NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ UNIT 2: BASIC ATOMIC STRUCTURE and

BASICS OF REDOX **(Part 2)**

I-II) See Unit 2 Part 1

Goals for this note packet: At the completion of this work, you should be able to

* work with an electron configuration to determine the number of valence electrons
* articulate the general tendencies in chemical reactivity of metals, nonmetals, metalloids and noble gases based upon electronegativity, valence electron theory and the octet rule
* define oxidation
* define reduction
* identify the oxidized species of a chemical reaction
* identify the reduced species of a chemical reaction
* identify the oxidizing agent
* identify the reducing agent

III) The Periodic Table of Elements:

A) Everything on the Periodic Table represents an element.

1) Every element symbol has a capital letter. If there is a second letter in the symbol, it is

written with a small case letter.

a) Those elements with three letters in their symbol are awaiting the assignment of

a *trivial* name. The symbols represent the atomic number.

2) Depending upon the date of publication of these notes, there are roughly 118 element

represented on the Periodic Table, and they are divided into:

18 vertical columns (called families or groups),

7 horizontal periods and

2 related series (the actinide and lanthanide series)

3) The elements are organized based upon \*increasing atomic number.

4) We will concern ourselves with the Main Group elements (Groups 1,2,13-18). We will often refer

to the Transition Metal Elements (Groups 3 -11), and the elements in group 12

B) A somewhat arbitrary means of categorizing the elements is based upon the activity of the

outermost electrons (the most loosely held electrons ....and those most likely to participate in

making new bonds) ....A picture containing text, building material

Description automatically generated the \* valence electrons

Val*a*nce curtain ... While not spelled the same, I like to think of this curtain, being so named, because it is the "outermost" drape .... the furthest from the window (metaphorically, the nucleus)

& the last to be put on (configured) and the first to be taken off. How does this metaphor work for you? Do you have any questions?

<http://oxbowherald.com/writing/blog/with-valances-for-windows-all-you-need-is-your-imagination>

1) Based upon the activity of valence electrons, there are **4** broad categories of elements

a) Metals are elements which lose electrons in a chemical reaction, when reacted with

nonmetals. (Metals become oxidized when reacted with nonmetals.)

i) loss of electrons = \*oxidation

ii) oxidized species become \*more positive in charge, due to a loss of negative

electrons. e.g. 0 to +2 or +2 to +5

iii) You may sometimes hear that fossil fuels are oxidized when combusted in

oxygen. This is generally accurate, as the carbon atoms of the fossil fuel(s)

lose electrons to oxygen, and form carbon dioxide. The carbon of CO2 is

in a +4 oxidation state … a more positive state, then carbon is in the original

fuel.

This holds true as well, for glucose … It is oxidized biochemically, in that

carbon atoms become more positive.

iv) In the case of metals, you will often hear that a metal (such as iron) has been

oxidized (**or rusted**) in the presence of oxygen or some other nonmetal.

In this case, iron atom loses electrons and becomes a +3 or +2 ion.

v) Oxidation does NOT require oxygen … but derives the name from oxygen.

vi) The key is to grasp that oxidation is a loss of electrons, and many atoms can

become oxidized …. BUT(!) Metal atoms, in the presence of nonmetals are

especially vulnerable to this sort of electron activity.

vii) As a general rule, metals do NOT react or bond with other metals. For our

work, we will consider it more common for \*metals to bond with nonmetals

b) Metalloids (or Semimetals) blend the characteristics of metals and nonmetals & are

elements with properties which fall between the extremes of metallic and

nonmetallic properties. They are associated with the "staircase" of the

periodic table and this staircase separates metals and nonmetals, as well.

c) Nonmetals ***tend*** to gain electrons in a chemical reaction especially when reacted with

a species of lesser electronegativity, like a metal or even another nonmetal.

(Nonmetals tend to become reduced.)

i) Gain of electrons = \*reduction

ii) a reduced species becomes \*more negative, due to the gain of negative

electrons.

iii) fluorine is the most readily (easily) reduced element … followed by oxygen.

It is very common for oxygen to change its electron configuration by gaining

2 more electrons from some other atom. Oxygen, **in compounds** is often a

-2 species.

iv) It is common for nonmetal atoms to bond with other nonmetal atoms.

\* Covalent Bonding

\* Nonmetals bonded to nonmetals form \*molecules

\* It is somewhat common to see one nonmetal as more vulnerable to

some level of oxidation and the other more capable of being reduced.

We will see this again, when we take a look at effective nuclear charge

and \*electronegativity

d) Noble Gases often seen as a subset of the nonmetals, these elements tend to neither

gain nor lose electrons under normal Earth-like conditions. That, is,

under normal Earth-like conditions, noble gases tend not bond to other

species, and you won’t find them in many compounds. There are a few

exceptions …but not many.

3) Elements tend to interact in such a way as to stabilize their valence electron levels, and

lower their overall energy.

a) For first-year students we could look at these reactions, as an attempt to reach 8

valence electrons.

This tendency to achieve 8 valence electrons is called the \*OCTET RULE.

However, it is just a guideline and not always accurate. Let’s just say that often (but

not always,) an atom will react to that it ends up with 8 valance electrons … or as

close as possible. (more later)

b) Metals tend to \* lose Electrons when reacting with nonmetals by

\*Oxidation (LEO) When oxidized the metal atom becomes a

more positive species.

c) Nonmetals tend to Gain Electrons when reacting with metals by Reduction (GER), and the nonmetal atom becomes a more negative species (due to a gain of electrons)



c) LEO says GER

<http://bananaoilmovies.wordpress.com/2010/11/05/a-farewell/>

**Relative Locations of the 4 Categories of Elements Found on the Periodic Table**

**Non -**

**Metals Noble**

**Gases**

**Metals**

**Metalloids**

**Metals**

IV) Electron Configuration: We believe that electrons are ordered from low levels of energy to

higher levels of energy, which correspond statistically to probable locations of the

electrons from the nucleus.

A) According to Bohr:

1) electrons are organized outside of and around the nucleus

2) electrons are found at specific distances from the nucleus. These distances are

called energy shells (K – Q) or principal energy levels (1 – 7).

j0237628 3) \* there are 7 principal energy levels, some with electrons of a quantized energy

Picture it!

4) electrons nearest the nucleus are lowest in energy. The energy of electrons

\* increases as their position from the nucleus increases.

(potential energy argument)

5) Ground State = The electrons arranged in \*the lowest possible energy levels

The ground state configuration is written on your copy of the periodic table.

a) The “shells” (or principal energy levels) tend to have a rule which predicts the

maximum number of electrons = 2n2, where n is the number of the level, 1,2,3,4 …

b) The rule describes the maximum number of electrons a level may hold … NOT the

the number it MUST hold … Think of this last statement like carrying in a load of

wood, into the house from the outside.

c) Octet Rule: A tendency for atoms to lose or gain electrons so that the resulting

species has 8 valence electrons.

This is simply a tendency …. not a hard and fast rule….

e.g) Oxygen atoms tend to gain 2 electrons….to get a valence of 8

O0 2-6 can become O-2 2-8

Na0 2-8-1 can become Na+1 2-8

Ca0 2-8-8-2 can become Ca+2 2-8-8

P0 2-8-5 can become P-3  2-8-8

d) As a general rule, atoms with fewer than 4 valence e- tend to lose electrons

and atoms with more than 4 valence e- tend to gain electrons to complete the octet.

6) Excited State Electron Configuration: This exists when an inner level electron absorbs

energy from an outside source and moves to a higher energy level.

a) A temporary state

b) When the electron returns to a lower energy level, the loss of potential energy is

converted to some form of electromagnetic spectrum energy. (radio waves,

microwaves, infrared, visible light, ultraviolet, x-ray, or gamma ray)

c) The configuration is NOT found on the periodic table references

d) Example: O: 2-6 O: 2-5-1

ground state excited state

e) Everyday Chemistry: Neon Light Sign

Sunlight

Flashlight

f) When an electron becomes “so excited” that it is removed from the influence of its

local nucleus, chemists switch terms from excited to oxidation! (Note the link in ideas

here)

**TRY THIS!!!!!**

1. Use the ground state electron configuration of 2-8-18-6
2. An atom of which element is represented? \* Se or selenium

b) The configuration suggests that this atom has how many valence electrons? \*6

c) Using the octet rule, which generalizes that atoms react in such a way, so as to attain 8 valence

electrons, will this atom tend to gain or lose electrons? \*gain 2 electrons…

2) Use the ground state electron configuration of 2-8-10-2

a) An atom of which element is represented? \* Ti or titanium

b) How many valence electrons does this atom have? \*2

c) Will this atom tend to gain, or to lose electrons, when reacted with another atom, such as oxygen?

\*lose

d) How many principal energy levels hold electrons? \*4

3) Us the ground state electron configuration of 2-5

a) An atom of which element is represented? \* Nitrogen

b) How many valence electrons does this atom have? \*5

c) Will this atom tend to gain, or to lose electrons, when reacted with another atom, such as oxygen?

\*gain

d) How many principal energy levels hold electrons? \*2

We have seen the effect of ions and excited state in lab…. Think about the flame tests and the application to fireworks, or just the blue-green color of the copper sulfate we have used.

V) Redox Reactions:

A) \*Electrons govern chemical reactions. They may be lost, gained, or shared (equally or

unequally) by chemical species

B) The effective nuclear charge of an atom’s nucleus is at the heart of whether a species gains or

loses electron(s).

1) The effective nuclear charge is the \*pull an electron experiences for a nucleus

2) Metals tend to have weak effective nuclear charges. Hence the valence electron tends to be

lost to Nonmetals which tend to have superior effective nuclear charges.

a) Note how this sets up the idea of some species losing electrons (oxidation) while other

species gain electrons (reduction)

C) **An oxidation number is** a positive or negative number assigned to a species. It is assigned to help

understand the number of electrons involved in bonding *to a species of a different element*, and to

indicate the degree of oxidation or reduction.

+1 -1

Given: Na0 + Cl20 → 2 NaCl

sodium chlorine sodium chloride

For instance, the sodium ion of NaCl is given an oxidation state of +1, compared to the original

Na0.

This +1 value indicates that 1 electron was involved in the bonding process to the Cl, (that's the

"1") and that the electron has been lost (that's the "+") to the chloride.

Thus, that simple symbol of the +1 oxidation state, indicates two pieces of important information.

Note that the name of the \*nonmetal changes its ending to -ide, when reduced.

The chloride conversely, is assigned a -1, indicating that the chloride species is a reduced species

(compared to chlorine, Cl0 , chloride is more negative), due to a gain of 1 electron. The “gained”

electron is the same electron, as that lost by the sodium. Thus, 1 electron was lost… 1 was

gained… illustrating the Law of the Conservation of Charge.

D) Redox Reaction: Any reaction in which there is a change in oxidation number**s** (LEO says GER)

**RED**uction / **OX**idation reaction: Electrons are \* lost and \* gained generally in a change

of \* oxidation states (or numbers) *generally* for two ***species***. ⮷

any chemical entity: a(n) molecule, atom or ion

1) **For every oxidation there must be a reduction**. The processes go together….



2)Oxidation State (a.k.a: \* Oxidation Number ): An arbitrarily assigned value

which explains or predicts the number of electrons of a *species*, involved in making a bond

with a species of a ***different*** element.

3) + or – values for oxidation states apply to species of compounds, or of ions in water.

0 is the oxidation state for pure elements. [thus, the oxidation state(s) of the oxygen species in

a molecule of O2 is 0, since the molecule is produced by species of the same (not different) element(s)]

4) The charge on an ion is only **ONE category** of oxidation states. Every encounter with an

oxidation state (number), is NOT necessarily an encounter with an ***ion***

a) Oxidation states can be applied to species of a molecule as well. They are used to

describe the number \*of shared electrons in a bond between the atoms of

a covalent (molecular) substance.

5) An oxidation number of a species may be \* positive if its electrons are attracted

more strongly to another nucleus **or** \* negative if the involved electrons tend

to be gained, relatively speaking.

a) The metal ions of a compound will most likely be assigned a \* positive

number

The nonmetals of a compound **may be assigned** a negative **or** a positive number.

✯✯i) The species with the positive oxidation # is often written first in a formula

OR RATHER: \*The species with the lower electronegativity value is written

first in a formula

ii) There are some exceptions…For 1st year students, NH3 is the most important.

✯✯ b) As written, there are 2 situations of serious importance when dealing with oxidation

states:

i) We use these **+** and **–** oxidation states, when dealing with species of

**compounds or ions dissolved in water.**

In light of the definition of oxidation state, why do pure elements get an oxidation

state of zero (0) assigned to them? \* oxidation states account for the electrons

used to bond species of different elements. Thus, in pure elements, 0 electrons are

used to bond to species of different elements.

ii) When dealing **with ions** in water

✪✪✪ Ions in aqueous solution are also called \***electrolytes or hydrated ions**

**✯✯✯**6) For many species, the oxidation number is related to the ionic charge …. but first year

students must understand that virtually any single integer value may be appropriate.

Normally the values are whole numbers, but they may be fractional.

a) ✪✪it is vital to know the oxidation #s so we can track the electrons of a

reaction...

0 +4 -2 0 +2 -2

A picture containing hanger

Description automatically generated 2Mg(s) + SiO2(s)  Si(s) + 2 MgO(s)

Note that there are 2 val. electrons. Will Ca tend to lose 2 e - or gain 6 e- to achieve a stable octet?

Do you see from where the +2 comes?

+2

Ca

2-8-8-2

in a compound, every calcium will be a +2

e.g.) CaS, Ca3(PO4)2

E) A simpler means of discussing loss and gain of electrons (than effective nuclear charge) is the idea

of **Electronegativity**: \*The tendency of an atom to attract the electrons of a bond to itself.

1) Metals tend to lose electrons to nonmetals (Thus metals tend to have a much lower

electronegativity relative to nonmetals (they also have a much lower effective nuclear

charge).

2) Nonmetals can bond with metals …. BUT(!) nonmetals can bond with other nonmetals.

a) This is where electronegativity really has an impact upon our ability to predict and

to explain various phenomenon.

**Pauling Electronegativity Values**

Table

Description automatically generated

<http://www.chem.ucla.edu/~harding/IGOC/E/electronegativity.html>

3) Fluorine is the most electronegative element. This means that when an atom of fluorine

bonds to another atom, the atom of fluorine tends to gain or draw the electrons of the bond

to its own nucleus.

Guided Practice: Use the provided oxidation states to identify the oxidized and reduced species.

The idea is to compare “before” [the reactant oxidation state] to “after” [the oxidation state of the product]

The answer to each question always comes from the REACTANT side (never the product side)

a) oxidation of aluminum: 4 Al(s) + 3 O2(g)  2 Al2O3(s) + 3351.4 kJ

0 0 +3 -2

4 Al(s) + 3 O2(g)  2 Al2O3(s) + 3351.4 kJ

reduced species = \* O20 or O0  because its oxidation state became \* more negative as a product

oxidized species = \* Al0 because its oxidation state became \* more positive as a product

0 0 -3 +1

b) Making Ammonia (Haber Process): N2(g) + 3H2(g)  2NH3(g)

reduced species = \* N20 or N0  because its oxidation state became \* more negative as a product

oxidized species = \* H20 or H0  because its oxidation state became \* more positive as a product

0 0 +1 -1

c) Making Table Salt: 2 Na(s) + Cl2(g)  2 NaCl(s)

<http://listverse.com/2008/03/04/top-10-amazing-chemical-reactions/>

reduced species = \* Cl20 or Cl0  because its oxidation state became \* more negative as a product

oxidized species = \* Na0 because its oxidation state became \* more positive as a product

+6 -1 0 0

d) Purifying Uranium : ­­­UF6(s) U(s) + 3 F2(g) notice there is only 1 reactant … but there

are 2 different species in that reactant.

reduced species = \* U+6  because its oxidation state became \* more negative as a product

oxidized species = \* F-1 because its oxidation state became \* more positive as a product

(note: F6-1 is not correct, because the fluoride ions are not bonded to each other ...each is bonded via a covalent bond [surprisingly] to the uranium)

individually to the uranium ion)

0 0 +1 -2

e) Making Laughing Gas: 2 N2(g) + 2 O2(g) → 2 N2O(g)

reduced species: \* O20 or O0 oxidized species: \* N20 or N0

+3 -2 0 +1 -2 0

f) Purifying Gold: Au2S3(s) + 3 H2(g) 🡪 3 H2S(g) + 2 Au(s)

reduced species: \*Au+3 oxidized species: \* H20 or H0

0 +4 -2 0 +2 -2

g) Purifying Silicon: Mg(s) + SiO2(s)  Si(s) + 2 MgO(s)

reduced species: \*Si+4 oxidized species: \*Mg0

0 +2 -1 +3 -1 0

h) Purifying Nickel: 2 Al(s) + 3 NiCl2(aq) → 2 AlCl3(aq) + 3 Ni(s)

reduced species: \*Ni+2 oxidized species: \* Al0

+4 -2 0 +1 -2 +1 +5 -2

i) Making Nitric Acid: 4 NO2 + O2 + 2 H2O → 4 HNO3(aq)

reduced species: \* O20 or O0 oxidized species: \* N+4

0 +2 +6 -2 0 +2 +6 -2

j) Corrosion of the Statue of Liberty: Fe(s) + CuSO4(aq) → Cu(s) + FeSO4(aq)

reduced species: \* Cu+2 oxidized species: \* Fe0

+3 -2 0 0 +4 -2

k) Ore Reduction**♣**: 2 Fe2O3(s) + 3 C(s)  4 Fe(s) + 3 CO2(g)

reduced species: \* Fe+3  oxidized species: \* C0

**♣**N.B. Ore: a general term referring to a metal ion-containing mineral, that may be trapped in a larger mixture known as, a rock.

Iron ore: deemed valuable for its oxidized form of iron: Fe+2 and Fe+3, bonded in a compound with reduced oxygen (oxide).

The *reduction of an ore* refers to converting the metal CATION back into the metal ATOM by having the ion GAIN electrons

back. **History Buffs**: The Hall Process and later the Bessemer Process are often seen as turning points of the Industrial

Revolution in the West.

**+1 -1** **+1 -2** **0**

COOL CONCEPT!

**(Purely Honors Chemistry)**

Disproportionation Reaction: a redox reaction, in which the \* same reactant species is both the oxidized species and the reduced species.

l) **Challenge**: Teeth Whitening: 2 H2O2 → 2 H2O + O2(g)

reduced species: \* O-1 oxidized species: \* O-1

**+1 -2 +1** **0** **+1 -1** **+1 +1 -2** **+1 -2**

m) **Challenge:** 2 NaOH + Cl2→ NaCl + NaClO + H2O

reduced species: \*Cl20 or Cl0 oxidized species: \*Cl20 or Cl0

Individual Practice: Analyze the changes in oxidation states (before and after) so that you can identify the

oxidized and reduced species of each reaction. You must include the oxidation state of the species

with each answer. Remember: **The answer always comes from the reactant side!!!!!**

0 -4 +1 +4 -2 +1 -2

1) 2 O2 (g) + CH4(g) → CO2(g) + 2 H2O(l)

reduced species: \*O20 or O0 oxidized species: \* C-4

0 +3 +5 -2 +2 +5 -2

2) Fe(s) + 2 Fe(NO3)3(aq) → 3 Fe(NO3)2(aq)

reduced species: \*Fe+3 to the Fe+2 oxidized species: \*Fe0 to the Fe+2 (*interesting n’est pas?)*

0 +1 +6 -2 +2 +6 -2 0

3) Mg (s) + H2(SO4)(aq) → MgSO4(aq) + H2(g)

reduced species: \* H+1 oxidized species: \* Mg0

+3 -1 0 0 +3 -3 +1 -1

4) 4 BCl3 (s) + P4(s) + 6 H2(g) → 4 BP (s) + 12 HCl(g)

reduced species: \*P40 or P0 oxidized species: \*H20 or H0

0 +1 -1 +1 -1 0

5) Cl2(g) + 2 NaI(s) → 2 NaCl (s) + I2(s)

reduced species: \*Cl20 or Cl0 oxidized species: \*I-1

+1 +5 -2 +1 -1 0

6) 2 KClO3(s) → 2 KCl(s) + 3 O2(g)

reduced species: \*Cl+5 oxidized species: \*O-2

+4 -2 0 +6 -2

7) 2 SO2(g) + O2(g) → SO3(g)

reduced species: \*O20 or O0 oxidized species: \*S+4 to the S+6

F) The agents: The agents are the opposite of their names. In short, the "agent" is that species whose

presence enables the activity for which it is named. ... HUH????

e.g.) The presence of the oxidizing agent allows oxidation to proceed, hence the

oxidizing agent is the reduced species.

1) Oxidizing Agent: \* The reduced species

(a.k.a. an *oxidizer or oxidant*)

a) a strong oxidizing agent is reduced, easily (readily).

b) a weak oxidizing agent *is* reduced, but more slowly when compared to a stronger one.

2) Reducing Agent: \* The oxidized species

(a.k.a. an *antioxidant….Wait a minute … I have heard this term before …. Hey!* )

3) Spectator ions: Not always present … but these are ions which do not change in oxidation

state.

 **TIME FOR A METAPHOR ... MAKE SOME CONNECTIONS!!**

Think about a **sports agent**: Does the sports ***agent*** play the sport?

Does the travel ***agent*** take the arranged trip?

Does the insurance ***agent*** purchase the prepared policy?

So, is the oxidizing ***agent*** the oxidized species ????

**Interpret:** The N+5 of NaNO3 is a strong oxidizing agent (oxidizer)

\*N+5 is easily / readily reduced (oxidizing agents or oxidizers are reduced species)

**Interpret:** The Mn+7 of KMnO4 is a strong oxidizing agent(oxidizer)

\* Mn+7 is easily / readily reduced

**Interpret**: Sodium hypochlorite is a stronger oxidizing agent than 3% hydrogen peroxide

\* Sodium hypochlorite is more easily reduced than hydrogen peroxide

D) A “real world” application: CLOROX bleach / Pool Chlorine

Recall that an oxidizing agent is any substance which causes another substance to \* lose one or more electrons.

The decolorizing action of bleaches is due in part to their ability to remove these electrons which are activated by visible light to produce the various colors. The hypochlorite ion [(ClO)-1], found in many commercial preparations, is reduced to chloride ion and hydroxide ion forming a basic solution as it accepts electrons from the colored material as shown below.

+1 -2 -1

(ClO)-1 + 2e- + H2O → Cl + 2(OH)-1

Robert Asato, Ph.D, Leeward Community College

E) Getting Rid of Skunk Odor! H2O2 mixed with NaHCO3 and Dawn Dishwashing liquid….

It’s a redox reaction when reacted with skunk thiols (R-SH)

Take one liter of 3% hydrogen peroxide (available in pharmacies), add one quarter cup of baking soda and 1 teaspoon liquid dishwashing detergent.  Wash the cat or dog (or child) with this mixture and rinse with lots of water.  Presto!  The smell is almost completely eliminated.

This latter point is an important one.  People who have struggled with tomato juice and were successful in reducing the smell (no chemical effect, but they probably managed to physically rinse away some of the odiferous compounds) often noted that the scent would come back.

This is because the skunk mixture also contains compounds called thioacetates which are not particularly smelly but over time react with moisture to form thiols.  As the concentration of thiols increases, the skunk aroma returns.  But under the mildly alkaline conditions described in the hydrogen peroxide recipe, these thioacetates are immediately converted to thiols which in turn are oxidized.  Therefore the lingering smell is greatly reduced.

<https://www.mcgill.ca/oss/article/environment-history-science-science-everywhere/solution-skunk-pollution>

<https://www.h2o2.com/industrial/applications.aspx?pid=110&name=Mercaptan-Control#:~:text=Mercaptans&text=Hydrogen%20peroxide%20has%20been%20shown,sometimes%20required%20for%20vigorous%20oxidation>.

PRACTICE: The answers are at the end of the packet.  **Remember answers always come from the reactant side!**

0 +1 -1 +1 -1 0

1) Given: F2(g) + 2KCl(aq) 🡪 2KF(aq) + Cl2(g)

a) Assign oxidation numbers to each species (I did it for you ….)

b) What species is oxidized? (be sure to record the oxidation number of your answer, even when it is 0)

c) What species is reduced? (be sure to record the oxidation number of your answer, even when it is 0)

d) What species is the oxidizing agent? (be sure to record the oxidation number of your answer, even when it is 0)

e) What species is the reducing agent? (be sure to record the oxidation number of your answer, even when it is 0)

f) How are the species of a redox reaction related to the “agents”?

0 +2 -1 +3 -1 0

2) Given: 2 Al(s) + 3 NiCl2(aq)  2 AlCl3(aq) + 3 Ni(s)

a) Assign oxidation numbers to each species (I did it for you )

b) What species is oxidized? (be sure to record the oxidation number of your answer, even when it is 0)

c) What species is reduced? (be sure to record the oxidation number of your answer, even when it is 0)

d) What species is the oxidizing agent? (be sure to record the oxidation number of your answer, even when it is 0)

e) What species is the reducing agent? (be sure to record the oxidation number of your answer, even when it is 0)

0 +1 -1 +3 -1 0

3) Given: 2 Al(s) + 6 HCl(aq)  2 AlCl3(aq) + 3 H2(g)

a) What species is oxidized? How do you know? ...The oxidation state

b) What species is reduced?

0 +4 -2 0 +2 -2

4) Given: Mg(s) + SiO2(s)  Si(s) + 2 MgO(s)

a) What species is the oxidizing agent? How do you know?

b) What species is the reducing agent?

0 0 +6 -2

\_\_\_5) Given: 2 N2(g) + 3 O2(g)  🡪 2 N2O3(g) Which species is the oxidizing agent?

a) N20 b) O20 c) N-3 d) O-2

0 +4

6) Given: 2 Fe2O3(s) + 3 C(s) → 4 Fe(s) + 3 CO2(g)

From a chemical (or redox) point of view, what happens to the three moles of carbon as they react with

the rust? The atoms of C0 are Defense:

\_\_\_7) Based upon the formula alone, in which compound is oxygen probably in a positive oxidation state?

a) NaOH b) Ag2O c) NaClO d) OF2

8) What is meant, in chemical terms, by the phrase: “Fluorine gas (F2(g)) is a strong oxidizing agent.”?

For question 9 a –c, use your knowledge of chemistry and the following passage, which is an adaptation from McQuarrie & Rock Descriptive Chemistry 1985 p. 153) Numbers for the lines of print have been provided.

**1** Copper is slightly less abundant than nickel and is found in many different ores. An

ore is a general term referring to the **rocks** that are really mixtures of a number of

**3** valuable minerals (a.k.a. elements or compounds).

Copper generally occurs as various sulfides, although in some ores copper is present in

the form of sulfates, carbonates and other oxygen containing compounds. Deposits of

**6** the free metal are very rare, being found only in Michigan. Most copper-containing

ores have a copper content of less than 1 percent, but some richer ores have up to

4 percent copper.

**9** Copper ores contain other metals and metalloids such as selenium, and tellurium,

which are important by-products when the copper ore is reduced to copper metal.

Some important copper minerals (a.k.a. compounds of copper) are ***chalcocite,*** (Cu2S),

***chalcopyrite*** (CuFeS2), and ***malachite*** (CuCO3•Cu(OH)2), which is a crystalline

mixture of two compounds.

9)

a) In lines 5-6 you read: *“Deposits of the free metal are very rare…”* What does the author mean by the

term “free metal”? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ What is the oxidation state associated with

the atoms of the free metal copper? \_\_\_\_\_

b) In line 9 a reference is made to copper ore being reduced to copper metal. Chemically speaking,

what must happen to the metallic ions of an ore, in order to be reduced to the metal? \_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

c) What elements, other than metals and nonmetals may be obtained from refining copper ores?

+1 -1 +2 +5 -2 +2 -1 +1 +5 -2

\_\_\_10) Given the chemical equation: KI + Pb(NO3)2 🡪 PbI2 + KNO3 you can state that

a) no changes in oxidation states occur

b) lead changes in oxidation state from Pb+2 to Pb0

c) iodide changes in oxidation state from I0 to I-1

d) potassium changes in oxidation state from K+1 to K0

+1 -1 0 +1 -1 0

\_\_\_11) Given the chemical equation: 2 KCl + F2 🡪 2 KF + Cl2

The oxidation number of the fluorine atoms in F2 changes from:

a) -1 to -2 c) -1 to 0

b) -1 to +1 d) 0 to -1

ANSWERS

1) Given: F2(g) + 2KCl(aq) 🡪 2KF(aq) + Cl2(g)

a) Assign oxidation numbers to each species

b) What species is oxidized? Cl1-

c) What species is reduced? F20

d) What species is the oxidizing agent? F20

e) What species is the reducing agent? Cl1-

f) Answers will vary … think about how you identify an oxidized species …vs. an oxidizing agent … We’ll share answers in class….

2) Given: 2 Al(s) + 3 NiCl2(aq)  2 AlCl3(aq) + 3 Ni(s)

a) Assign oxidation numbers to each species

b) What species is oxidized? Al0

c) What species is reduced? Ni2+

d) What species is the oxidizing agent? Ni2+

e) What species is the reducing agent? Al0

3) Given: 2 Al(s) + 6 HCl(aq)  2 AlCl3(aq) + 3 H2(g)

a) What species is oxidized? Al0

b) What species is reduced? H1+

4) Given: Mg(s) + SiO2(s)  Si(s) + 2 MgO(s)

a) What species is the oxidizing agent? Si4+

b) What species is the reducing agent? Mg0

5) b) O20

6) From a chemical (or redox) point of view, what happens to the three moles of carbon as they react with

the rust? They are oxidized. Defense: The oxidation number of the C changes from 0 to +4

7) d) OF2

8) It is easily / readily reduced

9) a) +1

b) **The pure element**  **Zero (0)**

c) **They gain electrons**

d) metalloids such as Se and Te

10) a) no changes in oxidation states occur

11) d) 0 to -1