The following questions are excerpts from the NABCEP Study Guide For Photovoltaic System Installers

Working Safely with PV Systems

1. A fall protection system must be in place for all work done at heights in excess of
   a. 4 feet
   b. 6 feet
   c. 8 feet
   d. 10 feet
23. Temporarily shorting the output terminals of a PV module will
a. destroy the module if the short is not immediately cleared
b. have no effect on the module
c. destroy the insulation on the module wiring if the short is not immediately cleared
d. cause damage only if the module is connected in series with other modules

24. If the open circuit voltage of a crystalline silicon PV array is 315 V at 25°C, then, according to the NEC, if the array is operated at -20°C, maximum system voltage must be corrected to
a. 267 V
b. 315 V
c. 372 V
d. 378 V
Working Safely with PV Systems

26. If the maximum power voltage of a crystalline silicon PV module is 17.1 V at STC, then at 60°C (module temperature) and 1000 W/m² incident on the module, the maximum power voltage of the module will be closest to

a. 20.1 V  
b. 17.1 V  
c. 14.1 V  
d. 12.0 V

Conducting a Site Assessment
30. Using the sun path chart of Figure 5 in the this Guide, assuming that if the altitude is less than 30° when the azimuth is 45°, the months of the year when the array will be shaded at any time between 9 a.m. and 3 p.m. include

a. None
b. November, December and January
c. September through March
d. April through August
31. Suppose a PV array consists of three rows of rack mounted modules facing south, as shown in the Figure. Suppose also that all rows are on a level surface and that the tops of the modules are spaced three feet higher than the bottoms. Suppose also that the array is to be used at latitude 30° N. In order to avoid any shading of modules from other modules at 12 p.m. on December 21, the spacing between rows, d, must be no less than
a. 0.24 feet  
b. 4.13 feet  
c. 6 feet  
d. 9 feet

32. Using the sun path chart of Figure 5 in this Guide, the minimum annual sun altitude between the hours of 9 a.m. and 3 p.m. sun time is closest to
a. 10°
 b. 20°
 c. 30°
 d. 45°
Conducting a Site Assessment

33. With the PV array rack mounted at ground level, which would normally be of greatest concern?
   
a. Overheating of the modules  
b. Electrical hazards from exposed (conductors) open circuit voltages  
c. Earthquake stresses on the modules  
d. Physical damage to the array and wiring
Conducting a Site Assessment

35. If a proposed PV installation site has an unobstructed south-facing roof area of 60 m$^2$, and if thin-film modules with six watts-per-square-foot power output at STC are to be installed on 50% of the roof, then the maximum available PV array output power (based on the sum of module ratings) at STC will be closest to

a. 4500 watts
b. 3600 watts
c. 2250 watts
d. 1900 watts

Selecting a System Design
Selecting a System Design

39. A PV system is to be selected for operating a PV water pumping system. The pump will require 300 W of PV modules for proper operation. A 12-Vdc model and a 48-Vdc model are available. If both pumps operate at the same power level, the resistance of the wire to the 48-V pump, compared to the resistance of the wire to the 12-V pump, assuming the same percentage voltage drop in the wiring, may be

a. 1/16th as much
b. 1/4th as much
c. 4 times as much
d. 16 times as much

Adapting the Mechanical Design
Adapting the Mechanical Design

40. Assume a roof-mounted PV array is to consist of two source circuits of four modules each. Assume the drawings are to scale and that the roof is large enough for any of the configurations shown. Which of the following configurations can be expected to result in the coolest operation of the modules?

Adapting the Electrical Design
Adapting the Electrical Design

48. If the lowest temperature of the PV modules is expected to be 10° F, then the maximum system voltage for the PV system of Figure 4 will be closest to:

a. 24.6 V  
b. 36.2 V  
c. 40.0 V  
d. 48.7 V

<table>
<thead>
<tr>
<th>Modules (Crystalline Silicon)</th>
<th>$V_{oc}$ (STC)</th>
<th>$I_{sc}$ (STC)</th>
<th>$V_{mp}$ (STC)</th>
<th>$I_{mp}$ (STC)</th>
<th>$P_{om}$ (STC)</th>
<th>Voltage Temperature Coefficient</th>
<th>Dimensions</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21.0 V</td>
<td>7.2 A</td>
<td>17.1 V</td>
<td>7.0 A</td>
<td>120 W</td>
<td>-0.5%/°C</td>
<td>68 cm x 142 cm</td>
<td>24 lb</td>
</tr>
</tbody>
</table>
Adapting the Electrical Design

57. The purpose of an inverter is to
a. convert dc at one voltage to ac at the same or another voltage
b. convert ac at one voltage to dc at the same or another voltage
c. convert dc at one voltage to dc at another voltage
d. convert ac at one voltage to dc at another voltage

Adapting the Electrical Design

59. A 2500-W inverter is used to supply a 120-V ac load of 1500 watts. This means that the ampacity of the wire at the inverter output must be at least
a. 12.5 A
b. 15.6 A
c. 20.8 A
d. 26.0 A
Adapting the Electrical Design

60. A 2500-W inverter with an input-voltage range of 22 V to 32 V has an efficiency of 88% at full output. This means the maximum inverter input current at full rating will be closest to

a. 129 A  
b. 100A  
c. 89 A  
d. 69 A

Adapting the Electrical Design

61. If the maximum ac output rating of an inverter with 120-V ac output is 1500 W, the rating of the circuit breaker at the point-of-utility connection should be

a. 15 A  
b. 20 A  
c. 25 A  
d. 30 A
Adapting the Electrical Design

62. If the inverter in a utility-interactive PV system begins to hum quietly about five (5) minutes after closing the connection to the utility, then, it is most likely
   a. working
   b. overloaded
   c. connected to a motor load on the utility side
   d. not working

Adapting the Electrical Design

63. If the PV array in Figure 9 of this Guide is operated at a minimum temperature of -20° C, then the inverter maximum input voltage rating must be at least
   a. 29.2 V
   b. 34.3 V
   c. 42.0 V
   d. 49.1 V
Adapting the Electrical Design

![Diagram of electrical system](image)

<table>
<thead>
<tr>
<th>Modules</th>
<th>$V_{oc}$ (STC)</th>
<th>$I_{sc}$ (STC)</th>
<th>$V_{mp}$ (STC)</th>
<th>$I_{mp}$ (STC)</th>
<th>$P_{max}$ (STC)</th>
<th>$V_{mp}$ Temp Coefficient</th>
<th>Dimensions</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crystalline Silicon</td>
<td>21.0 V</td>
<td>7.2 A</td>
<td>17.1 V</td>
<td>7.0 A</td>
<td>120 W</td>
<td>-0.4%/°C</td>
<td>66 cm x 142 cm</td>
<td>11 kg</td>
</tr>
</tbody>
</table>

Installing Systems and Subsystems at the Site
Installing Systems and Subsystems at the Site

77. In order for a PV array to directly face the sun at 2:30 p.m. sun time on June 21 at 30° N latitude (see Figure 5 of this Guide), which array orientation is correct?
   a. 60° W of S with a tilt of 40° with respect to the horizontal
   b. directly west with a tilt of 60° with respect to the horizontal
   c. directly west with a tilt of 30° with respect to the horizontal
   d. 45° W of S with a tilt of 60° with respect to the horizontal

Conducting a Site Assessment
Performing a System Checkout and Inspection

80. The first step in system checkout after completing the installation is
a. test open-circuit voltage
b. visually check the entire system
c. install the source-circuit fuses
d. close all disconnects
Performing a System Checkout and Inspection

81. Before applying PV power to either an inverter, a charge controller, batteries or a load, one should first
   a. check the polarity of the PV output
   b. install the source circuit fuses
   c. call the electrical inspector
   d. close all disconnects

Performing a System Checkout and Inspection

82. Assume the STC maximum-power voltage of a crystalline silicon PV array is 68.4 V. If the irradiance is 800 W/m² and the module temperature is 50°C, assuming the inverter is tracking maximum power with a 1.6% voltage drop between modules and inverter input, the inverter input voltage should be closest to
   a. 68.4 V
   b. 60.5 V
   c. 54.7 V
   d. 47.1 V
Performing a System Checkout and Inspection

83. A 4-kWSTC crystalline silicon PV array is operated in a utility-interactive mode with no battery backup. The inverter tracks maximum power, and the array is operating at 50° C with 900 W/m² incident on the array. There is a 2% power loss in the wiring and the inverter is 94% efficient. On a typical PV system, the inverter output power will be closest to

a. 3316 watts
b. 2985 watts
c. 2612 watts
d. 1492 watts

Maintaining and Troubleshooting a System
Maintaining and Troubleshooting a System

87. When connecting and disconnecting wires while troubleshooting a PV system, the best way to avoid electrical shock is to
   a. inspect all questionable terminals, wear rubber gloves and turn off all switches
   b. keep one hand behind your back, with all switches turned off and only touch grounded surfaces
   c. turn off switches, measure voltages and currents, and wear protective equipment
   d. wear shoes with soft rubber soles, turn off all switches, and don't touch metal surfaces

Maintaining and Troubleshooting a System

88. If the current in one source circuit is significantly lower than the currents in the remaining source circuits of a PV array, and all modules are in full sun, then without disconnecting any conductors, an appropriate follow-up test is
   a. measure the individual module currents in this source circuit
   b. measure the voltage at the inverter input
   c. measure the short circuit current of this source circuit
   d. measure the individual module voltages in this source circuit
Maintaining and Troubleshooting a System

90. A utility-interactive PV system with no batteries consists of 15 100-W modules in series that feed a 1500-W inverter. The inverter output power is found to be 780 W when the modules are operating at 50°C with an irradiance level of 800 W/m². If three modules are observed to be shaded, which conclusion is most likely?

a. The inverter input current is probably too low
b. The system is probably functioning properly
c. The inverter is probably not tracking maximum power
d. The modules probably do not have bypass diodes

Maintaining and Troubleshooting a System

91. Suppose the irradiance on the array is measured with a handheld solar meter at 955 W/m² and the input current to the inverter is measured to be 8.35 A. The voltage across the top fuse is 0.01 V, and the voltage across the bottom fuse is 10 V. From this information, it can be concluded that

a. the charge controller is in the float phase
b. the top fuse is blown
c. the bottom fuse is blown
d. the battery disconnect is open
Maintaining and Troubleshooting a System

Assume that the following specifications apply to the equipment in the system. The system is operating in standard utility-interactive mode.

<table>
<thead>
<tr>
<th>Modules (Crystalline Silicon)</th>
<th>$V_{DC}$ (STC)</th>
<th>$I_{SC}$ (STC)</th>
<th>$V_{oc}$ (STC)</th>
<th>$I_{mp}$ (STC)</th>
<th>Max Power (STC)</th>
<th>dimensions</th>
<th>weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>210 V</td>
<td>17 V</td>
<td>25 A</td>
<td>4.5 A</td>
<td>4.5 A</td>
<td>75 W</td>
<td>41 cm x 157 cm</td>
<td>7.3 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Distances/Dimensions</th>
<th>Modules to Junction Box</th>
<th>Junction Box to Combiner</th>
<th>Combiner to Charge Controller</th>
<th>All other wiring lengths to dist panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 m (max one way)</td>
<td>25 m (one way)</td>
<td>Negligible</td>
<td>negligible</td>
<td></td>
</tr>
<tr>
<td>Wire Sizes</td>
<td>10 AWG Cu</td>
<td>8 AWG Cu</td>
<td>10 AWG Cu</td>
<td>8 AWG Cu</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module Mounting Details</th>
<th>Mount Type</th>
<th>Mount Tilt</th>
<th>Module facing</th>
<th>Site Latitude</th>
<th>Max module temp</th>
<th>Min module temp</th>
<th>Max total load</th>
</tr>
</thead>
</table>
Maintaining and Troubleshooting a System

92. Suppose the irradiance on the array is measured with a handheld solar meter at 955 W/m² and the dc current from the charge controller is measured to be 0 A, and the inverter is supplying 0.5 A to the battery. The fuses have been confirmed to be good, and the charge controller is fully operational and indicating a full battery. From this information it can be concluded that

a. the standby loads are interfering with the inverter operation
b. the charge controller is set above the inverter set point
c. the utility disconnect is open
d. the charge controller is set below the inverter set point