NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ UNIT 3: BONDING AND COMPOUNDS (PART 1)

I) **What is a chemical bond?** … a relatively more stable (or lasting) attraction between atoms or ions, which

leads to the production of a new chemical compound or species.

The term, *chemical bond* or just the term, *bond*, may be due to the:

\*sharing of electrons, between atoms,

as the electrons of one atom are attracted to the nuclear charge of a second atom, and the electrons of that second atom are simultaneously attracted to the nuclear charge of the first atom

(covalent bonding)

\*electrostatic force of attraction

between \* oppositely charged species

\*(+ and – ions)

(ionic bonding)

OR

A third broad category of bond, the **metallic bond** seems to blend the two basic ideas, found above.

Metallic bonding does not however, play a huge role in our discussions, for this class, save to help explain

how to atoms of the **same metallic element** bond to form a crystal of that metallic element (e.g. a chunk of

iron or a gold ring)

II) **Why do bonds form?** … It ain’t really all that simple of an answer….but generally,

A) Bonds form because the process of bonding tends to \*lower the potential energy between the

charged particles that compose atoms.

Much of it goes back to lowering potential energy due to coulombic forces of attraction.

The thinking goes along these lines reactions (resulting in new bonds being formed) tend to

occur so as to decrease enthalpy \*(the overall energy of a compound ,)

and to increase the entropy \*(the distribution of that energy).

1) A chemical reaction really has two processes going on … breaking the bonds of the

reactants, and making the NEW bonds found in the products.

ALL bond breaking processes are endothermic (breaking a bond absorbs energy)

ALL new bond making processes are exothermic (making new bonds releases energy)

original system **added energy**

MC900078802[1] **Visualize!!** — —

When enough energy is added the bond is broken, and the atoms separate, & essentially move away from each other.

bond length

\*This dash bond represents 2 shared e- (or 1 pair of e-)

\*A chemical bond is an example of **po**tential energy

\*This bond has a length, thus giving each atom

a **po**sition relative to each other

This system of two separate species (due to a broken bond) has more

energy than the original system, because the position between the

species has increased, due to the energy used to break the bond.

Thus bond breaking is endothermic (absorbs energy)

The new relative position is greater, hence the potential energy is greater … This greater energy in part

is due to the added bond breaking energy of the endothermic reaction. **The opposite is true of bond making,**

**because atoms must get closer (lose position) in order to bond … thus potential is converted into kinetic.**

2) We classify a chemical reaction (overall) as either exothermic or endothermic based upon

the amount of energy required to break bonds of reactants, relative to the amount of energy

released as new bonds are made …

a) When we write a chemical reaction, we tend to write, only the difference between

theses two processes of breaking bonds and making new bonds.

Imagine… A-B and Y-Z react to form A-Z and Y-B.

Imagine it takes 500 kJ of energy to break up A-B and Y-Z bonds

Imagine 700 kJ of energy are released as the products A-Z and Y-B are made.

500 kJ + AB + YZ → AZ + YB + 700 kJ

We would tend to write: **AB + YZ → AZ + YB + 200 kJ**

This tells us, that 200 kJ of energy were released into the surrounding

environment, (air or water) as the new bonds were made.

3) Exothermic reactions: Reactions in which \* more energy is released (lost) as new

bonds are made, then is gained as old bonds are broken.

a) From the point of view of the chemicals, the surrounding environment, the air or

the water, will become warmer, because energy is being lost by the chemicals to

the surroundings, as the new bonds are formed.

b) Chemical reactions as well as physical changes (e.g. freezing water to ice or

dissolving NaOH(s) in water), can be exothermic, for slightly different reasons.

Each however, result in more energy being released than absorbed.

This energy is lost to the environment (the surrounding air or water). The temperature of the surroundings goes up!

e.g.) 2 Al(s) + 6 HCl(aq) → 2 AlCl3(aq) + 3 H2(g) + 1,055 kJ

4 Fe(s) + 3 O2(g) → 2 Fe2O3(s) + 1,648 kJ

CH4(g) + O2(g) → CO2(g) + 2 H2O(ℓ) + 890 kJ (The flame!!!)

Focus: Were exothermic reactions to occur in water, we should expect to see an increase

in the temperature of the water, as the reactions proceed …

4) Endothermic reactions: Reactions in which more energy is absorbed by the reactants, as

bonds are broken, then is released as new bonds are made.

e.g.) Photosynthesis: 2803 kJ + 6 CO2(g) + 6 H2O(ℓ) → C6H12O6(aq) + 6 O2(g)

e.g.) Physical Change: Dissolving of NH4NO3 in water

This energy is absorbed from the water surrounding the NH4NO3. The energy is used to drive the dissolving process, thus the temperature of the water goes down.

24 kJ + NH4NO3 + H2O(ℓ) → NH4+1(aq) + NO3-1(aq)

III) Bonding theories should help us to predict the circumstances under which bonds form as well as

the properties of the resultant compounds

A) there are three (really) broad classifications of chemical bonds … each is

***dependent upon the type of atoms or ions (species) involved in the bonding***

|  |  |  |
| --- | --- | --- |
| **Species / Type of**  **Ion or Atom** | **Type of Bond** | **Characteristic of the Bond** |
| metal ion & nonmetal ion | ionic | electrons are transferred completely, creating an electrostatic charge attraction. The electronegativity difference > 1.7 |
| nonmetal atom and nonmetal atom | covalent (2 types)   * polar covalent * nonpolar covalent | at least 1 pair of electrons (and up to 3 pair) are shared   * unequally with an   electronegativity diff. < 1.7 but > 0.4     * equally with an electronegativity difference of 0 to 0.4 |
| metal and metal | metallic | electrons delocalize and are pooled among the species and are attracted to multiple nuclear cores. |

Recall: Electronegativity is related to the ability of one atom to attract (gain) the electron(s) of

another atom. It is on a scale of 0.7 to approximately 4.0. Fluorine is the most electronegative

element known, with a value of 3.98 (essentially, 4.0). Oxygen is the second most

electronegative element, with a value of 3.5. The following table offers some other examples.

![A close up of a keyboard

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDcRXhpZgAATU0AKgAAAAgABAE7AAIAAAAGAAAISodpAAQAAAABAAAIUJydAAEAAAAMAAAQyOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE93bmVyAAAFkAMAAgAAABQAABCekAQAAgAAABQAABCykpEAAgAAAAM2MAAAkpIAAgAAAAM2MAAA6hwABwAACAwAAAiSAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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<https://socratic.org/questions/which-elements-have-the-highest-electronegativities-on-the-periodic-table>

IV) Ionic Bonding produces ionic compounds:

For me, the cartoon, tells me a good deal … What is an ionic bond….?????

A picture containing text, book

Description automatically generated

A) An ionic compound is produced by ionic bonds between the species.

1) An ionic bond:

* forms when one atom \*transfers, completely an electron to another atom.
* has this complete transfer of electrons. and one species is oxidized becoming a cation, while the second species is reduced becoming an anion. The oppositely charged ions attract each other and a bond is produced, as potential energy drops.
* is purely \*electrostatic … in that it is produced by the attraction of

\*oppositely charged ions.

* is often found between a metal cation and a nonmetal anion.

e.g.) NaCl (a salt), Mg(OH)2 (a base), Fe2O3 (a metal oxide, a rust)

**VISUALIZE:**

The formation of an ionic bond … Note, one atom completely transfers and

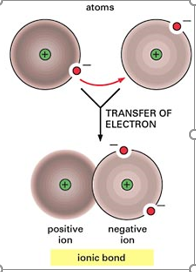
electron to a second atom … producing ions, which are electrostatically attracted

to each other. The result is an ionic compound, held together, via an ionic bond.

Notice how the negative ion has all of the “bonding” electrons. There is a total

transfer of ownership, as it were … Sort of like me, giving you a car … in which

the car is an electron…



Found at: <https://socratic.org/questions/covalent-bonding-vs-ionic-bonding> from Essential Cell Biology Garland Science 2004

Check out: Beverly Biology: <https://www.youtube.com/watch?v=VSc491HLzDo>

B) Very often, when added to water, an ionic compound will dissolve *AND* the electrostatic bond

is disrupted by water molecules. The ions of the compound separate, and are hydrated (surrounded)

by water, creating an \*electrolyte solution. Such a solution can

conduct an electrical current through the solution!

C) (Properties) Ionic compounds tend to:

* have very little odor, as they do NOT turn into gases easily. (We can only smell gases.. Hmmm!)
* have high melting points (Well over, 200°C)
* be very poor conductors of electricity, as solids …
* be made of metal ions bonded to nonmetal ions.
* somewhat soluble in water, but very poorly soluble in alcohol or gasoline
* conduct an electrical current through water, when dissolved
* solids at STP (0°C and 1 atmosphere) …. and even at room temperature (21°C !!!!)

V) Covalent Bonding and Molecular Compounds

A) Generally speaking, the simplest unit of a substance made via covalent bonding is called

\*a molecule or a molecular substance.

1) Thus, molecular substances have covalent bonds (There is no such term as molecular bond)

a) Molecular substances may be inorganic or organic

b) Molecular substances may be molecular elements or compounds …

i) The diatomic elements exist as molecular elements.

B) Covalent bonds are due to at least 1 pair of electrons being shared, so as to complete both atom’s

valence shell.

* Electrons are shared. There is an overlap of electron space …sort of like shaking hands of linking arms…..
* Electrons may be \* shared equally or unequally
* Electrons are shared when neither atom has a *vastly* dominant electronegativity (attraction for electrons)
* Electrons in a covalent bond are attracted simultaneously to \* both nuclei
* No ions are formed in the making of a covalent bond … the species are atoms. There is NO COMPLETE TRANSFER of electrons… They find a “happy medium” between the atoms and both atoms benefit from the electrons of the bond.
* For our course, a covalent bond will exist between \* two nonmetal atoms.
* Covalent bonds are often described by their **bond length** and **bond strength** (the amount of energy required to break the bond and separate the atoms)
* Covalent bonds will be symbolized with a solid line linking two atoms

e.g.) H – Cl

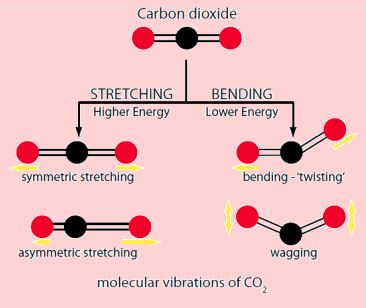
or it will be symbolized with solid wedges or hash line wedges

A picture containing object, clock

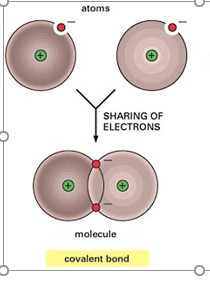
Description automatically generated

* A close up of a device

  Description automatically generatedCovalent bonds may be single, double or triple bonds (where 1 pair, two pairs or three pairs of electrons are shared)
* Covalent bonds can stretch, bend, rotate … Recall our work on CO2 and the absorption and release of infrared energy, and climate change ….



<http://www.chm.bris.ac.uk/motm/CO2/CO2h.htm>

 **VISUALIZE**

Found at: <https://socratic.org/questions/covalent-bonding-vs-ionic-bonding> from Essential Cell Biology Garland Science 2004

C) A nonmetal atom tends to make as many covalent bonds as are required, to complete their valence

shell, with 8 electrons. (H will try to complete its valence shell, with only 2 electrons)

1) For instance, consider an oxygen atom with a ground state electron configuration of 2-6

The atom requires 2 more electrons to complete its valence shell, and thus the atom

tends to make 2 covalent bonds. This helps to explain the double bond of O2 and the two

bonds found in a water molecule.

2) Consider an atom of H, with a ground state electron configuration of 1. The atom requires

only 1 more electron to complete the valence shell, which can hold only 2 electrons. Thus,

hydrogen atoms tend to make 1 covalent bond.

3) Consider an atom of C, with a ground state configuration of 2-4.

The atom requires 4 more electrons to complete the valence shell with 8 electrons. Hence,

**atoms of carbon tend to make 4 covalent bonds**.

1) For carbon, the bonds form so as to spread the valence electrons out.

4) Nitrogen has a ground state configuration of 2-5. How many covalent bonds will an atom of

nitrogen tend to make? \*3

D) NonPolar Covalent Bond: A covalent bond between atoms of the same nonmetal element

as well as C-H bonds. The electronegativity difference for such a

bond is between 0 and 0.4.

1) Essentially the nonpolar (meaning “no difference”) covalent bond has an electronegativity

difference of 0 to 0.4. However, we shall not be concerning ourselves with the theory in such

depth … Thus, knowing that a nonpolar covalent bond exists between atoms of the same

nonmetal element OR Carbon to Hydrogen.

Think of it this way: Nonpolar covalent bond

same nonmetals joined

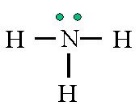
E) Polar Covalent Bond: A covalent bond between atoms of DIFFERENT nonmetal elements.

Generally there is an electronegativity difference of 0.4 to 1.6

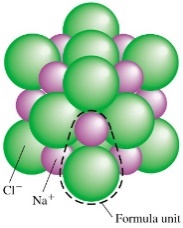
Think of it this way: Polar covalent bond

Different nonmetals joined

**TRY THIS:** Use the following 4 choices and their diagrams to answer the following four questions.



1) O2 3) NH3





2) NaCl 4) Fe crystal

1) Which of the substances is made with polar covalent bonding?

2) Which of the substances is made with nonpolar covalent bonding?

3) Which of the substances is made with ionic bonds?

4) Which of the substances is made with metallic bonds?

The answers are on the next page…

answers to TRY THIS: 1) 3 2) 1 3) 2 4) 4

F) Molecular (a.k.a. Covalent) Compounds Properties

* may exist as solids, liquids or gases at room temperature
* may / may not have an odor … but so many do!
* have a melting point, generally below 200°C
* if solid, tend to be soft, and mushy … think, wax
* may / may not be soluble in water
* tend to be NONELECTROLYTES. They may dissolve in water but tend not to break down into ions. The molecular acids are a common exception to this idea.

**TRY THIS!**

\_\_\_1.  *I am providing you with "before and after" diagrams for this question. Analyze them to see if they help you.*

A student took the temperature of 150.0 mL of water. She then dissolved 5.00 grams of NH4Cl(s) into

the water according to the equation

H2O(l)

NH4Cl(s) + 14.7 kJ 🡪 NH4+1(aq) + Cl-1(aq)





just 150 mL water 150 mL of water plus

the dissolving NH4Cl

<http://www.wpclipart.com/science/beaker/beaker.jpg>

**THINK! Is this dissolving process, endothermic or exothermic?**

**Is the chemical NH4Cl absorbing energy from the water, OR releasing energy into the water?**

**If the chemical were absorbing energy, what should happen to the temperature of the water?**

**If the chemical were releasing energy, what should happen to the temperature of the water?**

She took the temperature of the resulting solution. Using the above equation and her knowledge of

thermal energy, she could predict that the reaction was:

a) endothermic & the temperature of the water increased

b) endothermic & the temperature of the water decreased

c) exothermic & the temperature of the water increased

d) exothermic & the temperature of the water decreased

\_\_\_2 Given the reaction : A(s) +B(aq) 🡪 C(s) + D(aq) + 170 kJ

If the reaction occurred in water, the temperature of the system at the end of the reaction should have:

a) increased b) decreased c) remained the same

**Think: Is this chemical reaction endothermic or exothermic?**



**Are the chemicals, as they react, absorbing energy from the environment or are**

**the chemicals, as they react, releasing energy into the environment?**

**If the chemicals were absorbing energy, what should happen to the temperature of the water?**

**If the chemicals were releasing energy, what should happen to the temperature of the water?**

For questions 3 - 5 use the following choices. A choice may be used once, more than once or not at all.

a) endothermic b) *exothermic*

\_\_\_3) 52.4 kJ + 2 C(g) + 2 H2(g) 🡪 C2H4(g)

H2O(ℓ) Water, over an arrow, suggests something is being dissolved

\_\_\_4) NaOH(s) 🡪 Na+1(aq) + OH-1(aq) + 44.3 kJ in water, thus, this is just a physical change…

\_\_\_5) HCl(aq) + Fe(s) 🡪 FeCl2(aq) + H2(g) + 598 kJ

\_\_\_6) A student took the temperature of 150.0 mL of water. She then dissolved 30.00 grams of KClO3(s) into

the water according to the equation:

H2O(ℓ)

KClO3(s) + 41 kJ 🡪 K+1(aq) + ClO3-1(aq)

She took the temperature of the resulting aqueous solution. Using the above information and her

knowledge of chemistry she could infer that the reaction was :

a) endothermic & the temperature of the surrounding water increased

b) exothermic & the temperature of the surround water increased

c) exothermic & the temperature of the surrounding water decreased

d) endothermic & the temperature of the surrounding water decreased

7) Imagine that you and a friend are sitting in front of a wood fire. The reacting chemicals in this case, are the

wood and dioxygen (O2(g)) gas from the air. Is the reaction exothermic or endothermic?

Wood + O2(g) → CO2(g) + H2O(g)

8) Consider liquid water freezing into solid water-ice. Is this exothermic or endothermic?

H2O(l) → H2O(s)

9) What confuses you or what do you think you now know? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

Ans:

1) b energy is absorbed by the reactants. the source of energy is most probably from the water, thus energy would move from the water to the chemicals, and the temperature of the resulting solution would be lower than the water's temperature.

2) a it is an exothermic reaction (energy is on the product side) ... the chemicals release more energy than absorbed and thus the water gains that energy.

3) a 4) b 5) b 6) d

7) exothermic ... energy is being released from the reacting chemicals ... far more than was added to get the fire going...

8) exothermic ... this is a cooling process and yes, also exothermic ... the chemical (water) must lose energy to the envrionment...

**Try This**

H H O

| | //

H―C―C―C―O―H

| |

H N

/ \

H H

\_\_\_1) Given the structural formula:

How many covalent bonds are represented in the molecule?

(1) 13 (2) 11 (3) 10 (4) 4

\_\_\_2) Which type of chemical bond is formed between two atoms of bromine?

(1) metallic (2) hydrogen (3) ionic (4) covalent

Which substance contains metallic bonds?

(1) Hg(ℓ) (3) NaCl(s)

(2) H2O(ℓ) (4) C6H12O6(s)

\_\_\_3)

Which of these formulas contains a polar covalent bond?

(1) Br2 (3) HF

(2) KCl(4) Na2O

\_\_\_4)

Which type of bond is formed when electrons are transferred from one atom to another?

(1) covalent (3) hydrogen

(2) ionic (4) metallic

\_\_\_5)

Which type of bond is found in sodium bromide (NaBr)?

(1) covalent (3) ionic

(2) hydrogen (4) metallic

\_\_\_6)

What is the total number of electron **pairs** that are shared between the **two carbon atoms** in a molecule of ethyne?

(1) 1 (3) 3

(2) 2 (4) 4

\_\_\_7)

Ethyne:

H―C ≡ C―H

\_\_\_8)

When an atom of chlorine and an atom of hydrogen become a molecule of hydrogen chloride (HCl), a chemical bond is:

1) broken and energy is released

2) broken and energy is absorbed

3) formed and energy is released

4) formed and energy is absorbed

\_\_\_9)



Which molecule contains a nonpolar covalent bond?

\_\_\_10)



The results of these tests suggest that:

(1) both solids contain only ionic bonds

(2) both solids contain only covalent bonds

(3) solid A contains only covalent bonds and solid B contains only ionic bonds

(4) solid A contains only ionic bonds and solid B contains only covalent bonds

A chemist performs the same tests on two homogeneous white crystalline solids, A and B. The results are shown in the table below.

\_\_\_11) The bond between Cl atoms in a Cl2 molecule is

(1) ionic and is formed by the sharing of two valence electrons

(2) ionic and is formed by the transfer of two valence electrons

(3) covalent and is formed by the sharing of two valence electrons

(4) covalent and is formed by the transfer of two valence electrons

\_\_\_12) Which solid element is malleable and conducts electricity?

(1) iron (2) iodine (3) iodine (4) phosphorus

\_\_\_13) A solid substance was tested in the laboratory. The test results are listed below.

The solid: • dissolves in water • is an electrolyte • melts at a temperature > 200°C

Based on these results the solid substance could be:

(1) Cu (2) CuBr2 (3) C (4) C6H12O6

14) Explain, *in terms of valence electrons*, why the bonding in magnesium oxide, MgO, is similar to the

bonding in barium chloride, BaCl2.

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

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Answers:

1) 1 count up the dashes (each dash represents a covalent bond)

2) 4 bromine is a nonmetal

3) 1

4) 3 different nonmetal atoms

5) 2 transfer of electrons is a key term for the formation of an ionic bond

6) 3 sodium is a metal and bromide (bromine) is a nonmetal

7) 3

8) 3 bond formation always releases energy

9) 3 nonpolar (same) covalent (nonmetals)

10) 4 check out those melting points … they are clear giveaways. Once done, check out the conductivity in water

11) 3 chlorine is a nonmetal

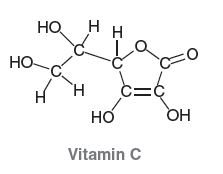
12) 1 generally, the only solids which can conduct electricity are metals

13) 2 the test results are all appropriate for an ionic compound. CuBr2 is the only ionic compound (metal/nonmetal)

14) Both compounds are ionic compounds. This means that the ionic bonds were produced by the complete transfer of valence electrons

FINDING MEANING IN A STRUCTURAL / CONDENSED OR SKELETAL FORMULA

Structural formulas are insanely helpful, as they show you the number, type and position of each atom of a molecule.



e.g.) Which a little care, you can get the formula for vitamin C from the

structural formula: There are 6 Carbons, 6 Oxygen, and 8 H

for: C6H8O6.

<https://www.clutchprep.com/organic-chemistry/practice-problems/13578/draw-the-bond-line-structure-160-for-vitamin-c>

![A close up of a logo

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V2d3h5eoOEhYaHiImKkpOUlZaXmJmaoqOkpaanqKmqsrO0tba3uLm6wsPExcbHyMnK0tPU1dbX2Nna4eLj5OXm5+jp6vHy8/T19vf4+fr/xAAfAQADAQEBAQEBAQEBAAAAAAAAAQIDBAUGBwgJCgv/xAC1EQACAQIEBAMEBwUEBAABAncAAQIDEQQFITEGEkFRB2FxEyIygQgUQpGhscEJIzNS8BVictEKFiQ04SXxFxgZGiYnKCkqNTY3ODk6Q0RFRkdISUpTVFVWV1hZWmNkZWZnaGlqc3R1dnd4eXqCg4SFhoeIiYqSk5SVlpeYmZqio6Slpqeoqaqys7S1tre4ubrCw8TFxsfIycrS09TV1tfY2dri4+Tl5ufo6ery8/T19vf4+fr/2gAMAwEAAhEDEQA/APpGiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACqlreNcXt7AygC3dVUjvlA39adeXjW2xIbaW4mkyERBgcd2Y8KP19ATxWNNZa5aSzXttNBJJM4kkgjTgYULgZPzDAHdTnJ/2aAOiorIt9SvdSt1Fla+QxGJJp1YIhzyFUhWc/gB78YqQ6hc6eNuqwNInRbm1jZwx7AoMsp/Me4zigCzdXbW97ZQqoIuJGUk9sIzf0q1WHd22qam0VzD5dh5BZoY5BukYlSuWIyE4PH3u2e60lnq2ooz2d7YyS3igbNilVcerN9wD3Byf7oPy0AbtQX9wbTTrm5VQzQxNIAehwCf6Vl3i6/Cq3EUsEu3JaCKPp7cn5h9Cp78/doe6u9d017e1tzbLNGY5riZWAQkYYIpAZiPUhR9cEUAbMT+ZCjnjcoNOrn/tWq6RcoL5RdWjEL5kMTHb24CgsD7HI5+8OFq3L/bF7C72/lWKkfJHJ80je5I4T24b3zytAGrVa1umuJ7qNlAEEuwEd/lB/rWXZatqKl7O8sZJbxANm1dqsP7zN90D3BJPPyg/LUctrrli0t3BJDOZX8ySCOPpwBjk5Ycdip78/doA6GisiPUb7UrZTYW3kcfvJp1ICt3VFIUsc8ZIUfXkVBa+I2jlNtqtrNHcKM/uoWYtzj7gyRzxkFl/2s8UAb1FY11eawsQuobRUiVv+PcrvkZe5bafl+ihz356Ult4kjvVWOztZpbtl3eUeFAzjcZOm3IxkZPB4yCKANqisGbVdQ0u6A1KFZoJCMPCm0KT/AAgknP0baT2z90Wv7Qu9QQ/2VA0ceObi5jK5PoqHBJ9zgfXkUAalFc/b+Jvs7G31iCWGdcAmOIncScAbRkgk8AgspPAbPFW5f7Zu42kg8myXHyRSfM59ywyFPthh656UAatFYdnq2o/PaXNhJJerjbwUQj+8zYKgf7pYn0HIDJtX1DSrwLqcAnhlZVR4I9vzHsvJzz2O1ifu7ugAN+isqPUbjVo1bR18u3YZ+1zoQD/uIcE/U4HpmnHU57LEep2shcnEctrG0iSn0wMlT7Hj3PNAGnRWJeXus26Ldi0QQ5+a3Cl3C+rMpOD/ALqtj36h1t4ij1BQmm2ss1wVDFH+VEU9GMgyCDg427icHjg4ANmio7dZlt1F06PL/E0alV/AEn+dSUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABSYBIOOR0NLRQAVnrBIPEbz7D5RtVQN23b2OPyrQooACARg8iiiigChq8Dz28AiQuy3ULHA6KJFJP5Cr9FFABSEZ680tFAFDQ4ZLfQrOKdCkiRKGU9Qav0UUAFZ9tBJHrt9KUIjeKEK3Ykb8/wAx+daFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAf/Z)However, your research and reading will lead you to other formats to describe molecules, and they are not always so clear … For instance, look at a skeletal formula for **lycopene**. Lycopene is a powerful antioxidant which may help with heart health and providing protection against certain cancers. It is found in tomatoes, watermelon, and pink grapefruit. Its skeletal structure is:

<https://www.chemspider.com/Chemical-Structure.394156.html>

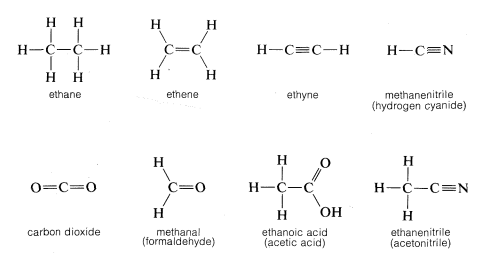
If you go “Huh?”, you would not be alone. The following pages will hopefully help you make sense of the variety of ways, organic molecules (in particular), are written.

**1) Covalent bonds are often symbolized with some sort of wedge-shape or straight line.**

a straight means the bond is in the plane of the paper. Each dash represents

1 pair of shared electrons (or simply just 2 electrons).

Most commonly, you shall see solid lines between two atoms or points on a molecule which represent (a)

 covalent bond(s).

<https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Book%3A_Basic_Principles_of_Organic_Chemistry_(Roberts_and_Caserio)/02%3A_Structural_Organic_Chemistry._The_Shapes_of_Molecules_and_Functional_Group/2.1%3A_Structural_Formulas>

Wedges are sometimes used in structural formulae.

![A screenshot of a cell phone

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For example;

A picture containing object

Description automatically generated

Methanol (Methyl alcohol)

<https://www.thoughtco.com/wedge-and-dash-projection-definition-602137>

<https://images.wisegeek.com/nerve-cell-with-labels.jpg>

Here’s a comparison of two slightly different views (top and side) of methanal (formaldehyde)

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<https://courses.lumenlearning.com/suny-potsdam-organicchemistry/chapter/2-2-hybrid-orbitals/>

**2) The carbon atoms of an organic compound are always included in a structural formula … but they**

**may or may NOT be included, as a “C”.** **A favorite shorthand is the use of a vertex.**

A vertex is any angular point … and where these “points” exist, a chemistry student may assume that there

is a carbon atom, **AS WELL AS** the hydrogen atoms, required to complete the 4-bonds every carbon will

make.

A great example of this, is seen with what chemists call a benzene ring. Benzene is a hexagonally shaped

ring structure and it is very special (and common!!!) A 6-sided diagram is often used to represent a

benzene ring or some variation of a benzene ring.

Each line intersection (vertex) represents a carbon atom, as well as the hydrogen atoms required to complete

the 4-bond requirement for each C atom are assumed, unless otherwise indicated. Notice the double bonds

between carbon atoms (indicated by the circle in diagram 3)

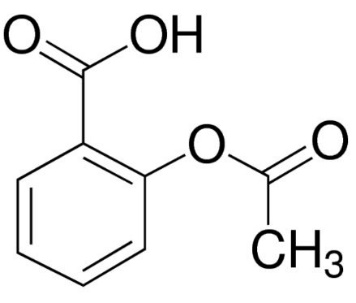
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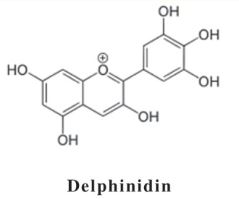
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This is a benzene molecule (C6H6) and, so it this one …. and this one too!

<https://classnotes.org.in/class11/chemistry/organic-chemistry-some-basic-principles-techniques/nomenclature-of-simple-aromatic-compounds/>

Here are two applications of a benzene ring (or some derivative) in molecules….





Aspirin (acetylsalicylic acid)

<https://www.sigmaaldrich.com/catalog/product/sigma/a5376?lang=en&region=US>

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5613902/>

A variation of delphinidin, called, delphinidin 3-glucoside is the

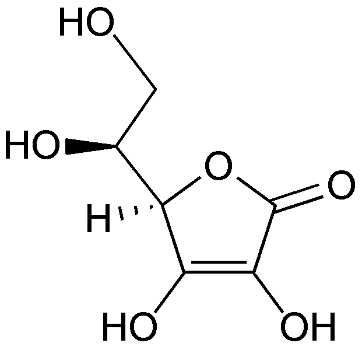
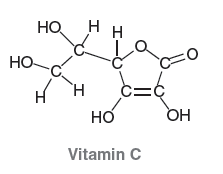
basis of the blue pigment in hydrangea and blueberries.

**3) While benzene has a backbone of just carbon atoms, it isn’t that unusual to find ring structures**

**with oxygen atoms (e.g. cyclic ethers, or cyclic esters) or nitrogen atoms (e.g. pyridine compounds)**

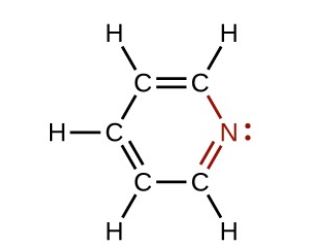
You may see wedge-shaped bonds. The author is simply trying to indicate the 3-dimensional position of

the bond and group of atoms.



<https://www.clutchprep.com/organic-chemistry/practice-problems/13578/draw-the-bond-line-structure-160-for-vitamin-c> & <https://commons.wikimedia.org/wiki/File:Ascorbic_acid_structure.png>

A pyridine ring is not the same as a benzene ring … but there are similarities…

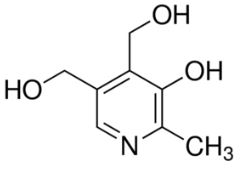


<https://courses.lumenlearning.com/chemistryformajors/chapter/amines-and-amides/>

Some molecules built off the pyridine ring are important vitamins.

![A drawing of a face

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDcRXhpZgAATU0AKgAAAAgABAE7AAIAAAAGAAAISodpAAQAAAABAAAIUJydAAEAAAAMAAAQyOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE93bmVyAAAFkAMAAgAAABQAABCekAQAAgAAABQAABCykpEAAgAAAAM2NwAAkpIAAgAAAAM2NwAA6hwABwAACAwAAAiSAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Vitamin B-6 (Pyridoxine) Vitamin B-9 (Folic Acid)

<https://www.sigmaaldrich.com/catalog/product/sigma/p5669?lang=en&region=US> <http://www.softschools.com/formulas/chemistry/folic_acid_formula/483/>

**4) The most off-putting for many students are what are called, Skeletal Formula or Structures**

Often, you just see polygon shapes and/or crooked lines. Sometimes, the polygon shape has an oxygen or nitrogen in it. Well, remember, chemists are moving fast and they use a shorthand.

Again, where two lines intersect, (a vertex) we may assume there is a carbon atom, bonded to enough (unseen) hydrogen atoms, so as to complete carbon’s required 4 bonds.

Take a look at the following formulae for a molecule of ethanol (ethyl alcohol). This is a good time to show you the condensed formula, while on our way to study skeletal formule.

![A screenshot of a cell phone

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDcRXhpZgAATU0AKgAAAAgABAE7AAIAAAAGAAAISodpAAQAAAABAAAIUJydAAEAAAAMAAAQyOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE93bmVyAAAFkAMAAgAAABQAABCekAQAAgAAABQAABCykpEAAgAAAAM2MgAAkpIAAgAAAAM2MgAA6hwABwAACAwAAAiSAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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<https://study.com/academy/lesson/structural-formula-definition-examples.html>

Skeletal formulae are often, what you get on those pharmaceutical inserts describing the active drug.

Here is a look at the steroid, prednisone. Image from <https://en.wikipedia.org/wiki/Prednisone>

![A drawing of a person

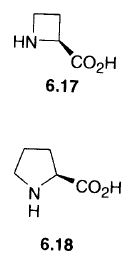
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Here is a look at a very simple hydrocarbon, pentane and all forms (isomers) of it. A hydrocarbon is an organic molecule made of ONLY carbon and hydrogen. Pentane has a formula of C5H12. It has only single bonds between the carbon atoms. The skeletal formula can look downright weird … but by now, I am hoping you are feeling a little more comfortable…. formulae from: <https://sites.google.com/site/ellesmerealevelchemistry/module-4-core-organic-chemistry/4-1-basic-concepts-and-hydrocarbons/4-1-1-basic-concepts-in-organic-chemistry/4-1-1-e-structural-isomers>

![A close up of a hanger

Description automatically 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A favorite story of mine, is about Lily of the Valley

From Chemistry In The Garden by J.R. Hanson

(Royal Society of Chemistry 2009 p. 63)

The rhizomes (primitive root structures) of the plant, lily-of-the-valley produce azetidine-2-carboxylic acid (figure 6.17) which diffuses out into the adjacent soil and facilitates the dominance of this plant. Other plants absorb this unusual amino acid and mistake it for proline (figure 6.18).

However, the resultant proteins cannot function correctly and the

plant dies, allowing the rhizomes of the lily-of-the-valley which

can tolerate this amino acid, to spread.

![A close up of a green plant

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDcRXhpZgAATU0AKgAAAAgABAE7AAIAAAAGAAAISodpAAQAAAABAAAIUJydAAEAAAAMAAAQyOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAE93bmVyAAAFkAMAAgAAABQAABCekAQAAgAAABQAABCykpEAAgAAAAMzMgAAkpIAAgAAAAMzMgAA6hwABwAACAwAAAiSAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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