

OILFIELD CORROSION

1. A rusty nail is a very familiar type of corrosion. A green coating over copper is also a form of _____.
2. Corrosion is the deterioration of a substance, usually a metal, caused by a reaction between that substance and its environment.

Corrosion occurs in oilfield equipment such as pumps, pipelines or storage tanks because they are made of (metal / wood).
3. When this equipment is properly protected from such environmental factors as air or water, the equipment is (more likely to corrode / less likely to corrode).
4. Corrosion is a very costly problem. It costs companies billions of dollars a year. Therefore, understanding the corrosion process may help to reduce this _____.
5. Various problems can result from corrosion. For example, equipment may be damaged. The damaged equipment will need to be repaired or _____.
6. During this maintenance of the equipment, the loss of production time also costs the company _____.
7. If the equipment is not replaced or repaired, the possibility of accidents or injury can (decrease / increase).
8. A corroded pipeline is one example of a health or safety hazard. A leak may occur and release a gas, such as hydrogen sulfide, that is very _____.
9. Careful monitoring and using preventive measures can help reduce the cost of corrosion damage by reducing possible health or safety hazards, _____ of production time and _____ of equipment.

BASIC CHEMISTRY

10. The corrosion process involves an electrochemical reaction. In order to better understand corrosion, it would be helpful for you to know some basic chemistry.

Atoms are the smallest particles of any substance. An atom has three parts:

a proton which has a positive charge, an electron which has a negative charge, and a neutron which has _____ charge.

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ANSWER MASK

11. An atom that is balanced or stable has the same number of negative charges as it does positive charges. Therefore, you know that a balanced atom has an equal number of electrons and _____.
12. So, a stable atom with three protons has _____ electrons.
13. If an atom has two protons and three electrons, it is (a balanced atom / an unbalanced atom).
14. An unbalanced or unstable atom is called an ion. An ion always carries a charge.

An atom with three protons and four electrons has a (positive / negative) charge.
15. An atom with two protons and one electron carries a _____ charge.
16. It is called a positive charged _____.
17. Cl is the symbol for chlorine. If you saw the symbol Cl^- , you could assume that this is a (positive / negative) charged ion.
18. Therefore, it has more electrons than _____.
19. The symbol for sodium is Na. The symbol Na^+ means that this ion carries a _____ charge.
20. Na^+ has more _____ than _____.
21. Ions with opposite charges are attracted to one another.

So, the Na^+ will attract an ion that has "extra" electrons. The Na^+ will attach to a _____ charged ion.
22. If the Na^+ joins the Cl^- , the compound NaCl (table salt) forms. This compound now has (a positive charge / a negative charge / no charge).
23. It is now (a balanced or stable group of atoms / still an ion).

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ANSWER MASK

24. Ions are a very important part of the corrosion process. Because ions carry a charge, they are capable of producing an electric current. This electric current is vital in the electrochemical reaction associated with _____.
25. To have an electric current, you (need ions / do not need ions).
26. An ion can produce an electric current because it carries a _____.
27. With this electric current, _____ will occur.
28. Without an electric current, the chances of corrosion occurring are (minimal / high).

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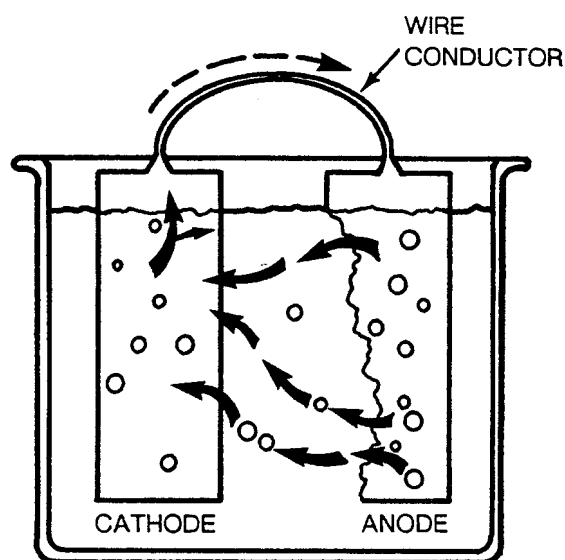
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THE CORROSION CELL

29. The corrosion process takes place within a corrosion cell. This corrosion cell contains four parts: two electrodes, an electrolyte, and a conductor.



CORROSION CELL

An electrode is a metal in which an electric current either enters or exits.

Referring to the diagram, the electric current is flowing between the _____ electrodes.

30. The electrode that corrodes is called the anode. It is the area in which the current (enters / exits) into the electrolyte.
31. The other electrode is the cathode. It does not _____.
32. As you see in the diagram, the current leaves the anode and enters the solution called the _____.

ANSWER MASK

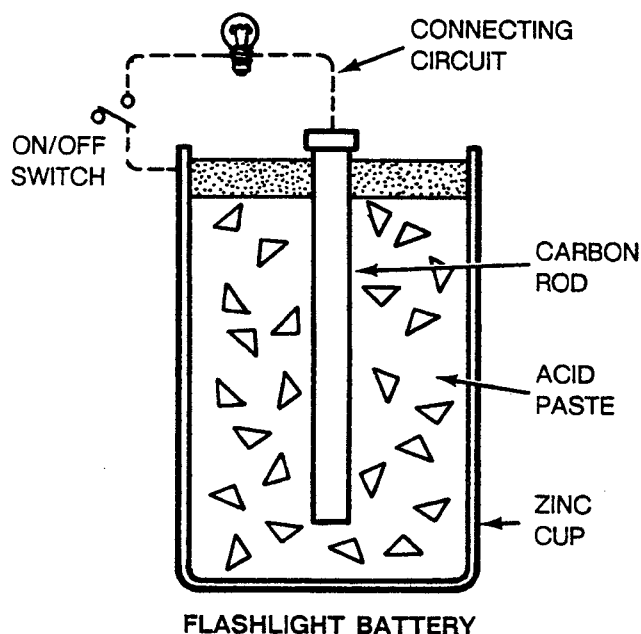
33. The electrolyte is a substance, either liquid or solid, which is capable of conducting an electric current.

Therefore, you know the electrolyte contains many charged (atoms / ions).

34. It is because of these charged ions that the electrolyte is a good conductor of _____ .
35. In order for the electrolyte to be effective, it must contact both _____ .
36. To complete this corrosion process, the cathode must be connected to the _____ .
37. This is done by a conductor. The conductor keeps the _____ flowing.
38. Let's review the corrosion cell.

You are familiar with a battery. It functions as a _____ .

39. This diagram is of a flashlight battery.



When the flashlight is "off," the corrosion cell is not complete because the connecting circuit is _____ .

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ANSWER MASK

40. Have you ever seen a battery leak? This is because a hole has corroded through the outer cup (in this case it is made of zinc).

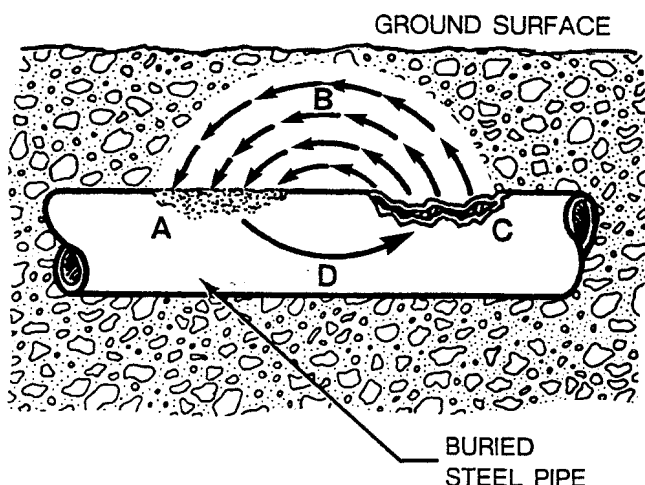
Zinc is, therefore, the _____.

41. This makes the _____ the _____.

42. The acid paste is the _____.

43. In the above instances, the conductor was an (external / internal) path.

44. However, the conductor may also be an internal conductor. For example, in the illustration below the anode and the cathode are contained on the same pipe.



Even where there is only one piece of metal, there will always be _____ electrodes.

45. Identify the following areas on the diagram.

Area A is the _____.

Area B is the _____.

Area C is the _____.

46. In this example, the conductor is the pipe itself; it connects the cathode to the _____.

47. The electrolyte solution is (soil / water).

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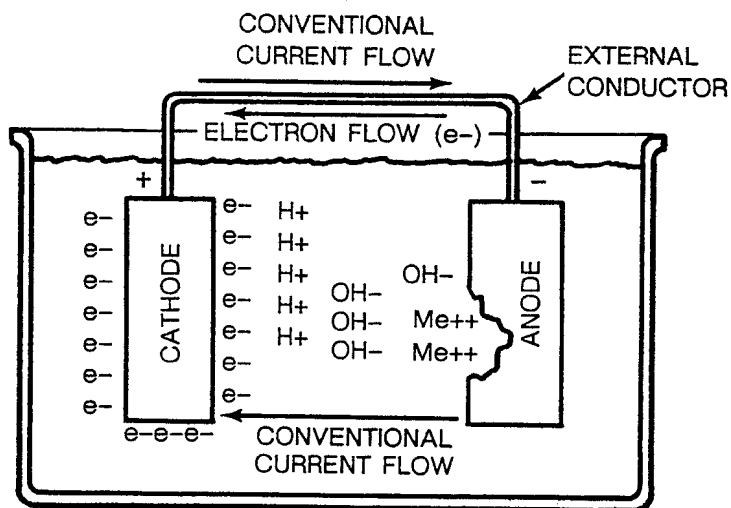
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ELECTROCHEMICAL PROCESS OF CORROSION

48. Now that you understand the basic movement of the electrical current, you are ready to learn the electrochemical process of corrosion.



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Within a corrosion cell, an area on the surface of the cathode, in contact with the electrolyte, has a surplus of electrons and is therefore _____ charged.

49. Positively charged hydrogen ions (H^+) in the electrolyte are (attracted to / repelled by) the negatively charged area on the surface of the cathode.
50. Free electrons, which are (negatively / positively) charged combine with the (negatively / positively) charged hydrogen ions to form hydrogen molecules.
51. This release of electrons changes the electrical potential of the cathode. To regain its former state, electrons migrate (toward / away from) the area where the electrons were released.
52. The cathode is connected to the anode by the _____ .
53. Since the cathode needs to replace electrons, the external conductor provides a path for them to migrate from the _____ .
54. To regain its former state, this area of the anode attracts electrons from other areas in the anode.

The loss of electrons from other areas in the anode results in these areas being _____ charged.

55. The positively charged areas on the anode that are in contact with the electrolyte attract _____ charged ions (OH^-).

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