Lesson 7: Can we explain now why hydrogen has such a high energy output per gram compared to other fuels?

Unit Question: What fuel should we use for our cars?

NAME: _____

PERIOD: _____ DATE: _____

Lesson 4.7: Can we explain now why hydrogen has such a high energy output per gram compared to other fuels?

RECAP

1. Let's review what we figured out about covalent bonds.
    a. What happens to the electrons in the covalent bonds in molecules like CH_4, CO_2, H_2, and H_2O?

    b. The octet rule says that atoms form bonds to fill their valence shells and achieve stability. Complete the table for H, O, N, C.

Element Name	Element Symbol	No. Valence Electrons	No. Covalent Bonds
Hydrogen			
Oxygen			
Nitrogen			
Carbon			

2. Let's review what we figured out from our magnetic sphere investigations and from the bond energies and bond length charts.
    a. Atoms are composed of positively charged nuclei surrounded by a negatively charged cloud of electrons. When bonds form, the nuclei of one atom attract the electrons of another atom, pulling the atoms toward each other. What is the definition of bond length?

    b. What is the definition of bond energy?

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c. Revisit data from our last class on bond energy and bond length. What is the general relationship between bond energy and bond length?

Bond	Energy (kJ/mol)	Length (pm)
H — H	432	75
H — F	565	92
H — Cl	427	127
H — Br	363	141
H — I	295	161

3. Let's review what we learned from the lesson where we observed the temperature changes for two different chemical processes.
   a. What do we call reactions that result in a decrease in temperature?

   b. What do we call reactions that result in an increase in temperature?

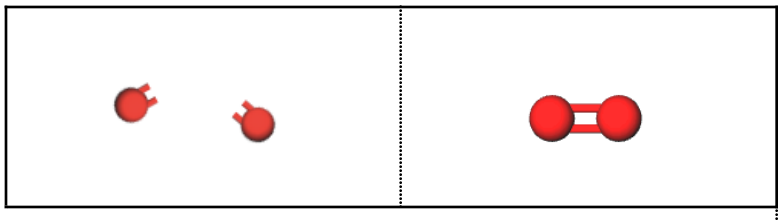
4. Let's recall what we learned about bond-breaking and bond-forming. Think about a magnet coming together or being pulled apart.
   a. Does bond breaking require or release energy?

   b. Is breaking bonds endothermic or exothermic?

   c. Does bond making require or release energy?

   d. Is forming bonds endothermic or exothermic?

   e. Below is a diagram of a bond forming and breaking of O_2.



Images from: MolView

      i. What stays the same during bond formation and bond breaking?

      ii. What changes in bond formation and bond breaking?

MODELING and COMPUTATIONS

5. To answer part of our unit question of "Why does burning hydrogen release more energy than burning octane?", we must look at the chemical reactions and the bonds forming and breaking.
    a. Using two model kits, in groups of four, model both chemical reactions.

Process	Equation
Combustion of Hydrogen	H_2 (ℓ) + O_2(ℓ)→ H_2O (g)
Combustion of Octane	C_8H_{18} (ℓ) + O_2 (g) → H_2O (g) + CO_2 (g)

b. In your model count and record how many of each element you have on each side of the equation.

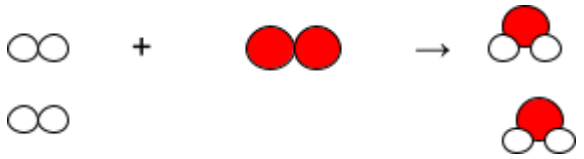
Process	Element	No. of each element as the REACTANT	No. of each element as the PRODUCT
Combustion of Hydrogen	**H**		
	O		
Combustion of Octane	**C**		
	H		
	O		

c. For each process, do you have the same number of each element on both the reactant and product side of the equation?

d. Matter cannot be created or destroyed. This is the law of conservation of matter. Chemical equations must follow this law. We call this balancing chemical equations.
    i. Work with another two groups to model the balanced chemical equations for combustion. Add to your model so that you have the same number count of each atom as products and reactants. Use this table to help you.

Balanced Chemical Equations - *ELEMENT* count			
Process	**Element**	**No. of each element as the REACTANT**	**No. of each element as the PRODUCT**
Combustion of Hydrogen	**H**		
	O		
Combustion of Octane	**C**		
	H		
	O		

i. Model the ***balanced chemical equations***.

Model of hydrogen combustion	
Model of octane combustion	

ii. Use your models to complete the table by counting the number of each molecule in your balanced equation for each process.

Balanced Chemical Equations - *MOLECULE* count		
Process	**MOLECULE**	**No. of each MOLECULE**
Combustion of Hydrogen	**H_2**	
	O_2	
	H_2O	

Combustion of Octane	**C_8H_{18}**	
	O_2	
	H_2O	
	CO_2	

iii. We add a coefficient in front of each molecule in a balanced equation to indicate the number of each molecule. Coefficients are greater than one (2,3,4,5...). We do not use **one** as a coefficient in balanced equations. In the blank lines provided, add the coefficients to show that you have a balanced equation that obeys the law of conservation of mass.

BALANCED CHEMICAL EQUATIONS	
Process	**Equation**
Combustion of Hydrogen	____ H_2 (ℓ) + ____ O_2 (ℓ) → _____ H_2O (g) + energy
Combustion of Octane	_____ C_8H_{18} (ℓ) +_____ O_2 (g)→ ____ H_2O (g) + _____ CO_2 (g) + energy

Practice Balancing: Use the PhET Simulation to balance these equations

More to practice, here's the balancing equation practice sheet

NEXT STEPS:

1. Reflect on today's question: Can we explain now why hydrogen has such a high energy output per gram compared to other fuels?
2. Open up the IMT for this unit, complete all boxes for lesson 7
3. Make sure all parts of the L4.7 student sheet are complete & complete the check for understanding on schoology.