Chemistry 11

Unit 2 – The Nature of Matter

Keyterms

- Be sure to recognize and be able to use the keyterms on page 59

Matter

- Anything with mass and occupies space is matter. That means EVERYTHING is matter.
- Matter can consist of 3 states:

Solid

Liquid

Gas

Matter

- Extensive properties are those that depend on the amount of matter

  eg. mass, volume, electrical resistance

- Intensive properties are those that do not depend on the amount of matter and just on the chemical nature of the matter

  eg. density, melting point, boiling point

Physical and Chemical Properties

- Physical properties describe physical changes, which really mean **changes of state**

  eg. melting point, transparency, magnetic properties, toughness

- Chemical properties describe chemical changes, those that involve the formation of new substances (some of which may not be visible)

  eg. chemical stability, reactivity, toxicity, flammability

Physical and Chemical Changes

- The energy required to cause chemical changes is generally greater than that needed to cause physical changes
- This is because physical changes require only molecular rearrangement while chemical changes require intermolecular rearrangement

Thermal Energy vs Temperature vs Heat

- Thermal energy is total energy stored in the particles of an object/material
- Temperature is the average mechanical (movement) energy of the particles in an object/material
- Heat is the transfer of energy from one object to another based on a difference in temperature

Characteristics of Matter - Solids

- Solids keep their shape because the particles are strongly attracted to one another and are held in a fairly rigid arrangement
- Particles are very closely packed. They are not free to move from one point to another in the solid
- If a solid is heated, its particles begin to vibrate more strongly. Enough heat breaks the attractive force causing it to become a liquid

Characteristics of Matter - Liquids

- Liquids are held together by weak attractive forces
- There are small spaces between the particles, making it slightly compressible
- The particles tend to remain together but are free to slide around each other (translation) and take the shape of the container they are held in
- When heated, particles of a liquid translate and vibrate more rapidly until the attractive forces break to becoming a gas

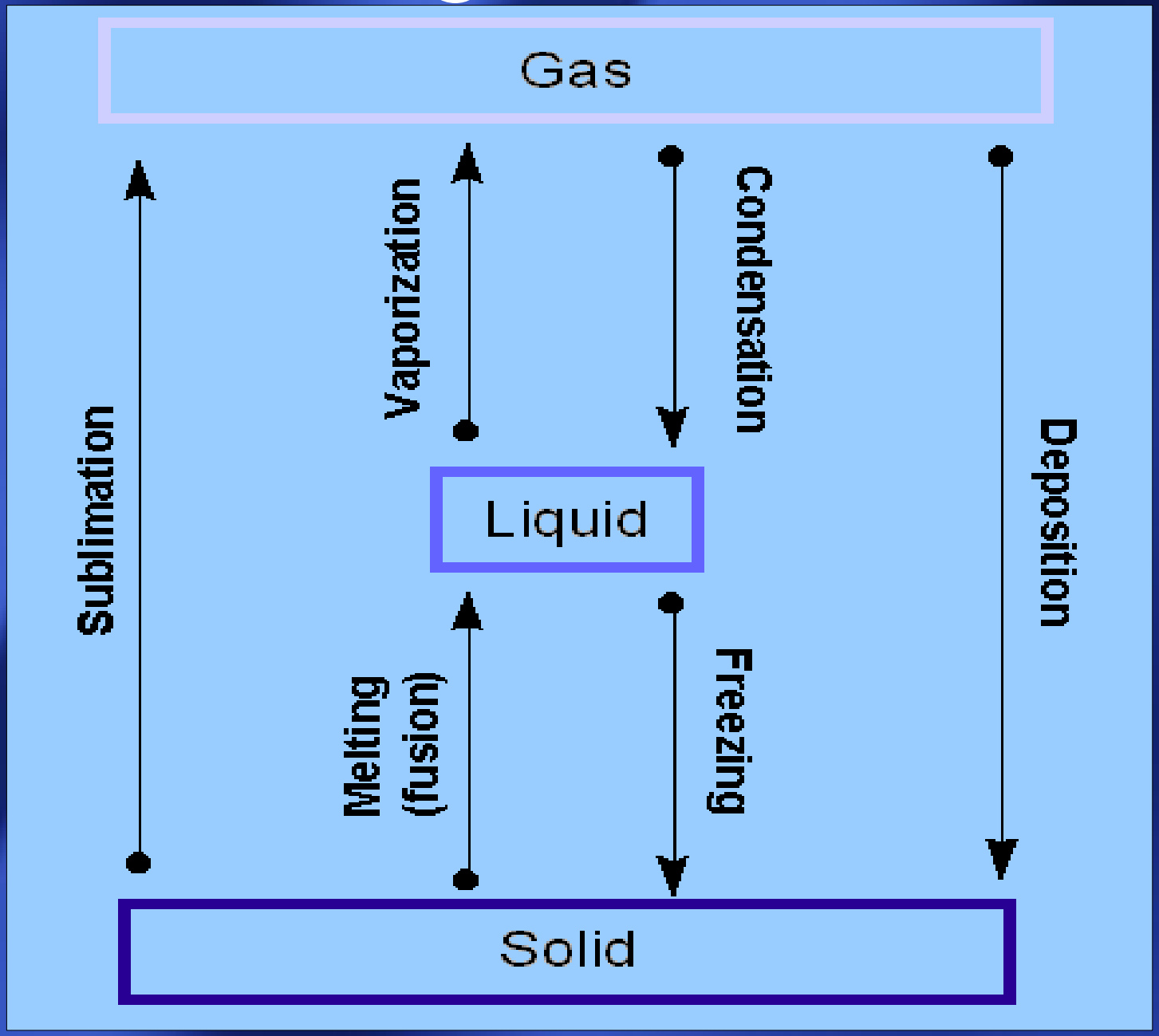
Characteristics of Matter - Gas

- Expands to fill the container it is in
- Attractive forces acting between gas particles are very small or nonexistent
- Easily compressed, indicating that particles are widely separated
- The particles vibrate and translate freely
- Since energy has been provided to break the attractive forces of both the solid and the liquid phases, gases have the highest potential energy of the three states of matter.

KMT

- This theory explains how matter changes states based on the changes in particle motion
  1. All matter is made of particles
  2. There is space between particles
  3. Particles are constantly in motion
  4. Particle motion is based on their amount of kinetic energy

Changes of State



Changes of State

- Energy is required to change state
- Potential energy within particles changes to kinetic energy
- When enough kinetic energy is built up, solids change to liquids and liquids change to gases
- When kinetic energy changes back into potential energy, particles change back from gases to liquids to solids.

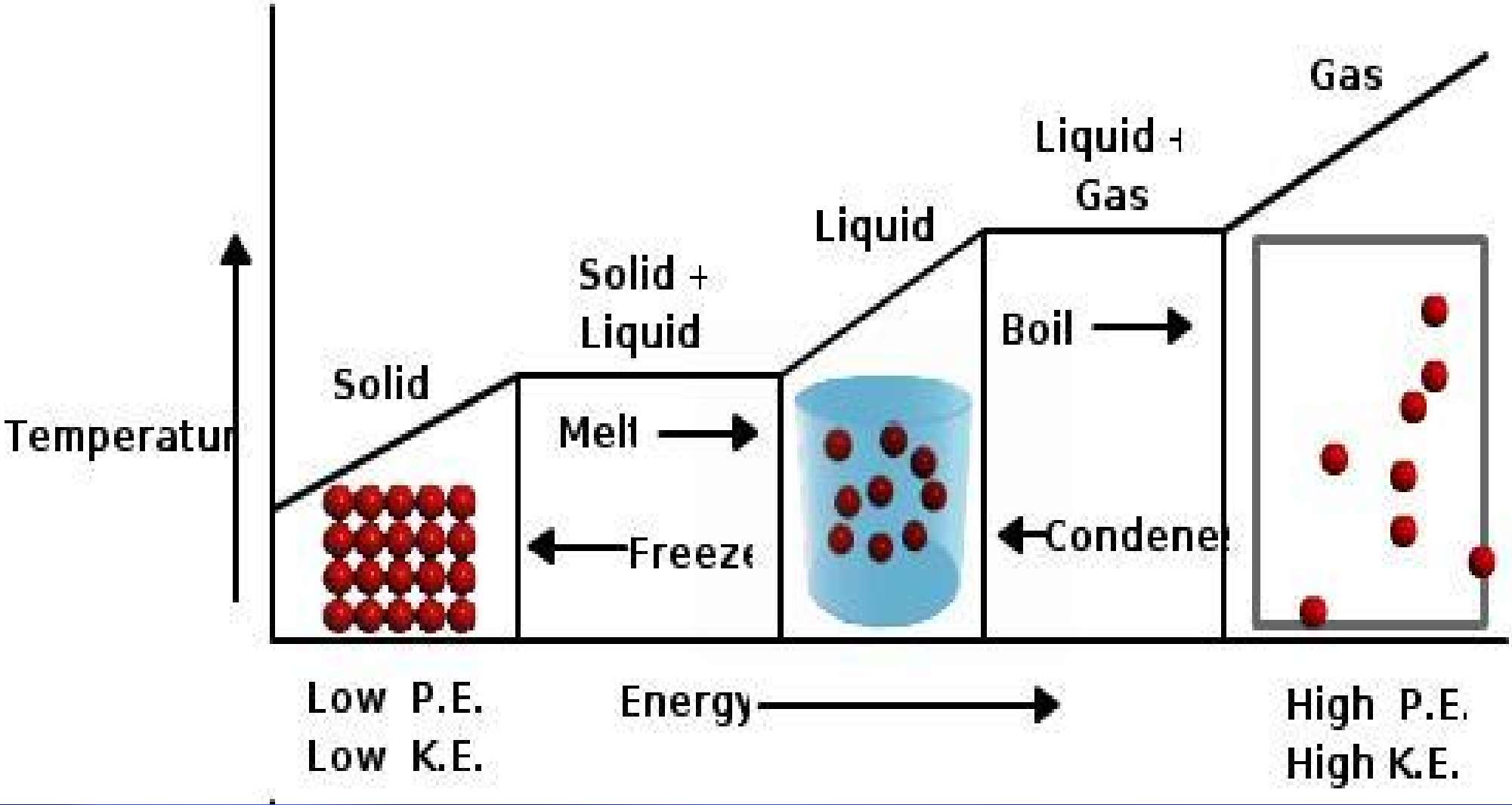
Physical Properties

- Melting point is the temp where a solid becomes a liquid
- Melting is caused by the space between solid particles moving far enough apart for them to slip past each other
- Heat of Fusion is the amount of heat needed to melt a given amount of substance at its melting point

Physical Properties

- Boiling Point is the temp where a liquid changes to a gas
- Particles that gain enough energy to separate itself from other like particles become gaseous and have evaporated
- Heat of Vaporization is the amount of heat needed to evaporate a given amount of substance at its boiling point

Changes of State



Some Chemical Properties

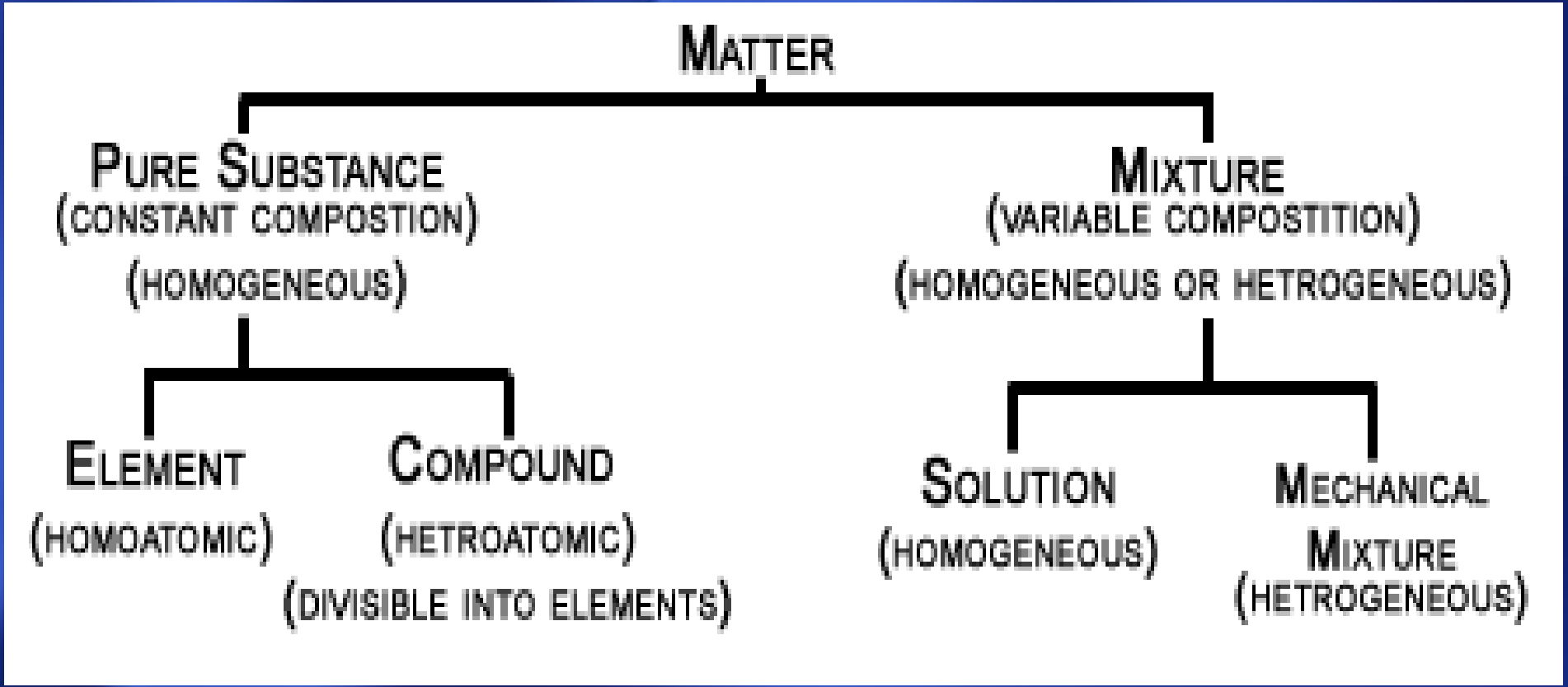
- Reactivity usually refers to how quickly a substance reacts (reaction rate) or if it reacts at all
- Reactivity depends on several factors that you'll look at in Chemistry 12
- Heat of Formation is the heat released when a substance is made from its elements
- Heat of Combustion is the heat released when a compound reacts with oxygen and burns completely (combusts)

Worktext

- Review Questions 1 – 23 on pages 70-72

Matter

- It can also be classified more thoroughly according to its particles.



Pure Substances

- Pure substances are uniformly blended (homogeneous) and are either elements or compounds
- Elements are substances that cannot be decomposed into simpler materials by chemical reactions and exhibit constant composition or fixed proportions.
- Compounds are pure substances that are formed from two or more elements in which the elements are always combined in the same fixed proportions by mass.

Mixtures

- Mixtures have variable compositions and can be solutions or mechanical mixtures.
- Solutions (homogeneous mixtures) have the same properties throughout the sample.
- Mechanical Mixtures (heterogeneous mixtures) consist of two or more regions called phases that differ in properties.

Elements


Alkali Metals
Alkaline Earth Metals
Transition Metals
Oxygen Group
Halogens
Noble Gases

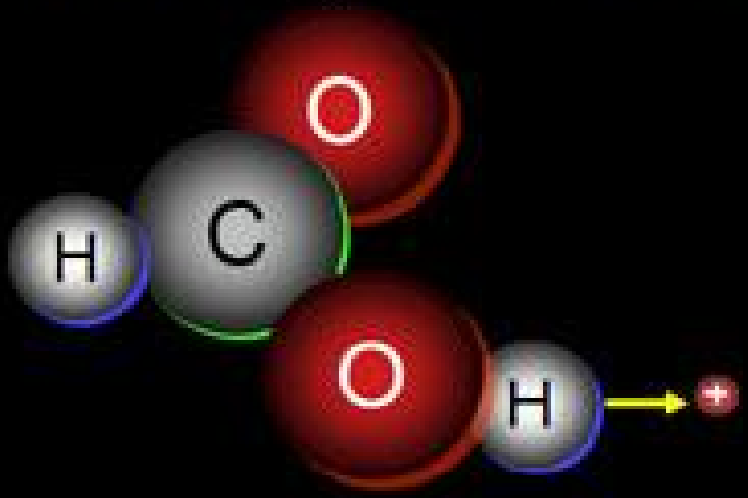
Compounds

- Compounds are formed from the chemical combination of atoms
- The formation of compounds require the addition of energy (synthesis reactions)
- The breakdown of compounds require the removal of energy (decomposition reaction)

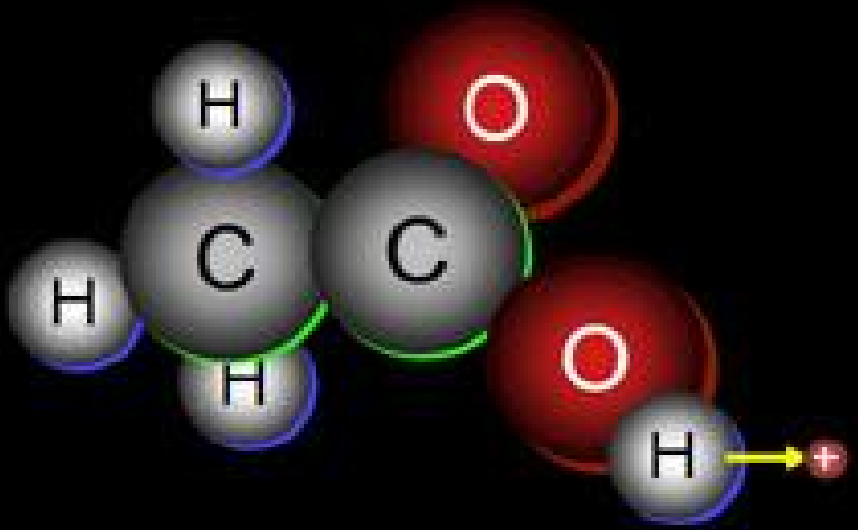
Organic vs Inorganic

- Organic compounds are those based on carbon and hydrogen atoms

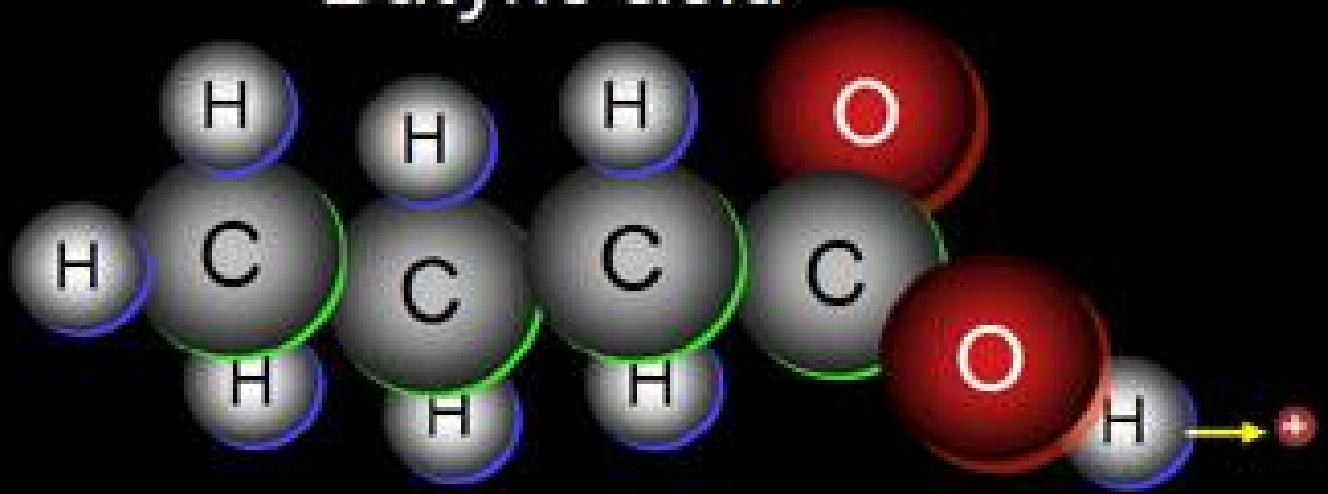
Formic acid (ant bite venom)



Acetic acid (vinegar)



Butyric acid



Organic vs Inorganic

- Inorganic Compounds are anything else not based on carbon and hydrogen.

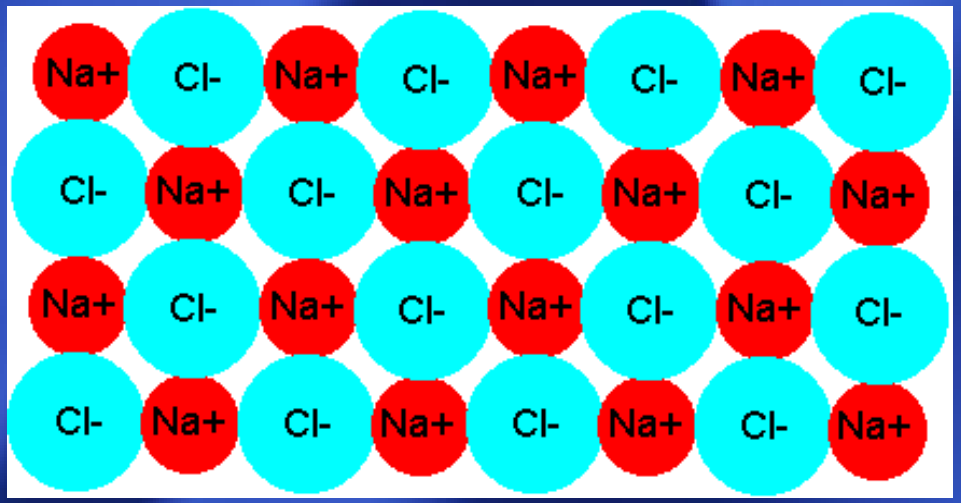
Binary vs Non-Binary

- Binary compounds have only two elements

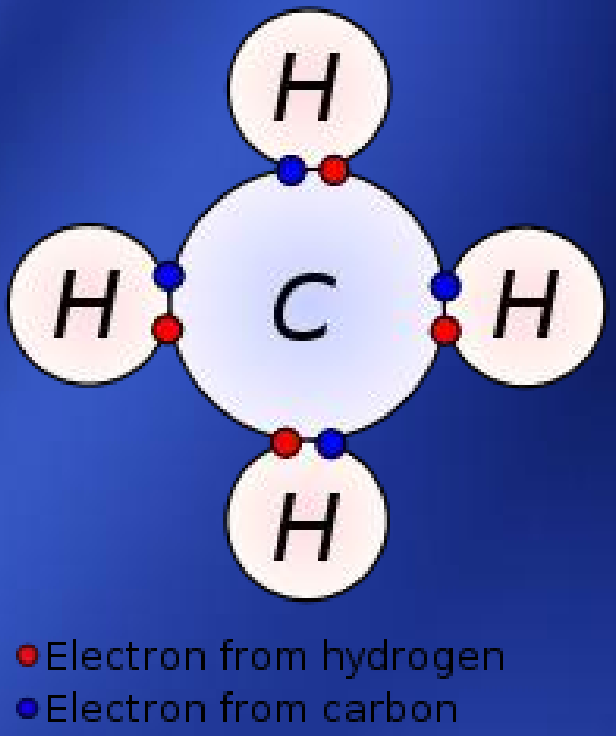
- Non-binary have more than two elements

Ionic vs Molecular

- Ionic compounds are formed from ions, often a metal and a non-metal ion, and form ionic bonds

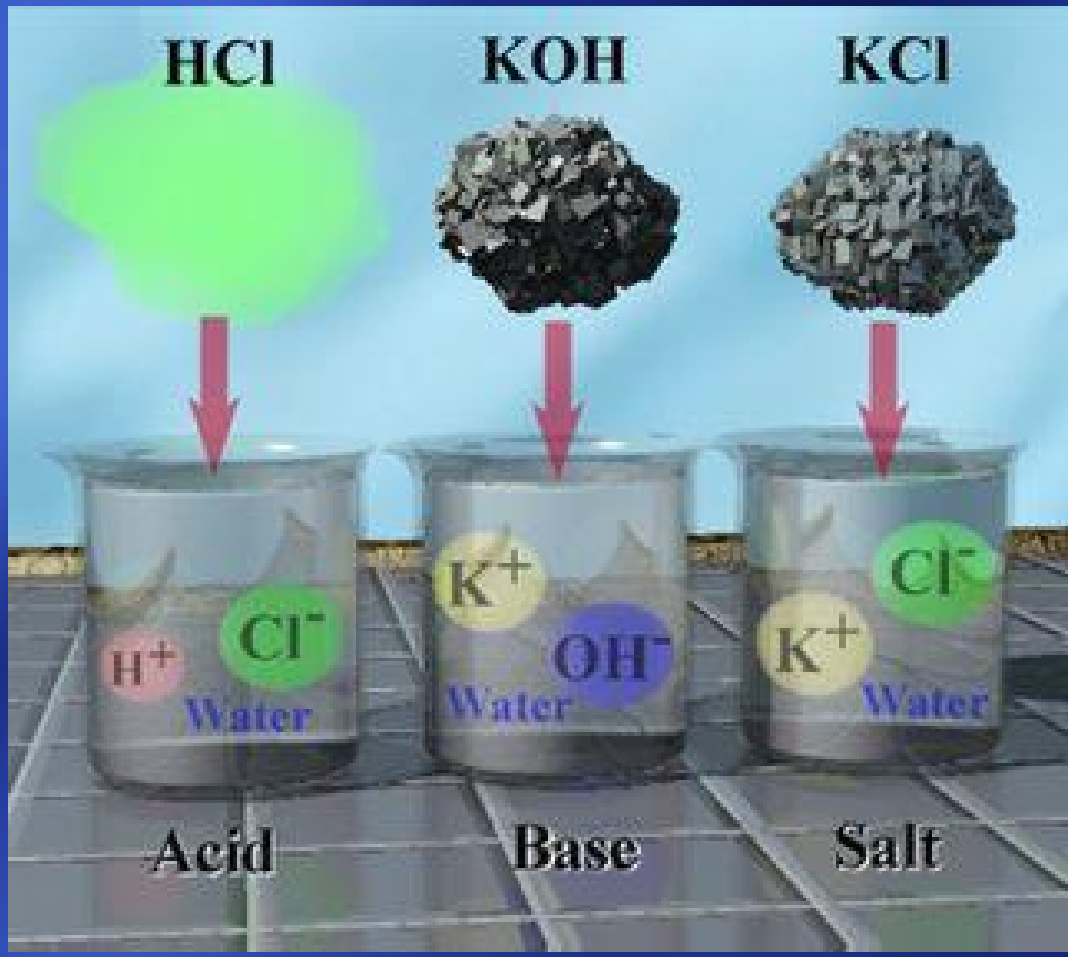


- Molecular compounds are formed from atoms and are bound covalently



Ionic Compounds

- Acids – Compound having at least 1 H+ ion bound to a negative ion (anion)
- Bases – Compounds having at least 1 OH- ion bound to a positive ion (cation)
- Salts – Any ionic compound that does not contain an H+ ion or a OH- ion



Classification of Mixtures

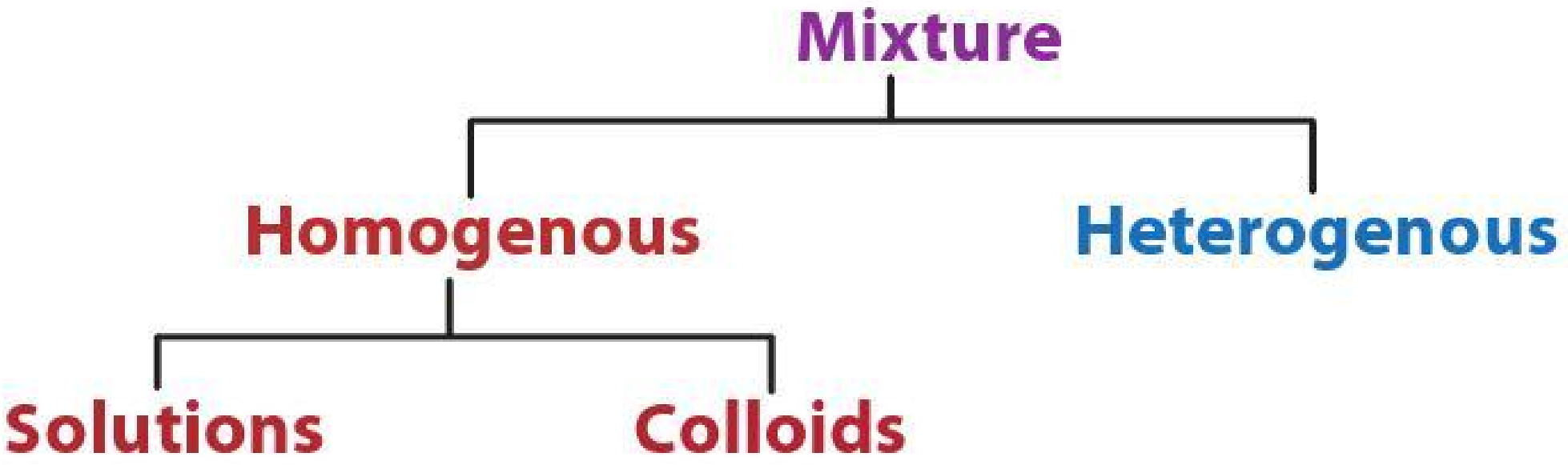


Figure 2.2.6 *Classification of mixtures*

Mixtures

- Homogenous mixtures – consist of one phase
  - Solutions – composed solute (the thing being dissolved) particles atomically interdispersed between solvent (the thing doing the dissolving) particles
  - Colloids – small particles interdispersed throughout a medium which can be in two different states

Mixtures

- Heterogeneous mixtures – when more than 1 phase or layer is visible
  - Mechanical mixture – can be separated through mechanical (by hand) means
  - Suspension – sediments that can be dispersed throughout a medium but can be separated by centrifugation

2.2 Activity

- Read worktext page 82 and complete the activity in pairs.

Worktext

- Complete review questions on page 83- 85.

Physical vs. Chemical Change

- Physical changes are those where the particles themselves do not change in composition, only in energy. Physical changes are changes in state.
- Chemical changes are those where the particles themselves have been changed. Chemical changes can be shown by:
  - changes in colour
  - formation of new products (solids, liquids, gases)
  - temperature change

Separating Mixtures

- Mixtures can be separated using different means including:
- filtration
- evaporation
- chromatography
- distillation

Worktext

- Read pages 86 – 92

Lab – Chromatography Lab

- Read Lab manual page 24 – 29 and copy data tables 1, 2, and 3 on page 28

- **Part A** – Set up your materials as described. You should have 3 sets of test tubes.
- **Part B** – Mr Lau will choose either red/yellow or blue for you to test
- **Part C** – You will test green food colouring and the unknown mixture.

Review

- Matter is anything with mass and takes up space
- Matter can be classified by state or by its particles
- Pure substances are composed of only 1 type of particle while mixtures are composed of more than 1 type of particle
- Changes of state occur because of energy changes at the particle level. Increasing kinetic energy (decreasing potential energy) makes particles move faster and further apart. Decreasing kinetic energy (increasing potential energy) slows them done and they move closer together.

Review

- Physical changes are changes of state
- Chemical changes changes the particles and will provide different forms of evidence
- Separating mixtures will depend on the composition of the mixture

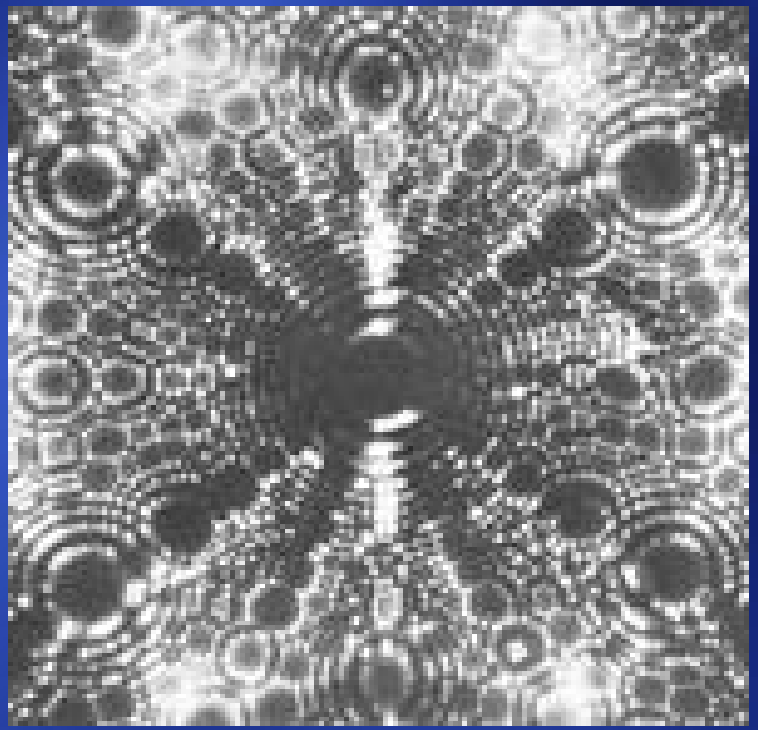
Atoms, Molecules, Ions

- What is the difference between the three?

Atoms

- Smallest possible piece of a certain kind of matter (particle).
- There are as many different kinds of atoms as there are elements.

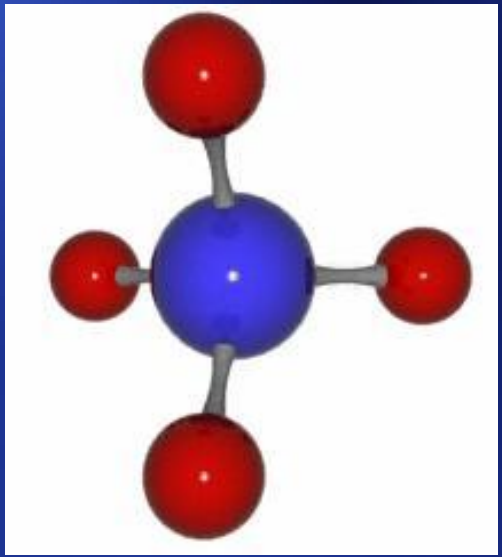
- Therefore, **an atom is the smallest particle of a chemical element that can take part in a chemical reaction.**



Molecules

- Smallest possible group of atoms
- Made up from two elements in which the elements are always combined in the same fixed proportions by mass

- Therefore, **a molecule is the smallest fundamental unit (group of atoms) of a chemical compound that that can take part in a chemical reaction.**



What about Elements and Compounds?

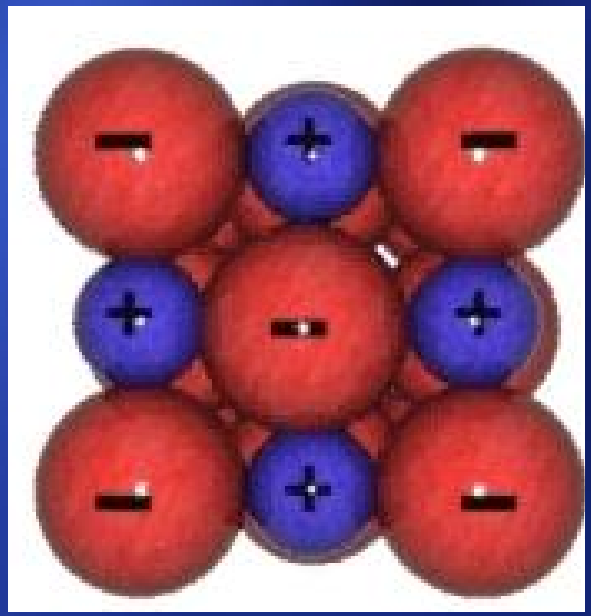
- Atoms are the smallest unit of an element
- Molecules are the smallest unit of a compound
- They refer to the same things, only on a **smaller scale**

Ions

- Ions are atoms or molecules that have developed a negative or positive charge.

Example: salt (NaCl)

- composed of Sodium and Chlorine atoms.
- Sodium has a positive charge whereas Chlorine carries a negative charge cancelling each other out to create a stable compound.



Ions

- Ions can be either:
- monoatomic, made up of only 1 atom
  - eg. Li^+, Cl^-
- diatomic, made up of 2 atoms
  - eg. ClO^-
- triatomic, made up of 3 atoms
  - eg. I_3^-
- polyatomic, made up of many atoms
  - eg. $H_2PO_4^-$, NO_3^-, NH_4^+

Wiki Video

- http://sthsintsci.wikispaces.com/file/view/Chem-

Laws

- There are three laws you need at this point:
  - Law of Conservation of Mass
  - Law of Definite Proportions
  - Law of Multiple Proportions

Law of Conservation of Mass

In a chemical reaction, the mass of ***all*** reactants will equal the mass of ***all*** products

Law of Definite Proportions

A specific compound will always contain the same elements in the same definite proportions

Law of Multiple Proportions

Some combination of elements may be capable of forming more than one compound

Determining Combining Capacity

- Compounds have an electronic charge of zero, meaning that the sum of the combining capacities of all the elements within a compound must be zero.
- Some of the elements have one, and only one, combining capacity.
- Others have combining capacities that are consistent with a few exceptions

Determining Combining Capacity

- These combining capacities need to be memorized:
- Group 1 metals always have a combining capacity of +1.
- Group 2 metals always have a combining capacity of +2.
- Group 13 elements have a combining capacity of +3.
- Group 17 elements have a combining capacity of -1 in binary compounds such as NaCl and CaF_2

Determining Combining Capacity

- Hydrogen is +1 when it combines with a nonmetal and -1 when it combines with a metal (NaH - sodium hydride).
- Oxygen is almost always -2
- Sulphide has a combining capacity of -2.
- Transition metals, Group 3-12, do not follow a straightforward pattern and many of them have the ability to form more than one positive ion.

What is the combining capacity of the copper in $CuBr_2$?

- Solve an **algebraic equation** to determine the combining capacity of Cu.
- The sum of the combining capacities = 0.
- Bromine is in Group 17, and CuBr2 is a binary compound, so the Br is -1. Therefore:
- 1Cu + 2Br = 0
- 1Cu + 2(-1) = 0
- 1 Cu + (-2) = 0
- Cu = +2

What is the combining capacity of gold in Au_2O_3 ?

- Oxygen has a combining capacity of -2.
- 2Au + 3O = 0
- 2Au + 3(-2) = 0
- 2Au + (-6) = 0
- 2Au = +6 (adding 6 to both sides)
- Au = +6/2 = +3 (dividing both sides by two)

Naming Binary compounds of Group 1 and 2 Metals

- The name of the metallic part of the compound is written down first followed by the name of the nonmetallic part of the compound.
- The ending of the name of the nonmetallic element is changed to "ide"

MgO = magnesium/oxygen = magnesium oxide

KF = potassium/fluorine = potassium fluoride

Constructing the Formula of an Ionic Compound

- Ionic compounds are made up of metal and non-metal compounds
- Ionic compounds are neutral molecules:
  sum of + charges = sum of - charges
- To write the formula for ionic compounds, you use the criss-cross rule.
- See textbook page 70

Constructing the Name of Ionic Compounds

- If the ion has only 1 possible charge, just write the names of the ions together.

  $ZnCl_2$: Zn^{2+} = zinc ion, Cl^- = chloride ion

  $ZnCl_2$ = zinc chloride

Constructing the Name of Ionic Compounds

- If the ion has only more than 1 possible charge, you use the reverse criss-cross (un-criss-cross) rule to find the ion charges.

  PbO_2 : Pb^{2+}, O^-

  Since the negative charge can be found in our tables, we know that the oxygen ion is O^{2-}

  This means that we have doubled the charge on the oxygen, so we double the charge on the lead:

  $(Pb^{4+})_1$ $(O^{2-})_2$ = lead (IV) oxide

Naming Compounds containing Polyatomic Ions

- Naming these compounds is the same as naming other ionic compounds. Use the reverse criss-cross.

$Mg(OH)_2$: Mg^{2+} = magnesium ion

$(OH)^-$ = hydroxide ions

$Mg(OH)_2$ = magnesium hydroxide

Naming Compounds containing Polyatomic Ions

$Fe_2(SO_4)_3$: Fe^{3+} = iron ion

$(SO_4)^{2-}$ = sulphate ion

$Fe_2(SO_4)_3$ = iron(III) sulphate

Naming Hydrates

- Some ionic compounds are formed with water molecules.

  eg. copper(II) sulphate in water = $CuSO_4 \cdot 5H_2O$

  This shows that for every 1 $CuSO_4$ molecule, there are 5 H_2O attached.

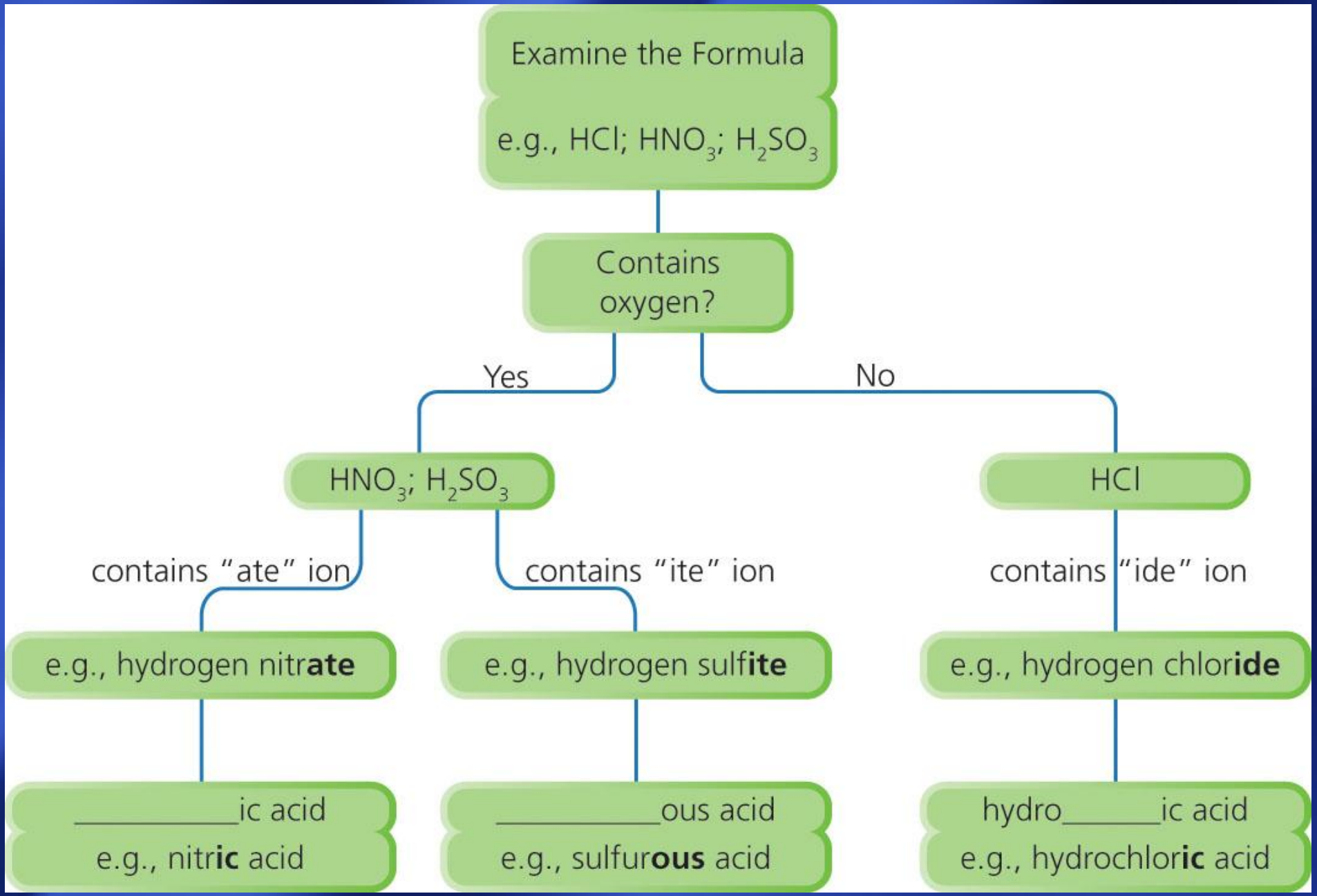
  Use the table on page 72 to find the name of hydrate number.

  $CuSO_4 \cdot 5H_2O$ = copper(II) sulphate pentahydrate

Acids

- Many compounds that contain hydrogen atoms are known as acids and have their own names.
- These compounds give up a hydrogen cation (positive) when dissolved in water
- The names of these acids are derived from the names of the anions (negative) that are produced in these reactions.

Naming Acids



Naming Covalent Compounds

- Covalent compounds uses the prefix-naming system.

Number	Prefix
1	mono
2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca

Naming Covalent Compounds

- Covalent or molecular compounds are made up of two non-metals.
- The prefix mono can be left off in the first name in the compound.
- Double vowels are also avoided most of the time.

Examples

NF_3 = nitrogen trifluoride

Si_2I_6 = disilicon hexaiodide