

## Answers to Review #1: Classification of Matter

### 1. Definitions:

- a) **Chemistry:** The study of matter, its properties and its transformations (how it can change).
- b) **Matter:** Anything that has mass and volume (takes up space). The science word for “stuff”.
- c) **Qualitative property:** a characteristic of matter that is always true for that type of matter and can be described, but not measured. For example: colour, state, and odour.
- d) **Quantitative property:** a characteristic of matter that is always true for that type of matter and can be measured and assigned a numerical value. For example: melting point, boiling point and density.
- e) **Physical property:** a physical characteristic of a substance that is always the same for that substance, for example, colour, density, clarity, solubility and electrical conductivity. Physical properties can be determined without changing the identity or composition of the substance in any way.
- f) **Chemical Property:** a chemical characteristic of a substance that is always the same for that substance. It describes how the substance behaves and changes in the presence of other chemicals, heat or light. Examples of chemical properties include how the substance behaves in water, in acid, with oxygen, etc. Chemical properties can NOT be determined without changing the composition or identity of the substance.
- g) **Physical Change:** a change in the state or arrangement of the particles in a substance, without changing the composition or identity of the substance in any way. Examples include: grinding, dissolving in water (as long as the substance does not react with the water), melting, vapourizing etc.
- h) **Chemical Change:** the rearrangement of the atoms in a substance to produce a new substance or substances with new chemical and physical properties. eg. when a metal reacts with acid to produce hydrogen gas.
- i) **Pure Substance:** a substance that contains only one type of particle. Pure substances can be either elements or compounds.
- j) **Mixture:** a substance that contains two or more types of particles. Mixtures can be either solutions (homogeneous) or mechanical mixtures (heterogeneous).
- k) **Element:** a substance that contains only one type of atom.
- l) **Compound:** a substance that contains two or more types of atoms, chemically bonded together.
- m) **Solution:** a homogeneous mixture. Solutions are evenly mixed and have only one phase (one visible region of matter).
- n) **Homogeneous:** means that the substance is the same, or uniform, throughout. Separate parts (phases) can not be distinguished.
- o) **Heterogeneous:** means that a mixture is not the same throughout. Separate parts (phases) can be distinguished.
- p) **Solvent:** the part of a solution that does the dissolving; it is usually present in the larger proportion.
- q) **Solute:** the part of solution that has been dissolved; it is usually present in the smaller proportion.
- r) **Metal:** any element that is found on the left-hand side of the staircase line on the Periodic Table; tends to lose electrons to form positively charged ions.
- s) **Non-metal:** any element that is found on the right-hand side of the staircase line on the Periodic Table; tends to gain or share electrons to complete a stable octet electron arrangement.
- t) **Metalloid:** an element that is found close to the staircase line on the Periodic Table and has properties of both metals and non-metals.

## 2. Explain the difference between the following:

- a) **A compound and a solution:** A **compound** is a pure substance which is composed of two or more elements chemically bonded together in a fixed, constant ratio. The elements in a compound can not be separated by physical means, only by chemical methods. A **solution** is not a pure substance. It is a homogeneous mixture of two or more substances that can be separated by physical means. The components of a solution can be combined in variable ratios.
- b) **A mixture and a solution:** A **mixture** is any combination of substances in which the elements or compounds are not chemically bonded together, they are merely mixed. Mixtures may be either homogeneous (solutions) or heterogeneous (mechanical mixtures). A **solution** is a homogeneous mixture that has only one phase and the components of the mixture are uniformly dispersed throughout each other.
- c) **A physical property and a chemical property:** A **physical property** is a characteristic of a substance that is always the same for that substance. Physical properties can be determined without changing the identity or composition of the substance in any way, for example, colour, density, clarity, solubility and electrical conductivity. A **chemical property** is a characteristic of a substance that is always the same for that substance. It describes how the substance behaves and changes in the presence of other chemicals, heat or light. The identity of the substance IS changed when chemical properties are being observed. Examples of chemical properties include how the substance behaves in water, in acid, with oxygen, etc.
- d) **A molecule and a mole:** A molecule is that name for a particle that is made when two or more atoms are chemically bonded together. A mole is the name for a very large number of things:  $6.02 \times 10^{23}$  things. This number is also called Avogadro's number and it is used to count very small things like electrons, atoms and molecules.
- e) **A chemical change and a physical change:** a **chemical change** refers to the rearrangement of the atoms in a substance to produce a new substance or substances with new chemical and physical properties. eg. when a metal reacts with acid to produce hydrogen gas. A **physical change** refers to a change in the state or arrangement of the particles in a substance, without changing the composition or identity of the substance in any way. No new substances are produced. Examples include: grinding, dissolving in water (as long as the substance does not react with the water), melting, vapourizing etc.
- f) **A metal and a non-metal:** Metals and non-metals are two types of elements. Metals include any element that is found on the left-hand side of the staircase line on the Periodic Table that tend to lose electrons to form positively charged ions. Metals are good conductors of electricity. Non-metals include any element that is found on the right-hand side of the staircase line on the Periodic Table that tend to gain or share electrons to complete a stable octet electron arrangement. Non-metal elements are poor conductors of electricity.

**3. Classify the substances as pure substances or mixtures, element, compound, solution or mechanical mixture:**

<b>Substance</b>	<b>Pure Substance or Mixture?</b>	<b>Element or Compound?</b>	<b>Solution or Mechanical Mixture?</b>
a) an iron bar	Pure Substance	Element	
b) Lucky Charms™ cereal	Mixture		Mechanical Mixture
c) concrete (sand, gravel and lime)	Mixture		Mechanical Mixture
d) ammonia gas (NH <sub>3</sub> )	Pure Substance	Compound	
e) brass (zinc and copper)	Mixture		Solution (an alloy)
f) aluminum foil	Pure Substance	Element	
g) tap water	Mixture		Solution
h) won-ton soup	Mixture		Mechanical Mixture
i) granite rock	Mixture		Mechanical Mixture
j) iron (III) oxide (rust)	Pure Substance	Compound	
k) ozone (O <sub>3</sub> )	Pure Substance	Element	
l) sterling silver (silver and copper)	Mixture		Solution (an alloy)
m) 24 karat (pure) gold	Pure Substance	Element	
n) chocolate milk	Mixture		Mechanical Mixture
o) stainless steel (Fe, C and Cr)	Mixture		Solution (an alloy)
p) sulfur	Pure Substance	Element	
q) distilled water	Pure Substance	Compound	
r) silver nitrate	Pure Substance	Compound	

4. Complete the following chart comparing the characteristic properties of metals and non-metals. Classify each property as being a physical (P) or chemical (C) property:

<b>Characteristic Property</b>	<b>Chemical or Physical Property?</b>	<b>Metals</b>	<b>Non-metals</b>
<b>Usual state at SATP</b>	Physical	Usually solid at SATP (except mercury)	Can be solid, liquid or gases at SATP
<b>Common (usual) colour</b>	Physical	Usually silver-coloured (except gold and copper)	Can be any colour, or colourless.
<b>Malleability</b>	Physical	Are malleable (can be pounded into a thin sheet)	Are brittle as solids (shatter when hit with a hammer)
<b>Conductor of electricity?</b>	Physical	All are good conductors of electricity	All are poor conductors of electricity
<b>Ductility</b>	Physical	Are ductile (can be drawn out into a thin wire)	Are not ductile (can not be drawn out into a thin wire)
<b>Description of melting point (high or low)</b>	Physical	Most have relatively high melting points	Most have relatively low melting points (many are gases at SATP)
<b>General number of valence electrons</b>	Physical	Have 1, 2 or 3 valence electrons	Have (4), 5, 6, 7 or 8 valence electrons
<b>Gain or lose electrons to form ions?</b>	Chemical	Tend to lose electrons to form positive ions	Tend to gain electrons to form negative ions
<b>pH of solution of the element in water?</b>		React with water to produce a basic solution	React with water to produce an acidic solution
<b>pH of the solution of the oxide in water?</b>		The oxide dissolves in water to produce a basic solution	The oxide dissolves in water to produce an acidic solution

### 5 and 6. The physical and chemical properties of various elements:

Element	Aluminum	Hydrogen	Chlorine	Magnesium	Sulfur
Metal or Non-metal?	Metal	Non-metal	Non-metal	Metal	Non-metal
Colour	Silver-coloured	Colourless	yellowish-green	Silver-coloured	Yellow
State at SATP*	Solid	Gas	Gas	Solid	Solid
Conduct electricity?	yes	no	no	yes	no
Density*	2.70 g/mL	0.0899 g/mL	3.214 g/L	1.74 g/mL	2.07 g/mL
Melting Point*	933.5 K	13.81 K	171.65 K	922 K	392.2 K
Clarity	Opaque	Transparent	Transparent	Opaque	Opaque
Malleable or Brittle as Solid	Malleable	Brittle	Brittle	Malleable	Brittle
Shiny or Dull?	Shiny	Dull	Dull	Shiny	Dull
Reaction with acid	Produce H <sub>2</sub> gas and a salt	No reaction	No reaction	Produce H <sub>2</sub> gas and a salt	No reaction
Reaction with water	Produces a basic solution	No reaction	Produces an acidic solution	Produces a basic solution	Forms an acid
Reaction with O <sub>2</sub>	Produces a metal oxide	Explosive, produces water	Forms chlorine dioxide	Produces a metal oxide	Forms sulfur dioxide
Electron configuration	1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup> 3s <sup>2</sup> 3p <sup>1</sup>	1s <sup>1</sup>	1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup> 3s <sup>2</sup> 3p <sup>5</sup>	1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup> 3s <sup>2</sup>	1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup> 3s <sup>2</sup> 3p <sup>4</sup>
Ionization Reaction	Al → Al <sup>3+</sup> + 3e <sup>-</sup>	H → H <sup>1+</sup> + e <sup>-</sup>	Cl + e <sup>-</sup> → Cl <sup>1-</sup>	Mg → Mg <sup>2+</sup> + 2e <sup>-</sup>	S + 2e <sup>-</sup> → S <sup>2-</sup>

\* from the Periodic Table

### 7. Four signs of chemical change:

- a new colour appears
- a gas is produced (as visible bubbles or there is a new odour)
- a precipitate forms (a solid forms when two solutions are mixed)
- heat, light or sound is given off or absorbed

8. Classify each of the following as physical or chemical changes. If it is a chemical change, what is the evidence that a chemical change had occurred?
- a) toasting bread: chemical- the bread changes colour
  - b) sugar dissolving in coffee: physical- the sugar is still there, it has just dissolved
  - c) allowing pop to go flat: physical- the carbon dioxide was dissolved in solution, it just comes out
  - d) boiling water: physical- water is converted to water vapour, but it is still water
  - e) alka-seltzer fizzing in water: chemical- the alkaseltzer reacts in water to produce gas bubbles
  - f) evaporation of water: physical- the water changes state from liquid to gas, but it is still water
  - g) boiling an egg: chemical- the egg white changes colour from colourless to white
  - h) breaking glass: physical- we still have glass, just smaller pieces of glass
  - i) tarnishing of silver: chemical- the silver changes colour from silver to black as silver sulfide is formed
  - j) grinding coffee beans: physical- we still have the same coffee beans, they are just in smaller pieces
  - k) heating platinum until it glows red: physical- as soon as the platinum cools down, it goes back to looking the same as it did before it was heated, so there was no chemical change
  - l) explosion of nitroglycerin: chemical- heat, light and sound given off
  - m) firing a cap pistol: chemical- sound given off (and smoke)
  - n) zinc dissolving in hydrochloric acid: chemical- zinc changes from silver-coloured to colourless (also, bubbles of hydrogen gas are produced)