higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

CHEMICAL PLANT OPERATION N6

22 November 2024

This marking guideline consists of 6 pages.

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QUESTION 1

1.1 C
1.2 C
1.3 C
1.4 C
1.5 C

(5 × 1) **[5]**

QUESTION 2

2.1 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 in solution.✓

$P_a = X_a Pa^o$ (where P_a refers to the equilibrium vapour pressure).✓

Dalton's law is a gas law and is only applicable to gases.✓

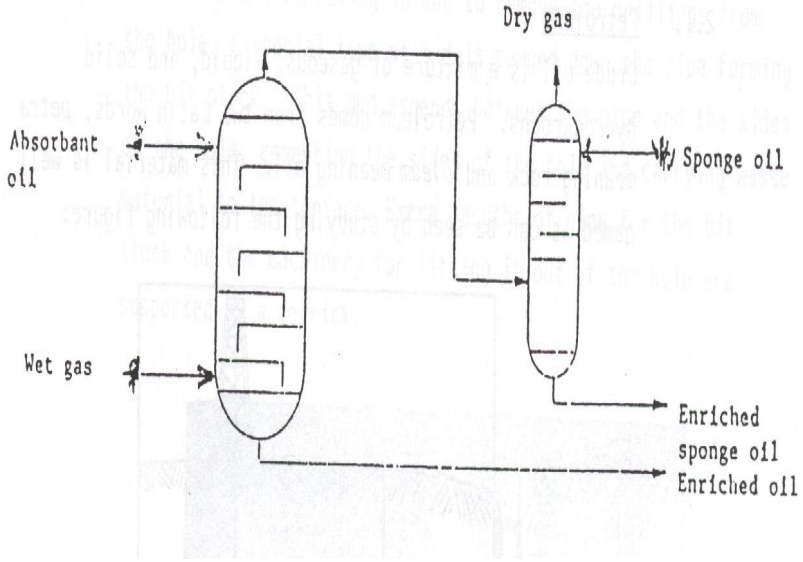
$P_{Total} = P_1 + P_2 + P_3 \cdots P_N$ (where P refers to the total gas pressure).✓ (4)

2.2 The liquid is led from the one tray to the next by means of downspouts or down-comers.✓ These may be circular pipes or preferably portions of the tower cross-section set aside for liquid which is agitated into 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-circuiting 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)

2.3 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, fractionation is used on heavy fuel oils, diesel oils, kerosene, naphtha and gas oils. (5)

2.4 2.4.1 The purpose of the absorption process is to purify gas or vapour by removing oil products from it. (1)

2.4.2



(4)

(4 marks for any correct labelling)

[20]

QUESTION 3

3.1 Refers to the combining of lower weight hydrocarbons to form high-octane gasoline✓ to reverse the main reactions that occur during cracking.✓ Therefore, it builds hydrocarbon molecules in the gasoline range that possess high anti-knock qualities.✓ Low-molecular weight paraffins, e.g. iso-butane and olefins, may be united thermally without a catalyst or catalytically using sulphuric✓ acid as alkylating agent. Thus, it refers to the union of an olefin with aromatic or paraffin hydrocarbon.✓ (5)

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

3.3 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 use in this country.✓ The agents employed for this purpose are activated alumina and bauxite, silica gel, sulphuric acid, glycerine 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.✓ (5)

3.4 3.4.1 It is the breaking up of any hydrocarbon in such a way that carbon-carbon bonds break up to form new hydrocarbon products.✓

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

3.4.2 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, e.g. ethylene to form ethane.

Example: $CH = CH + H_2 \rightarrow CH_3CH_3$✓

Other reactions can also be used as examples like the addition of hydrogen to carbon monoxide to form methanol and higher alcohols. (3)

3.5 3.5.1 Cracking processes produce large amounts of olefins and have better anti-knock 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)

3.5.2 They have the same empirical formula as the olefin series, but differ in that its members are completely saturated.✓ It predominates in most gas oils and lubricating oils and is present in the residual product.✓ (2)

[25]

QUESTION 4

4.1 4.1.1 Strong acid ✓ + weak base✓ → Acid salt

4.1.2 Strong base✓ + weak acid✓ → Basic salt

(2 × 2) (4)

4.2 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 glycerine, 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)

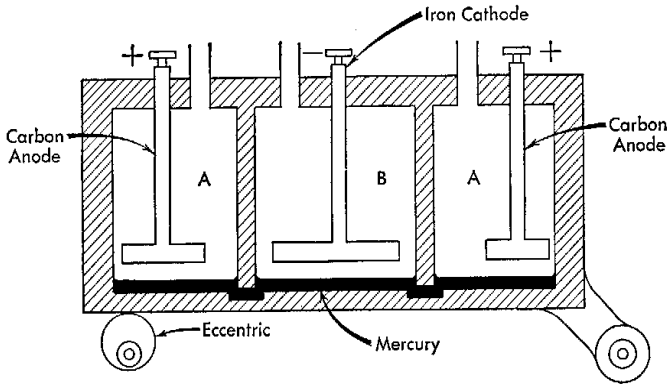
4.3 Some of the troublesome impurities in 50% caustic are colloidal iron, NaCℓ and NaC*l*O.✓ The iron is often removed by treating the caustic with calcium carbonate.✓ The chlorate may be removed by allowing the caustic to drop through a column of 50% aqueous ammonic solution.✓ (3)

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4.4 4.4.1 Strong acid
4.4.2 Strong base
4.4.3 It represents a ten-fold change in hydrogen ion concentration

(3 × 2) (6)

4.5 **A typical Mercury Cell**



$$\underline{2NaHg + 2H_2O \rightarrow 2NaOH + H_2 + Hg}$$

(5 marks for the correct labelled diagram, 1 mark for balancing of the equation and 2 marks for correct chemical equation) (8)

[25]

QUESTION 5

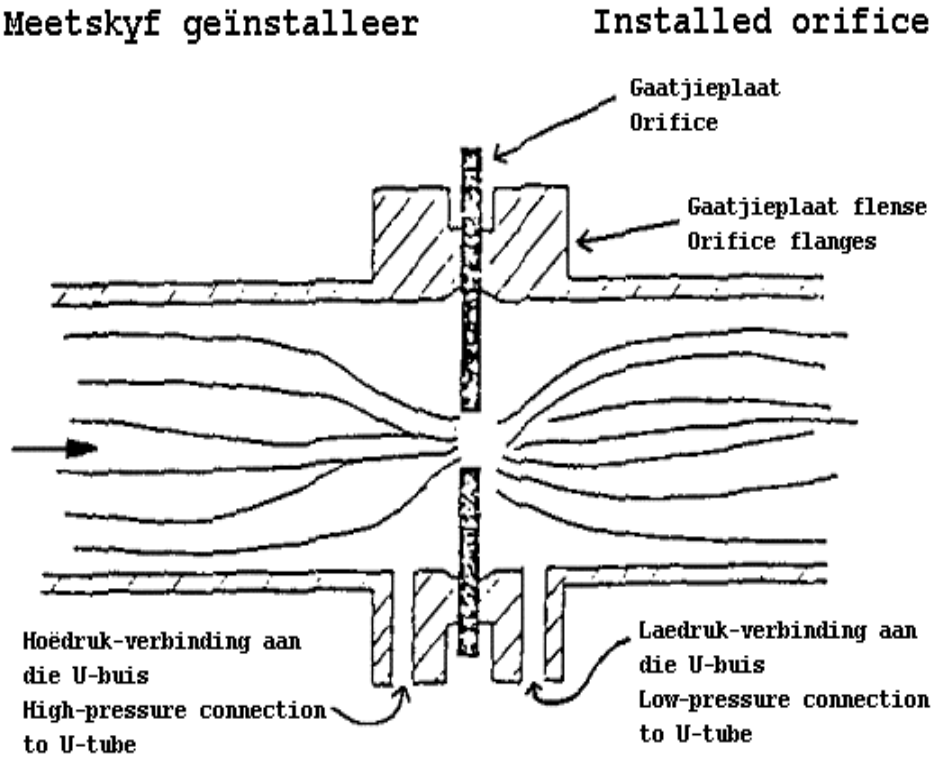
5.1 True
5.2 False
5.3 False
5.4 False
5.5 False

(5 × 1) **[5]**

QUESTION 6

6.1 Reciprocating piston
Rotating or oscillating piston
Rotating disc
Mutating disc
Fluted spiral rotor
Sliding vane
Oval gear
Rorating vane (turbine)
Screw (helical) type (Any 5 × 1) (5)

6.2



They are composed of a flat-machined metal disc with a hole in the middle.✓
They are mounted between two flanges in the pipe for measurement purpose.✓
There is considerable permanent loss to downstream from the orifice plate.✓
Suitable points depending on the characteristics of the pipe systems are chosen for the pressure difference meter and flow rate can be measured.✓
(6 marks for correct labelling, 4 marks for description) (10)

6.3 Rankine scale is the thermodynamic kelvin scale, but expressed in terms of Fahrenheit.✓ Thus, the temperature of the triple point of water on Rankine scale corresponding to 273,16 K is very nearly 491,96 Rankine.✓ (2)

6.4
- Gas-purge system
- Buoyancy type
- Weighing-tube type
- Acoustic resonance type (Any 3 × 1) (3)

[20]

TOTAL: 100

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