



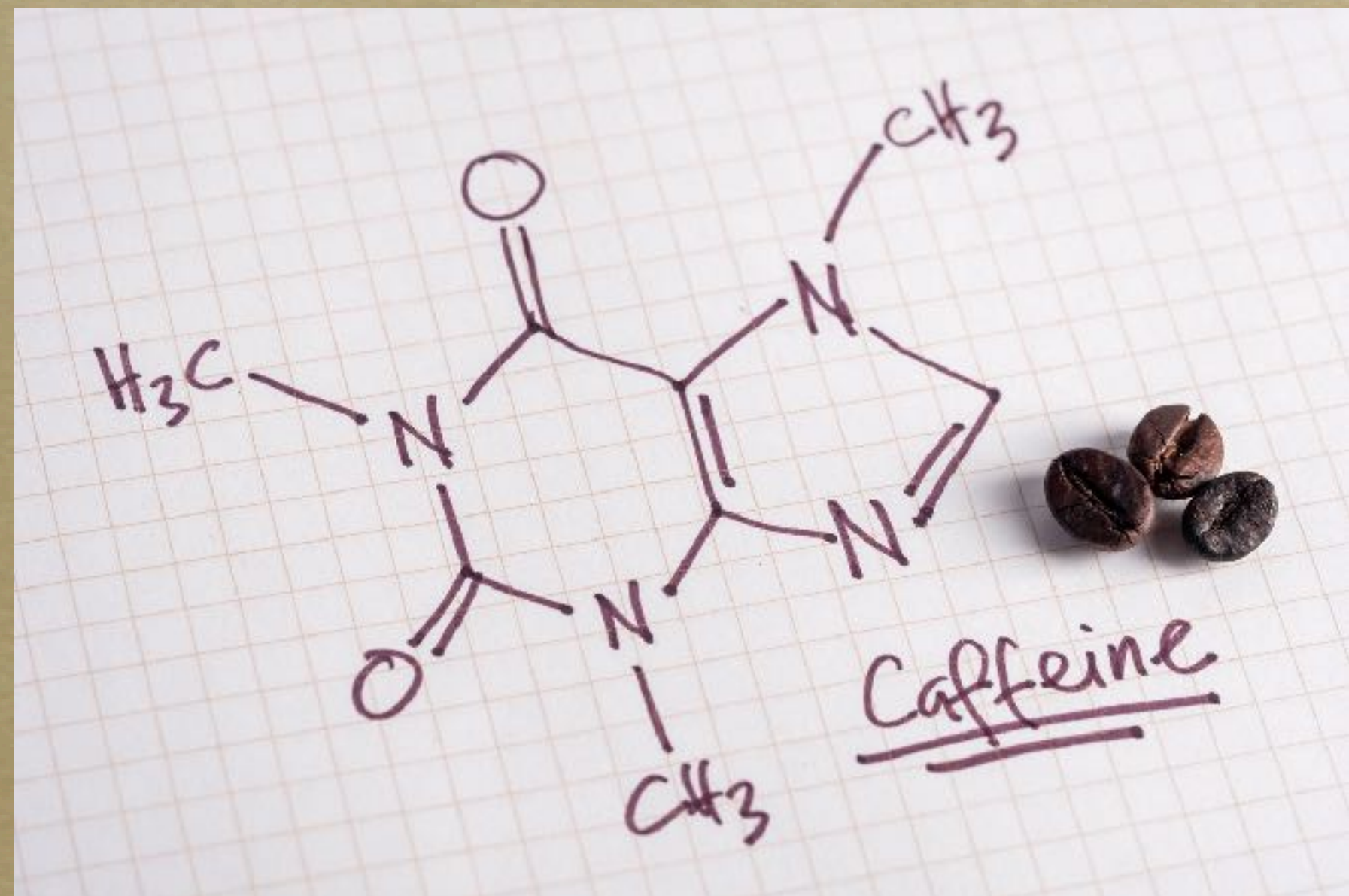
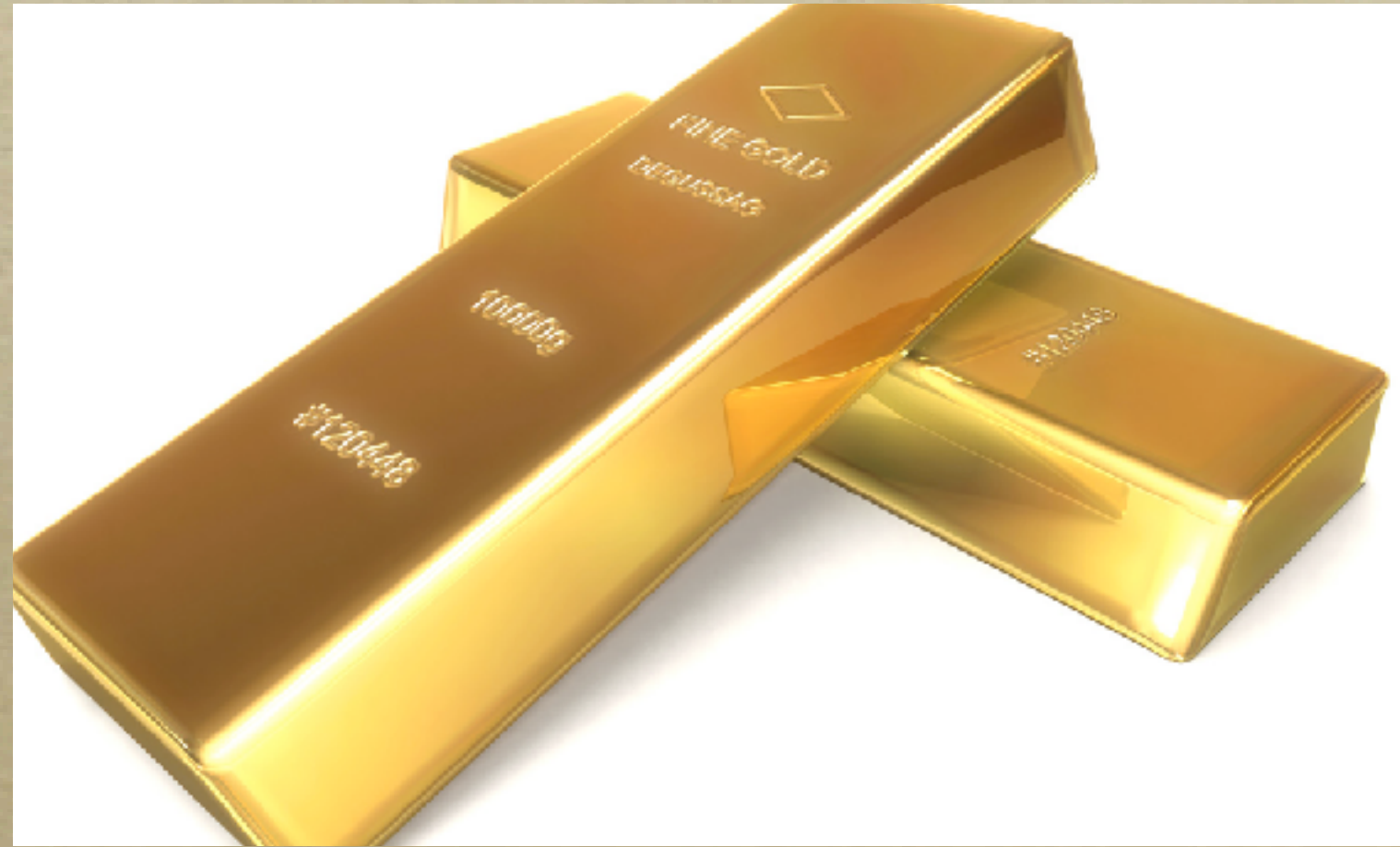
# States & Properties of Matter

Unit 1 - Topics 4 & 5

# Pure Substances

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## Topic 4 - Elements and Compounds



# Elements

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- Pure substances that only contain one kind of **atom** and cannot be separated into a simpler substance.
- *Examples:* Sodium (Na) and Copper (Cu)



- Have their own unique properties
- Represented by a distinct symbol
- *92 naturally occurring elements (rest are man made)*

# PERIODIC TABLE OF ELEMENTS

PubChem

1 <b>H</b> Hydrogen Nonmetal																	2 <b>He</b> Helium Noble Gas						
3 <b>Li</b> Lithium Alkali Metal	4 <b>Be</b> Beryllium Alkaline Earth Metal																	5 <b>B</b> Boron Metalloid	6 <b>C</b> Carbon Nonmetal	7 <b>N</b> Nitrogen Nonmetal	8 <b>O</b> Oxygen Nonmetal	9 <b>F</b> Fluorine Halogen	10 <b>Ne</b> Neon Noble Gas
11 <b>Na</b> Sodium Alkali Metal	12 <b>Mg</b> Magnesium Alkaline Earth Metal																	13 <b>Al</b> Aluminum Post-Transition Metal	14 <b>Si</b> Silicon Metalloid	15 <b>P</b> Phosphorus Nonmetal	16 <b>S</b> Sulfur Nonmetal	17 <b>Cl</b> Chlorine Halogen	18 <b>Ar</b> Argon Noble Gas
19 <b>K</b> Potassium Alkali Metal	20 <b>Ca</b> Calcium Alkaline Earth Metal	21 <b>Sc</b> Scandium Transition Metal	22 <b>Ti</b> Titanium Transition Metal	23 <b>V</b> Vanadium Transition Metal	24 <b>Cr</b> Chromium Transition Metal	25 <b>Mn</b> Manganese Transition Metal	26 <b>Fe</b> Iron Transition Metal	27 <b>Co</b> Cobalt Transition Metal	28 <b>Ni</b> Nickel Transition Metal	29 <b>Cu</b> Copper Transition Metal	30 <b>Zn</b> Zinc Transition Metal	31 <b>Ga</b> Gallium Post-Transition Metal	32 <b>Ge</b> Germanium Metalloid	33 <b>As</b> Arsenic Metalloid	34 <b>Se</b> Selenium Nonmetal	35 <b>Br</b> Bromine Halogen	36 <b>Kr</b> Krypton Noble Gas						
37 <b>Rb</b> Rubidium Alkali Metal	38 <b>Sr</b> Strontium Alkaline Earth Metal	39 <b>Y</b> Yttrium Transition Metal	40 <b>Zr</b> Zirconium Transition Metal	41 <b>Nb</b> Niobium Transition Metal	42 <b>Mo</b> Molybdenum Transition Metal	43 <b>Tc</b> Technetium Transition Metal	44 <b>Ru</b> Ruthenium Transition Metal	45 <b>Rh</b> Rhodium Transition Metal	46 <b>Pd</b> Palladium Transition Metal	47 <b>Ag</b> Silver Transition Metal	48 <b>Cd</b> Cadmium Transition Metal	49 <b>In</b> Indium Post-Transition Metal	50 <b>Sn</b> Tin Post-Transition Metal	51 <b>Sb</b> Antimony Metalloid	52 <b>Te</b> Tellurium Metalloid	53 <b>I</b> Iodine Halogen	54 <b>Xe</b> Xenon Noble Gas						
55 <b>Cs</b> Cesium Alkali Metal	56 <b>Ba</b> Barium Alkaline Earth Metal	*	72 <b>Hf</b> Hafnium Transition Metal	73 <b>Ta</b> Tantalum Transition Metal	74 <b>W</b> Tungsten Transition Metal	75 <b>Re</b> Rhenium Transition Metal	76 <b>Os</b> Osmium Transition Metal	77 <b>Ir</b> Iridium Transition Metal	78 <b>Pt</b> Platinum Transition Metal	79 <b>Au</b> Gold Transition Metal	80 <b>Hg</b> Mercury Transition Metal	81 <b>Tl</b> Thallium Post-Transition Metal	82 <b>Pb</b> Lead Post-Transition Metal	83 <b>Bi</b> Bismuth Post-Transition Metal	84 <b>Po</b> Polonium Metalloid	85 <b>At</b> Astatine Halogen	86 <b>Rn</b> Radon Noble Gas						
87 <b>Fr</b> Francium Alkali Metal	88 <b>Ra</b> Radium Alkaline Earth Metal	**	104 <b>Rf</b> Rutherfordium Transition Metal	105 <b>Db</b> Dubnium Transition Metal	106 <b>Sg</b> Seaborgium Transition Metal	107 <b>Bh</b> Bohrium Transition Metal	108 <b>Hs</b> Hassium Transition Metal	109 <b>Mt</b> Meitnerium Transition Metal	110 <b>Ds</b> Darmstadtium Transition Metal	111 <b>Rg</b> Roentgenium Transition Metal	112 <b>Cn</b> Copernicium Transition Metal	113 <b>Nh</b> Nihonium Post-Transition Metal	114 <b>Fl</b> Flerovium Post-Transition Metal	115 <b>Mc</b> Moscovium Post-Transition Metal	116 <b>Lv</b> Livermorium Post-Transition Metal	117 <b>Ts</b> Tennessine Halogen	118 <b>Og</b> Oganesson Noble Gas						
		*	57 <b>La</b> Lanthanum Lanthanide	58 <b>Ce</b> Cerium Lanthanide	59 <b>Pr</b> Praseodymium Lanthanide	60 <b>Nd</b> Neodymium Lanthanide	61 <b>Pm</b> Promethium Lanthanide	62 <b>Sm</b> Samarium Lanthanide	63 <b>Eu</b> Europium Lanthanide	64 <b>Gd</b> Gadolinium Lanthanide	65 <b>Tb</b> Terbium Lanthanide	66 <b>Dy</b> Dysprosium Lanthanide	67 <b>Ho</b> Holmium Lanthanide	68 <b>Er</b> Erbium Lanthanide	69 <b>Tm</b> Thulium Lanthanide	70 <b>Yb</b> Ytterbium Lanthanide	71 <b>Lu</b> Lutetium Lanthanide						
		**	89 <b>Ac</b> Actinium Actinide	90 <b>Th</b> Thorium Actinide	91 <b>Pa</b> Protactinium Actinide	92 <b>U</b> Uranium Actinide	93 <b>Np</b> Neptunium Actinide	94 <b>Pu</b> Plutonium Actinide	95 <b>Am</b> Americium Actinide	96 <b>Cm</b> Curium Actinide	97 <b>Bk</b> Berkelium Actinide	98 <b>Cf</b> Californium Actinide	99 <b>Es</b> Einsteinium Actinide	100 <b>Fm</b> Fermium Actinide	101 <b>Md</b> Mendelevium Actinide	102 <b>No</b> Nobelium Actinide	103 <b>Lr</b> Lawrencium Actinide						

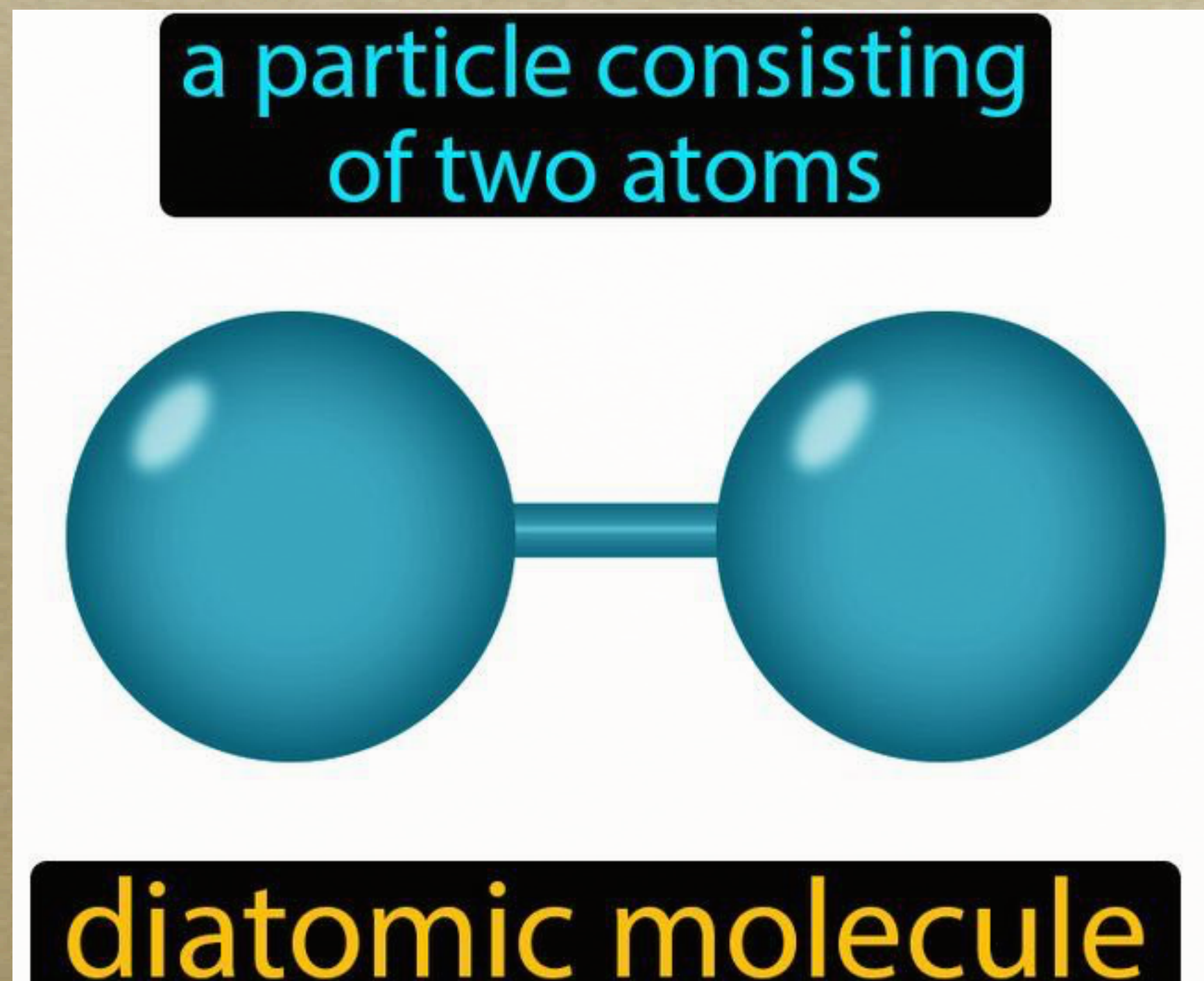
1  
**H**  
Hydrogen  
Nonmetal

Atomic Number  
**Symbol**  
Name  
Chemical Group Block

# Diatomic Elements

## 'The Diatomic 7'

- There are seven elements that exist as chemically bonded **pairs** of two atoms.
- $H_2$ ,  $N_2$ ,  $O_2$ ,  $F_2$ ,  $Cl_2$ ,  $Br_2$ ,  $I_2$



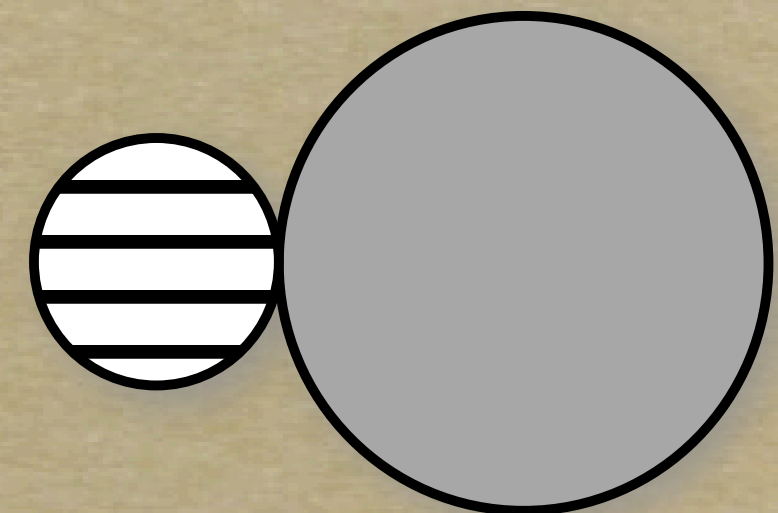
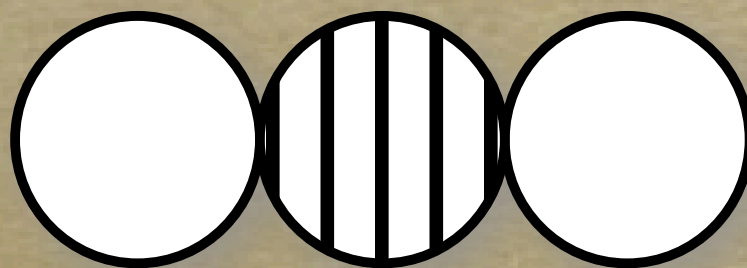
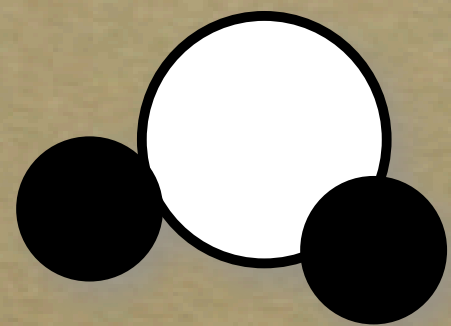
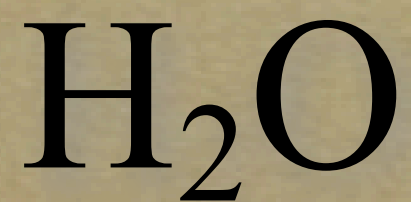
**'HOFBrINCl'**

hydrogen 1 <b>H</b>																	helium 2 <b>He</b> 4.0026						
lithium 3 <b>Li</b> 6.941	beryllium 4 <b>Be</b> 9.0122																	boron 5 <b>B</b> 10.811	carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.0064	oxygen 8 <b>O</b> 15.9994	fluorine 9 <b>F</b> 18.9984	neon 10 <b>Ne</b> 20.180
sodium 11 <b>Na</b> 22.990	magnesium 12 <b>Mg</b> 24.305																	aluminum 13 <b>Al</b> 26.982	silicon 14 <b>Si</b> 28.086	phosphorus 15 <b>P</b> 30.974	sulfur 16 <b>S</b> 32.065	chlorine 17 <b>Cl</b> 35.453	argon 18 <b>Ar</b> 39.948
potassium 19 <b>K</b> 39.098	calcium 20 <b>Ca</b> 40.078	scandium 21 <b>Sc</b> 44.956	titanium 22 <b>Ti</b> 47.867	vanadium 23 <b>V</b> 50.942	chromium 24 <b>Cr</b> 51.996	manganese 25 <b>Mn</b> 54.938	iron 26 <b>Fe</b> 55.845	cobalt 27 <b>Co</b> 58.933	nickel 28 <b>Ni</b> 58.693	copper 29 <b>Cu</b> 63.546	zinc 30 <b>Zn</b> 65.39	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	selenium 34 <b>Se</b> 78.96	bromine 35 <b>Br</b> 79.904	krypton 36 <b>Kr</b> 83.80						
rubidium 37 <b>Rb</b> 85.468	strontium 38 <b>Sr</b> 87.62	yttrium 39 <b>Y</b> 88.906	zirconium 40 <b>Zr</b> 91.224	niobium 41 <b>Nb</b> 92.906	molybdenum 42 <b>Mo</b> 95.94	technetium 43 <b>Tc</b> [98]	ruthenium 44 <b>Ru</b> 101.07	rhodium 45 <b>Rh</b> 102.91	palladium 46 <b>Pd</b> 106.42	silver 47 <b>Ag</b> 107.87	cadmium 48 <b>Cd</b> 112.41	indium 49 <b>In</b> 114.82	tin 50 <b>Sn</b> 118.71	antimony 51 <b>Sb</b> 121.76	tellurium 52 <b>Te</b> 127.60	iodine 53 <b>I</b> 126.90	xenon 54 <b>Xe</b> 131.29						
cesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33	* 57-70	lanthanum 71 <b>Lu</b> 174.97	hafnium 72 <b>Hf</b> 178.49	tantalum 73 <b>Ta</b> 180.95	tungsten 74 <b>W</b> 183.84	rhenium 75 <b>Re</b> 186.21	osmium 76 <b>Os</b> 190.23	iridium 77 <b>Ir</b> 192.22	platinum 78 <b>Pt</b> 195.08	gold 79 <b>Au</b> 196.97	mercury 80 <b>Hg</b> 200.59	thallium 81 <b>Tl</b> 204.38	lead 82 <b>Pb</b> 207.2	bismuth 83 <b>Bi</b> 208.98	polonium 84 <b>Po</b> [209]	astatine 85 <b>At</b> [210]	radon 86 <b>Rn</b> [222]					
francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]	** 89-102	actinium 103 <b>Lr</b> [262]	rutherfordium 104 <b>Rf</b> [261]	bohrium 105 <b>Db</b> [262]	seaborgium 106 <b>Sg</b> [266]	bohrium 107 <b>Bh</b> [264]	hassium 108 <b>Hs</b> [265]	meitnerium 109 <b>Mt</b> [268]	unnilium 110 <b>Uun</b> [271]	ununium 111 <b>Uuu</b> [272]	unbibium 112 <b>Uub</b> [277]	untrium 113 <b>Uut</b> [283]	unquadrium 114 <b>Uuq</b> [289]									
		* Lanthanide series	lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	praseodymium 59 <b>Pr</b> 140.91	neodymium 60 <b>Nd</b> 144.24	promethium 61 <b>Pm</b> [143]	samarium 62 <b>Sm</b> 150.36	europium 63 <b>Eu</b> 151.96	gadolinium 64 <b>Gd</b> 157.25	terbium 65 <b>Tb</b> 158.93	dysprosium 66 <b>Dy</b> 162.50	holmium 67 <b>Ho</b> 164.93	erbium 68 <b>Er</b> 167.26	thulium 69 <b>Tm</b> 168.93	ytterbium 70 <b>Yb</b> 173.04							
		** Actinide series	actinium 89 <b>Ac</b> [227]	thorium 90 <b>Th</b> 232.04	protactinium 91 <b>Pa</b> 231.04	uranium 92 <b>U</b> 238.03	neptunium 93 <b>Np</b> [237]	plutonium 94 <b>Pu</b> [244]	americium 95 <b>Am</b> [243]	curium 96 <b>Cm</b> [247]	berkelium 97 <b>Bk</b> [247]	californium 98 <b>Cf</b> [251]	einsteinium 99 <b>Es</b> [252]	fermium 100 <b>Fm</b> [257]	mendelevium 101 <b>Md</b> [258]	nobelium 102 <b>No</b> [259]							

# Compounds

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- Pure substances that aren't elements are **compounds**.
- composed of more than one kind of atom
- The elements in the compounds can only be separated by a chemical change!
- Fixed ratio (for example → 1:2, 1:1)



# Understanding Chemical Formulas

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## *Subscripts*

- little numbers following an element symbol
- how many atoms of that element are present

H<sub>2</sub>O      2 Hydrogens, 1 Oxygen

CO<sub>2</sub>      1 Carbon, 2 Oxygens

NaCl      1 Sodium, 1 Chlorine



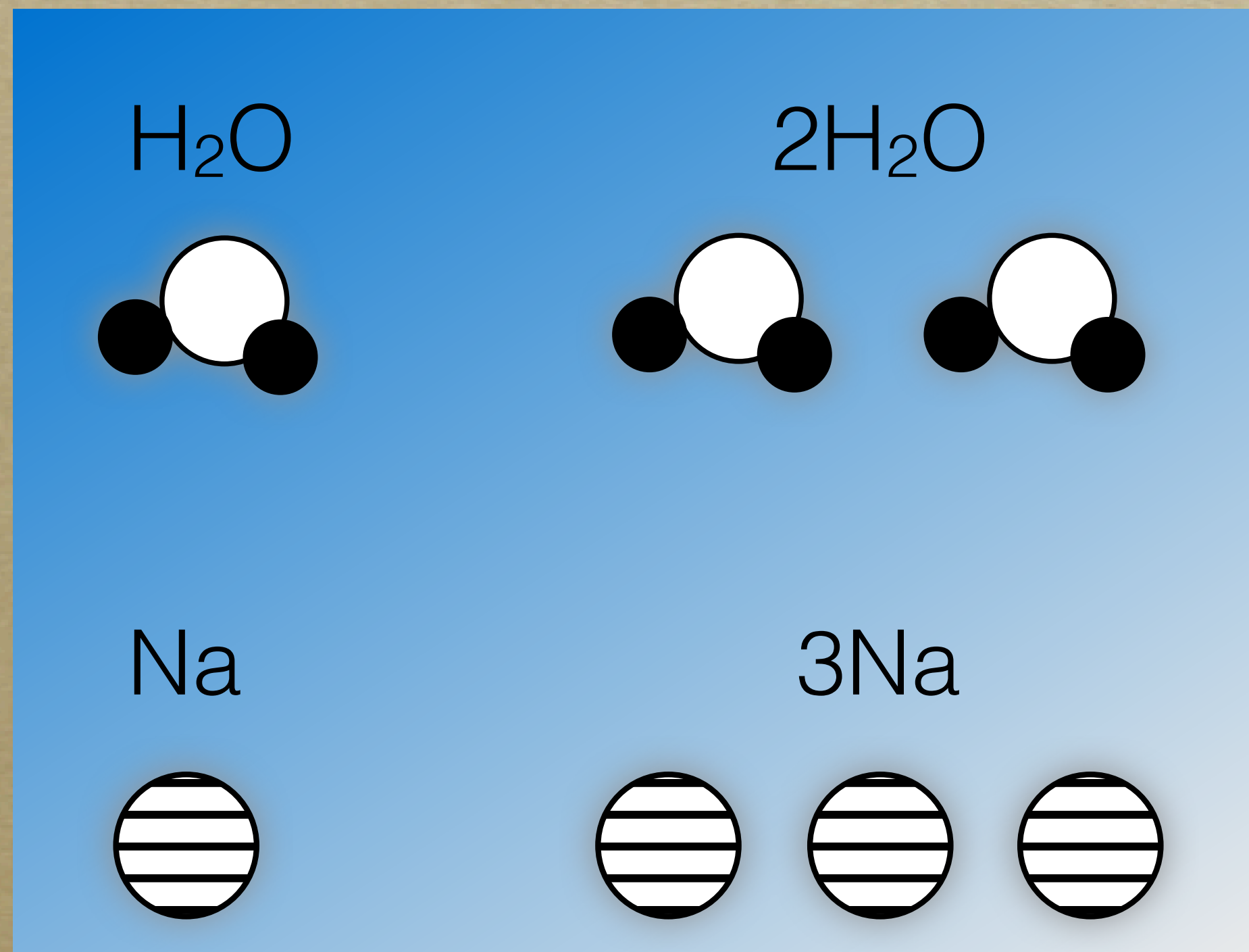
No subscript = 1

# Understanding Chemical Formulas

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## *Coefficients*

- number in front of a formula
- how many atoms or molecules you have



No coefficient = 1



# Practice with Formulas

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Na<sub>2</sub>S: How many atoms of Na are there? 2

CO: C = 1 O = 1

CO<sub>2</sub>: C = 1 O = 2

Br<sub>2</sub>: Br = 2

H<sub>2</sub>SO<sub>4</sub>: H = 2 S = 1 O = 4

How many molecules of KCl in 4KCl? 4

How many molecules of Na<sub>2</sub>S in 3Na<sub>2</sub>S? 3

Na + S is a mixture. Likewise, Na<sub>2</sub>S ⊕ KCl is a mixture. WHY?

# Regents Practice

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Which of these contains only one substance?

- (1) distilled water
- (2) sugar water
- (3) saltwater
- (4) rainwater

Which terms are used to identify pure substances?

- (1) an element and a mixture
- (2) an element and a compound
- (3) a solution and a mixture
- (4) a solution and a compound

## Regents Practice

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Which substance represents a compound?

(1) C(s)

(2) Co(s)

(3) CO(g)

(4) O<sub>2</sub>(g)

What is the total number of different elements present in NH<sub>4</sub>NO<sub>3</sub>?

(1) 7

(2) 9

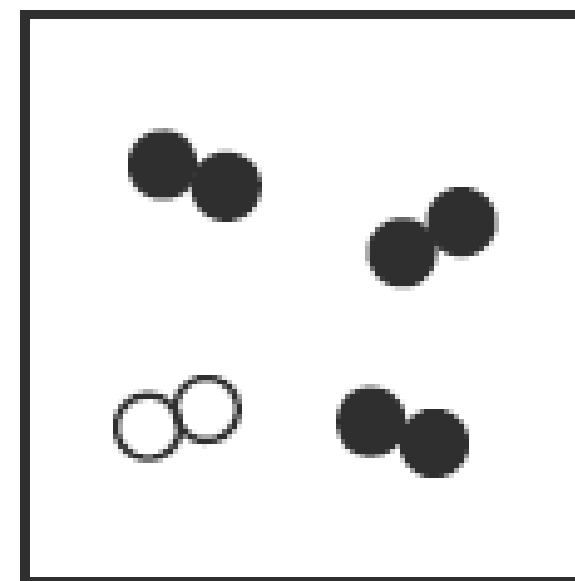
(3) 3

(4) 4

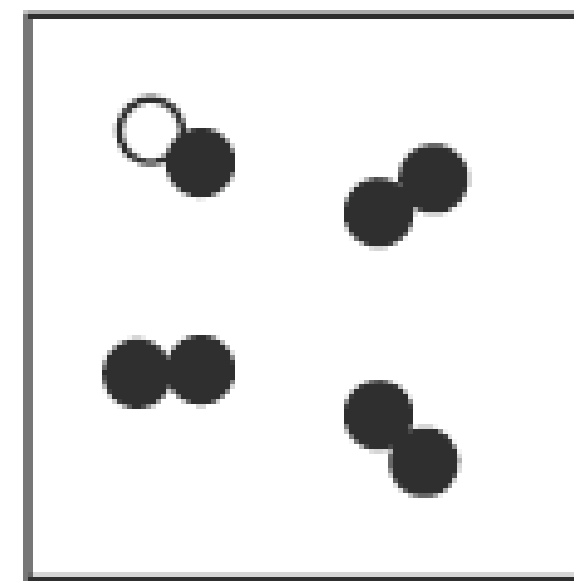
# Regents Practice

Which two particle diagrams represent mixtures of diatomic elements?

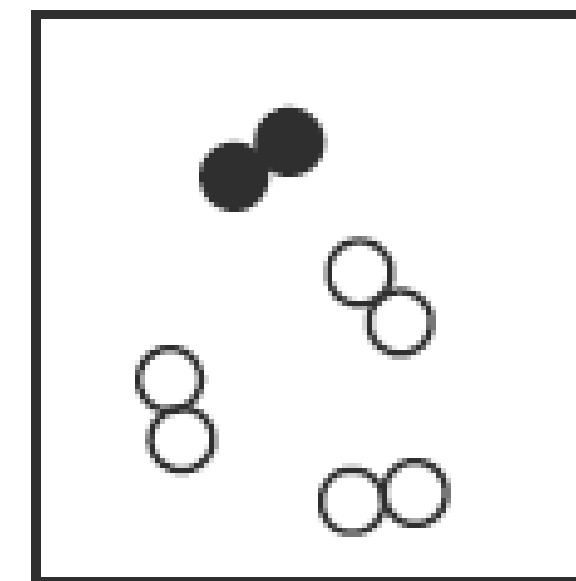
Key
○ = atom of one element
● = atom of another element



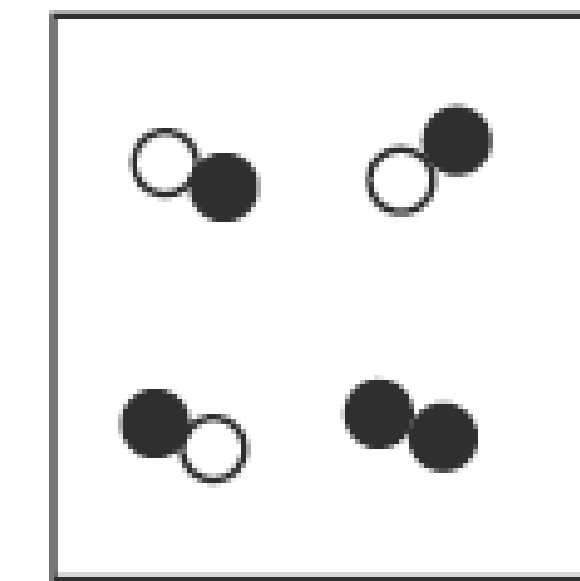
A



B



C



D

- (1) A and B
- (2) A and C

- (3) B and C
- (4) B and D

# Changes

## Topic 5

### PHYSICAL CHANGES

In a physical change, matter changes form but not chemical identity.



### CHEMICAL CHANGES

In a chemical change, a chemical reaction occurs and new products are formed.



# Changes in Matter

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## Physical

- Change from one form to another **without** the **change in its chemical identity**.
- Still the **same substance**
- Effect on physical properties (i.e. density)
- Generally easy to reverse.

## Chemical

- Change that is accompanied with the **change in its chemical identity**
- Forms **new substance**
- Effect on physical and chemical properties
- **Not easy to reverse** without additional chemical reactions

# Physical vs. Chemical Changes *Practice*

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- Explain whether the two pictures below are examples of chemical or physical changes.



**Physical change** - in this case, it's still water. You just changed from solid water (ice) to liquid water.



**Physical change** - in this case, the sugar is still there and we can recover it if we evaporated all of the water.

# Energy & Change

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## Energy

- The ability to do work.
- Energy changes with BOTH chemical and physical changes.



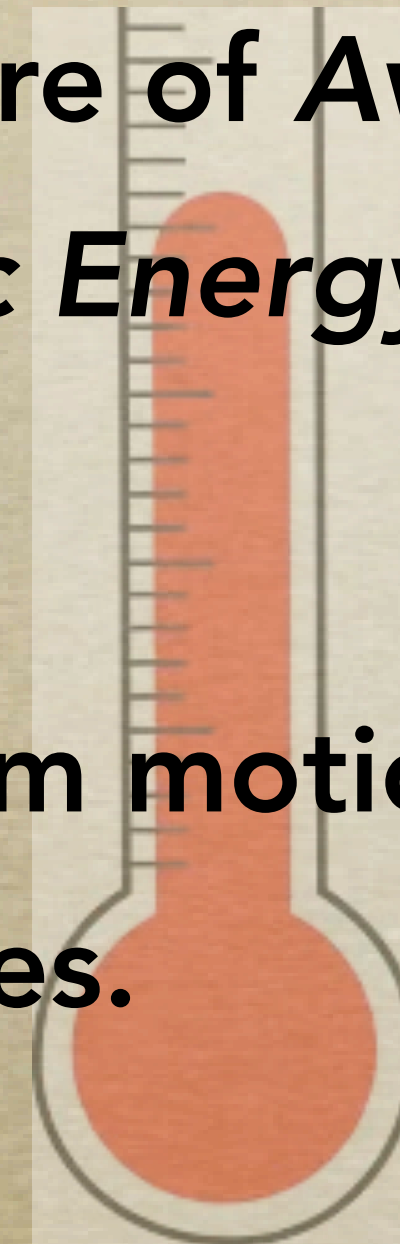
## Heat

- Energy transferred between objects of different temperature.
- Heat flows from warm to cold.



## Temperature

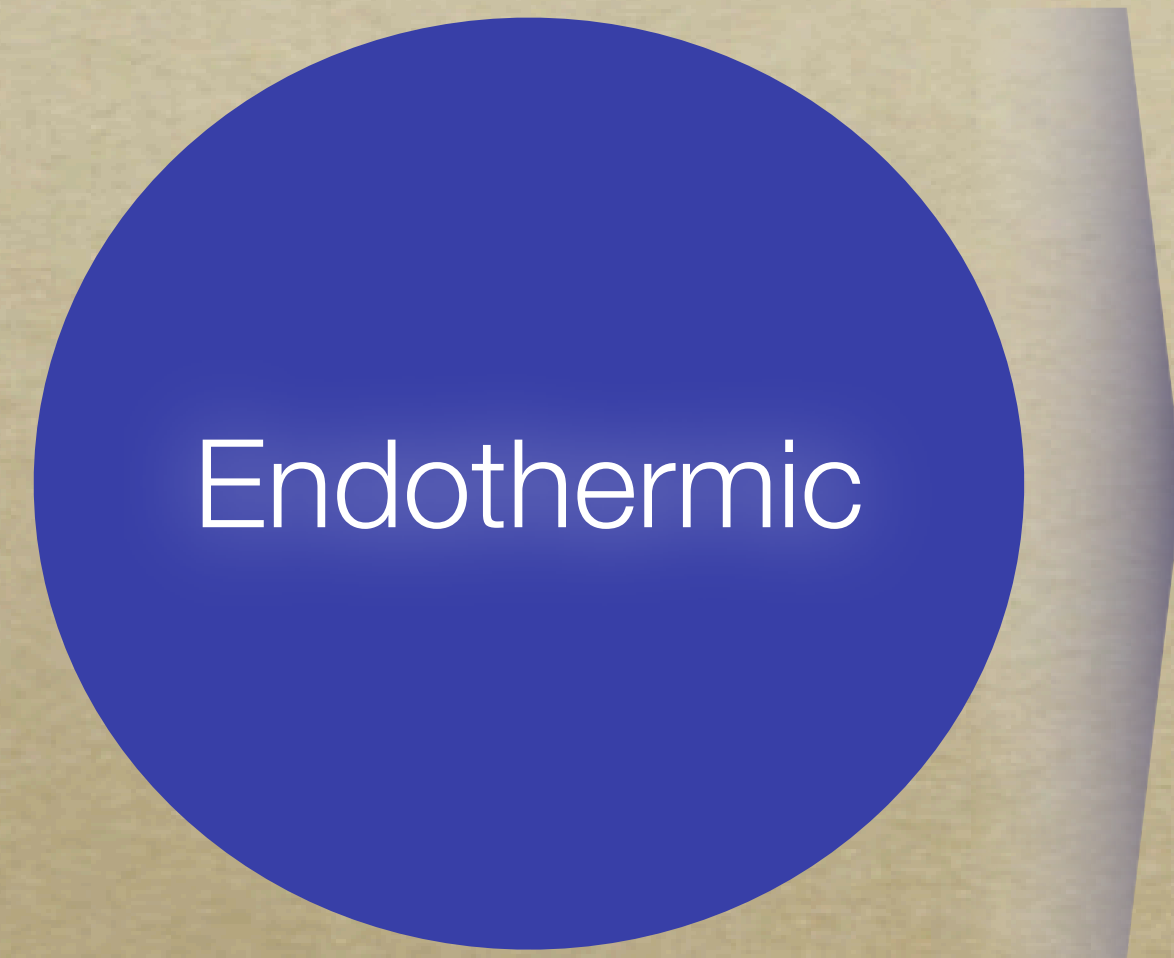
- Measure of *Average Kinetic Energy*.
- Random motion of particles.



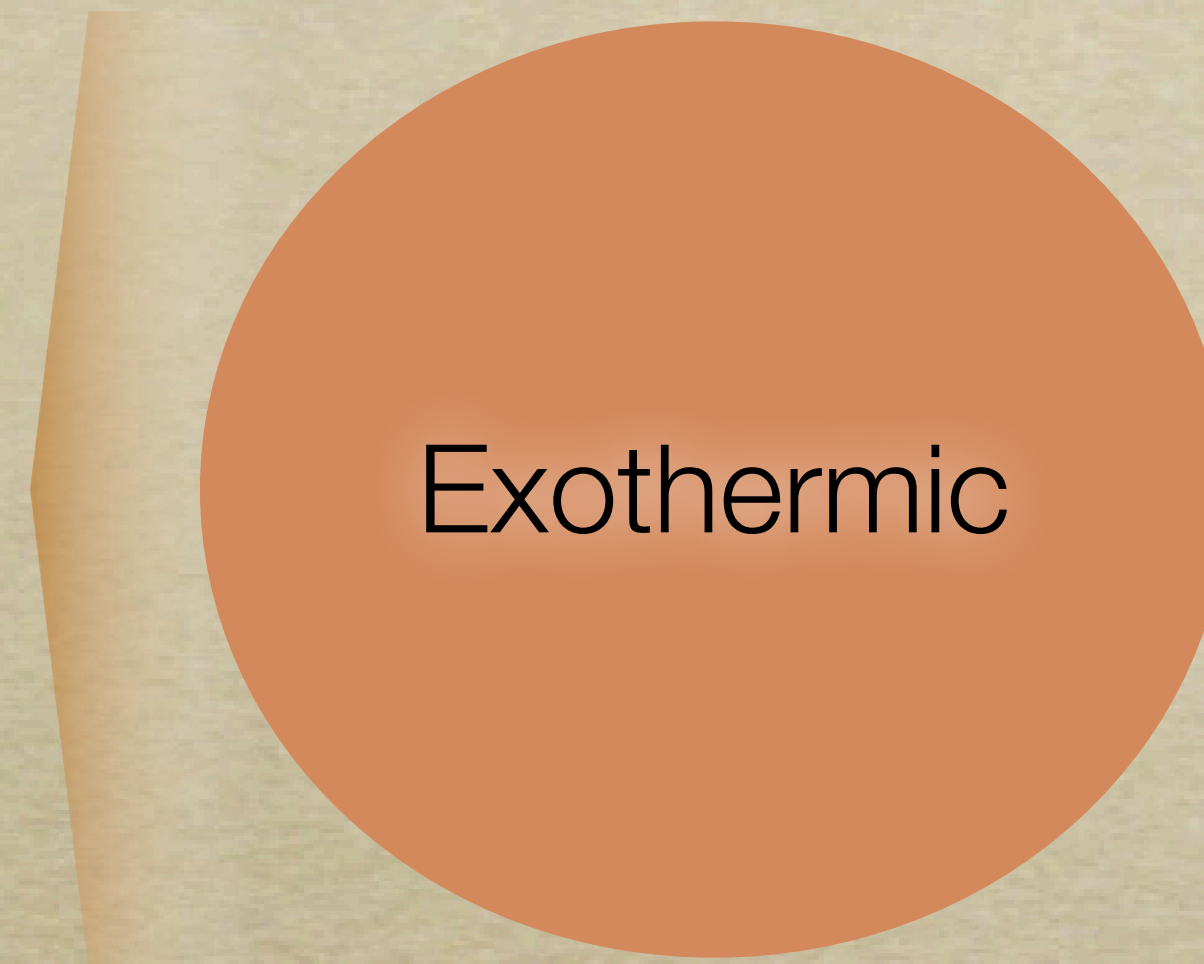


# Energy Changes

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- Requires heat.
- Ex. Melting ice.

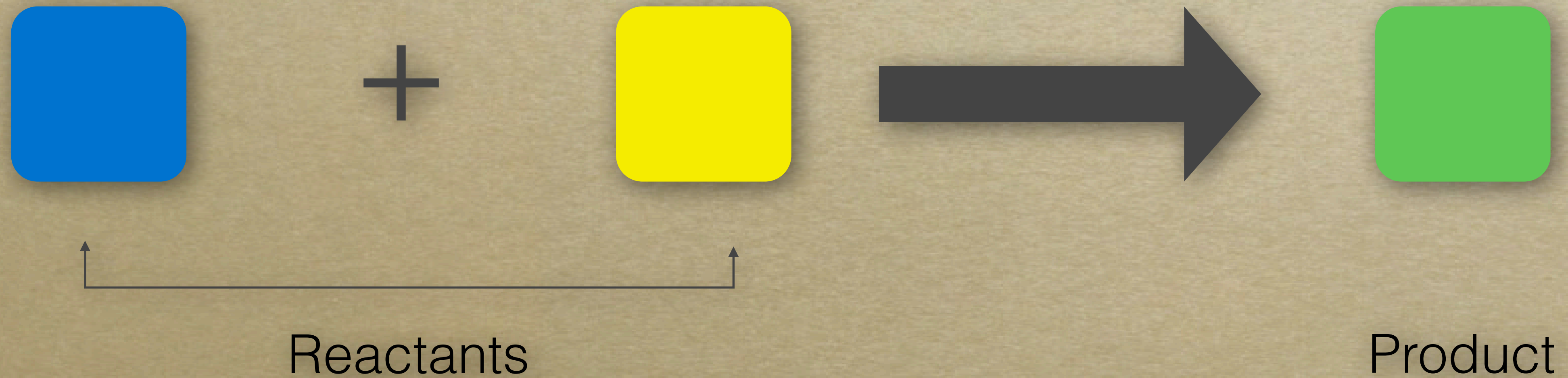


- Produces heat.
- Ex. Burning a log.

# Chemical Equations

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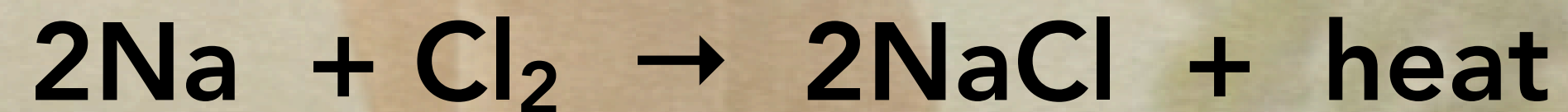
- In Math, you use an equal sign (=) in an equation.
- In Chemistry, we use an arrow ( $\rightarrow$ ) in an equation.
- An equation describes a chemical change.



# Law of Conservation of Energy

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- **Energy cannot be created or destroyed. *Total energy is constant!***
- **Input = output**



Physical or Chemical change? **Chemical**

Exothermic or Endothermic? **Exothermic**

Is the equation balanced (*shows conservation of mass*)? **Yes**

# Another Example

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Physical or Chemical change? **Physical**

Exothermic or Endothermic? **Endothermic**

Is the equation balanced (*shows conservation of mass*)? **Yes**

# Regents Practice

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Which substance can *not* be decomposed by a chemical change?

- (1) Ne
- (2) N<sub>2</sub>O
- (3) HF
- (4) H<sub>2</sub>O

Which process represents a chemical change?

- (1) melting of ice
- (2) corrosion of copper
- (3) evaporation of water
- (4) crystallization of sugar

Which process is a chemical change?

- (1) melting of ice
- (2) boiling of water
- (3) subliming of ice
- (4) decomposing of water

# Regents Practice

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Which set of procedures and observations indicates a chemical change?

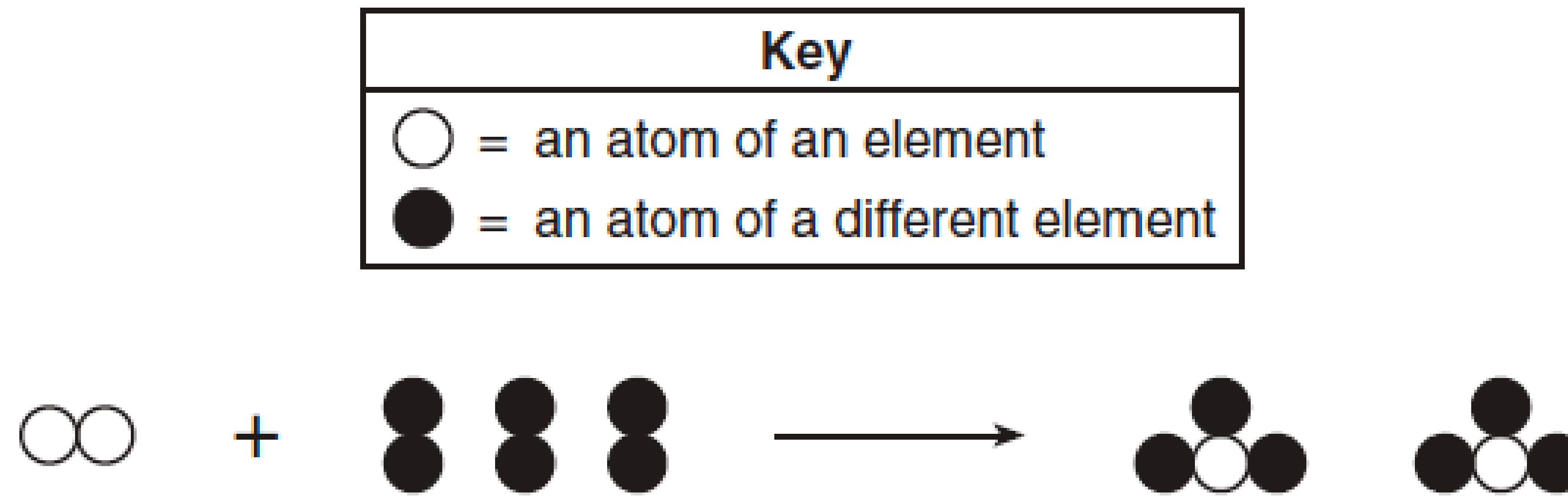
- (1) Ethanol is added to an empty beaker and the ethanol eventually disappears.
- (2) A solid is gently heated in a crucible and the solid slowly turns to liquid.
- (3) Large crystals are crushed with a mortar and pestle and become powder.
- (4) A cool, shiny metal is added to water in a beaker and rapid bubbling occurs.

Which two substances can *not* be broken down by chemical change?

- (1) C and CuO
- (2) C and Cu
- (3) CO<sub>2</sub> and CuO
- (4) CO<sub>2</sub> and Cu

# Regents Practice

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Which statement describes the type of change and the chemical properties of the product and reactants?

- (1) The equation represents a physical change, with the product and reactants having different chemical properties.
- (2) The equation represents a physical change, with the product and reactants having identical chemical properties.
- (3) The equation represents a chemical change, with the product and reactants having different chemical properties.
- (4) The equation represents a chemical change, with the product and reactants having identical chemical properties.

# Regents Practice

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Which substance can be broken down by chemical means?

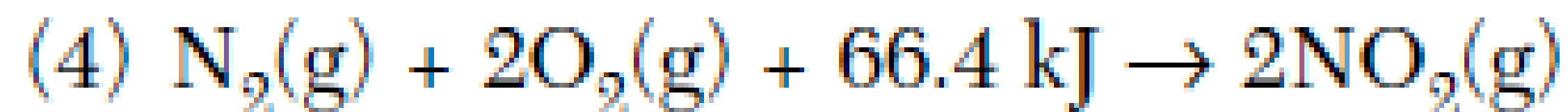
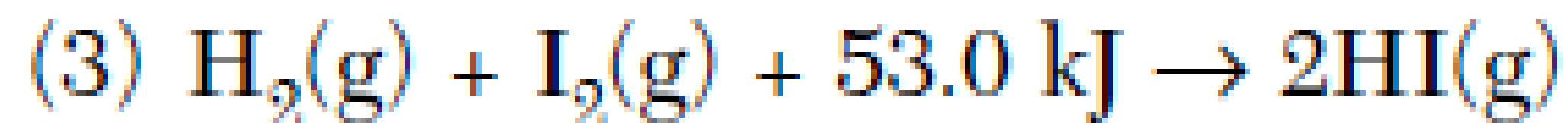
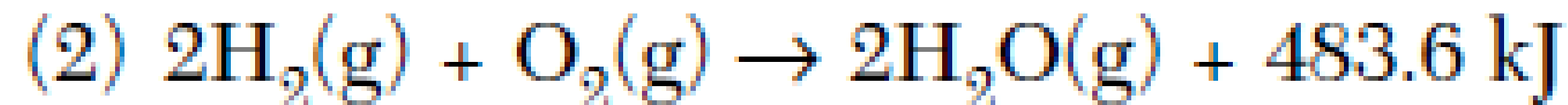
(1) CO

(2) Ce

(3) Ca

(4) Cu

Which equation represents a physical change?







Do or do not. There is no try.

- *The Empire Strikes Back / Yoda*

# Unit Essentials



## Topic 2: States & Properties of Matter

### **ESSENTIALS: Know, Understand, and Be Able To...**

- Matter is classified as a substance or a mixture of substances.
- Substances can be differentiated by physical properties.
- Physical properties of substances, such as density, conductivity, malleability, solubility, and hardness, differ among substances.
- Describe the states of the elements at STP.
- Use a simple particle model to differentiate among properties of solids, liquids, and gases
- A physical change results in the rearrangement of existing particles in a substance. A chemical change results in the formation of different particles with changed properties.

**TEXT REFERENCE:** p. 39-42 and 44-47

## Topic 3: Mixtures

### **ESSENTIALS: Know, Understand, and Be Able To...**

- A pure substance has a constant composition throughout a sample
- Mixtures are composed of two or more substances that can be separated by physical means.
- When substances are mixed together, either a homogeneous or a heterogeneous mixture is formed
- A solution is a homogeneous mixture of solute dissolved in a solvent
- The proportions of components in a mixture can be varied.
- Differences in properties such as density, particle size, boiling point, freezing point and solubility permit physical separation of components of a mixture.
- Describe the processes of filtration and distillation in the separation of a mixture.

**TEXT REFERENCES:** p. 44-47

# Topic 4: Pure Substances

## **ESSENTIALS: Know, Understand, and Be Able To...**

- Elements are substances that are composed of atoms that have the same atomic number.
- Elements cannot be broken down by chemical change.
- Elements can be differentiated by physical properties substances, such as density, conductivity, malleability, solubility, and hardness.
- Elements can also be differentiated by chemical properties.  
**Chemical properties** describe how an element behaves during a chemical reaction.
- A compound is a substance composed of two or more different elements that are chemically combined in a fixed proportion. A chemical compound can be broken down by chemical change.
- Use particle models/diagrams to differentiate among elements, compounds, and mixtures.

**TEXT REFERENCES:** p. 48-52

# Topic 5: Changes

## **ESSENTIALS: Know, Understand, and Be Able To...**

- During a physical change the chemical makeup of a substance **does not** change. Physical changes can be reversed. Dissolving and phase changes are examples.
- During a chemical change the chemical makeup of a substance **does** change. Chemical changes cannot be reversed. Burning, rusting, cooking, digesting, etc. are examples.
- Chemical changes can be described by equations which include reactants and products.
- Equations are written in balanced form. This illustrates the Conservation of Matter, which states that matter can neither be created or destroyed.
- Physical and chemical changes can be exothermic or endothermic. Be able to distinguish between exothermic and endothermic reactions using experimental data.
- The Law of Conservation of Energy states that energy can neither be created nor destroyed.

**TEXT REFERENCES:** p. 53-55