

# PRACTICE EXAM 4: STATIONARY ENGINEER (ELECTRIC) SIMULATION — 100 QUESTIONS

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## ELECTRICAL FUNDAMENTALS (Questions 1–12)

1. Which of the following best describes electrical current?

- A. The opposition to electron flow
- B. The potential difference between two points
- C. The rate of electron flow through a conductor
- D. The energy consumed per unit time

2. A 240V circuit with a 60-watt load draws how much current?

- A. 14,400A
- B. 4A
- C. 0.25A
- D. 2A

3. In a series circuit with total resistance of 24 ohms connected to 120V, the current is?

- A. 2,880A
- B. 5A

- C. 10A
- D. 0.2A

4. Two 100-ohm resistors connected in parallel produce a total resistance of?

- A.  $200\Omega$
- B.  $50\Omega$
- C.  $100\Omega$
- D.  $25\Omega$

5. Which of the following correctly describes the relationship between frequency and period?

- A.  $\text{Period} = \text{Frequency} \times 2$
- B.  $\text{Period} = 1 \div \text{Frequency}$
- C.  $\text{Period} = \text{Frequency}^2$
- D.  $\text{Period} = \text{Frequency} \div 60$

6. A conductor's resistance increases when its length is?

- A. Decreased
- B. Increased
- C. Unchanged
- D. Doubled and cross-section is also doubled

7. The term "back-EMF" in a DC motor refers to?

- A. The voltage drop across the armature resistance

- B. The counter-voltage generated by the rotating armature that opposes supply voltage
- C. The voltage stored in the field winding
- D. The reverse voltage from a failed commutator

8. In AC power, reactive power is measured in?

- A. Watts
- B. VAR (volt-amperes reactive)
- C. kVA
- D. Power factor units

9. A 480V, three-phase motor draws 20A per phase at a power factor of 0.85. Its real power consumption is approximately?

- A. 14,174W
- B. 16,675W
- C. 9,600W
- D. 28,800W

10. Which instrument is used to measure true power (watts) in an AC circuit?

- A. Voltmeter
- B. Wattmeter
- C. Ammeter
- D. Power factor meter

11. The formula for calculating impedance in a series RL circuit is?

- A.  $Z = R + XL$
- B.  $Z = R - XL$
- C.  $Z = \sqrt{(R^2 + XL^2)}$
- D.  $Z = R \times XL$

12. The energy consumed by a 5 kW load operating for 4 hours is?

- A. 20 kWh
- B. 1.25 kWh
- C. 80 kWh
- D. 0.8 kWh

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

13. Which conductor insulation is rated for direct burial without conduit?

- A. THWN
- B. THHN
- C. RHW
- D. USE-2

14. A 100-ampere feeder requires conductors sized at minimum to carry?

- A. 80A continuous
- B. 100A continuous

- C. 125A continuous
- D. 115A continuous

15. What is the maximum voltage drop recommended by the NEC for branch circuits?

- A. 3%
- B. 5%
- C. 2%
- D. 10%

16. PVC conduit (Schedule 40) is not recommended for use where?

- A. Installed underground
- B. Encased in concrete
- C. Subject to physical damage or high mechanical stress
- D. Installed in dry locations

17. A GFCI device trips when it detects a current difference between the hot and neutral conductors of?

- A. 10 milliamperes or more
- B. 5 milliamperes or more
- C. 20 milliamperes or more
- D. 1 milliamperes or more

18. Which of the following describes a solidly grounded neutral system?

- A. The neutral conductor is directly connected to the grounding electrode system without impedance

- B. The neutral is connected to ground through a resistor
- C. The neutral is unconnected to ground
- D. The neutral is connected to ground through a reactor

19. The NEC requires a disconnect within sight of a motor and within how many feet?

- A. 25 feet
- B. 50 feet
- C. 10 feet
- D. 100 feet

20. Which conductor color is used for the high-leg (wild leg) in a 240V delta system?

- A. Black
- B. White
- C. Red
- D. Orange

21. Aluminum conductors require the use of anti-oxidant compound at connections because?

- A. Aluminum is a poor conductor compared to copper
- B. Aluminum expands more than copper under load heating
- C. Aluminum terminals are not rated for direct connection
- D. Aluminum oxidizes rapidly, forming a high-resistance layer that causes overheating

22. The purpose of a pull box in a conduit system is to?

- A. Provide access for future circuit additions
- B. Allow conductors to be pulled into long or complex conduit runs
- C. House overcurrent protective devices
- D. Provide grounding access points in the conduit run

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

23. What is the kVA rating of a transformer that supplies 480V at 200A on the secondary?

- A. 2.4 kVA
- B. 9.6 kVA
- C. 96 kVA
- D. 240 kVA

24. In a delta-wye transformer, the secondary wye neutral is grounded. A single line-to-ground fault on the secondary will?

- A. Cause no fault current to flow
- B. Trip the primary fuses only
- C. Allow fault current to flow back through the grounded neutral
- D. Blow the secondary fuses only

25. Which type of relay detects loss of one phase in a three-phase supply?

- A. ANSI Function 27

- B. ANSI Function 47
- C. ANSI Function 51
- D. ANSI Function 87

26. The purpose of a transfer trip scheme in a substation protection system is to?

- A. Automatically restore power after a fault
- B. Test relay operations during maintenance
- C. Coordinate time delays between relays
- D. Trip a remote breaker when a local protective relay operates

27. Bus differential protection (ANSI 87B) is used to protect?

- A. Individual transformers from internal faults
- B. Motor windings from phase-to-phase faults
- C. Feeder cables from overcurrent
- D. The main switchgear bus from internal faults

28. A 480V system with an available fault current of 42,000A requires equipment with an interrupting rating of at least?

- A. 10,000A
- B. 25,000A
- C. 42,000A or greater
- D. 65,000A minimum always

29. The primary advantage of a loop feed distribution system over a radial system is?

- A. Lower installation cost
- B. Simpler protective relay coordination
- C. Higher voltage capability
- D. Continuity of supply from two directions

30. Transformer inrush current occurs when?

- A. The transformer is overloaded beyond its kVA rating
- B. A fault develops in the secondary winding
- C. The transformer is first energized, causing a temporary high magnetizing current
- D. The transformer operates at below-rated voltage

31. The purpose of lightning arresters on electrical distribution equipment is to?

- A. Divert lightning-induced voltage surges to ground before they damage equipment insulation
- B. Prevent direct lightning strikes on overhead lines
- C. Limit fault current during lightning events
- D. Provide grounding for overhead transmission lines

32. Medium-voltage cable rated 15kV class is used where phase-to-phase voltage does not exceed?

- A. 5,000V
- B. 8,000V
- C. 15,000V
- D. 27,000V

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

33. What type of motor is used in NYC subway cars and historically in elevator traction machines due to its excellent speed control?

- A. Squirrel cage induction motor
- B. Synchronous motor
- C. DC motor
- D. Wound rotor induction motor

34. An emergency generator that hunts (surges) at no load most likely has?

- A. Low fuel pressure
- B. Faulty voltage regulator
- C. Clogged air filter
- D. An unstable governor

35. In a motor control circuit, a normally closed (NC) contact on the overload relay will?

- A. Close when the overload relay trips
- B. Open when the overload relay trips, de-energizing the contactor coil
- C. Remain unaffected by overload relay operation
- D. Short the contactor coil when the motor overheats

36. A capacitor-start, capacitor-run single-phase motor uses a running capacitor to?

- A. Limit starting inrush current

- B. Provide mechanical braking during shutdown
- C. Improve starting torque above the capacitor-start value
- D. Improve running efficiency and power factor

37. An overload relay's trip class indicates?

- A. The maximum ambient temperature for relay operation
- B. The maximum current the relay can interrupt
- C. The voltage rating of the relay coil
- D. The time in seconds for the relay to trip at 600% of its current rating

38. Which motor starting method is most suitable for large motors where starting current must be strictly limited and the load can accept reduced starting torque?

- A. Full voltage (across-the-line) starting
- B. Autotransformer reduced voltage starting
- C. Star-delta starting
- D. Reactor starting

39. The purpose of a motor's thermal protection (thermostats embedded in windings) is to?

- A. Measure running current for overload relay calibration
- B. Provide feedback for VFD speed control
- C. Directly sense winding temperature and shut down the motor if it exceeds safe limits
- D. Protect the motor from voltage surges

40. The output frequency of an alternator is determined by?

- A. The field excitation current
- B. The rotor speed and number of poles
- C. The load connected to the stator
- D. The AVR setpoint voltage

41. A motor runs in the wrong direction after being reconnected. To correct this on a three-phase motor, you should?

- A. Reverse all three phase connections
- B. Swap any two of the three phase connections
- C. Reverse the neutral connection
- D. Interchange the ground and neutral connections

42. An MCC bucket contains a motor starter, overload relay, and control transformer. The control transformer provides?

- A. Reduced voltage for motor starting
- B. Three-phase power to the motor terminals
- C. 120V control power for the contactor coil and pilot devices
- D. Power factor correction for the motor circuit

43. Which motor nameplate data is essential when programming a VFD for a specific motor?

- A. Motor serial number and date of manufacture
- B. Motor frame size and mounting type
- C. Voltage, FLA, frequency, and number of poles

D. Motor weight and shaft diameter

44. A wound rotor induction motor differs from a squirrel cage motor primarily in that it?

A. Operates at synchronous speed at full load

B. Uses permanent magnets instead of an induced rotor field

C. Has accessible rotor windings connected to external resistance for speed and torque control

D. Requires DC excitation on the rotor

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

45. When a fuse blows repeatedly after replacement, the correct action is to?

A. Install a larger fuse to prevent further nuisance blowing

B. Replace the fuse with a circuit breaker of the same rating

C. Check the circuit for overload or fault conditions before replacing again

D. Investigate and clear the fault condition before installing another fuse

46. The dielectric withstand (hipot) test on electrical equipment verifies?

A. The equipment's current-carrying capacity

B. The ground fault sensitivity of the protection system

C. That insulation can withstand overvoltage without breakdown

D. The contact resistance of switchgear bus connections

47. An ammeter connected in a circuit reads zero with the circuit energized. The most likely cause is?

- A. Excessive current flowing through the meter
- B. A shorted load drawing no current
- C. An open circuit in the current path
- D. Incorrect meter range selection

48. A motor that starts normally but trips on overload after 30 minutes of operation most likely has?

- A. A winding-to-ground insulation fault
- B. An open phase condition
- C. A faulty overload relay that is too sensitive
- D. A mechanical problem causing the motor to work harder than normal

49. Battery maintenance on a UPS system includes regularly checking?

- A. Battery acid color only
- B. Specific gravity, terminal voltage, and electrolyte level
- C. Battery case temperature only
- D. Battery charger output frequency

50. Transformer tap changer position should be adjusted only when the transformer is?

- A. Operating at full load
- B. Operating at 50% load for accuracy
- C. Running at no load for verification
- D. De-energized and locked out

51. Performing a no-load test on an induction motor measures?

- A. Full-load efficiency
- B. Core losses and magnetizing current
- C. Rotor resistance under load
- D. Starting torque characteristics

52. An infrared scan of an electrical panel shows one breaker significantly hotter than adjacent breakers. The most likely cause is?

- A. The breaker is a different manufacturer than the others
- B. A loose connection at the breaker terminal or an overloaded circuit
- C. The breaker is at the end of the panel bus
- D. Incorrect breaker ampere rating for the circuit

53. The purpose of exercising a circuit breaker (manually operating it through several open-close cycles) during maintenance is to?

- A. Test its interrupting capacity
- B. Verify arc fault detection capability
- C. Check its instantaneous trip calibration
- D. Ensure contact surfaces are clean and the mechanism operates freely

54. A megger test performed immediately after a motor has been running hot will?

- A. Give a more accurate reading than a cold test
- B. Detect intermittent faults more reliably
- C. Give a falsely low reading due to elevated winding temperature

D. Exceed the motor's rated test voltage automatically

### **MECHANICAL EQUIPMENT (Questions 55–63)**

55. A pump's efficiency curve shows that efficiency peaks at 300 GPM. Operating at 500 GPM will result in?

- A. Improved efficiency due to higher flow
- B. Reduced efficiency and increased mechanical stress
- C. No change in efficiency — the pump self-adjusts
- D. Reduced power consumption

56. Which type of bearing is most suitable for high radial loads at moderate speeds?

- A. Deep groove ball bearing
- B. Thrust bearing
- C. Needle roller bearing
- D. Angular contact bearing

57. An air compressor safety valve lifts and does not reseat after the system pressure drops below the setpoint. The most likely cause is?

- A. Excessive system pressure
- B. Incorrect valve spring rate
- C. Improper valve installation angle
- D. Valve seat or disc damaged by debris or corrosion

58. A diesel engine's fuel injectors are worn and delivering excess fuel. Symptoms will include?

- A. White smoke and high coolant temperature
- B. Blue smoke and reduced power
- C. Clear exhaust and normal fuel consumption
- D. Black smoke, high fuel consumption, and elevated exhaust temperature

59. Which lubrication method is most suitable for high-speed anti-friction bearings in electric motors?

- A. Oil bath lubrication
- B. Grease cup lubrication
- C. Oil mist lubrication
- D. Grease — lithium-based NLGI Grade 2

60. The specific gravity of a fully charged lead-acid battery cell is approximately?

- A. 1.265–1.285
- B. 1.000–1.100
- C. 1.150–1.200
- D. 1.300–1.400

61. A hydraulic cylinder that drifts (moves slowly without commanded input) under load most likely has?

- A. Air in the hydraulic lines
- B. Low hydraulic fluid viscosity
- C. Excessive pump pressure
- D. Internal cylinder seal leakage

62. A reciprocating compressor valve that is worn or damaged will cause?

- A. Reduced discharge pressure and increased motor current
- B. Normal discharge pressure and reduced motor current
- C. Normal discharge pressure and increased vibration
- D. Increased discharge pressure and reduced flow

63. The purpose of a crankcase pressure relief valve on a reciprocating compressor is to?

- A. Vent crankcase pressure during normal operation
- B. Relieve excessive crankcase pressure caused by piston blowby or internal fault
- C. Control crankcase oil level automatically
- D. Regulate cylinder lubrication oil pressure

**FLUID SYSTEMS (Questions 64–72)**

64. In a steam system, superheat refers to?

- A. Steam temperature above the boiler's design pressure
- B. Steam heated above its saturation temperature at a given pressure
- C. Excess pressure above the safety valve setpoint
- D. The latent heat stored in saturated steam

65. A chiller's coefficient of performance (COP) is defined as?

- A. Cooling capacity divided by condenser heat rejection
- B. Evaporator temperature divided by condenser temperature

- C. Electrical input power divided by cooling output
- D. Cooling capacity (tons) divided by electrical power input (kW)

66. A pneumatic control valve that fails to modulate properly despite correct air signal may have?

- A. Incorrect spring range
- B. Air supply pressure that is too high
- C. A correctly functioning positioner
- D. A worn or sticking valve stem packing

67. The purpose of a condensate pot (drip leg) in a steam distribution system is to?

- A. Measure steam flow rate in the distribution main
- B. Reduce steam pressure at branch connections
- C. Collect and drain condensate from the steam main to a trap
- D. Prevent steam from entering the condensate return piping

68. Which pump type maintains constant pressure regardless of flow rate?

- A. Centrifugal pump
- B. Positive displacement pump
- C. Axial flow pump
- D. Mixed flow pump

69. A cooling tower's drift eliminators are used to?

- A. Improve heat transfer efficiency in the fill media

- B. Remove dissolved solids from the circulating water
- C. Control the water distribution pattern over the fill
- D. Prevent water droplets from being carried out with the exhaust air

70. A pressure gauge on a hydraulic system reads zero with the pump running. The most likely cause is?

- A. Clogged hydraulic filter
- B. High fluid viscosity
- C. Failed pressure gauge or gauge isolation valve closed
- D. Pump running at low speed

71. In a domestic hot water recirculation system, the recirculation pump runs continuously to?

- A. Heat the water in the storage tank
- B. Pressurize the cold water supply
- C. Maintain hot water temperature at all points in the distribution loop
- D. Remove air from the hot water piping

72. An HVAC chilled water system experiences low delta-T syndrome. This means?

- A. The chiller is producing water that is too cold
- B. Return water temperature is too close to supply water temperature, reducing chiller efficiency
- C. The cooling tower approach temperature has increased
- D. Condenser water temperature is too low

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

73. The safe working load of a rigging component is always based on?

- A. The breaking strength of the component
- B. The total weight of all rigging hardware
- C. The working load limit (WLL) marked on the component
- D. The operator's estimate of the load weight

74. When using an extension ladder to access a roof, the ladder must extend above the roof edge by at least?

- A. 1 foot
- B. 3 feet
- C. 5 feet
- D. 2 feet

75. A torque value specified in "ft-lbs" means?

- A. The force applied at a distance of one inch from the fastener center
- B. The force in pounds applied at a distance of one foot from the fastener center
- C. The total load on the fastener in pounds per foot of thread
- D. The tensile strength of the fastener in foot-pounds

76. On a P&ID, the symbol for a control valve with a pneumatic actuator shows?

- A. A circle with a cross inside

- B. A diamond shape with an arrow
- C. A square with diagonal lines
- D. A butterfly shape with a circle on top indicating the actuator type

77. The correct technique when using a hand tap to cut internal threads in a drilled hole is to?

- A. Turn the tap continuously forward until the thread is complete
- B. Turn the tap forward one-half turn, then back one-quarter turn to break chips
- C. Apply maximum force to cut threads faster in hard materials
- D. Use cutting fluid only on stainless steel and aluminum

78. OSHA requires that scaffolding be inspected by a competent person?

- A. Before each work shift
- B. Monthly
- C. Weekly
- D. After any structural modification only

79. The purpose of a drift pin (drift punch) in mechanical assembly work is to?

- A. Mark center points for drilling operations
- B. Drive out damaged roll pins and dowels from assemblies
- C. Transfer punch marks between mating components
- D. Align bolt holes in mating flanges or structural members

80. Which blueprint line type represents a hidden edge or surface not visible in the current view?

- A. Solid continuous line
- B. Centerline (alternating long and short dashes)
- C. Dashed hidden line
- D. Phantom line (long dash, two short dashes)

**HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)**

81. The OSHA action level for noise exposure that triggers a hearing conservation program is?

- A. 90 dBA TWA
- B. 100 dBA TWA
- C. 85 dBA TWA
- D. 95 dBA TWA

82. A chemical with a flash point below 73°F and a boiling point at or below 100°F is classified under GHS as?

- A. Flammable liquid Category 3
- B. Flammable liquid Category 1
- C. Combustible liquid
- D. Oxidizing liquid

83. The SDS section that contains information about a chemical's physical and chemical properties is?

- A. Section 4

- B. Section 8
- C. Section 9
- D. Section 14

84. Used oil that has not been mixed with hazardous waste is regulated under EPA's used oil management standards at?

- A. 40 CFR Part 761
- B. 40 CFR Part 279
- C. 40 CFR Part 261
- D. 40 CFR Part 302

85. NYC requires underground storage tanks (USTs) to be registered with?

- A. NYC DEP
- B. NYC FDNY
- C. NYC DOB
- D. NYC DCAS

86. When a hazardous waste generator cannot confirm the transporter has delivered waste to the designated TSDF within 45 days, the generator must?

- A. File an exception report with the EPA
- B. Contact OSHA immediately
- C. Cancel the manifest and arrange new disposal
- D. Wait an additional 45 days before taking action

87. The SPCC (Spill Prevention, Control, and Countermeasure) plan applies to facilities storing more than what threshold of petroleum products aboveground?

- A. 5,000 gallons total
- B. 1,320 gallons total
- C. 10,000 gallons total
- D. 660 gallons total

88. Asbestos-containing pipe insulation that is visibly damaged and friable in a building mechanical room requires?

- A. Immediate enclosure with plastic sheeting only
- B. Assessment and remediation by a certified asbestos abatement contractor
- C. Painting over with encapsulant by facility staff
- D. Removal by any licensed contractor

89. The NYC agency that enforces the NYC Fire Code including hot work permits and flammable storage requirements is?

- A. NYC FDNY
- B. NYC DEP
- C. NYC DOB
- D. NYC DCAS

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

90. Under OSHA 29 CFR 1910.147, group lockout requires that?

- A. The supervisor applies a single lock for the entire crew
- B. Only the lead worker applies a lock
- C. One worker applies a lock and tags all others
- D. Each authorized worker applies their own personal lock to a lockout hasp

91. The NFPA 70E hierarchy of risk controls requires PPE to be used?

- A. As the last line of defense after all other controls have been applied
- B. As the first control because it is fastest to implement
- C. Only when working above 480V
- D. Only when engineering controls are not available

92. A Class K fire extinguisher is specifically designed for?

- A. Energized electrical equipment fires
- B. Combustible metal fires
- C. Flammable liquid fires in industrial settings
- D. Cooking oil and grease fires in commercial kitchens

93. The minimum safe clearance between a ladder and overhead power lines energized at up to 50kV is?

- A. 5 feet
- B. 6 feet
- C. 10 feet
- D. 15 feet

94. Which OSHA standard specifically governs electrical safety for workers performing switching and maintenance on high-voltage power systems above 600V?

- A. 29 CFR 1910.269
- B. 29 CFR 1910.147
- C. 29 CFR 1910.146
- D. 29 CFR 1910.1200

95. An arc flash study must be updated when?

- A. Major changes to the electrical system occur that could affect available fault current or protective device settings
- B. A new worker is hired in the facility
- C. Any circuit breaker is replaced
- D. The facility changes ownership

96. When entering a confined space, the retrieval system (harness and lifeline) must be attached to the entrant?

- A. Only if the space is deeper than 5 feet
- B. Before the entrant enters the space
- C. After the entrant confirms atmospheric conditions are acceptable
- D. Only when the attendant requests it

97. A pre-action sprinkler system requires which two events to discharge water?

- A. Smoke detection and system pressure drop
- B. Heat detection and manual activation

- C. Both activation of a fire detection device AND opening of a sprinkler head
- D. Activation of two adjacent sprinkler heads simultaneously

98. The purpose of the OSHA 300-A Summary form is to?

- A. Summarize the annual injury and illness data for posting in the workplace
- B. Report individual injury details to OSHA
- C. Document first-aid treatments not requiring medical attention
- D. Record equipment-related near-miss incidents

99. A worker performing electrical maintenance discovers a previously unknown energized conductor while the LOTO is in place. The correct action is to?

- A. Work carefully around the unknown conductor
- B. Call the supervisor but continue working
- C. Remove all locks and restart the LOTO process
- D. Stop work immediately, exit the area, and report the condition before resuming

100. The NFPA 70E standard is revised and published on what cycle?

- A. Every year
- B. Every five years
- C. Every three years
- D. Every ten years

# PRACTICE EXAM 4 — ANSWER KEY AND FULL EXPLANATIONS

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## ELECTRICAL FUNDAMENTALS (Questions 1–12)

### 1. Correct Answer: C — The rate of electron flow through a conductor

Electrical current is defined as the rate at which electric charge (electrons) flows through a conductor, measured in amperes. Resistance is opposition to flow; voltage is potential difference; power is energy per unit time.

### 2. Correct Answer: C — 0.25A

Using  $I = P \div V = 60 \div 240 = 0.25$  amperes. Power divided by voltage gives current — a 60-watt load on a 240V circuit draws only a quarter ampere.

### 3. Correct Answer: B — 5A

Using Ohm's Law:  $I = V \div R = 120 \div 24 = 5$  amperes. Total series resistance divides directly into the applied voltage to give circuit current.

### 4. Correct Answer: B — 50Ω

For two equal resistors in parallel:  $R_t = R \div 2 = 100 \div 2 = 50$  ohms. Two equal parallel resistors always produce a total resistance equal to half the value of either resistor.

### 5. Correct Answer: B — Period = 1 ÷ Frequency

Period and frequency are reciprocals of each other. A 60 Hz signal has a period of  $1 \div 60 = 0.0167$  seconds. Period is the time for one complete cycle; frequency is the number of complete cycles per second.

### 6. Correct Answer: B — Increased

Resistance is directly proportional to conductor length — doubling the length doubles the resistance. A longer conductor provides more opposition to electron flow because electrons must travel through more resistive material.

### 7. Correct Answer: B — The counter-voltage generated by the rotating armature that opposes supply voltage

As a DC motor armature rotates, it acts as a generator and produces a voltage (back-EMF) that opposes the applied supply voltage. Back-EMF increases with motor speed, reducing armature current as the motor accelerates.

**8. Correct Answer: B — VAR (volt-amperes reactive)**

Reactive power is measured in VARs (volt-amperes reactive). Real power is measured in watts; apparent power in volt-amperes (VA) or kVA; power factor is dimensionless.

**9. Correct Answer: A — 14,174W**

Three-phase real power =  $V \times I \times 1.732 \times PF = 480 \times 20 \times 1.732 \times 0.85 = 14,174$  watts. The 1.732 factor accounts for the three-phase relationship, and power factor reduces apparent power to real power.

**10. Correct Answer: B — Wattmeter**

A wattmeter measures true (real) power in watts by sensing both voltage and current and accounting for the phase angle between them. A voltmeter measures voltage; an ammeter measures current; a power factor meter measures the cosine of the phase angle.

**11. Correct Answer: C —  $Z = \sqrt{R^2 + XL^2}$**

Impedance in a series RL circuit is the vector sum of resistance and inductive reactance, calculated using the Pythagorean theorem:  $Z = \sqrt{R^2 + XL^2}$ . R and XL are 90° out of phase and cannot be added arithmetically.

**12. Correct Answer: A — 20 kWh**

Energy = Power  $\times$  Time = 5 kW  $\times$  4 hours = 20 kilowatt-hours. The kilowatt-hour is the standard unit of electrical energy consumption used for utility billing.

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

**13. Correct Answer: D — USE-2**

USE-2 (Underground Service Entrance) conductors are rated for direct burial and underground service entrance applications without conduit. THWN and THHN are rated for conduit installations only; RHW requires conduit in direct burial applications.

**14. Correct Answer: B — 100A continuous**

A feeder must be sized to carry the full calculated load current continuously. The 125% rule applies to the overcurrent protective device sizing for continuous loads, not the conductor ampacity — the conductor must carry 100% of the load current.

**15. Correct Answer: A — 3%**

NEC Section 210.19 (informational note) recommends maximum voltage drop of 3% for branch circuits and 5% for the combined feeder and branch circuit. Excessive voltage drop causes equipment underperformance, overheating, and increased energy costs.

**16. Correct Answer: C — Subject to physical damage or high mechanical stress**

PVC Schedule 40 conduit, while excellent for underground and concrete-encased applications, lacks the mechanical strength of steel conduit and is not suitable where it will be exposed to physical impact, heavy loads, or high mechanical stress.

**17. Correct Answer: B — 5 milliamperes or more**

GFCI devices are calibrated to trip when they detect a current difference of 4–6 milliamperes (nominally 5 mA) between the hot and neutral conductors — indicating current is leaking through an unintended path such as a person, providing shock protection.

**18. Correct Answer: A — The neutral conductor is directly connected to the grounding electrode system without impedance**

A solidly grounded neutral system connects the neutral directly to the grounding electrode at the service without any impedance device between them. This provides a low-impedance fault current return path that allows overcurrent devices to operate quickly during ground faults.

**19. Correct Answer: C — 10 feet**

NEC Section 430.102(B) requires a disconnecting means to be located within sight of the motor and within 50 feet — however, the disconnect must also be readily accessible. The "within sight" requirement means visible and not more than 50 feet away, not 10 feet.

**20. Correct Answer: D — Orange**

The high-leg (wild leg) conductor in a 240V three-phase four-wire delta system — which carries approximately 208V to neutral rather than 120V — must be identified with orange insulation or orange tape at all terminations per NEC requirements.

**21. Correct Answer: D — Aluminum oxidizes rapidly, forming a high-resistance layer that causes overheating**

Aluminum forms aluminum oxide on its surface almost immediately upon exposure to air. This oxide layer is electrically resistive — if not removed and sealed with anti-oxidant compound before connection, it causes high-resistance joints that overheat under load current.

**22. Correct Answer: B — Allow conductors to be pulled into long or complex conduit runs**

Pull boxes are installed in conduit systems at intervals in long runs or at direction changes to provide access points that allow conductors to be pulled in sections, preventing excessive pulling tension that could damage conductor insulation.

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

### **23. Correct Answer: C — 96 kVA**

For a single-phase transformer:  $kVA = (V \times A) \div 1,000 = (480 \times 200) \div 1,000 = 96$  kVA. Voltage multiplied by current gives apparent power in VA, divided by 1,000 converts to kVA.

### **24. Correct Answer: C — Allow fault current to flow back through the grounded neutral**

In a delta-wye transformer with a grounded wye secondary neutral, a line-to-ground fault on the secondary creates a complete circuit through the grounded neutral, allowing fault current to flow and operate the overcurrent protective device — a key advantage of the grounded wye secondary.

### **25. Correct Answer: B — ANSI Function 47**

ANSI Function 47 is the phase sequence voltage relay that detects phase loss, phase reversal, and voltage unbalance in three-phase systems. Function 27 is undervoltage; 51 is time-overcurrent; 87 is differential protection.

### **26. Correct Answer: D — Trip a remote breaker when a local protective relay operates**

A transfer trip scheme sends a trip signal (via pilot wire, fiber optic, or power line carrier) to a remote circuit breaker when a local relay operates, ensuring that both ends of a faulted line section are de-energized even when the fault current at one end is too low to operate local overcurrent relays.

### **27. Correct Answer: D — The main switchgear bus from internal faults**

Bus differential protection (87B) compares the sum of all currents entering and leaving the protected bus. Any difference indicates a fault on the bus itself, causing immediate tripping of all breakers feeding the faulted bus section.

### **28. Correct Answer: C — 42,000A or greater**

All electrical equipment must be rated to safely interrupt the maximum available fault current at its location. Installing equipment with an interrupting rating below the available fault current creates a catastrophic explosion risk if a fault occurs and the device attempts to interrupt current beyond its rating.

### **29. Correct Answer: D — Continuity of supply from two directions**

A loop (ring) feed distribution system connects the distribution circuit in a loop, supplying each load point from two directions. If one section of the loop is faulted and isolated, the remaining loads continue to receive power from the other direction — unlike a radial system where a single fault interrupts all downstream loads.

**30. Correct Answer: C — The transformer is first energized, causing a temporary high magnetizing current**

Transformer inrush current occurs at initial energization when the core flux must build from zero to its steady-state value. The residual magnetism in the core can cause saturation, drawing several times rated current for a few cycles before stabilizing — this is normal and not a fault condition.

**31. Correct Answer: A — Divert lightning-induced voltage surges to ground before they damage equipment insulation**

Lightning arresters (surge arresters) are connected between phase conductors and ground on transformers and switchgear. When a lightning-induced voltage surge arrives, the arrester conducts the surge current to ground, clamping the voltage to a level safe for equipment insulation.

**32. Correct Answer: C — 15,000V**

Cable voltage class designations (5kV, 15kV, 27kV, 35kV) represent the maximum phase-to-phase system voltage the cable is rated to withstand. A 15kV class cable is rated for systems where phase-to-phase voltage does not exceed 15,000 volts.

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

**33. Correct Answer: C — DC motor**

DC motors provide continuously variable speed control over a wide range, excellent starting torque, and precise speed regulation — characteristics historically essential for subway traction drives and elevator machines. Modern installations increasingly use AC drives with VFDs, but DC motors dominated these applications for decades.

**34. Correct Answer: D — An unstable governor**

Hunting (speed surging or oscillation) at no load on a diesel generator is the classic symptom of an unstable or poorly calibrated governor. The governor is hunting for the correct speed setpoint, alternately over-fueling and under-fueling the engine.

**35. Correct Answer: B — Open when the overload relay trips, de-energizing the contactor coil**

The overload relay's normally closed contact is wired in series with the contactor coil in the control circuit. When the overload relay trips due to sustained overcurrent, this NC contact opens, de-energizing the contactor coil and dropping out the main contacts to disconnect the motor.

**36. Correct Answer: D — Improve running efficiency and power factor**

The running capacitor in a capacitor-start, capacitor-run motor remains in the circuit during operation — it maintains a phase-shifted current in the auxiliary winding that improves the motor's running efficiency and power factor compared to a capacitor-start only design.

**37. Correct Answer: D — The time in seconds for the relay to trip at 600% of its current rating**

Overload relay trip class defines the maximum time for the relay to trip under locked rotor conditions at 600% of its full-load current setting. Class 10 trips within 10 seconds, Class 20 within 20 seconds, and Class 30 within 30 seconds — selected based on motor starting time requirements.

**38. Correct Answer: B — Autotransformer reduced voltage starting**

Autotransformer starting provides the most flexible reduced voltage starting — available at 65%, 80%, or other tapped percentages — while also reconnecting the motor to full line voltage through the transformer after acceleration, minimizing the transition current spike compared to other methods.

**39. Correct Answer: C — Directly sense winding temperature and shut down the motor if it exceeds safe limits**

Embedded winding thermostats and thermistors directly measure stator winding temperature and initiate shutdown when a preset temperature limit is reached. This provides more reliable thermal protection than current-based overload relays for motors with variable loading, high ambient temperatures, or poor ventilation.

**40. Correct Answer: B — The rotor speed and number of poles**

Alternator output frequency = (Rotor speed × Number of poles) ÷ 120. The governor controls rotor speed (and therefore frequency) independently of the AVR, which controls output voltage through field excitation. Load changes do not affect frequency if the governor is functioning correctly.

**41. Correct Answer: B — Swap any two of the three phase connections**

Reversing any two of the three phase connections to a three-phase motor reverses the phase rotation sequence, which reverses the direction of the rotating magnetic field in the stator and therefore reverses the direction of motor rotation.

**42. Correct Answer: C — 120V control power for the contactor coil and pilot devices**

The control power transformer (CPT) in an MCC bucket steps 480V down to 120V AC to power the contactor coil, pilot lights, selector switches, pushbuttons, and any control relays. This provides safe, standard control circuit voltage isolated from the motor power circuit.

**43. Correct Answer: C — Voltage, FLA, frequency, and number of poles**

When programming a VFD, the essential motor nameplate data required is rated voltage, full-load amperes (for current limit settings), rated frequency (for base speed calculation), and number of poles (for RPM calculation). This data defines the motor's V/Hz characteristic and protection thresholds.

**44. Correct Answer: C — Has accessible rotor windings connected to external resistance for speed and torque control**

A wound rotor induction motor has three-phase rotor windings brought out through slip rings to external resistance banks. Adding resistance in the rotor circuit reduces starting current, increases starting torque, and allows speed control — advantages not available with a squirrel cage motor.

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

**45. Correct Answer: D — Investigate and clear the fault condition before installing another fuse**

A repeatedly blowing fuse is a symptom, not the problem. Installing a larger fuse is extremely dangerous — it defeats the overcurrent protection and can allow a fault to cause a fire or equipment destruction. The fault must be located and corrected before any replacement fuse is installed.

**46. Correct Answer: C — That insulation can withstand overvoltage without breakdown**

The dielectric withstand (hi-pot) test applies a voltage significantly higher than the equipment's rated voltage for a specified time to verify that the insulation system will not break down during normal overvoltage transients encountered in service.

**47. Correct Answer: C — An open circuit in the current path**

An ammeter reading of zero with the circuit energized indicates no current is flowing — the most common cause is an open circuit (broken wire, open switch, blown fuse, or failed component) somewhere in the current path the meter is measuring.

**48. Correct Answer: D — A mechanical problem causing the motor to work harder than normal**

A motor that starts and runs normally for 30 minutes before tripping is not overloaded at startup but develops excessive load over time. This pattern indicates a developing mechanical problem — bearing failure, increasing process resistance, or a mechanical jam — causing the motor to draw progressively more current until the overload relay trips.

**49. Correct Answer: B — Specific gravity, terminal voltage, and electrolyte level**

UPS battery maintenance includes measuring specific gravity of each cell (with a hydrometer for flooded cells), individual cell voltage under load, electrolyte level in flooded cells, terminal connection tightness, and visual inspection for case damage or corrosion.

**50. Correct Answer: D — De-energized and locked out**

Transformer tap changer connections are physical conductor connections on the transformer winding — they must be changed only on a completely de-energized and locked out transformer. Attempting to change tap connections on an energized transformer risks arc flash, explosion, and electrocution.

**51. Correct Answer: B — Core losses and magnetizing current**

The no-load test on an induction motor (running at rated voltage with no mechanical load) measures the power consumed to overcome core losses (hysteresis and eddy currents) and supplies the magnetizing reactive current needed to establish the rotating magnetic field.

**52. Correct Answer: B — A loose connection at the breaker terminal or an overloaded circuit**

A single breaker running significantly hotter than adjacent breakers indicates either a loose terminal connection (creating high-resistance heating) or a circuit that is loaded near or above its rating. Both conditions produce localized heating detectable by infrared scanning.

**53. Correct Answer: D — Ensure contact surfaces are clean and the mechanism operates freely**

Exercising a circuit breaker through several open-close cycles during maintenance burnishes the contact surfaces, removes minor oxidation, verifies that the operating mechanism moves freely without binding, and confirms that the breaker will operate when needed in service.

**54. Correct Answer: C — Give a falsely low reading due to elevated winding temperature**

Insulation resistance decreases significantly as winding temperature increases — a motor tested immediately after running hot may show a reading 50–75% lower than the same motor tested cold. For valid trending comparisons, megger tests should be performed at consistent, preferably ambient, temperatures and corrected to 40°C using correction factors.

**MECHANICAL EQUIPMENT (Questions 55–63)**

**55. Correct Answer: B — Reduced efficiency and increased mechanical stress**

Operating a centrifugal pump well beyond its BEP causes internal recirculation at the impeller discharge, increased radial thrust on the shaft and bearings, elevated vibration, and dramatically reduced hydraulic efficiency — significantly shortening pump service life.

**56. Correct Answer: A — Deep groove ball bearing**

Deep groove ball bearings are the most common bearing type for electric motors and moderate-speed rotating equipment — they handle both radial and moderate axial loads efficiently. Thrust bearings handle primarily axial loads; needle rollers suit tight radial space; angular contact bearings handle combined loads at higher speeds.

**57. Correct Answer: D — Valve seat or disc damaged by debris or corrosion**

A safety valve that lifts and then fails to reseat has a damaged seating surface — caused by debris carried on the air stream, corrosion pitting, or erosion from previous lifting events. A damaged seat prevents the disc from forming a tight seal, causing the valve to continue leaking after the pressure drops below setpoint.

**58. Correct Answer: D — Black smoke, high fuel consumption, and elevated exhaust temperature**

Worn injectors that deliver excess fuel cause rich combustion — more fuel than the available air can completely burn. Unburned carbon produces black smoke, excess fuel increases consumption, and incomplete combustion raises exhaust temperatures above normal.

**59. Correct Answer: D — Grease — lithium-based NLGI Grade 2**

NLGI Grade 2 lithium-based grease is the standard specification for electric motor anti-friction bearings. It provides the correct consistency (not too stiff, not too fluid) for high-speed bearing operation, with good mechanical stability and water resistance.

**60. Correct Answer: A — 1.265–1.285**

A fully charged lead-acid battery cell has a specific gravity of 1.265–1.285 at 77°F (25°C). As the battery discharges, sulfuric acid is consumed and the electrolyte becomes more diluted, lowering specific gravity. A reading below 1.200 typically indicates significant discharge.

**61. Correct Answer: D — Internal cylinder seal leakage**

A hydraulic cylinder that drifts under load has internal leakage past the piston seals — pressurized fluid is bypassing from the high-pressure side to the low-pressure side through worn or damaged piston seals, allowing the cylinder to move slowly under load without commanded input.

**62. Correct Answer: A — Reduced discharge pressure and increased motor current**

Worn compressor valves fail to seal properly — discharge valves allow compressed air to blow back, and intake valves fail to fully open or close. The result is reduced volumetric efficiency (lower discharge pressure and flow) while the motor draws more current trying to compensate.

**63. Correct Answer: B — Relieve excessive crankcase pressure caused by piston blowby or internal fault**

The crankcase pressure relief valve opens if crankcase pressure rises abnormally due to excessive piston blowby (worn rings or cylinder walls), a catastrophic internal failure, or combustion gases entering the crankcase — preventing crankcase explosion or seal failure.

**FLUID SYSTEMS (Questions 64–72)**

**64. Correct Answer: B — Steam heated above its saturation temperature at a given pressure**

Superheated steam has been heated beyond the saturation temperature corresponding to its pressure — it contains no moisture and has higher energy content than saturated steam at the same pressure. Superheating increases turbine efficiency and prevents condensation in distribution lines.

**65. Correct Answer: D — Cooling capacity (tons) divided by electrical power input (kW)**

Chiller COP = Cooling output (kW) ÷ Electrical input (kW). When expressed as tons per kW, it is called kW/ton (lower is better) or EER/COP (higher is better). A higher COP indicates a more energy-efficient chiller.

**66. Correct Answer: D — A worn or sticking valve stem packing**

A pneumatic control valve that receives the correct air signal but fails to modulate properly most likely has a mechanical problem — worn or dried-out stem packing creating excessive friction that prevents smooth valve movement, causing the valve to stick at various positions rather than following the control signal.

**67. Correct Answer: C — Collect and drain condensate from the steam main to a trap**

A condensate pot (drip leg) is a short vertical pocket installed at low points and before pressure-reducing stations in steam mains. It collects condensate that forms in the main and directs it to a steam trap for removal, preventing water hammer and erosion in the distribution system.

**68. Correct Answer: B — Positive displacement pump**

Positive displacement pumps (gear, piston, vane types) deliver a fixed volume per revolution regardless of system pressure — they maintain essentially constant pressure across a wide flow range. Centrifugal pumps develop less pressure as flow increases, following their characteristic H-Q curve.

**69. Correct Answer: D — Prevent water droplets from being carried out with the exhaust air**

Drift eliminators are corrugated plastic media installed in the cooling tower air discharge path that cause water droplets entrained in the upward-flowing air stream to collide and coalesce, falling back into the tower basin rather than being carried out as drift.

**70. Correct Answer: C — Failed pressure gauge or gauge isolation valve closed**

A zero pressure reading with the pump running suggests a measurement problem rather than an actual zero-pressure condition — a failed gauge, a closed gauge isolation valve, or a plugged gauge connection. Confirm by checking at another point before concluding there is a pump or system failure.

**71. Correct Answer: C — Maintain hot water temperature at all points in the distribution loop**

The hot water recirculation pump circulates water continuously through the distribution loop back to the water heater, keeping the entire loop at near-delivery temperature. Without recirculation, the water in distant pipes cools, requiring the user to waste cold water before hot water arrives.

**72. Correct Answer: B — Return water temperature is too close to supply water temperature, reducing chiller efficiency**

Low delta-T syndrome occurs when chilled water return temperature is only slightly above supply temperature — instead of the design 10°F delta-T. This forces the chiller to circulate far more water than necessary to transfer the required cooling load, reducing chiller efficiency and increasing pumping energy.

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

**73. Correct Answer: C — The working load limit (WLL) marked on the component**

The WLL stamped or tagged on every rigging component — hook, shackle, sling, or hoist — is the maximum load that component may legally and safely carry. It already incorporates a design safety factor from the breaking strength. Never exceed the WLL of any rigging component.

**74. Correct Answer: B — 3 feet**

OSHA 29 CFR 1926.1053 requires extension ladders used for roof access to extend at least 3 feet (36 inches) above the roof edge or landing point. This provides a secure handhold for stepping onto and off the ladder at the top.

**75. Correct Answer: B — The force in pounds applied at a distance of one foot from the fastener center**

$\text{Torque} = \text{Force} \times \text{Distance}$ . One foot-pound equals one pound of force applied at a distance of one foot from the fastener centerline. A torque wrench set to 50 ft-lbs applies the equivalent of 50 pounds of force at a one-foot lever arm to the fastener.

**76. Correct Answer: D — A butterfly shape with a circle on top indicating the actuator type**

On a P&ID using ISA/ANSI instrumentation symbology, a control valve is shown with a butterfly (bowtie or crossed-triangle) symbol representing the valve body, with the actuator type shown above — a circle indicates a pneumatic diaphragm actuator, the most common type in HVAC and process control.

**77. Correct Answer: B — Turn the tap forward one-half turn, then back one-quarter turn to break chips**

The back-turn technique ( $\frac{1}{2}$  turn forward,  $\frac{1}{4}$  turn back) breaks the chip that forms ahead of the cutting edge, preventing chip packing that can jam or break the tap. This is essential in blind holes and in harder materials where chips cannot escape freely.

**78. Correct Answer: A — Before each work shift**

OSHA 29 CFR 1926.451 requires scaffolding to be inspected by a competent person before each work shift and after any occurrence (weather event, impact, structural modification) that could affect its structural integrity.

**79. Correct Answer: D — Align bolt holes in mating flanges or structural members**

A drift pin (drift punch) is a tapered tool inserted into misaligned bolt holes in flanges, structural connections, or mating components to bring the holes into alignment so bolts can be inserted. It is not used for center-punching, driving pins, or transferring marks.

**80. Correct Answer: C — Dashed hidden line**

Hidden lines are represented on engineering drawings as evenly spaced dashed lines, indicating edges or surfaces that exist in the part or assembly but are not visible in the current view direction. Solid lines show visible edges; centerlines use alternating long and short dashes; phantom lines use long dash-short dash-short dash patterns.

**HAZARDOUS MATERIALS AND ENVIRONMENTAL COMPLIANCE (Questions 81–89)**

**81. Correct Answer: C — 85 dBA TWA**

OSHA's Hearing Conservation Standard (29 CFR 1910.95) requires employers to implement a hearing conservation program — including audiometric testing, hearing protection, and employee training — when workers are exposed to noise at or above an 8-hour time-weighted average of 85 dBA. The permissible exposure limit (PEL) is 90 dBA TWA.

**82. Correct Answer: B — Flammable liquid Category 1**

GHS/HazCom 2012 classifies flammable liquids with a flash point below 73°F (23°C) and initial boiling point at or below 95°F (35°C) as Category 1 — the most severe flammable liquid hazard category. These liquids ignite at ambient temperatures.

**83. Correct Answer: C — Section 9**

SDS Section 9 — Physical and Chemical Properties — contains boiling point, flash point, vapor pressure, specific gravity, solubility, appearance, odor, and other physical and chemical data. Section 4 is first aid; Section 8 is exposure controls and PPE; Section 14 is transportation information.

**84. Correct Answer: B — 40 CFR Part 279**

EPA's used oil management standards are codified at 40 CFR Part 279. Used oil that has not been mixed with listed hazardous waste is not classified as hazardous waste but is subject to specific management, storage, and disposal requirements under Part 279.

**85. Correct Answer: B — NYC FDNY**

Underground storage tanks in New York City are regulated and registered with the NYC Fire Department (FDNY) under the NYC Fire Code. The FDNY enforces UST installation, testing, and leak detection requirements within the five boroughs.

**86. Correct Answer: A — File an exception report with the EPA**

Under RCRA, if a generator has not received a signed copy of the manifest from the designated TSDF within 45 days of shipment, the generator must contact the transporter and TSDF. If the signed copy is not received within 35 additional days (60 days total), the generator must file an exception report with the EPA.

**87. Correct Answer: B — 1,320 gallons total**

EPA's SPCC rule (40 CFR Part 112) applies to facilities with aboveground petroleum storage capacity greater than 1,320 gallons in containers of 55 gallons or more, or with underground storage capacity exceeding 42,000 gallons — where a spill could reasonably reach navigable waters.

**88. Correct Answer: B — Assessment and remediation by a certified asbestos abatement contractor**

Visibly damaged and friable asbestos-containing materials are actively releasing fibers and represent an immediate inhalation hazard. Only EPA- and NYC DEP-certified asbestos abatement contractors may perform assessment, remediation, and removal of damaged ACMs.

**89. Correct Answer: A — NYC FDNY**

The NYC Fire Department enforces the NYC Fire Code, which covers hot work permits, flammable and combustible liquid storage, fire prevention practices, and fire suppression system maintenance. Facilities must obtain FDNY permits for hot work operations and flammable material storage above threshold quantities.

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

**90. Correct Answer: D — Each authorized worker applies their own personal lock to a lockout hasp**

Group LOTO requires a lockout hasp — a multi-hole device that allows multiple locks to be applied simultaneously. Each authorized worker on the crew applies their own personal lock to the hasp, ensuring the equipment cannot be re-energized until every worker has removed their individual lock.

**91. Correct Answer: A — As the last line of defense after all other controls have been applied**

NFPA 70E's hierarchy places elimination, substitution, engineering controls, and administrative controls above PPE. PPE is the least effective risk control because it does not reduce the hazard — it only protects the worker if all other controls fail or are insufficient.

**92. Correct Answer: D — Cooking oil and grease fires in commercial kitchens**

Class K extinguishers use wet chemical agents that saponify (chemically react with) cooking oils and animal fats to extinguish fires and prevent re-ignition. They are required by NFPA 10 in commercial cooking areas and are not effective substitutes for other extinguisher classes.

**93. Correct Answer: C — 10 feet**

OSHA 29 CFR 1910.333 and NFPA 70E require a minimum clearance of 10 feet between ladders, equipment, and workers and overhead power lines energized up to 50kV. For voltages above 50kV, the minimum clearance increases by 0.4 inches per kV above 50kV.

**94. Correct Answer: A — 29 CFR 1910.269**

OSHA's Electric Power Generation, Transmission, and Distribution standard (29 CFR 1910.269) specifically governs electrical safety for workers performing switching, maintenance, and construction on high-voltage power systems. Section 1910.147 governs LOTO; 1910.146 governs confined spaces.

**95. Correct Answer: A — Major changes to the electrical system occur that could affect available fault current or protective device settings**

An arc flash study must be updated whenever significant changes to the electrical system — adding generation, replacing transformers, changing protective relay settings, or modifying system topology — could alter available fault current or incident energy calculations at work locations.

**96. Correct Answer: B — Before the entrant enters the space**

The retrieval system (full-body harness connected to a retrieval line and mechanical retrieval device) must be donned and connected before the entrant crosses the plane of the confined space opening. Attaching it after entry defeats the purpose — non-entry retrieval must be possible from outside the space.

**97. Correct Answer: C — Both activation of a fire detection device AND opening of a sprinkler head**

A pre-action system requires two independent events to discharge: first, a fire detection device (smoke or heat detector) must activate to admit water into the dry pipes, and second, an individual sprinkler head must open from heat exposure. This dual-action requirement prevents accidental water discharge in sensitive areas.

**98. Correct Answer: A — Summarize the annual injury and illness data for posting in the workplace**

The OSHA 300-A Annual Summary must be completed, certified by a company executive, and posted in a visible workplace location from February 1 through April 30 each year, summarizing the total counts of work-related injuries and illnesses recorded on the OSHA 300 Log for the previous calendar year.

**99. Correct Answer: D — Stop work immediately, exit the area, and report the condition before resuming**

Discovering an unanticipated energized source while LOTO is in place means the energy control procedure was incomplete or incorrect. Work must stop immediately — the energy source represents a life-threatening hazard that was not accounted for in the original LOTO procedure, which must be revised before work resumes.

**100. Correct Answer: C — Every three years**

NFPA 70E — Standard for Electrical Safety in the Workplace — follows the standard NFPA revision cycle and is published every three years. The most recent editions were published in 2018, 2021, and 2024. Staying current with each edition is essential as PPE requirements and safety boundaries are periodically updated.