PRACTICE EXAM 5: STATIONARY ENGINEER (ELECTRIC) SIMULATION — 100 QUESTIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. What is the total resistance of a series circuit with resistors of 5Ω, 15Ω, and 30Ω?

A. 50Ω

B. 3.75Ω

C. 25Ω

D. 10Ω

2. A circuit draws 12A at 120V. What is its resistance?

A. 1,440Ω

B. 10Ω

C. 0.1Ω

D. 1.0Ω

3. Which of the following best describes the function of a capacitor in an AC circuit?

A. Opposes changes in current

B. Stores energy in an electric field and opposes changes in voltage

C. Converts AC to DC

D. Reduces circuit resistance

4. The phase angle between voltage and current in a purely inductive circuit is?

A. 0°

B. 45°

C. 90°, with current lagging voltage

D. 90°, with current leading voltage

5. A 1 kW electric heater operates for 8 hours. The energy consumed is?

A. 8 kWh

B. 0.125 kWh

C. 80 kWh

D. 4 kWh

6. What is the inductive reactance of a 0.5H inductor at 60 Hz?

A. 30Ω

B. 188.5Ω

C. 0.5Ω

D. 60Ω

7. Kirchhoff's Voltage Law states that the sum of all voltages around a closed loop equals?

A. The supply voltage

B. The total current times the total resistance

C. Zero

D. The largest voltage drop in the loop

8. A capacitor with a capacitive reactance of 20Ω in series with a resistor of 15Ω has an impedance of?

A. 25Ω

B. 35Ω

C. 5Ω

D. 17.5Ω

9. Which of the following increases the capacitance of a capacitor?

A. Increasing the distance between the plates

B. Using a thicker dielectric material

C. Increasing the surface area of the plates

D. Reducing the dielectric constant of the material

10. In a purely resistive AC circuit, the phase angle between voltage and current is?

A. 90°

B. 45°

C. 180°

D. 0°

11. The unit of inductance is?

A. Farad

B. Ohm

C. Tesla

D. Henry

12. A transformer with a turns ratio of 5:1 has a primary voltage of 2,400V. The secondary voltage is?

A. 12,000V

B. 2,400V

C. 1,200V

D. 480V

WIRING, CONDUCTORS, AND PROTECTIVE DEVICES (Questions 13–22)

13. Which conduit type is approved for direct burial in concrete and underground applications and is non-metallic?

A. RMC

B. IMC

C. EMT

D. PVC Schedule 80

14. The ampacity of a 10 AWG copper conductor with THWN-2 insulation in a conduit at 75°C is?

A. 15A

B. 20A

C. 35A

D. 40A

15. What is the purpose of a bonding bushing on a metallic conduit entering a service equipment enclosure?

A. To waterproof the conduit entry point

B. To provide a pull point for conductor installation

C. To secure the conduit mechanically to the enclosure

D. To ensure a low-impedance bonding connection between the conduit and enclosure

16. The NEC's 125% rule for continuous loads requires that overcurrent protective devices be sized at?

A. 125% of the continuous load current

B. 100% of the continuous load current

C. 115% of the continuous load current

D. 150% of the continuous load current

17. Which type of wiring method is used for temporary power at construction sites and is flexible?

A. Type NM cable

B. Type MC cable

C. Type SO (hard service) cord

D. Type AC cable

18. A single-phase 240V circuit uses two ungrounded (hot) conductors and no neutral. This is typical for?

A. Electric ranges, dryers, and HVAC equipment requiring 240V only

B. Standard 120/240V three-wire circuits with neutral

C. Three-phase delta circuits

D. Circuits requiring GFCI protection

19. When sizing conductors for motor circuits, the NEC requires the branch circuit conductor to be rated at minimum?

A. 100% of motor FLA

B. 125% of motor FLA

C. 115% of motor FLA

D. 150% of motor FLA

20. The maximum overcurrent protection for a 10 AWG copper conductor is?

A. 30A

B. 20A

C. 15A

D. 25A

21. An arc flash label on electrical equipment must include which of the following?

A. The equipment serial number and installation date

B. Available fault current only

C. The name of the qualified worker authorized to open the equipment

D. Incident energy level, working distance, and required PPE category

22. Which grounding electrode is considered the most effective and preferred by the NEC?

A. Concrete-encased electrode (Ufer ground)

B. Ground ring

C. Ground rod

D. Water pipe

POWER DISTRIBUTION AND HIGH-TENSION SYSTEMS (Questions 23–32)

23. A 2,000 kVA transformer operates at 80% power factor full load. Its real power output is?

A. 1,600 kW

B. 2,500 kW

C. 800 kW

D. 2,000 kW

24. The purpose of a neutral grounding resistor (NGR) on a medium-voltage generator is to?

A. Improve generator voltage regulation

B. Increase generator output current capacity

C. Protect generator windings from harmonic distortion

D. Limit ground fault current to protect the generator stator from damage

25. In a 480V system, the available three-phase fault current at a panel is 25,000A. The equipment installed must have an interrupting rating of at least?

A. 10,000A

B. 25,000A

C. 22,000A

D. 30,000A

26. A power transformer's no-load losses are primarily caused by?

A. Core losses — hysteresis and eddy currents in the iron core

B. Copper losses in the primary winding

C. Copper losses in the secondary winding

D. Load current flowing through winding resistance

27. What is the purpose of a recloser on an overhead distribution feeder?

A. To regulate voltage along the distribution feeder

B. To provide metering data for the utility

C. To balance load between phases automatically

D. To automatically reclose after a temporary fault clears, restoring power without manual intervention

28. The impedance voltage (%Z) of a transformer is typically measured by?

A. Open-circuit test at rated voltage

B. Short-circuit test with reduced voltage

C. Full-load test at rated current

D. Insulation resistance test at rated voltage

29. A 13.8kV medium-voltage switchgear lineup requires switchgear rated for which voltage class?

A. 5kV class

B. 15kV class

C. 27kV class

D. 38kV class

30. Ferroresonance in a power distribution system is a condition involving?

A. Excessive harmonic current in motor windings

B. Resonance between transformer core inductance and system capacitance causing overvoltage

C. Vibration in transformer windings at line frequency

D. Resonance between power factor correction capacitors and motor inductance

31. The primary protection for a large power transformer against internal winding faults is?

A. Thermal overload relay

B. Time-overcurrent relay (ANSI 51)

C. Buchholz relay (for oil-filled transformers)

D. Differential relay (ANSI 87T)

32. A three-phase four-wire wye system with a 208/120V rating supplies what voltage to a single-phase 120V load?

A. 208V

B. 120V

C. 240V

D. 277V

GENERATORS, MOTORS, AND MOTOR CONTROL (Questions 33–44)

33. The purpose of a load bank test on an emergency generator is to?

A. Measure generator insulation resistance

B. Test automatic transfer switch operation only

C. Verify generator capacity and performance under full rated load conditions

D. Calibrate the generator's voltage regulator

34. Which motor protection function detects a motor running with one phase open after starting?

A. ANSI Function 27 — undervoltage relay

B. ANSI Function 51 — time-overcurrent relay

C. ANSI Function 46 — current balance relay

D. ANSI Function 87 — differential relay

35. In a DC shunt motor, increasing the field resistance will?

A. Increase motor speed

B. Decrease motor speed

C. Increase motor torque without affecting speed

D. Decrease both speed and torque

36. The purpose of a power factor correction capacitor bank connected to a motor is to?

A. Reduce the reactive current drawn from the supply, lowering line current and improving power factor

B. Increase motor starting torque

C. Reduce motor winding temperature

D. Protect the motor from voltage surges

37. A synchronous generator operating in parallel with the utility grid must be synchronized before closing the tie breaker. Synchronization requires matching?

A. Only voltage magnitude before closing

B. Only frequency before closing

C. Only phase angle before closing

D. Voltage magnitude, frequency, phase angle, and phase sequence

38. Which type of motor enclosure is best suited for outdoor installations exposed to rain and hose-directed water?

A. Open drip-proof (ODP)

B. Totally enclosed fan-cooled (TEFC)

C. Totally enclosed wash-down duty (TEWD)

D. Explosion-proof (XP)

39. A capacitor-start induction motor fails to start but hums when energized. The most likely cause is?

A. Open circuit in the main winding

B. Overloaded driven equipment

C. Failed starting capacitor

D. Low supply voltage

40. In a reversing motor starter circuit, what prevents both forward and reverse contactors from energizing simultaneously?

A. Timer relay

B. Overload relay

C. Interlocking contacts (electrical and mechanical interlock)

D. Control transformer

41. An induction motor's slip increases when?

A. The motor operates at no load

B. The mechanical load on the motor increases

C. Supply frequency increases

D. Supply voltage increases

42. The KVAR rating of a power factor correction capacitor bank is selected to?

A. Match the motor's horsepower rating exactly

B. Correct the power factor to a target value by supplying reactive power locally

C. Limit motor starting current to 300% of FLA

D. Protect the motor from phase loss

43. Which starting method for large induction motors uses a tapped autotransformer and reconnects the motor to full voltage after acceleration?

A. Primary resistance starting

B. Part-winding starting

C. Wye-delta starting

D. Korndorfer (autotransformer) starting

44. The purpose of regenerative braking in a VFD application is to?

A. Provide emergency mechanical braking on loss of power

B. Return braking energy back to the power supply instead of dissipating it as heat

C. Protect the VFD from overvoltage during acceleration

D. Limit the maximum output frequency of the drive

ELECTRICAL TESTING, TROUBLESHOOTING, AND MAINTENANCE (Questions 45–54)

45. The correct method for verifying a circuit is de-energized before work begins is to?

A. Check that the disconnect switch handle is in the off position

B. Test with a properly rated voltage tester at the point of work

C. Confirm with the operator that the circuit has been turned off

D. Check the circuit breaker panel directory for the circuit status

46. A power quality analyzer detects high total harmonic distortion (THD) on the distribution panel. The most likely source is?

A. Single-phase resistive heating loads

B. VFDs, UPS systems, and electronic equipment

C. Power factor correction capacitors

D. Large single-phase motor loads

47. An insulation resistance test on a 4,160V motor should use a megger test voltage of?

A. 500V DC

B. 1,000V DC

C. 2,500V DC

D. 5,000V DC

48. A motor that vibrates excessively at exactly twice running speed (2×) most likely has?

A. A bent shaft

B. Shaft misalignment or looseness

C. An out-of-balance rotor

D. A defective bearing outer race

49. The purpose of the IEEE 43 standard in motor maintenance is to?

A. Define motor efficiency testing requirements

B. Establish motor winding resistance test procedures

C. Define overload relay selection criteria

D. Provide recommended practices for motor insulation resistance testing

50. Contact resistance of electrical bus connections is measured in?

A. Ohms using a standard ohmmeter

B. Micro-ohms using a DLRO (Digital Low-Resistance Ohmmeter)

C. Milliamps using a clamp meter

D. Volts using a high-impedance voltmeter

51. What does a rising insulation resistance trend over successive megger tests indicate?

A. Increasing moisture contamination in the winding

B. Approaching insulation failure

C. Improving or stable insulation condition

D. Overheating of the winding insulation

52. A three-phase transformer bank shows unequal secondary voltages with balanced primary voltages. The most likely cause is?

A. Overloading on one phase

B. An internal winding fault or open circuit in one transformer

C. Power factor correction capacitors on the secondary

D. Undersized overcurrent protection on the secondary

53. The purpose of a circuit breaker's time-current characteristic (TCC) curve is to?

A. Show the breaker's interrupting rating at various voltages

B. Determine the breaker's short circuit current capacity

C. Calibrate the breaker's instantaneous trip setting

D. Show the relationship between overcurrent magnitude and trip time

54. When should motor bearings be regreased during preventive maintenance?

A. Every time the motor is inspected regardless of operating hours

B. Based on motor speed, bearing size, and operating conditions per manufacturer specification

C. Only when the motor is removed from service for overhaul

D. Per a fixed schedule regardless of manufacturer recommendations

MECHANICAL EQUIPMENT (Questions 55–63)

55. A centrifugal pump operating at a higher speed than its design speed will?

A. Deliver more flow and pressure per affinity law relationships

B. Deliver less flow and lower head

C. Operate more efficiently than at design speed

D. Draw less current from the motor

56. Which seal type in a centrifugal pump requires periodic adjustment and produces a small controlled drip for lubrication?

A. Mechanical seal (balanced type)

B. Mechanical seal (unbalanced type)

C. Lip seal

D. Packing (compression packing)

57. The function of a pressure relief valve on a positive displacement pump is to?

A. Control flow rate to the system

B. Reduce pump noise during operation

C. Limit maximum system pressure when the discharge is blocked or restricted

D. Regulate pump speed automatically

58. A diesel generator's coolant temperature rises slowly over several weeks of normal operation. The most likely cause is?

A. Governor malfunction reducing engine load

B. Faulty voltage regulator increasing output voltage

C. Fouled heat exchanger or clogged coolant passages reducing cooling efficiency

D. Overloading of the generator beyond rated kVA

59. Rotor imbalance on a rotating machine is identified in vibration analysis by?

A. High vibration amplitude at 1× running speed in the radial direction

B. High vibration at sub-synchronous frequencies

C. Elevated bearing defect frequencies

D. High axial vibration at 2× running speed

60. Which compressor type is used in large central plant refrigeration systems due to its high capacity and efficiency?

A. Reciprocating compressor

B. Scroll compressor

C. Centrifugal compressor

D. Rotary vane compressor

61. A hydraulic accumulator in a system is used to?

A. Filter hydraulic fluid before it enters the pump

B. Cool hydraulic fluid during high-load operation

C. Store pressurized fluid to supplement pump flow during peak demand

D. Regulate pump speed based on system pressure

62. An engine governor that is set too high will cause?

A. Engine underspeed and low frequency output

B. Excessive fuel consumption and low output voltage

C. Engine overspeed and high frequency output

D. Engine hunting and unstable speed

63. The purpose of an aftercooler on an air compressor is to?

A. Pre-cool intake air before compression

B. Lubricate the compressor discharge valve

C. Cool compressed air after final-stage compression to remove moisture

D. Reduce compressor noise at discharge

FLUID SYSTEMS (Questions 64–72)

64. A pressure-reducing valve (PRV) that has failed open will cause?

A. No flow downstream of the PRV

B. Full upstream pressure to pass downstream, potentially damaging fixtures and equipment

C. Rapid cycling of the PRV between open and closed

D. Reduced flow but normal downstream pressure

65. In a chilled water system, what is the purpose of a two-way control valve at each air handling unit?

A. To modulate chilled water flow to maintain the desired supply air temperature

B. To balance static pressure across the chilled water system

C. To prevent reverse flow through the AHU coil

D. To regulate chilled water supply temperature at the chiller

66. Which boiler water treatment chemical prevents oxygen pitting corrosion in the boiler and condensate system?

A. Scale inhibitor (polyphosphate)

B. pH buffer (caustic soda)

C. Corrosion inhibitor (molybdate)

D. Oxygen scavenger (sodium sulfite or hydrazine)

67. The term "flash steam" in a condensate return system refers to?

A. Steam that bypasses a defective trap into the condensate line

B. Steam produced by pressure-relief valve operation

C. Steam formed in condensate piping due to friction losses

D. Steam that forms when hot condensate is discharged to a lower pressure region

68. In a fire sprinkler system, the water supply pressure required at the most remote sprinkler head is determined by?

A. The fire pump rated pressure

B. The building height only

C. The number of sprinkler heads in the system

D. Hydraulic calculations based on system design flow and pipe friction losses

69. A centrifugal chiller trips on high condenser pressure. The most likely cause is?

A. Low chilled water flow through the evaporator

B. Low refrigerant charge in the system

C. Fouled evaporator tubes reducing heat transfer

D. Fouled condenser tubes or reduced condenser water flow

70. The purpose of a strainer installed upstream of a control valve is to?

A. Remove dissolved minerals from the fluid

B. Reduce fluid velocity before the valve

C. Filter air out of the fluid stream

D. Protect the valve trim from debris that could cause wear or jamming

71. Which pipe joining method provides the highest pressure rating for steel piping?

A. Grooved mechanical coupling

B. Press-fit connection

C. Threaded connection

D. Butt-welded joint

72. A cooling tower's cycles of concentration (COC) is controlled by?

A. Adjusting the condenser water flow rate

B. Varying the cooling tower fan speed

C. Blowdown (bleed-off) to remove concentrated dissolved solids

D. Increasing biocide dosage frequency

CONSTRUCTION, TOOLS, AND RIGGING (Questions 73–80)

73. The safe working load of a chain sling is reduced when used in a choker hitch because?

A. Chain links are weaker in bending than in tension

B. The chain is more likely to kink in a choker configuration

C. The angle at the choke point creates additional stress concentration reducing capacity to approximately 75%

D. Choker hitches are not permitted with chain slings

74. The first step before starting any grinding, cutting, or welding operation in a facility is to?

A. Obtain a hot work permit and identify combustible hazards in the area

B. Ensure the work area is adequately ventilated

C. Notify the facility supervisor

D. Inspect the grinding wheel for cracks

75. When installing threaded rigid metal conduit (RMC), threads must be?

A. Tapered, with at least 5 full threads engaged at each fitting

B. Straight-cut for easier disassembly

C. Cut with a standard pipe die and coated with thread compound or tape

D. Welded after assembly for permanent installations

76. A mechanical advantage of 4:1 in a block-and-tackle system means?

A. The load can be moved four times faster than with a single rope

B. A 500 lb load requires approximately 125 lbs of pulling force (ignoring friction)

C. Four workers must pull simultaneously on the hauling line

D. The load can only be lifted four feet per pull

77. Which measuring tool provides the most precise measurement of shaft diameter or bearing bore?

A. Steel rule (ruler)

B. Vernier caliper

C. Feeler gauge

D. Outside micrometer

78. The purpose of a safety factor in rigging and structural calculations is to?

A. Allow equipment to be used beyond its rated capacity in emergencies

B. Compensate for the weight of the rigging hardware

C. Account for dynamic loads, wear, impact, and uncertainty in load weights

D. Provide a mathematical safety margin required by insurance regulations only

79. When two pipe flanges are bolted together, fasteners should be tightened in what sequence?

A. Starting from one side and progressing around the flange in order

B. Tighten each bolt fully before moving to the next

C. Random sequence to distribute load

D. Opposite (cross) pattern in multiple passes to achieve uniform gasket compression

80. On a mechanical drawing, a surface finish symbol indicates?

A. The type of paint or coating to be applied

B. The required surface roughness or smoothness of a machined surface

C. The material hardness specification

D. The tolerance on the dimension shown

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. A facility that generates exactly 2,200 lbs of hazardous waste in a calendar month is classified as?

A. Very Small Quantity Generator (VSQG)

B. Small Quantity Generator (SQG)

C. Large Quantity Generator (LQG)

D. Conditionally exempt generator

82. The GHS pictogram showing a flame over a circle represents?

A. Oxidizing hazard

B. Flammable material

C. Explosive material

D. Corrosive material

83. Section 11 of the SDS contains?

A. Regulatory information for transport

B. Toxicological information including routes of exposure and health effects

C. Ecological information and environmental fate

D. First-aid measures for acute exposure

84. NYC Local Law 63 requires building owners to audit, remediate, and report on?

A. Cooling tower Legionella management

B. Underground storage tank conditions

C. Lead-based paint hazards in pre-1960 residential buildings

D. Asbestos-containing materials in pre-1974 buildings

85. The primary purpose of a Safety Data Sheet (SDS) is to?

A. Provide emergency response guidance for fire departments only

B. Document workplace injury data for OSHA reporting

C. Satisfy transportation labeling requirements only

D. Communicate chemical hazard information to workers and emergency responders

86. Which federal law governs the cleanup of abandoned hazardous waste sites and establishes the Superfund program?

A. RCRA

B. TSCA

C. CERCLA

D. Clean Water Act

87. A facility's SPCC plan must be certified by?

A. An EPA-registered environmental consultant

B. An OSHA compliance officer

C. A licensed Professional Engineer (PE)

D. The facility's insurance carrier

88. The NYC DEP requires facilities discharging industrial wastewater to the city sewer system to obtain?

A. An industrial wastewater discharge permit

B. A stormwater pollution prevention plan only

C. A RCRA Part B storage permit

D. A CERCLA notification certificate

89. Which OSHA standard requires employers to provide respiratory protection when engineering controls cannot reduce airborne contaminants to below the PEL?

A. 29 CFR 1910.134

B. 29 CFR 1910.1200

C. 29 CFR 1910.146

D. 29 CFR 1910.147

SAFETY, LOTO, ARC FLASH, AND EMERGENCY PROCEDURES (Questions 90–100)

90. Under NFPA 70E, a "qualified person" for electrical work is defined as one who has?

A. Completed any electrical safety training course

B. At least five years of electrical experience

C. Training and experience to identify and avoid electrical hazards

D. An electrical license from the state authority

91. The incident energy at a given working distance is affected by which of the following factors?

A. The color of the arc flash PPE worn by the worker

B. Available fault current, protective device clearing time, and working distance

C. The number of workers present in the area

D. The ambient temperature in the equipment room

92. When a fire is detected in an electrical switchgear room protected by a clean agent system, personnel should?

A. Attempt to fight the fire with a Class C extinguisher before the system activates

B. Silence the alarm to prevent the system from discharging

C. Open doors and windows to ventilate the room

D. Evacuate immediately before the system discharges

93. The OSHA standard for fall protection in general industry requires fall protection when working at heights above?

A. 6 feet

B. 10 feet

C. 4 feet

D. 8 feet

94. Which of the following is a hazard specific to working in an energized electrical environment above 600V?

A. Reduced arc flash risk compared to low voltage

B. Lower fault current levels than 480V systems

C. Less PPE required due to self-clearing fault characteristics

D. Significantly higher incident energy levels and increased blast pressure during arc flash

95. The minimum safe approach distance for an unqualified worker near exposed energized conductors at 480V is defined by NFPA 70E as the?

A. Restricted approach boundary

B. Arc flash boundary

C. Limited approach boundary

D. Prohibited approach boundary

96. Which document must a Stationary Engineer review before performing maintenance on an unfamiliar piece of equipment?

A. The equipment purchase order

B. The facility's OSHA 300 Log

C. The most recent inspection report only

D. The manufacturer's operation and maintenance manual and equipment-specific energy control procedure

97. A fire watch person must be trained to?

A. Operate all fire suppression systems in the facility

B. Perform basic first aid on burn injuries

C. Recognize fire hazards, use a fire extinguisher, and activate the fire alarm

D. Perform hot work operations if the primary worker is unavailable

98. NFPA 72 is the standard that governs?

A. Fire suppression system design

B. Sprinkler system inspection and maintenance

C. Electrical safety in the workplace

D. Fire alarm system installation, inspection, and testing

99. When a worker must enter a confined space to perform welding, which atmospheric hazard must be continuously monitored throughout the entry?

A. Carbon dioxide levels only

B. Oxygen level, flammable gas concentration, and carbon monoxide

C. Hydrogen sulfide only

D. Nitrogen levels only

100. The purpose of the pre-job safety briefing (tailgate meeting) before beginning electrical maintenance work is to?

A. Document the work order for billing purposes

B. Review hazards, protective measures, roles, and emergency procedures specific to the task

C. Assign blame in case of an incident

D. Satisfy the foreman's administrative reporting requirements

PRACTICE EXAM 5 — ANSWER KEY AND FULL EXPLANATIONS

ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. Correct Answer: A — 50Ω

Total series resistance = R1 + R2 + R3 = 5 + 15 + 30 = 50 ohms. In a series circuit all resistances add directly because there is only one current path through all components.

2. Correct Answer: B — 10Ω

Using Ohm's Law: R = V ÷ I = 120 ÷ 12 = 10 ohms. Voltage divided by current gives resistance — the opposition the circuit presents to electron flow.

3. Correct Answer: B — Stores energy in an electric field and opposes changes in voltage

A capacitor stores energy between two conductive plates separated by a dielectric. It opposes sudden changes in voltage across it, passes AC while blocking DC, and is used for power factor correction and filtering applications.

4. Correct Answer: C — 90°, with current lagging voltage

In a purely inductive circuit, the magnetic field stores energy during each half cycle — current reaches its peak 90° after voltage reaches its peak, meaning current lags voltage by 90°. This is opposite to capacitive circuits where current leads voltage.

5. Correct Answer: A — 8 kWh

Energy = Power × Time = 1 kW × 8 hours = 8 kilowatt-hours. The kilowatt-hour is the standard commercial unit of electrical energy — one kilowatt of power consumed for one hour.

6. Correct Answer: B — 188.5Ω

Inductive reactance XL = 2π × f × L = 2 × 3.14159 × 60 × 0.5 = 188.5 ohms. Inductive reactance increases proportionally with both frequency and inductance.

7. Correct Answer: C — Zero

Kirchhoff's Voltage Law (KVL) states that the algebraic sum of all voltages around any closed loop equals zero — the sum of voltage rises (source) equals the sum of voltage drops (loads) in the loop.

8. Correct Answer: A — 25Ω

Impedance $Z = \sqrt{(R^2 + XC^2)} = \sqrt{(15^2 + 20^2)} = \sqrt{(225 + 400)} = \sqrt{625} = 25$ ohms. Resistance and reactance are 90° out of phase and must be combined using the Pythagorean theorem.

9. Correct Answer: C — Increasing the surface area of the plates

Capacitance is directly proportional to plate surface area — more plate area allows more charge to be stored for a given voltage. Capacitance decreases when plate separation increases or dielectric constant decreases.

10. Correct Answer: D — 0°

In a purely resistive AC circuit, voltage and current are perfectly in phase — they reach their peaks and cross zero simultaneously. There is no energy storage, no phase shift, and the power factor equals 1.0.

11. Correct Answer: D — Henry

The henry (H) is the SI unit of inductance. The farad is the unit of capacitance; the ohm is the unit of resistance; the tesla is the unit of magnetic flux density.

12. Correct Answer: D — 480V

Secondary voltage = Primary voltage ÷ Turns ratio = 2,400 ÷ 5 = 480V. A 5:1 turns ratio steps voltage down by a factor of five — this is a standard distribution transformer ratio used throughout commercial facilities.

WIRING, CONDUCTORS, AND PROTECTIVE DEVICES (Questions 13–22)

13. Correct Answer: D — PVC Schedule 80

PVC Schedule 80 conduit (heavier wall than Schedule 40) is approved for direct burial and concrete encasement applications. RMC and IMC are metallic conduits; EMT is not approved for direct burial without concrete encasement.

14. Correct Answer: C — 35A

Per NEC Table 310.15(B)(16), 10 AWG copper with 75°C-rated insulation (THWN-2 used at 75°C column) has an ampacity of 35 amperes. The 90°C column shows 40A, but most terminations are rated 75°C, limiting the usable ampacity to 35A.

15. Correct Answer: D — Ensure a low-impedance bonding connection between the conduit and enclosure

A bonding bushing with a lug provides a reliable electrical bonding connection between metallic conduit and the service equipment enclosure — ensuring the low-impedance fault current return path required by NEC Article 250 for service equipment.

16. Correct Answer: A — 125% of the continuous load current

NEC Section 210.20(A) requires overcurrent protective devices serving continuous loads (loads expected to continue for 3 hours or more) to be rated at not less than 125% of the continuous load current to prevent nuisance tripping from thermal buildup.

17. Correct Answer: C — Type SO (hard service) cord

Type SO hard service cord is a flexible, portable power cord rated for hard use in construction, industrial, and temporary power applications. NM, MC, and AC cables are fixed wiring methods not suitable for flexible temporary installations.

18. Correct Answer: A — Electric ranges, dryers, and HVAC equipment requiring 240V only

A two-wire 240V circuit (two hot conductors, no neutral) supplies loads that operate entirely at 240V and have no 120V components. Electric water heaters, baseboard heaters, central A/C units, and well pumps are common examples.

19. Correct Answer: B — 125% of motor FLA

NEC Section 430.22 requires motor branch circuit conductors to be sized at not less than 125% of the motor's nameplate full-load ampere (FLA) rating. This accounts for the continuous nature of motor loads and provides a thermal margin for the conductors.

20. Correct Answer: A — 30A

NEC Table 310.15(B)(16) allows 10 AWG copper conductors to carry up to 30 amperes at 60°C or 35 amperes at 75°C. The maximum overcurrent protection for 10 AWG copper is 30 amperes per NEC Section 240.4(D).

21. Correct Answer: D — Incident energy level, working distance, and required PPE category

NFPA 70E and NEC 110.16 require arc flash labels to include at minimum the incident energy in cal/cm², the working distance at which that energy was calculated, and the minimum PPE category or arc rating required — enabling workers to select appropriate protection before opening the equipment.

22. Correct Answer: A — Concrete-encased electrode (Ufer ground)

The concrete-encased electrode (Ufer ground) — a 20-foot or longer steel reinforcing bar or conductor encased in the building's concrete foundation — is considered the most effective grounding electrode because concrete maintains reliable moisture contact with the earth and provides an extremely large surface area.

POWER DISTRIBUTION AND HIGH-TENSION SYSTEMS (Questions 23–32)

23. Correct Answer: A — 1,600 kW

Real power = Apparent power × Power factor = 2,000 kVA × 0.80 = 1,600 kW. The transformer's kVA rating represents apparent power — actual useful work delivered depends on the power factor of the connected loads.

24. Correct Answer: D — Limit ground fault current to protect the generator stator from damage

A neutral grounding resistor limits the ground fault current on a medium-voltage generator to a low value (typically 5–10 amperes) — preventing the severe core burning and lamination damage that would result from an unrestrained ground fault current flowing through the stator iron.

25. Correct Answer: B — 25,000A

All electrical equipment must have an interrupting rating equal to or greater than the maximum available fault current at its location. Installing equipment with a lower interrupting rating than the available fault current creates a catastrophic hazard — the equipment can explode when attempting to interrupt a fault beyond its capability.

26. Correct Answer: A — Core losses — hysteresis and eddy currents in the iron core

No-load (core) losses occur continuously whenever a transformer is energized, regardless of load. They consist of hysteresis losses (energy to repeatedly magnetize and demagnetize the core) and eddy current losses (circulating currents induced in the core laminations). Copper losses only occur when load current flows.

27. Correct Answer: D — Automatically reclose after a temporary fault clears, restoring power without manual intervention

Distribution reclosers automatically interrupt a fault, pause briefly to allow the fault to clear (most distribution faults — tree contact, bird strike — are temporary), then reclose the circuit. If the fault persists after a preset number of reclose attempts, the recloser locks out permanently.

28. Correct Answer: B — Short-circuit test with reduced voltage

The impedance voltage (%Z) test is performed by short-circuiting the secondary winding and applying just enough primary voltage to produce rated current — typically 4–8% of rated voltage for power transformers. This voltage as a percentage of rated voltage equals the transformer's %Z.

29. Correct Answer: B — 15kV class

Switchgear voltage class must exceed the system operating voltage. A 13.8kV system requires 15kV class switchgear — the next standard class above 13.8kV. Using 5kV class would be inadequate; 27kV class would be oversized but acceptable if required by the authority having jurisdiction.

30. Correct Answer: B — Resonance between transformer core inductance and system capacitance causing overvoltage

Ferroresonance occurs in distribution systems — particularly when single-phase switching leaves capacitance (cable charging, power factor capacitors) resonating with a transformer's nonlinear core inductance. It produces sustained overvoltages and distorted waveforms that can damage equipment and blow fuses repeatedly.

31. Correct Answer: D — Differential relay (ANSI 87T)

The transformer differential relay (87T) compares currents entering and leaving the transformer on all windings. Any difference indicates an internal fault — the relay trips all connected breakers instantly, providing primary protection faster than any other relay type.

32. Correct Answer: B — 120V

In a 208/120V three-phase four-wire wye system, the 120V is the phase-to-neutral voltage available for single-phase 120V loads. The 208V is the phase-to-phase voltage available for three-phase or two-phase 208V loads.

GENERATORS, MOTORS, AND MOTOR CONTROL (Questions 33–44)

33. Correct Answer: C — Verify generator capacity and performance under full rated load conditions

A load bank test applies a controlled resistive load equal to the generator's full rated kW output, verifying that the engine, alternator, cooling system, and all controls perform correctly at full load — something that cannot be verified during normal light-load standby operation.

34. Correct Answer: C — ANSI Function 46 — current balance relay

ANSI Function 46 monitors negative sequence current — current produced by phase unbalance or phase loss. A phase loss condition (open phase) creates severe negative sequence current that Function 46 detects and uses to trip the motor before thermal damage occurs.

35. Correct Answer: A — Increase motor speed

In a DC shunt motor, the field winding is connected across the supply voltage. Increasing field resistance reduces field current, weakening the magnetic flux. Reduced flux decreases back-EMF, allowing more armature current to flow — resulting in increased speed above base speed (field weakening).

36. Correct Answer: A — Reduce the reactive current drawn from the supply, lowering line current and improving power factor

Power factor correction capacitors supply reactive (magnetizing) current locally to the motor, reducing the reactive component that must be drawn from the supply. This reduces total line current, lowers distribution losses, and improves the facility's power factor.

37. Correct Answer: D — Voltage magnitude, frequency, phase angle, and phase sequence

All four synchronizing parameters must match before closing the breaker to parallel a generator with the grid. Mismatched frequency causes large mechanical shock; mismatched phase angle causes inrush current spike; mismatched phase sequence causes catastrophic damage to the generator.

38. Correct Answer: C — Totally enclosed wash-down duty (TEWD)

TEWD motors are sealed to prevent water ingress from rain, hosing, or outdoor exposure — they exceed TEFC protection levels. ODP motors are not weather-protected; TEFC is suitable for most outdoor use; explosion-proof motors are for hazardous locations, not standard outdoor installations.

39. Correct Answer: C — Failed starting capacitor

A capacitor-start motor uses the starting capacitor to create a phase-shifted current in the auxiliary winding, producing starting torque. If the starting capacitor fails open, the auxiliary winding has no current, no starting torque is developed, and the motor hums at standstill while drawing locked rotor current.

40. Correct Answer: C — Interlocking contacts (electrical and mechanical interlock)

Reversing starters use both electrical interlocks (normally closed auxiliary contacts from each contactor wired into the coil circuit of the other) and mechanical interlocks (a physical bar between the two contactors) to make it physically and electrically impossible for both forward and reverse contactors to close simultaneously.

41. Correct Answer: B — The mechanical load on the motor increases

Slip is the difference between synchronous speed and actual rotor speed. As mechanical load increases, the rotor slows slightly — increasing slip — which induces more rotor current and develops more torque to carry the additional load. At no load, slip approaches zero.

42. Correct Answer: B — Correct the power factor to a target value by supplying reactive power locally

The KVAR rating of a capacitor bank is calculated to supply the exact amount of reactive power needed to raise the facility's power factor from its existing value to the target value — typically 0.90–0.95 — without overcorrecting, which causes leading power factor issues.

43. Correct Answer: D — Korndorfer (autotransformer) starting

The Korndorfer method is a specific autotransformer starting sequence where the motor first connects through the autotransformer in a closed-circuit transition, then transfers to full voltage — minimizing the current spike at transition compared to an open-circuit autotransformer transition.

44. Correct Answer: B — Return braking energy back to the power supply instead of dissipating it as heat

Regenerative braking in a VFD reverses power flow — the decelerating motor acts as a generator, and the drive's regenerative capability feeds this energy back into the AC supply grid. This recovers energy that would otherwise be wasted as heat in dynamic braking resistors.

ELECTRICAL TESTING, TROUBLESHOOTING, AND MAINTENANCE (Questions 45–54)

45. Correct Answer: B — Test with a properly rated voltage tester at the point of work

The only reliable method to verify a circuit is de-energized is to test directly at the point of work with a properly rated, CAT-rated voltage tester. Switch positions, panel directories, and verbal confirmation are not substitutes for direct testing — NFPA 70E requires verification at the work location.

46. Correct Answer: B — VFDs, UPS systems, and electronic equipment

Non-linear loads such as VFDs, UPS systems, computers, electronic ballasts, and variable-speed drives draw current in pulses rather than sinusoidal waveforms, injecting harmonic currents (3rd, 5th, 7th harmonics) into the distribution system and causing high THD.

47. Correct Answer: C — 2,500V DC

IEEE 43 recommends a 2,500V DC megger test voltage for motors with winding voltage ratings between 2,400V and 5,000V. For motors rated below 1,000V, 1,000V DC is recommended; for motors rated 5,000V and above, 5,000V DC is recommended.

48. Correct Answer: B — Shaft misalignment or looseness

Vibration at exactly 2× running speed (2× RPM) is the classic signature of shaft misalignment — particularly angular misalignment — and of mechanical looseness. Rotor imbalance produces primarily 1× running speed amplitude; bearing defects produce high-frequency signatures.

49. Correct Answer: D — Provide recommended practices for motor insulation resistance testing

IEEE Standard 43 provides the recommended practices for insulation resistance testing of rotating electrical machines — including test voltage selection, testing procedures, minimum acceptable values, correction factors for temperature, and interpretation of polarization index results.

50. Correct Answer: B — Micro-ohms using a DLRO

Bus connection and contact resistance is in the micro-ohm range for properly made connections. A Digital Low-Resistance Ohmmeter (DLRO) uses a high test current (typically 10–100A) and four-wire (Kelvin) measurement technique to accurately measure these very low resistance values. A standard ohmmeter lacks sufficient resolution.

51. Correct Answer: C — Improving or stable insulation condition

A rising insulation resistance trend over successive tests — with measurements corrected to a consistent temperature — indicates that insulation is drying out, contamination has been removed, or the insulation system is in good and improving condition. A falling trend is the concerning pattern.

52. Correct Answer: B — An internal winding fault or open circuit in one transformer

Unequal secondary voltages with balanced primary voltages — particularly if one secondary voltage is significantly low or zero — indicates a problem within that transformer: an internal winding fault, partial short circuit, or open circuit in one phase winding.

53. Correct Answer: D — Show the relationship between overcurrent magnitude and trip time

A time-current characteristic (TCC) curve plots trip time (vertical axis) versus current magnitude (horizontal axis) on a log-log scale. It shows how quickly the breaker trips at various overcurrent levels and is used for protective device coordination studies.

54. Correct Answer: B — Based on motor speed, bearing size, and operating conditions per manufacturer specification

Over-greasing is as damaging as under-greasing — excess grease churning generates heat and accelerates bearing failure. Regreasing intervals are determined by the manufacturer's specification, which accounts for motor speed, bearing size, operating temperature, and environmental conditions.

MECHANICAL EQUIPMENT (Questions 55–63)

55. Correct Answer: A — Deliver more flow and pressure per affinity law relationships

The pump affinity laws state that flow varies directly with speed, head varies with the square of speed, and power varies with the cube of speed. Running a centrifugal pump above design speed increases both flow and pressure — but also significantly increases power demand and mechanical stress on the pump.

56. Correct Answer: D — Packing (compression packing)

Compression packing (braided packing rings in a stuffing box) requires periodic gland adjustment to maintain a slight controlled drip — typically 40–60 drops per minute — which lubricates and cools the packing and shaft sleeve. Mechanical seals are designed for zero or near-zero leakage.

57. Correct Answer: A — Limit maximum system pressure when the discharge is blocked or restricted

Positive displacement pumps build pressure continuously if the discharge is blocked — they have no inherent pressure limiting characteristic unlike centrifugal pumps. A pressure relief valve bypasses flow back to the suction or reservoir when pressure reaches the setpoint, preventing pump, pipe, and equipment damage.

58. Correct Answer: C — Fouled heat exchanger or clogged coolant passages reducing cooling efficiency

A gradual temperature rise over weeks without a sudden event points to a progressive fouling problem — scale buildup, biological fouling, or debris accumulation in the heat exchanger reducing its thermal efficiency. Sudden temperature rises indicate more acute failures.

59. Correct Answer: A — High vibration amplitude at 1× running speed in the radial direction

Rotor imbalance produces a centrifugal force that rotates at exactly shaft speed, generating radial vibration at precisely 1× RPM. The vibration phase and amplitude are consistent around the bearing housing and respond predictably to balance corrections.

60. Correct Answer: C — Centrifugal compressor

Centrifugal (turbo) compressors are used in large central plant chillers (500+ tons) because of their high efficiency at large capacities, smooth continuous flow, low maintenance requirements (no reciprocating parts), and excellent performance at full and part load with inlet guide vane control.

61. Correct Answer: C — Store pressurized fluid to supplement pump flow during peak demand

A hydraulic accumulator stores energy by compressing a nitrogen gas charge against hydraulic fluid. During peak demand cycles, the accumulator releases stored fluid to supplement pump output — allowing a smaller pump to be used and reducing pressure fluctuations in the system.

62. Correct Answer: C — Engine overspeed and high frequency output

A governor set too high commands more fuel than needed to maintain rated speed — the engine runs above rated RPM. Since alternator frequency = (RPM × poles) ÷ 120, engine overspeed directly causes output frequency to exceed 60 Hz, which can damage frequency-sensitive loads.

63. Correct Answer: C — Cool compressed air after final-stage compression to remove moisture

An aftercooler reduces the temperature of compressed air from the final compression stage before it enters the distribution system or receiver tank. Cooling causes water vapor to condense, which is then removed by a moisture separator — preventing water from entering air tools, pneumatic controls, and distribution piping.

FLUID SYSTEMS (Questions 64–72)

64. Correct Answer: B — Full upstream pressure to pass downstream, potentially damaging fixtures and equipment

A PRV failed open allows the full, unregulated upstream pressure — which may be 80–150 PSI or higher — to pass downstream. This can rupture fixture supply hoses, damage valve seats, and exceed the pressure rating of downstream equipment and piping.

65. Correct Answer: A — To modulate chilled water flow to maintain the desired supply air temperature

Two-way control valves at each AHU throttle chilled water flow in response to the zone thermostat signal — reducing flow when less cooling is needed and increasing it when more cooling is required, thereby maintaining the desired supply air temperature leaving the AHU coil.

66. Correct Answer: D — Oxygen scavenger (sodium sulfite or hydrazine)

Dissolved oxygen in boiler feedwater and condensate return causes aggressive pitting corrosion of steel surfaces. Oxygen scavengers chemically react with and remove dissolved oxygen before it reaches the boiler — sodium sulfite is used in low-pressure boilers; hydrazine or other organic scavengers are used in high-pressure systems.

67. Correct Answer: D — Steam that forms when hot condensate is discharged to a lower pressure region

Flash steam forms when high-temperature, high-pressure condensate is discharged through a steam trap into a lower-pressure condensate return line. The pressure reduction causes a portion of the condensate to immediately re-vaporize (flash) into steam — this flash steam contains significant energy and should be recovered when possible.

68. Correct Answer: D — Hydraulic calculations based on system design flow and pipe friction losses

Fire sprinkler systems are designed using hydraulic calculations per NFPA 13 that account for the required flow at the most remote (hydraulically most demanding) sprinkler heads, pipe friction losses throughout the distribution system, and elevation pressure changes — ensuring adequate pressure at every design flow point.

69. Correct Answer: D — Fouled condenser tubes or reduced condenser water flow

High condenser pressure indicates the refrigerant cannot reject heat efficiently at the condenser. The most common causes are fouled (scaled or biologically fouled) condenser tubes reducing heat transfer, reduced condenser water flow, or high condenser water temperature from the cooling tower — all of which raise condensing pressure and temperature.

70. Correct Answer: A — Protect the valve trim from debris that could cause wear or jamming

Control valve trims — plugs, seats, and stems — are precision-machined to close tolerances. Debris in the fluid stream causes erosive wear, scoring of seating surfaces, and mechanical jamming that prevents proper valve modulation. A strainer upstream captures particulates before they reach the valve.

71. Correct Answer: D — Butt-welded joint

Butt-welded joints provide the highest pressure and structural integrity of any pipe joining method — the joint becomes an integral part of the pipe wall with the same strength as the parent material when properly executed. Grooved, threaded, and press-fit connections are limited to lower pressure ratings.

72. Correct Answer: C — Blowdown (bleed-off) to remove concentrated dissolved solids

As cooling tower water evaporates, dissolved minerals concentrate in the recirculating water. Blowdown (controlled discharge of a portion of the concentrated water) removes these solids and replaces them with fresh makeup water, maintaining the cycles of concentration within acceptable limits to prevent scale and corrosion.

CONSTRUCTION, TOOLS, AND RIGGING (Questions 73–80)

73. Correct Answer: C — The angle at the choke point creates additional stress concentration reducing capacity to approximately 75%

When a chain sling is used in a choker hitch, the tight bend radius at the choke point creates stress concentration in the chain links at that point, reducing the sling's load capacity to approximately 75% of its rated vertical hitch capacity — exactly as with synthetic and wire rope slings.

74. Correct Answer: A — Obtain a hot work permit and identify combustible hazards in the area

The first step before any hot work — welding, cutting, grinding, or brazing — is to obtain an authorized hot work permit and survey the area for combustible materials within the required clearance radius. All other preparations follow after the permit establishes the hazard boundaries and fire watch requirements.

75. Correct Answer: C — Cut with a standard pipe die and coated with thread compound or tape

RMC threads are cut with a standard taper pipe die (NPT taper) and the threads must be coated with listed thread compound or PTFE tape before assembly to maintain the conduit's electrical continuity and prevent corrosion at the joint. At least five full engaged threads are recommended.

76. Correct Answer: B — A 500 lb load requires approximately 125 lbs of pulling force (ignoring friction)

Mechanical advantage = Load ÷ Effort. A 4:1 system requires an effort of 500 ÷ 4 = 125 lbs to move a 500 lb load, ignoring friction. In practice, friction in the sheaves reduces actual mechanical advantage to approximately 3:1 for a theoretical 4:1 system.

77. Correct Answer: D — Outside micrometer

An outside micrometer measures shaft diameter, bearing dimensions, and similar external dimensions to a precision of 0.0001 inch — far greater than a steel rule (1/64") or vernier caliper (0.001"). Feeler gauges measure clearances and gaps, not external diameters.

78. Correct Answer: C — Account for dynamic loads, wear, impact, and uncertainty in load weights

The safety factor (design factor) accounts for loads that exceed static weight — dynamic shock loads during lifting, impact from sudden movement, wear degradation of the component over time, inaccuracies in estimated load weights, and the consequences of failure. Standard rigging safety factors are typically 4:1 or 5:1.

79. Correct Answer: D — Opposite (cross) pattern in multiple passes to achieve uniform gasket compression

Flange bolts must be tightened in a star (cross) pattern — tightening opposite bolts sequentially — and in multiple torque passes (typically 30%, 60%, 100% of final torque). This ensures the gasket is compressed uniformly across its entire face, preventing leaks from uneven seating.

80. Correct Answer: B — The required surface roughness or smoothness of a machined surface

Surface finish symbols on mechanical drawings specify the required surface roughness (Ra value in microinches or micrometers) of machined surfaces — critical for bearing fits, sealing surfaces, mating flanges, and precision assemblies where surface texture affects function and sealing performance.

HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)

81. Correct Answer: C — Large Quantity Generator (LQG)

A facility generating exactly 2,200 lbs (1,000 kg) of hazardous waste in a calendar month meets the threshold for Large Quantity Generator status. LQGs have the strictest RCRA requirements — 90-day accumulation limit, biennial reporting, and more stringent training and emergency planning requirements.

82. Correct Answer: A — Oxidizing hazard

The GHS pictogram showing a flame over a circle (oxidizer symbol) represents oxidizing hazards — chemicals that can cause or intensify fire by providing oxygen. A plain flame symbol represents flammable materials; an exploding bomb represents explosive hazards; a corrosion symbol represents corrosive materials.

83. Correct Answer: B — Toxicological information including routes of exposure and health effects

SDS Section 11 — Toxicological Information — describes the health effects of exposure including routes of entry (inhalation, ingestion, skin/eye contact), acute and chronic toxicity data, carcinogenicity, reproductive hazards, and target organ effects.

84. Correct Answer: C — Lead-based paint hazards in pre-1960 residential buildings

NYC Local Law 63 (and the broader Local Law 1) requires building owners to audit, remediate, and maintain records for lead-based paint hazards in residential dwellings built before 1960 where children under six years old reside — addressing the primary childhood lead exposure pathway.

85. Correct Answer: D — Communicate chemical hazard information to workers and emergency responders

The primary purpose of the Safety Data Sheet is to provide comprehensive hazard information — physical, health, environmental, and emergency response data — to workers handling the chemical, supervisors, and emergency responders who may encounter it during an incident.

86. Correct Answer: C — CERCLA

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) — commonly known as Superfund — established the federal program for cleaning up abandoned hazardous waste sites, created the National Priorities List, and established strict liability for responsible parties. RCRA governs ongoing waste management; TSCA governs chemical substances.

87. Correct Answer: C — A licensed Professional Engineer (PE)

EPA's SPCC rule (40 CFR Part 112) requires that SPCC plans for facilities above the threshold quantities be prepared and certified by a licensed Professional Engineer, who certifies that the plan meets all regulatory requirements and is appropriate for the facility's design and operations.

88. Correct Answer: A — An industrial wastewater discharge permit

NYC DEP's Bureau of Wastewater Treatment requires facilities that discharge industrial process wastewater, cooling water, or other non-domestic wastewater to the city's combined sewer system to obtain an industrial wastewater discharge permit and comply with pretreatment standards.

89. Correct Answer: A — 29 CFR 1910.134

OSHA's Respiratory Protection standard (29 CFR 1910.134) requires employers to establish a written respiratory protection program, provide appropriate respirators, and ensure proper medical evaluation, fit testing, and training when engineering controls cannot reduce airborne contaminants to below the permissible exposure limit.

SAFETY, LOTO, ARC FLASH, AND EMERGENCY PROCEDURES (Questions 90–100)

90. Correct Answer: C — Training and experience to identify and avoid electrical hazards

NFPA 70E defines a qualified person as one who has demonstrated skills and knowledge of electrical equipment construction and operation, and has received safety training to recognize and avoid the electrical hazards associated with the specific work to be performed. It is not defined by years of experience or licensure status alone.

91. Correct Answer: B — Available fault current, protective device clearing time, and working distance

Incident energy = f(fault current, clearing time, working distance). Higher available fault current and longer clearing times produce more incident energy; greater working distance reduces incident energy exposure. These three variables are the primary inputs to IEEE 1584 incident energy calculations.

92. Correct Answer: D — Evacuate immediately before the system discharges

Clean agent systems (FM-200, Novec 1230) discharge at concentrations that displace oxygen and can cause disorientation or loss of consciousness in an enclosed space. All personnel must evacuate immediately when the pre-discharge alarm activates — before the agent releases — and never re-enter until the space is ventilated and cleared.

93. Correct Answer: C — 4 feet

OSHA 29 CFR 1910.23 requires fall protection (guardrails, safety nets, or personal fall arrest systems) for walking-working surfaces in general industry when the elevation is 4 feet or more above a lower level. Construction standard 1926.502 requires protection at 6 feet.

94. Correct Answer: D — Significantly higher incident energy levels and increased blast pressure during arc flash

Medium and high-voltage systems (above 600V) can sustain arc flash events with incident energy levels of hundreds or thousands of cal/cm² — far exceeding anything encountered at 480V — along with massive blast pressure waves. The combination of high voltage, high available fault current, and longer clearing times creates extreme arc flash hazard.

95. Correct Answer: C — Limited approach boundary

NFPA 70E defines the limited approach boundary as the closest distance an unqualified worker may approach exposed energized conductors or circuit parts without an escort by a qualified person. Crossing this boundary requires the unqualified worker to be under the direct supervision of a qualified person with appropriate PPE.

96. Correct Answer: D — The manufacturer's operation and maintenance manual and equipment-specific energy control procedure

Before performing maintenance on unfamiliar equipment, the engineer must review the manufacturer's O&M manual to understand equipment-specific hazards, energy sources, and safe service procedures, as well as the facility's written energy control procedure for that specific equipment — ensuring all energy sources are identified and controlled.

97. Correct Answer: C — Recognize fire hazards, use a fire extinguisher, and activate the fire alarm

A fire watch person must be trained at minimum to recognize ignition hazards in the area, properly operate a portable fire extinguisher on incipient fires, and know how to activate the facility's fire alarm system. They are not required to operate building suppression systems or perform first aid beyond calling for help.

98. Correct Answer: D — Fire alarm system installation, inspection, and testing

NFPA 72 — the National Fire Alarm and Signaling Code — governs the design, installation, commissioning, inspection, testing, and maintenance of fire alarm systems. NFPA 13 covers sprinkler systems; NFPA 25 covers water-based suppression system inspection; NFPA 70E covers electrical safety in the workplace.

99. Correct Answer: B — Oxygen level, flammable gas concentration, and carbon monoxide

Welding in a confined space creates multiple simultaneous atmospheric hazards: oxygen depletion from the welding process and displacement by shielding gas, flammable gas accumulation from the work environment, and carbon monoxide from combustion. All three must be continuously monitored throughout the entry operation.

100. Correct Answer: B — Review hazards, protective measures, roles, and emergency procedures specific to the task

The pre-job safety briefing ensures every worker on the crew understands the specific hazards of the work to be performed, the protective measures in place (LOTO, PPE, boundaries), each person's role and responsibilities, and what to do in case of an emergency — before any work begins.