

1. The best electrolytes are molecules assembled with _____.

- (A) give-and-take ionic bonds
- (B) equal-sharing covalent bonds
- (C) unequal-sharing polar covalent bonds
- (D) metallic bonds

Hint: The best electrolytes are polar molecules whose atoms can be readily separated by polar water molecules.

2. What is the oxidation number of sulfur in H_2SO_4 ?

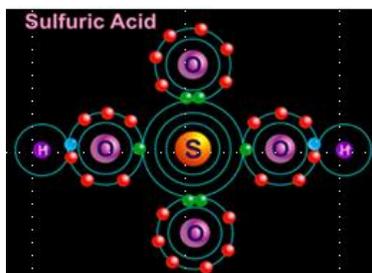
- (A) 2
- (B) 4
- (C) 6
- (D) 8

Hint: The total oxidation state for the molecule is 0.

Oxygen with its high electronegativity pulls electrons toward it, and since each oxygen atom will pull 2 electrons toward it to fill its outer shell, the total oxidation state for the oxygen atoms is -8 .

The 2 electrons on the hydrogen atoms move toward the oxygen atoms, giving each hydrogen atom a $+1$.

This leaves sulfur moving its 6 electrons toward the 4 oxygen atoms for an oxidation state of $+6$.



3. What is the oxidation state for tin sulfide, SnS_2 ?

- (A) 2
- (B) 4
- (C) 6
- (D) 8

1																	2
H																	He
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

Hint: Sulfur needs 2 electrons to fill its outer shell, so when four electrons move from tin toward sulfur, tin's oxidation state becomes $+4$.

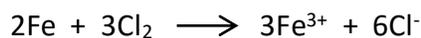
4. What do oxidizing agents do to another atom?

- (A) They remove electrons and raise the oxidation state.
- (B) They remove electrons and lower the oxidation state.
- (C) They give electrons and raise the oxidation state.
- (D) They give electrons and lower the oxidation state.

Hint: Oxidizing agents do what oxygen generally does, namely, move electrons toward it.

This lowers the atom's oxidation number and increases the oxidation number of the atom losing its electron.

5. In the chemical equation, which atom undergoes oxidation?



- (A) Fe
- (B) Cl in Cl_2
- (C) Fe^{2+}
- (D) Cl^-

Hint: By going from neutral atoms to negative ions, the chlorine atoms gained electrons.

Gaining electrons is what oxidation generally does, so gaining electrons is oxidation.

Chlorine atoms are doing the oxidizing, and iron was oxidized.

6. In which of the following molecules does chlorine have the largest oxidation number?

- (A) NaClO_4
- (B) NaClO_3
- (C) NaClO_2
- (D) NaClO

Hint: Oxygen has an oxidation number of -2 .

With 4 oxygen atoms, the total oxidation of oxygen is -8 .

Sodium has an oxidation number of $+1$.

That leaves chlorine with a positive oxidation of $+7$.

The maximum oxidation for chlorine occurs, then, with the maximum number of oxygen atoms.

7. In electrolysis, reduction takes place at the _____.

- (A) anode
- (B) **cathode**
- (C) battery
- (D) ionizing electrode

Hint: Reduction occurs when electrons move toward an atom's nucleus.

In a battery, the cathode provides the electrons.

8. In the electrolysis of zinc and copper, electrons leave neutral zinc atoms at the anode and travel to copper at the cathode. What do the electrons combine with?

- (A) zinc ions in solution
- (B) **copper ions in solution**
- (C) neutral copper atoms at the cathode
- (D) neutral zinc atoms at the cathode

Hint: In electrolysis, electrons travel from the anode to the cathode where they enter the solution and reduce positive ions in solution.

9. Without a salt bridge, electrolysis of zinc and copper stops because _____.

- (A) **positive electrical charges build up around the anode and negative electrical charges build up around the cathode**
- (B) positive electrical charges build up around the cathode and negative electrical charges build up around the anode
- (C) neutral copper atoms build up at the anode
- (D) the anode runs out of zinc

Hint: In electrolysis of zinc and copper, electrons are removed from neutral zinc atoms at the anode, leaving positive zinc ions to accumulate in solution around the anode. After a while, so many positive zinc ions accumulate around the anode that the electrons being stripped off the zinc atoms don't want to leave the anode and travel through the wire to the cathode.

A salt bridge delivers negative ions to the solution around the anode. The negative ions neutralize the positive zinc ions and allow zinc's electrons to flow from the anode to the cathode.

A mirror image of this occurs at the cathode as more and more electrons are delivered to the cathode. Without a salt bridge, so many negative ions accumulate around the cathode that they repel the electrons traveling down the wire to the cathode.

A salt bridge removes these negative ions around the cathode.

10. What is the opposite of ionization energy?

- (A) ionization potential
- (B) electronegativity
- (C) electron affinity**
- (D) reduction potential

Hint: Ionization energy is the energy needed to remove a valence electron from an atom.

Electron affinity is the energy released by the atom when a valence electron is added to the atom.

11. From which atom is it easiest to remove an electron from its outer shell?

- (A) magnesium**
- (B) nitrogen
- (C) chlorine
- (D) boron

1	H											2	He																						
3	Li	4	Be							5	B	6	C	7	N	8	O	9	F	10	Ne														
11	Na	12	Mg							13	Al	14	Si	15	P	16	S	17	Cl	18	Ar														
19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr
37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe
55	Cs	56	Ba	57	Lu	58	Hf	59	Ta	60	W	61	Re	62	Os	63	Ir	64	Pt	65	Au	66	Hg	67	Tl	68	Pb	69	Bi	70	Po	71	At	72	Rn

Hint: Magnesium has only 2 electrons in its valence shell is thus most willing to let a valence electron go.

12. In calculating the voltage generated by the electrolysis of two atoms, the voltage of each atom is added after comparing the atom's electron affinity to what atom?

- (A) hydrogen**
- (B) helium
- (C) sodium
- (D) oxygen

Hint: Electrolysis occurs because one atom is more attractive to electrons than another atom. The difference is measured in volts.

The only way to determine which atoms are most attractive to electrons is to compare all the atoms to the same atom.

Hydrogen is that atom because it can give or accept an electron.

13. 1 coulomb’s worth of electrical charges passing by a point each second is a measure of electrical current, called _____.

- (A) **amps**
- (B) Faradays
- (C) voltage
- (D) Faraday-moles

Hint: Current is measured in amps, after Andre-Marie Ampere who in the early 1800’s worked out the mathematics of electricity and magnetism.

14. Watts are units of power, measured as _____.

- (A) Newtons per second
- (B) joules
- (C) **joules per second**
- (D) joules per amp

Hint: Force is measured in newtons.

A force exerted over some distance (force x distance) is work, measured in newton-meters, or joules.

The rate at which work is done is joules per second, which is watts, after James Watt, a Scottish engineer who help launch the industrial revolution with his invention of an efficient steam engine.

15. Most of the aluminum in the earth is in the form of aluminum oxide (Al_2O_3). In order to make aluminum oxide into pure aluminum metal, the aluminum oxide has to be _____.

- (A) electroplated
- (B) ionized
- (C) oxidized
- (D) **reduced**

Hint: Pure aluminum metal consists of neutral atoms.

The aluminum atoms in aluminum oxide are oxidized by the oxygen atoms in the aluminum oxide molecule.

To get the oxidized aluminum atoms into a neutral state, aluminum’s electrons have to be returned to the aluminum atoms, and the aluminum atoms separated from the oxygen atoms.

Moving electrons toward an atom’s nucleus is reduction because it reduces the atoms oxidation state.

16. In a hydrogen fuel cell, _____.

- (A) **electrons are removed from hydrogen atoms**
- (B) electrons are removed from oxygen atoms
- (C) electrons are passed through a polymer semipermeable membrane
- (D) the electrons are paired up to make water molecule

Hint: Fuel cells strip electrons off atoms and channel those electrons through a wire as a current.

A fuel cell does this by allowing a hydrogen nucleus, but not its electron, to pass through a semi-permeable membrane.