higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE (VOCATIONAL)

INSTRUMENTATION TECHNOLOGY
NQF LEVEL 4

15 November 2024

This marking guideline consists of 10 pages.

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SECTION A

QUESTION 1

1.1 A
1.2 D
1.3 D
1.4 D
1.5 A
1.6 A
1.7 C
1.8 D
1.9 B
1.10 D

(10 × 1) **[10]**

QUESTION 2

2.1 False
2.2 True
2.3 True
2.4 True
2.5 False

(5 × 1) **[5]**

QUESTION 3

3.1 H
3.2 F
3.3 M
3.4 C
3.5 N
3.6 B
3.7 I
3.8 E
3.9 A
3.10 J

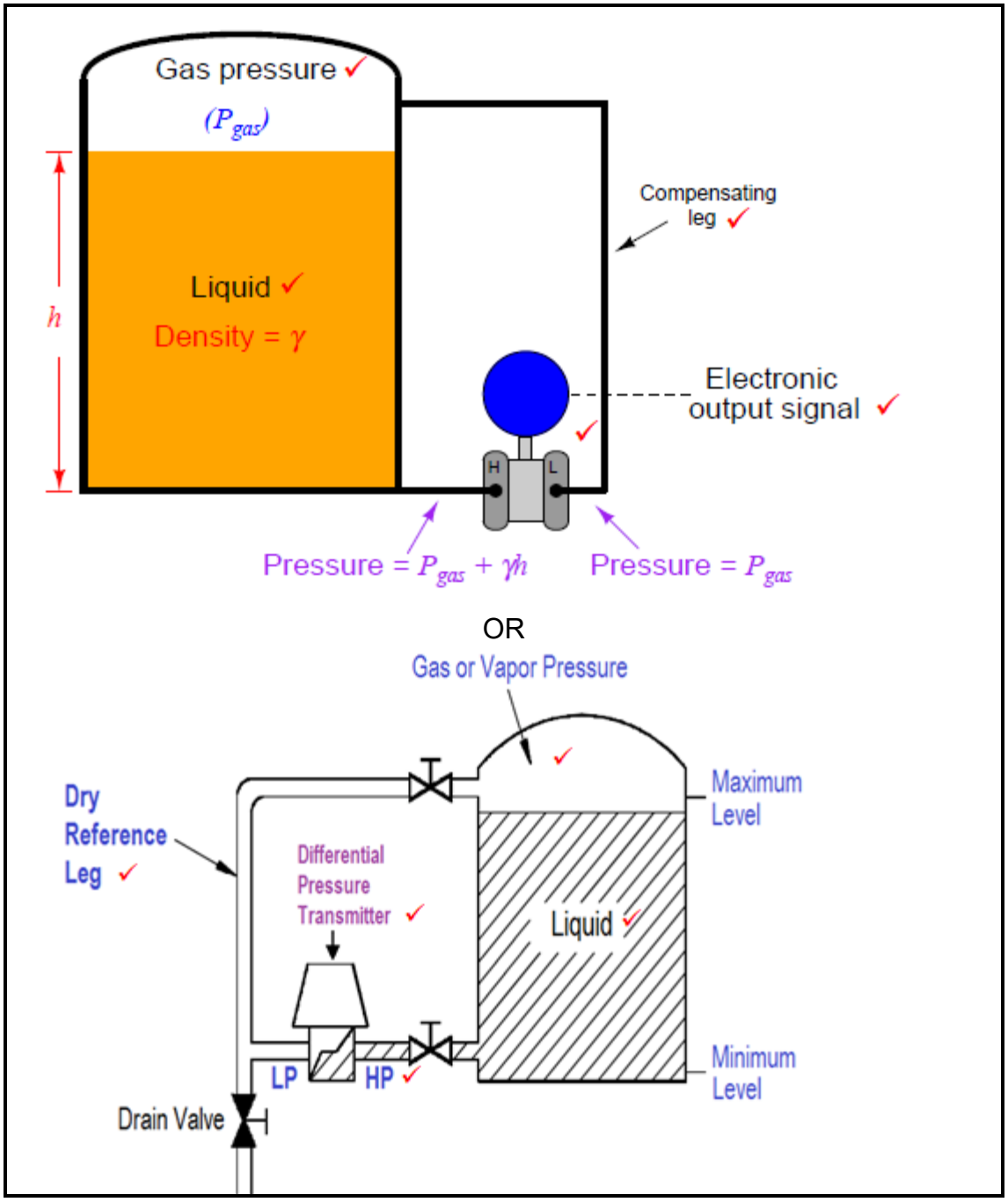
(10 × 1) **[10]**

TOTAL SECTION A: 25

SECTION B

QUESTION 4

4.1



(5)

4.2 4.2.1 One of the crystals is used for transmission of the ultrasonic signal✓ and the other acts a receiver of the reflected signal from the surface of the media.✓ (2)

4.2.2 Transit time is the time it takes for a transmitted ultrasonic signal to travel from the ultrasonic level transmitter✓ to the surface of the material to be measured and back to the receiver.✓ (2)

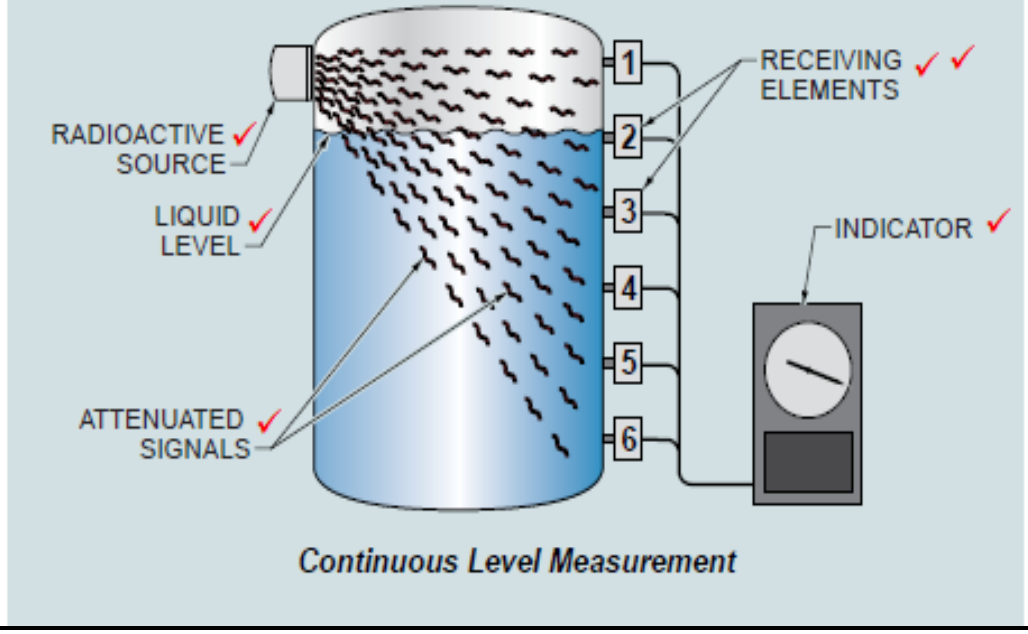
4.2.3
- Ultrasonic transmitters are easy to install on empty tanks or on tanks containing liquid.
- There is no contact with the media.
- No moving parts, the devices are virtually maintenance free.
- Because the device is non-contacting, the level measurement is unaffected by changes in the liquid density, dielectric, or viscosity.
- Changes in process pressure do not affect the measurement. (5)

4.3 4.3.1 Guided wave radar level measuring instrument (2)

4.3.2 A − Radar transmitter and receiver
B − Wave guide or probe
C − Transmitted signal
D − Material level
E − Reflection point
F − Reflected signal (6)

4.3.3 Guided wave radar (GWR) technology is based on the Time Domain Reflectometry (TDR) principle.✓ Low-power nanosecond-pulses are guided along with a probe submerged in the process media.✓ When a pulse reaches the surface of the material, it is measuring, part of the energy is reflected back to the transmitter,✓ and the time difference between the generated and reflected pulse is converted into a distance✓ from which the total level or interface level is calculated.✓ (5)

4.4



(6)
[33]

QUESTION 5

5.1 5.1.1
- Pneumatic
- Hydraulic
- Electric (3)

5.1.2 A strain gauge load cell typically has a beam, column, or other stress member✓ with strain gauges bonded to it.✓ When a weight load is impressed against a member, the strain gauge is deformed✓ and its electrical resistance changes.✓ The balance of the bridge provides an output that is proportional to the force acting upon the load cell.✓ (5)

5.2 Common issues
- Mechanical mounting:✓ Friction may induce offset or hysteresis.✓
- Overload:✓ If subjected to loads above its maximum rating, the material of the load cell may plastically deform.✓
- Wiring issues:✓ The wires to the cell may develop high resistance, e.g. due to corrosion.✓
- Electrical damage:✓ The load cells can be damaged by induced or conducted current.✓
- Nonlinearity:✓ At the low end of their scale, the load cells tend to be nonlinear.✓
- Particularity of application:✓ A load cell that is not well suited to the specific magnitude and type of pressure will have poor accuracy, resolution, and reliability.✓ (5 × 2) (10)

5.3 5.3.1
- Single point load cells
- Planar beam load cells.
- Bending beam load cells
- Shear beam load cells
- Button and washer load cell
- Dual shear beam load cells
- S-type load cells
- Compression load cells
- Ring torsion load cells
- Canister load cell (Any 4 × 1)

5.3.2
- Improper loading and orientation
- Wrapping of bearing plates
- Friction between bearing plate and load cell
- Cross-sensitivity
- Bonding faults
- Hysteresis
- Effects of moisture
- Temperature changes (Any 4 × 1)

(2 × 4) (8)

[26]

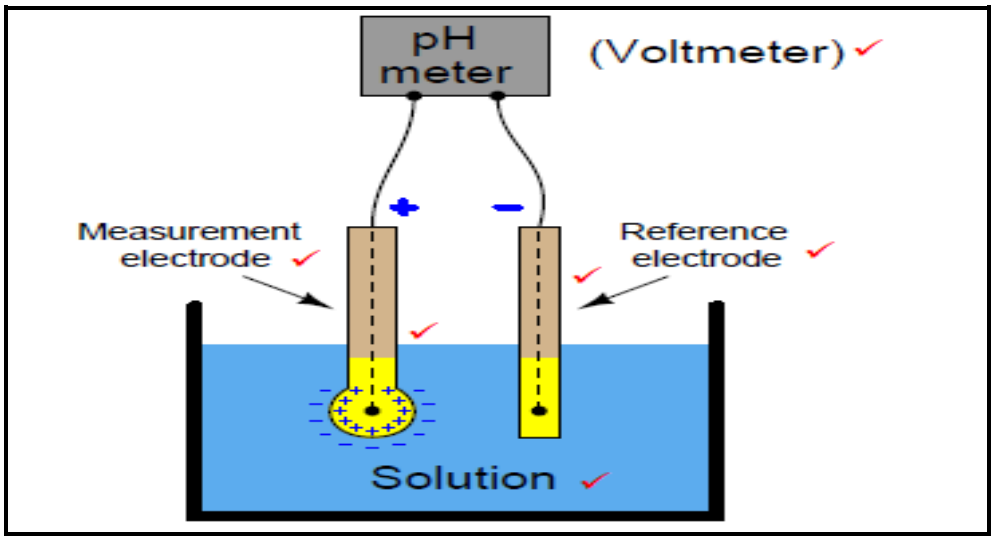
QUESTION 6

6.1 6.1.1 An electrochemical analyzer consisting of a metal measuring electrode and a standard reference electrode✓ that measure the voltage produced by an electrochemical reaction✓ between the metals of the electrodes and the chemicals in solution.✓ (3)

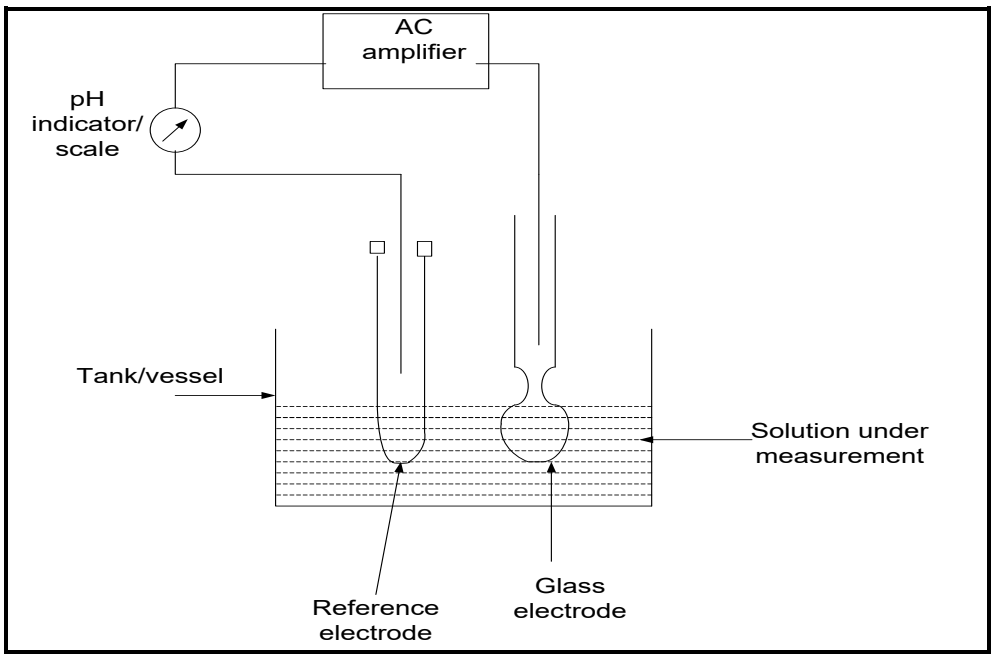
6.1.2 pH is the measurement of the acidity or alkalinity of a solution caused by the dissociation of chemical compounds in water. (2)

6.2 6.2.1 The pH value of a liquid can range from 0 to 14 (1)

6.2.2



OR



(6)

6.2.3 The measuring electrode or a pH sensitive electrode✓

- A measuring electrode is sensitive to the hydrogen ions.✓ It develops a potential/voltage directly proportional to the hydrogen ion concentration in the solution.✓✓

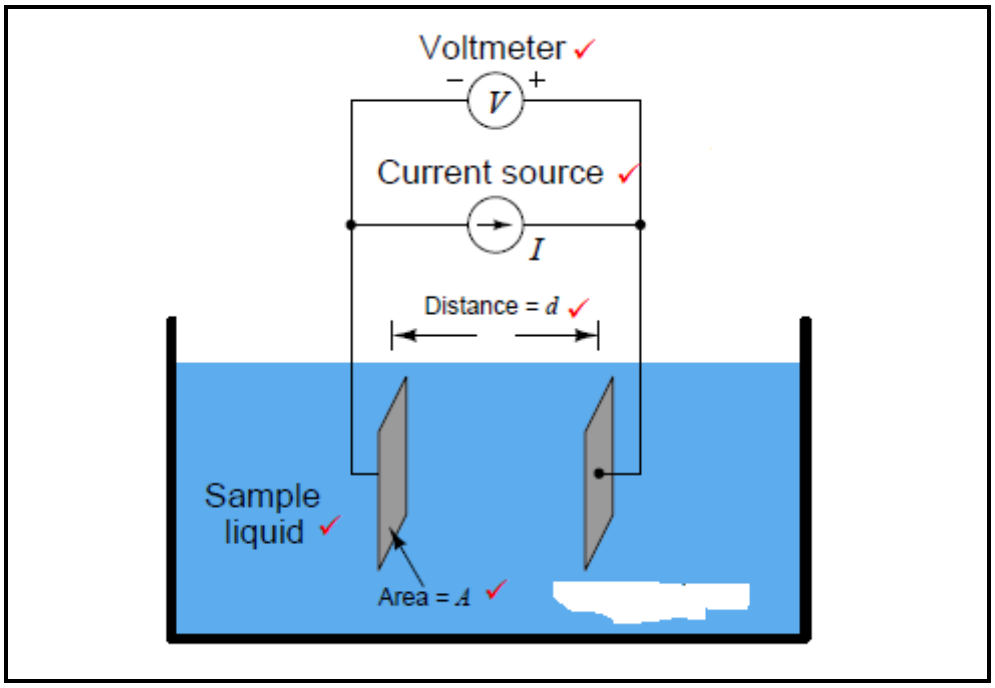
The reference electrode ✓

- The function of a reference electrode is to complete the electric circuit with the glass membrane electrode.✓ It must also provide a constant voltage potential✓ that is relatively invariable despite changes in either the chemical composition or the physical properties of the process fluid✓ (4 × 2) (8)

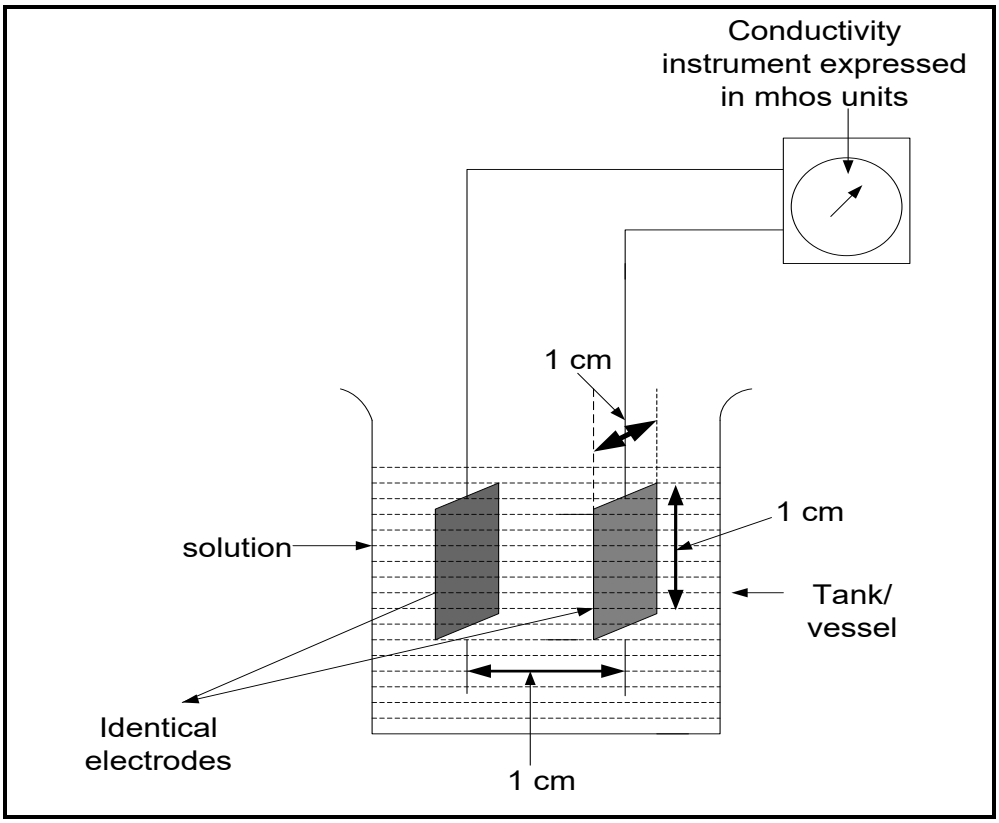
OR

A reference electrode provides a stable potential against which the measuring electrode can be compared.✓✓ The reference electrode potential does not change with the changing hydrogen ion concentration✓

6.3 6.3.1



(1 mark for the drawing and 1 mark for each correctly labelled element) (6)



6.3.2 A conductivity cell consists of two metal electrodes inserted in the solution (2)

6.3.3 The major problem with a two-electrode conductivity cell is that mineral and metal ions attracted to the electrodes tend to 'foul' the electrodes✓ over time, forming solid, insulating barriers on the electrodes.✓ Over time, the conductive barriers formed by ions bonded to the electrode surfaces will create calibration errors✓ by making the instrument 'think' the liquid is less conductive than it actually is.✓ (Any 3 × 1) (4)

6.3.4 Kelvin or four-wire resistance-measuring method✓✓ is a practical solution to the problem of electrode fouling faced by two-electrode conductivity probes. (2)

[34]

QUESTION 7

7.1 7.1.1 The value of a process variable which the controller is programmed to maintain (2)

7.1.2 The difference between the set-point and the process variable (2)

7.1.3 A wiring arrangement that prevents the machine from harming its operator or damaging itself by stopping when tripped (2)

7.1.4 A distributed control system (DCS) is a computerised control system for a process usually with many control loops,✓ in which autonomous controllers are distributed throughout the system,✓ but there is no central operator supervisory control✓

OR

A distributed control system (DCS) is a control system for a process plant✓ in which autonomous controllers are distributed throughout the system✓✓ (3)

7.1.5 Supervisory control and data acquisition (SCADA) is a control system architecture comprising computers,✓ networked data communications✓ and graphical user interfaces for high-level supervision of machines and processes.✓ (3)

7.2 There are five essential composing parts/elements of a SCADA system:
- Human Machine Interface (HMI)
- Supervisory system
- Remote Terminal Units (RTUs)
- Programmable Logic Controllers (PLCs)
- Communication infrastructures (5)

7.3 A limit alarm trip monitors a process signal and compares it against a preset limit. If the process signal moves to an undesirable condition, the alarm trip activates one or more of its relay outputs

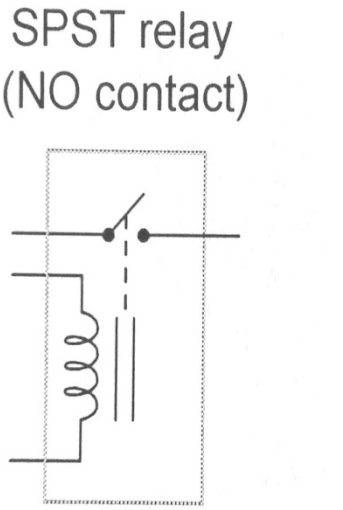
7.3.1
- Single-Pole/Single-Throw
- Single-Pole/ Double-Throw
- Double-Pole/Double-Throw (3)

7.3.2 When in the de-energized state, a normally-open (NO) relay contact does not permit current to flow to the common terminal,✓ resulting in an open circuit.✓ When the relay is energized, there is a closed circuit between the NO and the common terminal.✓

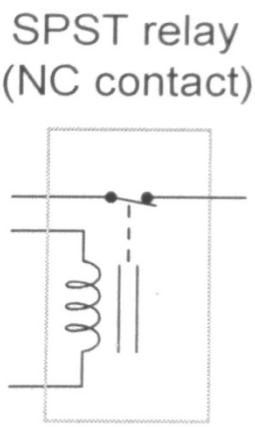
A normally-closed (NC) relay contact allows current to flow to the common terminal,✓ when the relay is in the normal (de-energized) state.✓ When the relay is energized, there is an open circuit between the NC and the C terminal✓ (6)

7.3.3 A status change (alarm condition) of a single high alarm occurs when the input rises above the trip point.✓ The status will return to a non-alarm condition when the input falls below the dead band.✓ (2)

7.3.4



2 marks



2 marks (4)

[32]

TOTAL SECTION B: 125
GRAND TOTAL: 150

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