in the diaphragm increases, the diaphragm will move towards the sensing unit and cause the baffle to move towards the bleed nozzle.
This restricts the escape of air to the atmosphere, so that the air pressure behind the diaphragm builds up until it again balances the pressure due to the liquid. When the pressure falls, the diaphragm moves away from the sensing unit and in increased amount of air is allowed to escape to the atmosphere. The pressure behind the diaphragm therefore falls, until it again balances the pressure due to the liquid. The air pressure behind connection to an indicator or recorder which shows the level of the tank contents.

(8)

5.5 If a simple voltaic cell, hydrogen is used as one electrode, the potential difference attained between the electrode will, if everything else is kept the same, be a function of the concentration of the hydrogen electrode. A hydrogen electrode, consists, in practice of a platinum plate or wire, covered with platinum black, a finely divided form of the metal. When hydrogen is bubbled over such an electrode it is absorbed into its surface and the electrode behaves as a hydrogen electrode. The standard or normal hydrogen potential is than of an electrode in contact with a solution of unit hydrogen ion activity, and this solution is hydrochloric acid having a concentration of 1,228 mol/dm. (8)

[40]

TOTAL: 200

Past Examination Papers

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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

AUGUST 2009

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

23 July 2009 (X-Paper)
09:00 – 12:00

This question paper consists of 4 pages.

TIME: 3 HOURS
MARKS: 200

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Write neatly and legibly

QUESTION 1

1.1	Use a sketch to describe the operation of a Higgens contractor.	(16)
1.2	Describe how the shape of a breakthrough curve will influence the method of operating a fixed-bed adsorber.	(9)
1.3	Discuss ion exchange under the headings:	
1.3.1	The process that could be used to soften hard water containing Ca	(10)
1.3.2	The rate of ion exchange	(5)
		[40]

QUESTION 2

2.1	Describe the application of the following processes in the separation of petroleum products:	
2.1.1	Absorption	(3)
2.1.2	Adsorption	(3)
2.1.3	Filtration	(3)
2.1.4	Crystallization	(3)
2.2	Define the following:	
2.2.1	Octane number	(3)
2.2.2	Hydrogenation	(3)
2.2.3	Alkylation	(3)
2.3	Name the FOUR methods used for the de-hydration of gas.	(4)
2.4	Give a chronological description of the co-product coke-oven procedure.	(15)
		[40]

QUESTION 3

3.1	Define distillation.	(5)
3.2	\/\/rite brief clarifying notes on:	
3.2.1	Relative volatility	(5)

3.2.2	The difference between Raoult's Law and Dalton's Law	(5)
3.2.3	Rectification	(5)
3.3	State FIVE characteristics tower packing should offer.	(7)
3.4	Write brief notes on the design features of:	
3.4.1	Shell and trays	(6)
3.4.2	Weirs	(7)

[25]

QUESTION 4

4.1	Name FOUR temperature scales.	(4)
4.2	Use a sketch to describe the operation of a mercury-in-steel thermometer.	(13)
4.3	Name THREE viscosity scales.	(4)
4.4	Draw a flow chart of the manufacture of aluminium sulphate by the Dorr procedure and give a chronological description of the process.	(20)

[40]

QUESTION 5

5.1	Describe the operation of the diaphragm type of depth measuring Instruments	(12)
5.2	Write brief notes on each of the following pH values:	
5.2.1	7	(2)
5.2.2	12	(2)
5.2.3	A change of 1 pH unit	(4)
5.3	Describe the operation of a positive displacement meter.	(15)
5.4	Name FIVE displacement meters.	(5)

[40]

TOTAL: 200

Marking Guidelines

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

AUGUST 2009

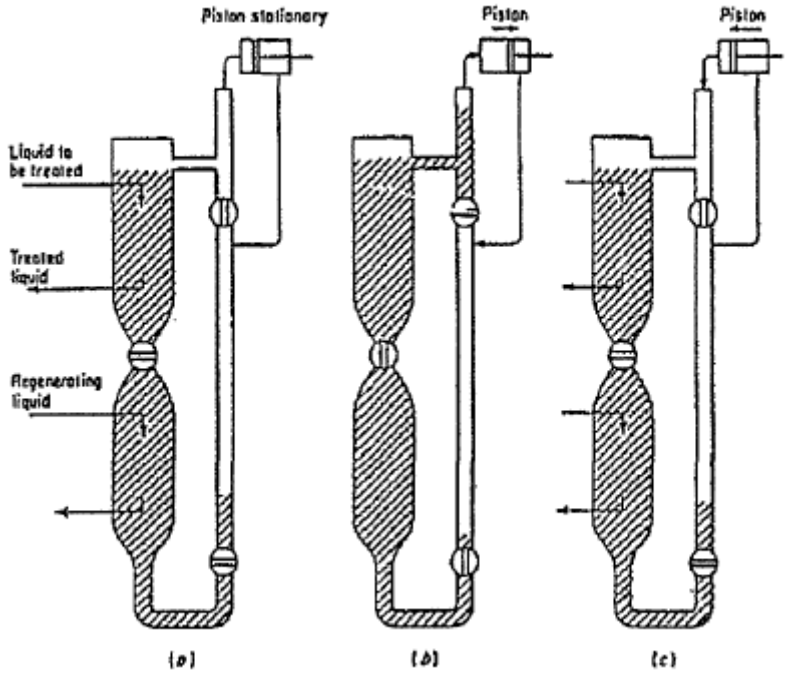
NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

QUESTION 1

1.1



(6)

The temporarily stationary upper bed of solids is contracted with liquid flowing downward, so that fluidization does not occur. In the lower bed, the solid is regenerated by an eluting liquid. After several minutes, the liquid flow is stopped, valves are turned as shown in figure b and the liquid-filled piston pump is moved as shown for a period of several seconds, were upon solid is moved clockwise hydraulically. In figure c with the valves readjusted to their original position, movement of solid is completed and liquid flows are started to complete the cycle. (10)

1.2
- If the breakthrough curve is steep, the eflluent air, substantially free of vapour, may be discharged to the atmosphere until the breakpoint is reached, where upon the influent steam must be diverted to a second absorber while the first is regenerated.
- On the other hand, if the breakthrough curve is flat, so that the breakpoint is a substantial portion of the absorbent remains unsaturated with absorbate, the gas may be permitted to flow through a second absorber in series with the first until the carbon in the first is substantially all saturated.
- The influent mjxture is then passed through the second and the third absorber in series while the first is generated. (9)

1.3.1 The ion-exchange solids first used were porous, natural or synthetic minerals containing silica, the zeolites, such as the mineral Na_2O. $A1_2O_3.4SiO_2.2H_2O$ for example. Positively charged ions (cations) of a solution which are capable of diffusing through the pores will exchange the Na^+ ions of such a mineral, which is therefore called a cation exchanger.

For example Ca^{2+} $Na_2R \Rightarrow CaR + Na^+$

Where R represents the residual material of the zeolite. In this manner "hard" water containing Ca_{2+} can be softened by contact with the zeolite, the less objectionable Na^{+} replacing the Ca_2 in solution and the latter becoming immobilized in the solid. The reaction is reversible, and after saturation with Ca the zeolite can be regenerated by contact with a solution of salt.

Eg $CaR + 2NaCl \Rightarrow Na_2R + CaCl_2$ (10)

1.3.2 The rate of ion exchange depends, as in ordinary adsorption, upon rates of the following individual processes:

- Diffusion of ions from the bulk of the liquid to the external surface of an exchanger particle.
- Inward diffusion of ions through the solid to the site of exchange.
- Exchange of the ions.
- Outward diffusion of the released ions to the surface of the solid and
- Diffusion of the released ions from the surface of the solid to the bulk of the liquid. (5)

[40]

QUESTION 2

2.1.1 Used to separate a higher boiling constituent from other components of a system of vapours and gasses.
Recovering of natural gasoline.
Obtain light hydro carbons. The absorbed products are recovered by fractionating or steam-stripping. (3)

2.1.2 Separation of a natural gasoline from natural gas. To remove undesirable colours from lubricating oil. (3)

2.1.3 Removal of wax from wax distillates. (3)

2.1.4 Wax is removed from oil to yield waxes of low oil content. Separation of p-xylene from Cs aromatics. (3)

2.2.1 Octane number is the percentage of iso-octane in a mixture with normal heptane, which as a sample fuel has the same knocking characteristics as gasoline in question. (3)

2.2.2 The addition of hydrogen to an olefin. (3)

2.2.3 The union of an olefin with a aromatic or paraffinic hydrocarbon. (3)

2.3 Compression, treatment with drying substances, adsorption and refrigeration. (4)

2.4
- Coal is transferred, crushed and screened.
- Coal is charged to a hot, empty oven.

- Coal is chemically transformed to coke and volatiles by pyrolysis.
- Hot coke is pushed out of the oven, quenched, and transported.
- Condensable products of distillation are liquefied and collected in the hydraulic main.
- Foul gas is cooled, and tar extracted.
- Ammonia is removed from gas as ammonium sulphate.
- Gas is cooled and subjected to benzol and toluol removal by absorption.
- Hydrogen sulphate is removed.
- Purified gas is metered and transferred to consumers. (16)

[40]

QUESTION 3

3.1 Distillation may be defined as the separation of the components of a liquid mixture by process involving partial vaporization. In general, the vapour evolved is recovered by condensation. (5)

3.2.1 Relative volatility may be defined as the volatility of one component of the liquid mixture divided by the volatility of another component of the liquid mixture. (5)

3.2.2 Raoult's law is a liquid law and must be expressed as applying only to the liquid solution.
Dalton's law is a gas law and is only applicable to gases. (5)

3.2.3 Rectification may be defined as a single unit distillation operation in which vaporization occurs in repeated steps to give a much greater overall separation than could be obtained by one simple distillation. (5)

3.3
- Provide for large interfacial surface between liquid and gas
- Possess desirable fluid-flow characteristics
- Be chemically inert to fluids being processed
- Have structural strength to permit easy handling and installation
- Represent low cost (7)

3.4.1 The trays are usually made of metal sheets, of special alloys if necessary, the thickness governed by the anticipated corrosion rate. The trays must be stiffened and supported and must be fastened to the shell to prevent movement with allowance for thermal expansion. The tower may be made of any number of materials. Glass, glass-lined metal, carbon, plastics, even wood but most frequently metals are used. (6)

3.4.2 The depth of the liquid on the tray required for gas contracting is maintained by an overflow (outlet) weir.
Straight weirs are most common; multiple v-notch weirs maintain a liquid depth which is less sensitive to variations in liquid flow rate consequently also from departure of the tray from level ness. In order to ensure reasonably

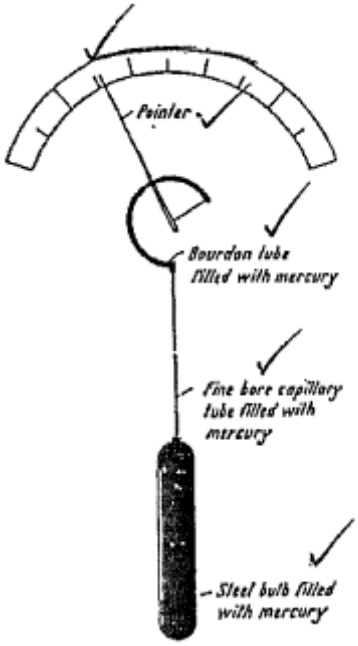
uniform distribution of liquid flow on a singly-pass tray, a weir length of 60 to 80 percent of the tower diameter is used. (7)

[25]

QUESTION 4

4.1 Reaumur-; Celsius-; Kelvin-; Rankine-. (4)

4.2



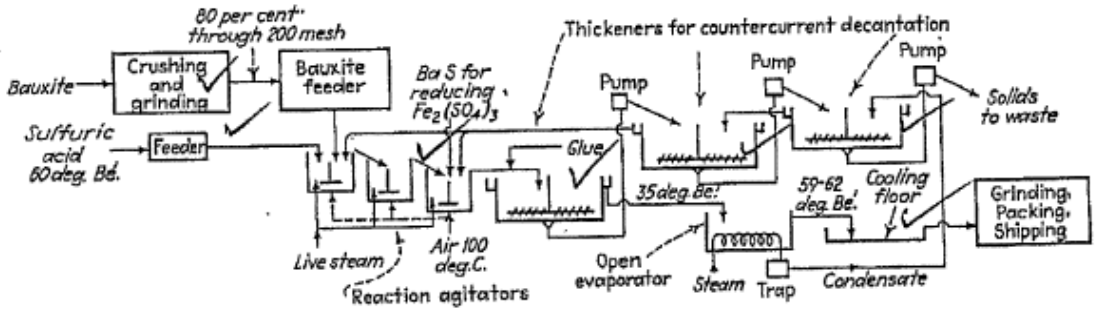
(5)

When the temperature rises, the mercury in the bulb expands more than the bulb so that some mercury is driven through the capillary tube into the Bourbon tube. As the temperature continues to rise, increasing amounts of mercury will be driven into the Bourbon tube, causing it to uncurl. One end of the Bourbon is fixed, while the, motion of the other end is communicated to the pointer or pen arm.

(8)

4.3 Saybolt-; Redwood-; Engler-. (3)

4.4



(7)

The bauxite is ground, and conveyed to storage bins.

- The reaction occurs in lead-lined steel tanks, where the reactants are thoroughly mixed and heated with the aid of agitators and live steam. These reactors are operated in series.
- Into the last reactor barium sulphide is added in the form of black as to reduce ferric sulphate to the ferrous slate and to precipitate the iron.
- The mixture from the reactors is sent through a series of thickeners operated which remove undissolved matter so that when discarded, contain practically no alum.
- The clarified aluminium sulphate solution is concentrated in an open, steam coil heated evaporator.
- The concentrated liquor is poured into flat pans, where it is cooled and completely solidified. (13)

[40]

QUESTION 5

5.1 The diaphragm box is suspended in the tank well above the sediment level. When level of liquid in the tank rises, the pressure on the diaphragm increases, and the diaphragm moves. This compresses the air within the closes system. The increased air pressure is transmitted by the capillary tube to the pressure measuring portion of the instrument which may be an indicator or a recorder. (12)

5.2.1 Neutral (2)

5.2.2 strong alkaline (2)

5.2.3 it represents a ten-fold change in hydrogen ion concentration (4)

5.3 The principle of the measurement is that as the liquid flows through the meter it moves a measuring element which seals off the measuring chamber into a series of measuring compartments each holding a definite volume. As the measuring element moves, these compartments are successfully filled and emptied. Thus for each complete cycle of the measuring element, a fixed quantity of liquid is permitted to pass form the inlet to the outlet of the meter. The seal between the measuring element and the
measuring chamber is provided by a film of the measured liquid. The number of cycles is indicated by means of a pointer moving over a dial. (15)

5.4 Reciprocating piston.
Rotating or oscillating piston type.
Rotating disk type.
Fluted spiral rotor type.
Sliding vane type.
Rotating vane type.
Oval gear type. (5)

[40]

TOTAL: 200

Past Examination Papers

higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2009

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

(**8050026**)

5 April 2011 (X-Paper)
09:00 – 12:00

This question paper consists of 4 pages.

TIME: 3 HOURS
MARKS: 200

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Write neatly and legibly

QUESTION 1

1.1	Write brief, explanatory notes on the principles of ion exchange.	(10)
1.2	Write brief notes on the following:	
1.2.1	The olefin series	(5)
1.2.2	The naphtene series	(5)
1.3	Write brief, clarifying notes on each of the following separation operations applied in oil refining:	
1.3.1	Filtration	(4)
1.3.2	Adsorption	(4)
1.3.3	Absorption	(4)
1.3.4	Extraction	(4)
1.3.5	Crystallisation	(4)
		[40]

QUESTION 2

2.1	Write explanatory notes on the production of producer gas.	(10)
2.2	Name TWO methods which can be used for coking coal and describe each method.	(10)
2.3	Discuss in chronological order how coal will decompose when heated.	(10)
2.3	Describe the purification of natural gas.	(10)
		[40]

QUESTION 3

3.1	Write brief, explanatory notes on the following:	
3.1.1	Bubble-cap plates	(10)
3.1.2	The characteristics tower packing should offer	(10)
3.2	Discuss the differences between the laws of Raoult and Dalton.	(10)
3.3	Write brief, explanatory notes on the following:	
3.3.1	Tray spacing	(5)

3.3.2 Weirs (5)

[40]

QUESTION 4

4.1 Draw a flow diagram of the production of aluminium sulphate by the Dorr procedure and give a chronological description of the process. (20)

4.2 Write brief, explanatory notes on each of the following steps in the preparation of caustic soda using a diaphragm cell:

4.2.1 Brine purification (5)

4.2.2 Evaporation and salt separation (5)

4.2.3 Special purification of caustic soda (5)

4.2.4 Chlorine drying (5)

[40]

QUESTION 5

5.1 Describe the operation of a positive displacement meter. (12)

5.2 Name FIVE displacement meters. (5)

5.3 Describe the operation of the diaphragm type of depth measuring instrument. (10)

5.4 Write short notes on each of the following pH values:

5.4.1 7 (2)

5.4.2 12 (2)

5.4.3 A change of 1 pH-unit (2)

5.5 Describe the maintenance and fault finding procedures for a rotameter. (5)

[40]

TOTAL: 200

Marking Guidelines

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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

APRIL 2009

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATIONS N6

(8050026)

QUESTION 1

1.1 Positively charged ions (cations) of a solution which are capable of diffusing through the pores will exchange with the Na^+ ions of such a mineral, which is therefore called a cation exchanger.

For example Ca^{2+} $Na_2R \Rightarrow CaR + Na^+$

Where R represents the residual material of the zeolite. In this manner "hard" water containing Ca_{2+} can be softened by contact with the zeolite, the less objectionable Na^+ replacing the Ca_2 in solution and the latter becoming immobilized in the solid. The reaction is reversible, and after saturation with Ca the zeolite can be regenerated by contact with a solution of salt.

Eg $CaR + 2NaCl \Rightarrow Na_2R + CaCl_2$ (10)

1.2.1 Olefin Series (C_nH_{2n})
Possess better antiknock properties than normal paraffin but have poorer properties than highly branched paraffin and aromatics. Their usefulness is somewhat reduced by their chemical reactivity.
Olefins are the most important class of compounds chemically derived from petroleum. (5)

1.2.2 Naphtene series (C_nH_{2n})
Has the same empirical formula as the olefin series, differs in that members are completely saturated.
These crudes contain high percentage of cyclic compounds and furnish relatively high-octane-number straight-run gasoline. (5)

1.3.1 Filtration
Is the usual method of removal of wax from wax distillates. The mixture of wax and adhering oil obtained from the press is frozen and allowed to warm slowly so that the oil drains (sweats) from the cake thus further purifying the wax. Contact filtration, involving the use of clay, is the common method of purification of oils. (4)

1.3.2 Adsorption
Is employed for about the same purpose as absorption: natural gasoline may be separated from natural gas by adsorption on charcoal. Adsorption is also used to remove undesirable colours from lubricating oil, usually employing activated clay. (4)

1.3.3 Absorption ·
Is widely employed in the recovery of natural gasoline from well gas and of vapours given off by storage tanks. Absorption also obtains light hydrocarbons from many refining processes. The solvent oil may be heavy gasoline, kerosene or even heavier oils. The absorbed products are recovered by fractionating or steam stripping. (4)

1.3.4 Extraction
Involves the removal of a component from a liquid by means of the selective solvent action of another liquid. The procedure of selective extraction by solvents is important in the further refining of lubricating oils. Another example is the production of benzene, toluene, and xylenes by extraction from specially processed petroleum. (4)

1.3.5 Crystallization
By means of crystallization wax may be removed from crude oil or from lubricating oil to yield crystalline and microcrystalline waxes or low oil content. (4)
[40]

QUESTION 2

2.1 Producer gas
- Producer gas is made bypassing air and steam through a thick bed of hot fuel.
- Air is admitted for combustion.
- Blow run: closing secondary air valve and allow producer gas to pass through.
- Up run: steam is admitted forming blue gas.
- Back run: steam is admitted and react with carbon.
- Final run:' puts a blanket of steam between the blue gas and the air.
- Blow purge: produces CO. (10)

2.2 Beehive coking
- coal is introduced through a hole in the brick chamber.
- the heat is sufficient to start distillation and pyrolysis.

Co-product coking
- is a narrow chamber tapering in width.
- used for carbonizing coal. (10)

2.3
- As the temperature is raised, the aliphatic carbon to carbon bonds are the first to break.
- Carbon to hydrogen linkages are severed next.
- The decompositions during carbonization are essentially reactions effecting the elimination of hetero cycle complexes and progressive aromatization.
- The average molecular weights of the volatile intermediate products constantly decreases as the temperature of carbonization rises. The decrease is marked by the evolution of water, carbon monoxide, hydrogen, methane and other hydrocarbons. (10)

2.4 Undesirable water and hydrogen sulphate must be removed.

Four methods used for dehydration:

- Compression
- Treatment with drying substance
- Adsorption
- Refrigeration

The Girbotol procedure is used to remove the H_2S. (10)

[40]

QUESTION 3

3.1.1 Bubble plate towers are widely used in industry. Distillation columns of this type consist of a series of plates as shown in the rectification column. There are a number of openings in each plate through which the vapours rise. Each of the openings has an elevated cap on it so that vapours are deflected by the cap into the liquid on the plate. The vapours bubble through the liquid where condensation and vaporization occur. (10)

3.1.2 Provide for a large interfacial surface between liquid and gas.
Possess desirable fluid-flow characteristics.
Be chemically inert to fluids being processed.
Have structural strength o permit easy handling and installation. (10)
Represent low cost.

3.2 Raoult's law is a liquid law and must be expressed as applying only to the liquid solution and to vapours in equilibrium, with the liquid solution. Dalton's law is a gas law and is only applicable to gasses. (10)

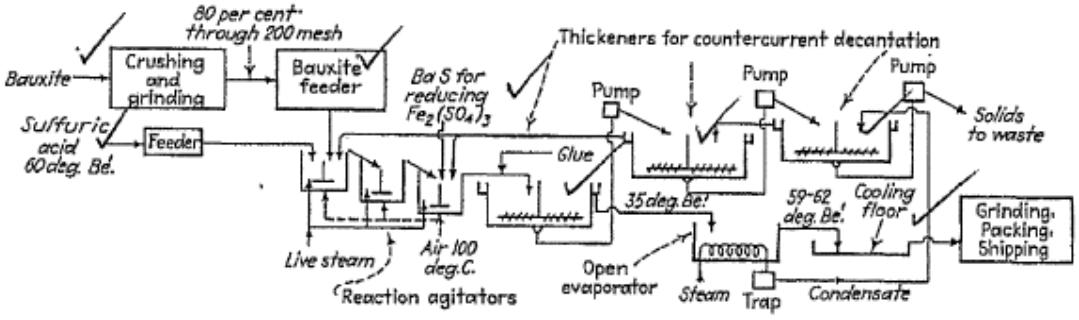
3.3.1 Tray spacing. Tray spacing is usually chosen on the basis of expediency in construction maintenance and cost and later checked to be certain that adequate insurance against flooding and excessive entertainment is present. (5)

3.3.2 Weirs. The depth of liquid on the tray required for gas contracting is maintained by an overflow (outlet) weir, much may or may not be a continuation of the downspout plate. Straight weirs are most common, multiple V-notch weirs maintain a liquid depth which is less sensitive to variations in liquid flow rate and consequently also form departure of the tray from levelness, circular pipes used as downspouts, are not recommended. Inlet weirs may result in a hydraulic jump of the liquid and are not generally recommended. In order to ensure reasonably uniform distribution of liquid flow on a single-pass tray, a weir length of from 60 to 80% of the tower diameter is used. (5)

[40]

QUESTION 4

4.1



Manufacture. Practically all alums and aluminium sulphate are now made from bauxile by reaction with 60% Be sulphuric acid. The bauxite is ground, next it is conveyed to storage bins. The reaction occurs in lead-lined steel tanks, where the reactants are thoroughly mixed and heated with the aid of agitators and live steam. These reactors are operated in series. Into the last reactor barium sulphide is added in the form of black ash to reduce ferric sulphate to the ferrous state and to precipitate the iron. The mixture from the reactors is sent through a series of thickeners operated counter currently, which remove undissolved matter and thoroughly wash the waste so that when discarded, it will contain practically to alum. The clarified aluminium sulphate solution is conce trated in an open, steam-coil heated evaporator. The concentrated liquor is poured into flat pans where it is cooled and completely solidified.
The solid cake is broken and ground to size for shipping. (20)

4.2.1 Brine purification. To make a purer caustic soda and to lessen clogging of the cell diaphragm with a consequent increase, purification of the NaCI solution of calcium, iron and magnesium compounds is practiced, using soda ash with some caustic soda. Sometimes sulphates are removed with BaCI or the hot brine is treated with hydroxyl and carbonate ions. The clear brines is neutralised with hydrochloric acid. (8)

4.2.2 Evaporation and salt separation. NaOH solution is evaporated in a double or triple-effect evaporator with salt separators and then passes through a settler and washing filter. The salt so recorded is again made into charging brine. (5)

4.2.3 Special purification of caustic. Some of the troublesome impurities in 50% cautic are colloidal iron, NaClO. The iron is often removed by treating the caustic with calcium carbonate. The chlorate may be removed by allowing the caustic to drop through a column of 50% aqueous ammonic solution. (7)
[40]

QUESTION 5

5.1 The principle of the measurement is that as the liquid flows through the meter it moves a measuring element which seals off the measuring chamber into a series of measuring compartments each holding a definite volume. As the measuring element moves, these compartments are successfully filled and emptied. Thus for each complete cycle of the measuring element, a fixed quantity of liquid is permitted to pass form the inlet to the outlet of the meter.

The seal between the measuring element and the measuring chamber is provided by a film of the measured liquid. The number of cycles is indicated by means of a pointer moving over a dial. (12)

5.2
- Reciprocating piston.
- Rotating or oscillating piston type.
- Nutating disk type.
- Fluted spiral roto type.
- Sliding vane type.
- Rotating vane type.
- Oval gear type. (5)

5.3 The diaphragm box is suspended in the tank well above the sediment level. When level of liquid in the tank rises, the pressure on the diaphragm increases, and the diaphragm moves. This compresses the air within the closed system. The increased air pressure is transmitted by the capillary tube to the pressure measuring portion of the instrument which may be an indicator or a recorder. (10)

5.4.1 Neutral

5.4.2 strong alkaline

5.4.3 it represents a ten-fold change in hydrogen ion concentration. (8)

5.5 Maintenance.
Rotameter flushed, removed dismantled, cleaned and examined. Weight of float checked.

Fault finding:
Test for sensitivity by noticing its responses to small changes of flow. (5)

[40]

TOTAL: 200

N6 Chemical Plant Operation is one of many publications introducing the gateways to Engineering Studies. This course is designed to develop the skills for learners that are studying toward a career in plant operation in the engineering and related fields and to assist them to achieve their full potential in an industrial engineering career.

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