higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# MARKING GUIDELINE

## NATIONAL CERTIFICATE

## CHEMICAL PLANT OPERATION N4

**4 December 2023**

**This marking guideline consists of 6 pages.**

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## QUESTION 1

1.1 E
1.2 F
1.3 H
1.4 G
1.5 D

(5 × 1) **[5]**

## QUESTION 2

2.1
- Density
- Viscosity
- Velocity
- Diameter

(½ mark each) (2)

2.2 Because of the resistance that a flowing fluid encounters on a pipe wall surface,✓ the fluid particles at the wall surface may be considered to have no net forward velocity.✓ This means that there is no slippage at the wall✓ and that the velocity of the fluid is zero at the wall surface.✓ Because the particles further away from the wall are less affected by this frictional resistance,✓ the maximum velocity occurs at the centre of the pipe✓ (6)

2.3 2.3.1 $\mathbf{A = \frac{\Pi d^2}{4}} = \frac{\Pi(0{,}0625)^2}{4} = 3{,}068 \times 10^{-3}\ m^2$✓

$Q = \frac{5{,}34}{60} = 0.089\ m^3/s$✓

$V = Q/A = \frac{0.089}{3{,}068 \times 10^{-3}} = 29\ m/s$ ✓

$\mathbf{NR_e = \frac{DV\rho}{\mu}}$

$= \frac{0{,}0625 \times 29 \times 800}{0{,}00521}$✓✓

$= 278310{,}941$✓ (6)

2.3.2 $\mathbf{\Sigma F = \frac{2fV^2L}{g_cD}}$

$= \frac{2 \times 0{,}0085 \times (29)^2 \times 10}{9{,}81 \times 0{,}0625}$✓✓

$= 233{,}18\ J/kg$✓ (4)

2.3.3 $\Delta P = \Sigma F \times \rho$
$= 233{,}18 \times 800$✓
$= 186\ 544$ Pa or 186, 544 kPa✓ (2)

**[20]**

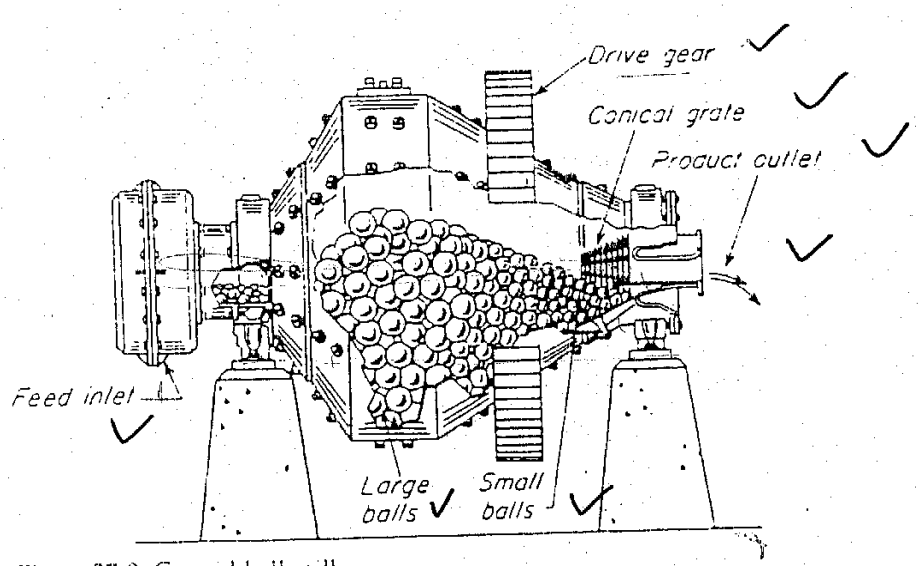
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**QUESTION 3**

3.1 3.1.1 Grinders reduce the feed to power. (2)

3.1.2 The angle between the roll faces at the level where they will just take hold of a particle and draw it into the crushing zone. (2)

3.2




SIX marks for any correct labelling and one mark for the drawing. (7)

3.3 <u>Toothed roll crusher</u>

- The roll face carry corrugations, break bars or teeth.✓
- Such crushers may contain two rolls✓
- like smooth roll crushers or one roll only working against a stationary curved breaker plate.✓
- Two corrugated rolls turning at different speeds and tearing the feed apart,✓ or a small, very smooth roll.
- Some crushing rolls for coarse feeds carry heavy, pyramidal teeth.✓
- Other designs have a large number of thin-tooth disks that saw through slabs or sheets of material.✓
- Tooth roll crushers are far more versatile than smooth roll crushers.✓
- They cannot handle very hard solids.✓
- They operate by compression, impact and shear.✓
- They reduce much larger particles.✓
- Heavy-duty toothed double-roll crushers are used primary for the reduction of coal.✓ (Any correct answers 7 × 1) (7)

**[18]**

## QUESTION 4

4.1
- The process is employed chiefly for partial softening✓ and often cheap lime is used for its reagent reactions.✓
- It can reduce calcium hardness to 35 ppm if opportunity is given for sufficient precipitation.✓
- It is particularly applicable to partial softening of municipal water and the conditioning of cooling water.✓ (4)

4.2 This term is applied to processes that reduce the hardness of water. (2)

4.3
- Distillation is the only process to remove all ions in water.
- Desalting (desalination) is applied to lower the saline content.
- The main methods are electro-dialysis and reverse osmosis.
- Electrodialysis utilises ion exchange membranes in an electric field, resulting in decreased salinity in one space and increased salinity in the next space.
- A direct current is passed through saline water in a series of cation and anion exchanger membranes, resulting in a salinity decrease.
- The water of increased salinity may be run to waste and the water of decreased salinity may be recirculated for drinking.
- Reverse osmosis is the application of a pressure greater than the osmotic pressure by forcing a concentrated brine solution through a semi-permeable membrane to get pure water. This is the opposite of ordinary osmosis.

(Any correct answers 6 × 1) (6)

4.4
- It is widely used to soften water.✓
- Hard water is sent through a container or tank containing Na2Z.✓
- The exchange of ions occurs here until practically all the zeolite (Z) been exchanged and the process comes to an end.✓
- During the softening process, calcium and magnesium ions are removed from the hard water by cation exchange for sodium ions.✓
- After the exchange resins have removed the calcium and magnesium ions, the resins are regenerated to the sodium form with a salt solution.✓
- When softened water is produced, the softener unit is temporary taken out of service and back-washed in order to cleanse and hydraulically reclassify the resins particles.✓
- The symbol R represents the cation-exchanger radical in the following reactions for softening:

$$\begin{matrix} Ca \\ \\ Mg \end{matrix}\begin{cases} (HCO_3)_2 \\ SO_4 \\ C\ell_2 \end{cases} + 2NaR \rightarrow \begin{matrix} Ca \\ Mg \end{matrix}\{R_2 + Na_2\begin{cases} (HCO_3)_2 \\ SO_4 \\ C\ell_2 \end{cases} \quad ✓$$

The regeneration reactions with sodium chloride:

$$\left.\begin{matrix}Ca\\Mg\end{matrix}\right\}R_2 + 2NaC\ell \rightarrow 2NaR + \left.\begin{matrix}Ca\\Mg\end{matrix}\right\}C\ell_2 \checkmark$$

(8)
**[20]**

## QUESTION 5

5.1
- Changes oils into fats.
- Extraction of petrol and oil from coal.
- Manufacturing of synthetic $NH_3$ (Haber process) to produce fertilisers.
- Releasing of weather balloons.
- Manufacture of hydrochloric acid.
- As a reduction agent to obtain metals from ore.
- Use as a liquid fuel for rockets. (Any correct answers 5 × 1) (5)

5.2
- Steel production.
- Underground gasification.
- Medical purposes.
- Liquid oxygen as rocket fuel.
- Aviation and diving.
- Synthetic fuel production.
- Aeration of waste water. (Any correct answers 5 × 1) (5)

5.3
- Flue gases from burning carbonaceous material --- $C + O_2 \rightarrow CO_2$
- By-product from the fermentation industry
- By-product of lime kilns
- Recovery from synthesis gas in ammonia (4)

5.4 Production of sulphur dioxide by burning sulphur:
- $SO_2$ is produced by burning sulphur
- As the gases from the combustion pass through the next exchanger, they heat the water for the boilers.
- The cooled gases are pumped into the absorbers by means of an acid-proof pump.
- The gas flows through the steam tower and is then cooled.
- The gas is then passed through a drying tower in which sulphuric acid is used.
- Sulphur dioxide is liquified by compression and stored in cylinders. (6)

**[20]**

## QUESTION 6

6.1 6.1.1 Atmospheric conditions have no effect on it.

6.1.2 Up to certain percentage of it can be used.

6.1.3 Strong caustic solutions will attack aluminium. But mild, inhibited basic caustic solutions will not attack aluminium.

(3 × 1) (3)

6.2
- High cost
- It is not easy to form
- It has a high springback
- Welding must be carried out in an inert atmosphere. (4)

6.3 It involves the scission splitting of the C–C✓ and C–H bonds✓ with the formation of C–O bond.✓ (3)

6.4
- Enhanced yields
- Reduced recycle intervals
- Higher reaction rates
- Reduced equipment size
- Reduced heat loss to nitrogen (5)

**[15]**

**TOTAL: 100**

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