56. These ~~negatively charged ions from the electrolyte combine with the positively charged metal ions to form a compound that will not dissolve in water. Eventually these **corrosion products** may flake off as the anode ________ .~~

**ANSWER MASK**

## ALTERING THE RATE OF CORROSION

### POLARIZATION

57. As you recall, negatively charged electrons are released at the ________ and travel through the external conductor to the ________ .

58. At the same time, positively charged hydrogen ions in the electrolyte are attracted to the ________ .

59. These hydrogen ions react at the surface of the cathode with negatively charged electrons to form hydrogen atoms and hydrogen gas. If the speed of *this* reaction is slowed down this will also ________ ________ the rates of the other reactions.

60. Under certain circumstances the hydrogen atoms and/or gas may block the path of hydrogen ions to the cathode. This will ( slow down / speed up ) the reaction at the cathode.

61. This will also reduce the amount of current flowing from the cathode through the conductor back to the anode.

    This, in turn, slows down the reaction at the anode because the flow of ________ has been reduced.

62. As the flow of current is reduced, the rate of corrosion is ________ .

63. This slowing down of the corrosion reaction is known as polarization. Since this reaction occurred at the cathode, it is called ________ polarization.

    Therefore, if polarization occurs, the corrosion damage will be ( increased / decreased ).

### PASSIVITY

64. Another process that retards or slows down a corrosion reaction is known as passivity.

    A passive film, which naturally forms, helps to prevent ________ from occurring.

65. Some metals, such as magnesium or aluminum are highly corrosive when exposed to air. Often, an oxide film naturally forms and coats the metal. Since this film protects the metal so it no longer corrodes, the film is ( corrosive / passive ).

66. This passive oxide film makes the metal resistant to ________.

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67. A film can also form from the corrosion process itself. A corrosion product may collect and form a protective layer on the anode.

Therefore when rust covers an area, it may eventually protect the ( metal / rust ).

68. When an area becomes more passive, corrosion is reduced. So this passive area acts more like the ( anode / cathode ).

69. An active-passive cell forms when a passive cathode is connected with an active ______________ .

70. A common example in the oilfield occurs when a rust covered pipe is scratched to bare metal. In this case, the scratched area becomes the anode and ______________ .

71. The covered area is the ______________ .

72. Caution must be taken not to accidentally scratch rusted areas since the rust actually ______________ the metal beneath it.

AREA EFFECT

73. The size, or area, of the cathode in relation to the anode can alter the rate of corrosion.

The larger the cathode the ( more / fewer ) electrons from the anode are needed in the corrosion process.

74. So, in a corrosion cell where the cathode is larger than the anode, the corrosion process ( increases / decreases ).

75. As the rate of corrosion increases, the damage caused by corrosion will ______________ .

76. On the other hand, if the cathode is small in relation to the anode, the corrosion rate is ______________ .

77. This situation is more desirable because damage is ______________ .

Let's review.

78. The corrosion process is ( an electrochemical / electromechanical ) process.

79. For a corrosion cell to exist, you must have (check all that apply):

_______ a catalyst
_______ an external electrical source
_______ an electrolyte
_______ a corrosion activator
_______ an anode
_______ a cathode
_______ a connecting conductor

80. In a corrosion cell where the cathode is much larger than the anode, the corrosion damage is ( mild / severe ).

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**ANSWER MASK**

81. The principle behind this is known as ______________ ______________.

82. As the corrosion product forms at the anode, a ______________ film forms.

83. This passive film helps to ( reduce / increase ) the corrosion.

## TYPES OF CORROSION CELLS

### GALVANIC CELL

84. Corrosion occurs for many reasons. Different anode and cathode combinations lead to the formation of different types of corrosion cells.

    The metals that are combined together within the corrosion cell can give some indication about how fast the anode will ______________.

85. When you combine two different types of metal together, you will have a galvanic cell.
    The following table is called a *Galvanic Series*. The metals are arranged according to how easily they corrode.

GALVANIC SERIES

| | |
|---|---|
| Anodic | |
| | Magnesium |
| | Aluminum |
| | Zinc |
| | Iron |
| | Cadmium |
| | Nickel |
| | Tin |
| | Lead |
| | Hydrogen (Reference point) |
| | Copper |
| | Silver |
| | Platinum |
| | Gold |
| Cathodic | |

Those metals near the top of the list are anodic. They ( do corrode / do not corrode ) easily.

86. They have a ( high resistance / low resistance ) to corrosion.

87. Therefore, they corrode ( slowly / rapidly ).

88. As you go down the series, the metals become more *noble* or ( anodic / cathodic ), and, therefore, ( more / less ) likely to corrode.

89. Referring to the Galvanic Series, if you were to couple magnesium with silver, you could expect the magnesium to be the anode and the silver to be the ______________.

90. If you couple a small piece of zinc with a large piece of copper, the metal that would corrode first is the ______________.

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**ANSWER MASK**

91. The copper would have a ( low resistance / high resistance ) to corrosion.

92. According to the area effect, damage to the zinc would be ______________ .

93. The closer the metals are listed in the Galvanic Series, the slower and less severe the corrosion reaction will be.

So, zinc coupled with copper would create a greater tendency for corrosion to occur than would ( aluminum / tin ) coupled with copper.

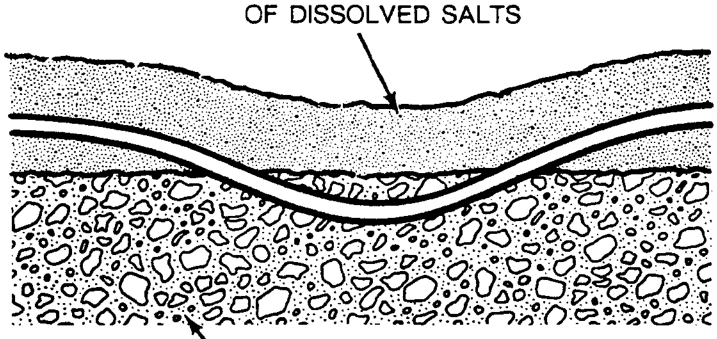
94. Therefore, if you have to couple two types of metals together, you should choose metals that are ( close together / far apart ) in the Galvanic Series.

## CONCENTRATION CELL

95. Another factor affecting corrosion is the concentration of atoms within the electrolyte. Concentration of such atoms as oxygen or salt are seldom consistent in water or soil.

An area that is highly concentrated has ( few / many ) atoms in the given space.

96. Many times, a pipe will lie within two types of soil.




The area of pipe that is in contact with a higher salt concentration is highly corrosive.

This area becomes the ______________ .

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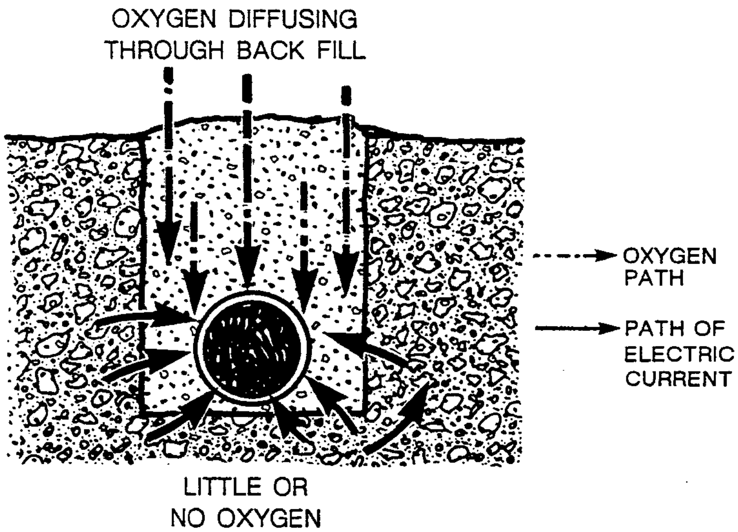
ANSWER MASK

97. A concentration cell can also be effected by the concentration of oxygen in the cell.

Unlike other concentration cells, the area with a higher concentration of oxygen is less corrosive; this area is now the ______________ .

98. Less oxygen gets beneath the pipe.




The area beneath the pipe has a ( lower concentration / higher concentration ) of oxygen than the area above the pipe.

99. The underside of the pipe is ( less likely to corrode / more likely to corrode ).

100. Oxygen levels tend to be lower in crevices and under deposits. These areas have a ( low concentration / high concentration ) level.

101. You would expect metal in these areas to be ( more resistant / less resistant ) to corrosion.

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